Universität für künstlerische und industrielle Gestaltung -
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Institut für Medien
Interface Cultures Department

«*CLTKTY? CLACK!*»
Exploring Design and Interpretation of Sound for Interactive Commodities

Daniel Hug

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Betreut von:
Univ.-Prof. Dr. Christa Sommerer
Univ.-Prof. Dr. Gerhard Buurman

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Contact:
Daniel Hug
Arlesheimerstrasse 52
CH-4053 Basel
d.hug@hearmeinteract.com

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To My Family

Abstract

Over the last years, a new type of everyday commodities has appeared on the consumer market. These devices are endowed with computing and communication technology, and often networked, becoming a part of the "Internet of Things". Sound offers many benefits for the design of such commodities, in particular because it offers an alternative to the visual display for the increasingly shrinking, even disappearing, computers. These devices also pose a new and exciting challenge for Auditory Display and Sonic Interaction Design, because these objects facilitate new configurations of sound, materiality and interaction, and also will lead to new forms of how interactive, even autonomous, objects become meaningful in a socio-cultural context.

In this thesis I set out to explore design approaches and interpretations of sound in interactive commodities. This exploration took place in a participatory, design-driven, sound-centered process, which led to the creation of prototypical instances of possible futures. These were the basis for a dialogical exploration of aesthetic experience and interpretational discourse. To achieve this in sufficient quantity and depth, I devised a series of design workshops as research labs. The design cases were created in the form of "Electroacoustic Wizard-of-Oz" experience mockups, which allowed the production and control of sound in realtime synchronization with the interactions. All projects were demonstrated and discussed with the participants of the respective workshop. Altogether, nine workshops were executed, resulting in 29 cases. A total of 91 students participated in the process. The video recordings of the demonstrations and the audio recordings of the discussions served as data for a comparative case study using a Grounded Theory based approach.

The analysis revealed a range of emerging topics. In particular, several categories of references used in design and interpretation emerged. These include both non-mediated and mediated references and a range of analogies, including formal, procedural and crossmodal analogies. A particular insight was that abstract and affective qualities play an important role in interpretation and are often combined with concrete, indexical sounds. Apart from this, also musical forms, and effects related to space or recording and reproduction technology can influence and direct interpretational processes. Further findings concern the relevance of establishing a source for sounds and attributing them to agency of human or machine. Related to this are the various forms sounds can relate to gesture and movement. Also structure and composition were found to have a significant relevance in design and impact on meaning making.

The last part of the thesis discusses the fundamental conditions for interpretations as they emerged in the workshops and argues for caution when working with naturalistic sounds, indexical references and sonic stereotypes. The various forms of ambiguity identified in the analysis are discussed and ambiguity is identified as a constant of interpretational processes, which even may offer benefits for the design of novel sounds. I then propose the metaphor of the "interpretational force field" as conceptual model for design and interpretation of sounding interactive commodities. Finally, I summarize some design approaches that emerged from the workshops, which culminates in a plea for sound design refinement and the consideration of the benefits and potential of sonic innovation.

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Basel, Zürich & Linz, February 2017

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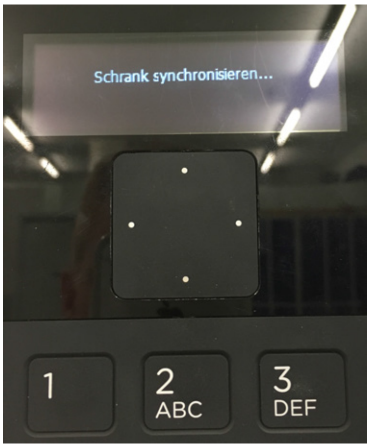
Introduction



"Cupboard synchronisation ongoing..."
(Foto: C. Polus)

Let us begin with a fictional story, based on non-fictional events.

It is the story of a simple cupboard, hanging lonely in a windowless utility room in the "Toni Areal", which hosts the Zurich University of the Arts. The cupboard features a small keypad and an even smaller screen. From its appearance, no one would guess that the cupboard is actually a smart cupboard, designed as guardian of the keys to some of the most precious gems of the school: the audio and video rooms with their expensive high-end equipment, carpet floors, comfy chairs and – quietness.

In fact, the cupboard is so smart, that it sometimes needs a break to order its memory and knowledge, a process called "syncing" in the world of the Internet of Things. And during this break, it does not let anyone interfere, ignoring all badge swipes, key presses and yells. When the thinking break finally is over, it responds to the desperate user, eager to finally open it, with a relaxed, slightly teasing, but also reassuring **«CLTKTY? ... CLACK!»**[1]

A truly smart cupboard!

The smart cupboard in this little anecdote is but one example of a new class of everyday commodities. These devices are endowed with computing and communication technology, and often even networked, becoming a part of the "Internet of Things". Recognizing the potential of using sound in the design of such interactive commodities, I became interested in finding out more about what this development entails for sound design. Due to the seamless integration of material and computational means, interactive commodities are a very different kind of product to deal with, and they are likely to integrate themselves in the socio-cultural network of artifacts of use in new ways. As a first approach to these "possible futures", I wanted to understand both the design and interpretational processess regarding sounds associated with interactions with such artifacts.

This resulted in a journey into an area, where not many points of orientation existed. And, if I was lucky, I might even discover things I would not have expected beforehand. As consequence,

[1] Apart from being a sound made by said smart cupboard, "CLTKTY" is reported to be the sound of a coin put into a vending machine, as shown in the graphic novel "Jimmy Corrigan: The Smartest Kid on Earth" (see http://www.writtensound.com/index.php?term=CLTKTY).

I chose an explorative approach and a method that aimed at diversity rather than predictability, enabled creative design activity and stimulated a discourse about the resulting prototypes as actual material for my investigation. Over several of years, I observed and analyzed design proposals made by my students in workshops. The results, in the form of their projects, were simply amazing and provided exactly the richness and inspiration I needed. What remained for me to do, was to turn this richness into something manageable, without unduly reducing its inherent complexity. And this turned out to become the actual "royal stage" of my journey. Here it was, where the surprising turns, analytic obstacles and confusing forks in the roads had to be faced.

The main findings of this analysis are first of all the insights into the interpretational processes as they occurred, in all their fuzziness and inconclusiveness, providing a detailed view of something which usually escapes attention in design processes as ephemeral epiphenomenon of design activity. But in many cases, "meta-topics" emerged from the phenomena of design considerations and interpretational argumentations, and proto-theories about understanding sound in interaction could be formulated. In all this, the method I chose esures that many phenomena of design and interpretation are likely to be encountered also under different, but comparable, circumstances.

The result, as it is presented in this thesis, is not a a short list of interpretational cause-effect relations, or a thorough taxonomy, let alone a unified, coherent theory. Instead, I offer a structured catalogue of phenomena associated with design and interpretation of sound of interactive commodities, based on what actually happened during the workshops, thereby making this rhizomatic diversity and complexity accessible and as such, as I hope, "useful".

This approach also necessarily leads to a certain level of redundancy in this thesis, as many phenomena described can be seen from different viewpoints. Many of the statements could – and had to – be read from various angles to approach the inherent interpretational density. The question if multiple aspects could – or should – be integrated or abstracted, and how this could be achieved without distorting the overall reality of heterogeneity, was a constant challenge during the analysis and writing process. And, most importantly, this analysis represents my own interpretational viewpoint of the discourse, as interpretation of interpretations. In many ways, this aggregation also can be seen as an expression of my experiences and insights through the years of both teaching sound design and designing myself.

This being said, this thesis does not really offer a concise conclusion. Rather it can (and maybe should) be read like something between a travel account and a lexicon. With this, I believe and hope to ensure that actual artistic and designerly practice can profit. In particular, this work is directed at sound designers in the area of Interaction Design (and, more generally, interaction designers with an interest in sound) who would like to gain a better understanding of the fundamental phenomena associated with meaning-making grounded in actual creative processes and designerly thinking. Another target group, although not explicitly addressed here, and although didactical issues are not discussed, are educators in the are of sound and interaction design. On the one hand, the method builds on an educational setting and offers many elements that can be used in teaching. But more importantly, as this work is dealing with the design of possible futures, it also addresses those, who are commited to the education of the designers of tomorrow: Our students.

In order to help the reader to navigate this thesis I will now provide a short overview over the various parts.

Part I: Sound for Interactive Commodities - Application Potentials, Design Challenges and Research Approach In the first part of this thesis I will describe the potential of using sound in the design of interactive, computerized artifacts of everyday use, the "interactive commodities". After a discussion of the main design paradigms in Auditory Display and Sonic Interaction Design, I will describe some questions regarding the emergence of meaning in socio-cultural context, arising from the new possibilities of combining computational interactivity, material and electroacoustic sound. In the last sections of Part I I then outline the aim and scope of this thesis and the methods used, namely the use of research workshops and Electroacoustic Wizard-of-Oz mockups and the analytic approach based on comparative case studies and Grounded Theory.

Part II: Documentation of Design Cases In the second part, I provide an overview over all cases that were used as data source for this work. The case descriptions are mostly based on the project reports provided by the students. Furthermore the cases are documented with images and the links to the video recordings (online) can be found. All cases are labeled with their "primary document" index generated by the qualitative analysis software, in order to reference them in the following chapters as well as in the source data. Furthermore, all quotes from the workshop discussions have an index number which allows to find them in the source data.

Part III: A Systematized Conglomeration of Design and Interpretation In Part III of this thesis, I will report on how participants of the workshops described and discussed their aesthetic experiences and interpretations of sound in interactive commodities, as manifested in the Wizard-of-Oz mockp demonstrations. In this journey we encounter a wide range of "interpretational forces", from non-mediated and mediated references, analogies, abstract and affective qualities and their combination with concrete, indexical sounds to musical forms, and effects related to space or recording and reproduction technology. Further findings concern the establishing of source for sounds and attributing them to agency of human or machine, and to gesture and movement. Finally, the impact of structure and composition on meaning making is discussed.

Part IV: Designing Interpretational Force Fields for interactive Sonic Identities The final part looks at the data from a more superordinate point of view, investigating broader concepts and underlying issues throughout the cases. In particular I will discuss a particular group of codes that converged on the themes of indexicality, ambiguity, and general "reliability of understanding". I argue for caution when working with naturalistic sounds, indexical references and in particular sonic stereotypes. The various forms of ambiguity are discussed and ambiguity is identified as a constant of interpretational processes, which even may offer benefits for the design of novel sounds for interactive commodities. Finally, I summarize some design considerations that emerged from the workshops, which culminate in a plea for sound design refinement and the power of sonic innovation for the design of interactive sonic identities for interactive commodities.

Online Source Data Repository: This thesis does not contain an annex section for two reasons: First, all relevant source data (discussion statements, codes and their quantifications) are always indicated directly in the context of their analysis and interpretation. Second, the entirety of the source data goes beyond the scope of a printed thesis, and accessing the information would be very cumbersome. Therefore I have decided to provide access to these materials via an online repository[2].

The repository contains a folder with all the video recordings from the project demonstrations. Furthermore, a simple HTML webpage[3] is provided, which includes the main project statistics, the unedited version of all transcripts of case discussions ("Primary Documents"), an unedited list of the related codes, as well as an overview over all network views which were used in the analysis. In addition, a PDF file[4] with a list of all codes and the associated quotations is provided.

[2] Available at http://people.zhdk.ch/daniel.hug/CLTKTYCLACK_data_Hug_2017/
[3] Direct link: https://tinyurl.com/data-overview-Hug2017
[4] Direct link: https://tinyurl.com/data-codes-quotations

Part I.

Sound for Interactive Commodities - Application Potentials, Design Challenges and Research Approach

Introduction to Part I

Artifacts of everyday use are complex elements in the systems of meaning making, which encompass individual psychology as well as the socio-cultural dimension. They are functional elements of use, and even agents in social networks. Computing technology and interactivity adds to this complexity, and the use of electroacoustic sound as "Auditory Display" questions the familiar relationship between material dimension and product sound. While sound has a great potential to be used in the design of such interactive commodities, it is unknown, how the design of the sounds could be approached and how interpretations of these sounds would emerge in the interaction with them. The first part of this thesis elaborates on these aspects and describes the specific objects of this research, and the methodical approach chosen.

1. The Potential for Sound in Interactive Commodities

Bubble (pushing vacuum): “Hoover! Hoover! Hoover!”
Eddy: “You have to turn it on, not just make the noise!”

Absolutely Fabulous, Season 5, Episode 1: “Cleaning”

1.1. A New Opportunity for Sound Design

When there is physical motion, there is often also sound. Among many other aspects, our experience of sound is related to the experience of movement, action, in a world of mechanical artifacts and machines. Sound has since long taken a core position in the efforts to communicate to people on an emotional, presumably less rational level, to elate and inspire, to intimidate and fanaticize (Welsch, 1996), and to convince and sell, which has been exploited not only by musicians and filmmakers (Sonnenschein, 2001; Grau and Keil, 2005), but also by advertising, branding (Bronner and Hirt, 2007; Steiner, 2009), and product design (Ulrich and Eppinger, 1995; Västfjäll, 2002; Özcan, 2008; Nykänen, 2008).

This world of products of everyday use has undergone significant changes in the last decades. a development which has been fueled by various factors. On the one hand, there is the technological advancement in terms of miniaturization and ever increasing processing power and storage spaces at reduced costs. Computers have shrunk down to the size of fingernails and are embedded in artifacts of everyday use, from wristwatches to household appliances and vehicles. The technology (and ideology) of the “Internet of Things” posits, that literally every thing is a possible resource for networked information technology. Combined with the increasing relevance of services and ecosystems in the management of our lives, this facilitates the proliferation of a new type of artifact that is interwoven in the fabric of our everyday experience, thus realizing Mark Weiser’s vision of the "ubiquitous computer" (Weiser, 1991), also aptly termed ”Everyware” by Adam Greenfield (Greenfield, 2006)[1].

The ”new everyday” (Aarts and Marzano, 2003) thus is permeated by networked technologies and complex, seemingly autonomous devices. These are often experienced as incomprehensible “black boxes”, endowed with agency and even will, or magic of some sort (Turkle, 2004; McCarthy, Wright and Wallace, 2006). The meaning and function of hitherto familiar objects is transformed and entirely new classes of commodities emerge, which I call here *”interactive commodities”*. The term “commodity” stands for the pragmatic, everyday nature of these artifacts.

Sound is of particular interest for such objects and environments, not only due to small or absent screens, peripheral, “eyes-free” use, and it’s relative economic implementation [2]. More specifically, according to (Franinovic, Hug and Visell, 2007), sound offers the following benefits for (interactive) product design:

- Creating or revealing new functionalities in a product:

[1] The notion of “ubiquity” and “Everyware” is extended to the notion as interactive technology being intervoven in architecture by McCullough (2004).

[2] Thanks to miniaturization and continuous improvement of the performance of electroacoustic components, sounds can be integrated relatively easily into interactive commodities.

- By displaying new informational capacities
- By displaying invisible affordances[3] of a computationally augmented artifact – for example, an everyday object that is linked to a computational process
- By distributing an information load linked to the functionality of a product to senses other than vision (Brewster, 2002)

• Shaping the sonic appearance of an artifact:
  - By improving aesthetic experience and sound quality (Lyon, 2000; Blauert and Jekosch, 1997)
  - By augmenting emotional aspects of the design (Williamson and Murray-Smith, 2005; Västfjäll, 2002)
  - By enhancing the interplay between material, shape, size and actions

• Improving performance and usability in the interaction process:
  - By providing feedback to aid users' control over an inter- face (Rath and Rocchesso, 2005), tool, device , or physical activity (Gaye, Maze and Holmquist, 2003)
  - By sonifying silent information associated to an action (e.g. the successful execution of a button press on a touchscreen)
  - By improving the focus and flow experienced by a user during a task

Thus, sound can provide new means of expression and communication about a product. Sound is a powerful medium to communicate information about a continuous, temporally structured process (e.g. boiling tea water, the sound of an engine). and by conseqence supports the execution of ongoing continuous control activities, such as filling a vessel, or driving a car.

A final motivation for using sound in interactive products is, that sonic displays (i.e. loudspeakers and suitable amplification) can be implemented and integrated relatively simple, and offers a very high efficiency in terms of balancing possible information density and reach with costs. And while the laws of physics ultimately limit the miniaturization of sound reproduction systems in terms of bandwidth and achievable loudness, technologies such as micromechanical systems (MEMS) technology[4] may soon change this[5]. But already today, smartphones and portable boom boxes show what is achievable even in small form factors.

In order to provide a concrete idea of where the potential of sound lies for interactive commodities, I will describe now several application scenarios.

1.2. From Smartphone to Cyborgs: Interfaces and Interaction Paradigms that Motivate Sound

On a general level, the potential of sound can be identified on the basis of a range of interface paradigms. For instance, interfaces that require touch, but does not offer sufficient haptic feedback, such as touchscreen keyboards, can profit greatly from auditory feedback (Ma et al., 2015). On the one hand, as devices shrink in size, so do displays. From studies dealing with the mobile phones, smartphones and their predecessors, the Personal Digital Assistants (PDAs), we know that sound can greatly contribute to their design. The potential has been discussed already in the heyday of these technologies: one of the first panel discussions at a Human-Computer Interaction related conference dealing with the functional benefits and design of information sound for PDAs

[3] Gibson (1979), who introduced this term, describes it as comprising all possibilities for and agent (people or animals) to interact with the given environment, in relation to the agent's capabilities.
[4] For an introduction and outlook to potential applications, see Klasco (2015).
[5] See, e.g., products such as the "Audiopixels" (http://www.audiopixels.com.au/).

took place at the User Interface Software and Technology (UIST) in 1995 (Hindus et al., 1995). Another example of a influential study about the use of sound in PDAs was Brewster's work, which presents a specific benefit of, and design criteria for, using auditory displays to overcome the lack of screen size limitations in the domain of mobile computing (Brewster, 2002).

Today, smartphones are so tightly intertwined with our everyday lives that they become actual extensions of our self, complement brain functions (such as remembering dates or names), act as mediators in social interactions, or even extend our limbs, for instance as bluetooth remote controls, or using NFC tags[6] for touchless payment. In some sense, humans have always extended their abilities and their self with technology, but the borders between the two increasingly blur, turning us into actual cyborgs. Consider, for instance, the case of Neil Harbisson, the first officially approved cyborg. Harbisson suffers from a rare condition of achromatopsia[7], or more specifically monochromatism, the inability to perceive color. In order to compensate for this, he developed the "Eyeborg" device together with Adam Montandon. The colors are mapped to specific tonal pitches. After winning the Europrix 2004 competition, Harbisson used the sonic augmentation of his eyes continuously, and the resulting long-time practice allowed him to differentiate 360 different hues mapped on only one single octave[8]. After obtaining a certificate for him being a cyborg from a medical doctor, he was allowed to wear the device also on a passport picture, which makes him the world's first official cyborg. This case is also a striking example of the "medicalization of cyberspace" (Miah and Rich, 2008) which ranges from online medical consultation to cybernetic treatment through implants, or robotic prostheses. Ultimately, the medicalization of cyberspace extends to the whole environment we live in[9]. Everyday technologies, such as smart watches, in combination with self-monitoring software, have made the "quantified self", beyond medical applications, a normality. Clothing garments such as "Softspot" by Moonlab (S. Seymour)[10] provide us with a glimpse of the potential of a "fashionable technology" (Seymour, 2008), which is truly seamlessly integrated in the familiar clothing. The prospect of augmenting the possibilities of our bodies with robotic limbs, not only compensating for lost abilities but improving our existing ones, is becoming increasingly realistic.

In many of these design cases, screens are problematic or inappropriate, for instance in furniture in the "smart home" (where design meets embedded computing) or fashion. There are many situations, where vision is already occupied by other, high-priority tasks, such as observing the street while driving a car, or watching TV in the "smart home". In this context falls also sound's potential in supporting attention management in peripheral interactions (Bakker, van den Hoven and Eggen, 2012). The so-called "eyes-free" interaction is gaining relevance and sound offers a powerful alternative display modality, although the development is still in an early stage (Oakley and Park, 2007). Some examples of possible approaches are a 3D audio radial pie menu that uses head gestures for selecting items and a sonically enhanced 2D gesture recognition system for use on a belt-mounted PDA (Brewster et al., 2003).

In this context, gestural interfaces have become increasingly available, even beyond the 2D touchscreen, thanks to affordable sensors, such as the Microsoft Kinect, or gesture recognition technology integrated into consumer products, such as Samsung "Smart TVs", introduced at CES 2012[11]. Several vision-based hand-gesture applications are proposed by Wachs et al. (2012). They identify several related challenges, some of which can be linked to questions of interface design and the use of sound. One challenge lies in training the system, which requires a certain

[6] Near field communication (NFC) is a set of standards for radio communication between devices which allows them to exchange data by bringing them into close proximity.

[7] A hereditary vision disorder which affects one person in 33,000.

[8] http://www.adammontandon.com/neil-harbisson-the-cyborg/, see also (Ronchi, 2009).

[9] This "megatrend" some call "ambient assisted living" (see http://www.heise.de/newsticker/meldung/Ambient-Assisted-Living-IT-Technik-fuers-Alter-217113.html).

[10] http://urbanwearables.technology/softspot-technology-turns-garments-into-smart-clothes/, and for the actual product, see http://www.supa.ai/.

[11] http://www.cnet.com/news/samsung-smart-interaction-hands-on-with-voice-and-gesture-control/

consistency in gesture execution, to achieve a minimal amount of training samples that the system can generalize. This is related to a feedback problem, as the user should not deal with an additional cognitive load during the training phase. Also here, sound offers potential solutions, as it allows to exploit the our experience of the direct link between physical movement and sound[12]. In general, designing multisensory interfaces can be beneficial, if learnability and mental load due to distributing attention between modalities are well balanced and the design is congruent (Shams and Seitz, 2008). But while experience from everyday life suggests the high relevance of multimodality, the empirical and systematic study of benefits and weaknesses, and related design suggestions, are still in a very premature stage (Sigrist et al., 2013)[13].

Finally, the idea of directly controlling machines or computers with our thoughts, omitting entirely any kind of physical interaction, has been around at least since the 50s science fiction movies. Currently these systems are both expensive and relatively slow, which restricts their use to people with very severe disabilities (McFarland and Wolpaw, 2011). The ability of sound to compensate for missing haptic feedback also offers design potentials in this context, just as in the case of multitouch interaction mentioned above.

1.3. EV, HEV, PHEV, or WROOM? The Example of the Electric Vehicle

In the following, I would like to illustrate both the potential and the design challenge of sound for interactive products with the example of an actual "killer app" with a major market potential: electric vehicles. The automotive industry always was a driving force for product related sounds, starting with the sound of the engine, but also the sounds of doors, car horn, turn indicator, servos, and so on. This is becoming particularly acute due to the discussion around the need for sounds for cars with alternative engines. Thanks to increased pressure from politics and market demand, cars combining combustion with electric drives, or even purely electric drives have started to make a significant impact on the market. An early example was the first Tesla Roadster. In 2008 an article about this vehicle, published in the Swiss newspaper "Neue Zürcher Zeitung", featured the headline "hum-hum, goes the sports car" ("Summ-summ macht der Sportwagen", see Figure on the next page).

At the time of this writing, Tesla is a success story - at least in terms of promoting the positive image of electric cars - and other brands have entered the mainstream consumer market with electronic cars as well as hybrids and plugin hybrids[14]. But their silent engines pose a challenge. On the one hand, a potential sign of power and engineering quality, as well as multisensory branding, is lost. On the other hand, there is a significant security issue associated with silent cars. As a consequence, several legislative bodies released guidelines or adapted legislations. An early example is the U.S. legislation Pedestrian Safety Enhancement Act of 2010 (111th Congress of the United States of America, 2010). The United Nations Economic Commission for Europe (UNECE) runs an "informal working group" on "quiet road transport vehicles", as part of the World Forum for Harmonization of Vehicle Regulations, who has issued a "Proposal for guidelines on measures ensuring the audibility of hybrid and electric vehicles" (United Nations Economic

[12] Filmmakers have realized this potential and and provided the gestural interaction with the Holoscreen featured in the movie "Minority Report" (Spielberg, 2002) with sounds that help to structure and clarify the process and functionality of the bodily movements.

[13] In this context it also should be noted, that at least for some time to come, so-called "natural interfaces" will be more or less limited by the technical constraints, dealing with fuzziness and unpredictability of human movement as well as complex situations in which they may take place (change of lighting or background, movement etc.). For a critique of the term "natural interfaces" see (Norman, 2010) and, in terms of applying the concept to sounds, also chapter 24 on page 195 in this thesis.

[14] A hybrid electric vehicle (HEV) combines a conventional combustion engine with an electric propulsion system. A plug-in hybrid electric vehicle (PHEV) in addition features rechargeable batteries to power the electric motor.

NZZ am Sonntag • 23. November 2008

Summ-summ macht der Sportwagen

Der Tesla-Zweisitzer fährt schnell und mit Strom. Eine Testfahrt mit dem «Auto der Zukunft»

Der Anlasser hält die erste Überraschung bereit. Eine kurze Melodie lässt erkennen, dass man den Zündschlüssel in die richtige Richtung gedreht hat und der Wagen startbereit ist. Die

solche Ladung im Niedertarif in der Stadt Zürich 4 Franken 30 – ein Schnäppchen, verglichen mit den derzeitigen Preisen an den Tankstellen. Das Batteriepaket soll laut den Tesla-Herstellern erst nach 150 000 Kilometern ausgewechselt werden müssen.

Der Strom für ihr derzeit einziges Modell soll wenn immer möglich aus erneuerbaren Quellen wie Sonne, Wind und Wasser kommen, heisst es bei Tesla. Die Firma hat denn auch vorgerechnet, dass man mit 25 Quadratmetern Solarzellen eine Strommenge produzieren kann, die für jährlich 20 000 Kilometer Fahrt mit dem Tesla genügen soll. Das Unternehmen plant, seinen

Figure 1.1.: Article about the Tesla Roadster in Neue Zürcher Zeitung (23.11.2008)

and Social Council, 2010). Furthermore, "Draft Recommendations for a Global Technical Regulation Regarding Audible Vehicle Alerting Systems for Quiet Road Transport Vehicles" were issued (United Nations Economic and Social Council, 2012) .

Judging from a presentation by an expert from Yamaha on "Ideal Sound for AVAS (Approaching Vehicle Audible Systems)", to be found on the UNECE website[15], there is a significant interest in the industry in such legislations. Companies with a strong background in audio technology, such as Yamaha, or the loudspeaker producer Harman, are pushing toward that market. For instance, in January 2011, Harman announced their HALOsonic (TM) noise management system for electric cars, combining electronic synthesis and noise cancellation to shape the car's sounds[16].

However, as reports in the media show, while the benefit of audibility is generally acknowledged, the actual design solutions are less convincing, reminding of "spaceship sounds"[17] or being described as a "whimper reminding of a reversing garbage truck" (Grünweg, 2011). Also the UNECE proposal mentioned above reports, that they received "a number of comments opposing the measure to generate sound in vehicles" (United Nations Economic and Social Council, 2010, p. 4). An article on the website "Green Car Reports" – and the related discussion board – illustrate the challenge: In this case, the proposed sounds were useless because they were considered too silent. But the proposal of increasing their volume triggered a storm of worried to angry posts, pointing out the somewhat absurd thought to add artificial noise to an otherwise silent technology (Gordon-Bloomfield, 2011b). And in a post about the "vehicle proximity notification" sounds of the 2012 Toyota Prius, the same author poses the question: "Would you want to buy a Toyota Prius if it made a noise like a deranged spaceship?" (Gordon-Bloomfield, 2011a).

[15] http://www.unece.org/fileadmin/DAM/trans/doc/2010/wp29grb/QRTV-03-04e.pdf
[16] http://www.harman.com/EN-US/Newscenter/Pages/HALOSonicFeature.aspx
[17] http://www.greencarreports.com/news/1066487_2012-toyota-prius-prius-v-prius-plug-in-hybrid-now-with-spaceship-sound

This demonstrates, that the sound of electric cars is ultimately a design problem. But the directions in which this design should be developed is both unclear and not really discussed. In current legislation related guidelines are only defining some simple technical aspects such as volume (in dB), requirements for pitch (or spectral range) and duration, or that the sound should be similar as the sound of a comparable vehicle with combustion engine (European Parliament, 2013, see Amendments 16, 20, 58 and 59). The current approaches thus are not driven by a systematic sound design, nor will they contribute to useful guidelines[18]. Finally, the engine noise issue with electric cars is only one aspect that puts sound at the center of design concerns. Increasingly, cars are basically computers on wheels, resulting in a potential increase of all kinds of functional auditory displays. Thus, in addition to the car's engine sound, and the many existing warning sounds (security belt, key in lock, lights on, etc., see, e.g. Fricke, 2009), the potential need for functional sounds for in-car entertainment and information systems in the passenger cabin is rising.

[18] Similar issues arise from regulations for all kinds of warning sounds, e.g. for doors in public transports, which results in generic – and generally annoying – beeps.

2. Design Concepts and Paradigms for Auditory Displays and Sonic Interaction

After having discussed some existing and potential application scenarios for sound in interactive commodities, I will now turn toward research and development concerned with design and evaluation of sounds used in the context of Human Computer Interface and Interaction Design. While sometimes it is claimed that sound is the "neglected modality" in interface and interaction design, there are certainly other reasons for that than a lack of consideration in research. Apart from the musical sciences, sound and noise have become an issue at least since the invention of the gramophone. The history of using sound in the design of interactive products is somewhat newer, but about as old as the discussion of the visual design of interactive interfaces. For instance, researchers have published design oriented research already in the early eighties, notably at the very first conference on "human factors in computing systems" organized by the Association of Computing Machinery (ACM CHI[1]) in 1982 where Sara Bly demonstrated the successful communication of information using sound (Bly, 1982). There was already, indeed, a substantial body of applied research in the domain of warning and notification sounds, which aimed at developing guidelines for their design, for instance the proposals by Pollack & Ficks (1954), Patterson (1982), or Sorkin (1987). The scope of these designs was usually rather narrow, restricted to pure tones, and parameters such as pitch and volume, and "design issues" were limited to things like discrimination, audible thresholds and masking. In the late eighties and beginning of the nineties, driven by the advent of the "multimedia computer", researchers and designers started to explore more complex sound design approaches.

Since the mid-nineties, the use of sound for interactive artifacts is investigated through the work of the International Community of Auditory Display (ICAD)[2]. According to Hermann et al., "Auditory Display researchers examine how the human auditory system can be used as the primary interface channel for communicating and transmitting information" (Hermann, Hunt and Neuhoff, 2011, p. 1). In Sonification, the research and resulting sound design criteria are aimed towards efficient communication of system or data status or changes and are mostly concerned with highly specialized applications such as medicine or geology (Kramer et al., 1999). On the other hand communities focusing on musical interactions and the related technologies, such as "New Interfaces for Musical Expression" (NIME)[3] and the "Sound and Music Computing" (SMC)[4] have emerged.

In the last years, there has been an increasing interest in integrating the various disciplines associated with sound and music computing and related applications. Among the most notable initiatives in this context are the IST project "The Sounding Object" (2001-2002)[5] or the FET-open Coordination Action "Sound to Sense, Sense to Sound" (S2S2, 2004-2007)[6], which has its "historical roots in research traditions that aimed at understanding the relationship between sound and sense, physics and meaning" (Polotti and Rocchesso, 2008, p.15). The subsequent FP6-NEST-PATH project "CLOSED - Closing the Loop on Sound Design and Evaluation" (2006 - 2009)[7] specifically addressed the relation between design, production (synthesis) and perception

[1] http://www.sigchi.org/conferences
[2] http://www.icad.org
[3] http://www.nime.org
[4] http://smcnetwork.org/
[5] Project Nr.: IST-2000-25287, http://www.soundobject.org
[6] Project Nr.: IST-2004-03773, http://smcnetwork.org
[7] Project Nr. 29085, http://closed.ircam.fr

which led to the development of psychoacoustic measurement tools suitable for the evaluation of continuous interaction scenarios, and related criteria to aid in the design of sound in interactive artifacts (Susini et al., 2006; Monache et al., 2008; Lemaitre et al., 2009a). In 2006 the conference "AudioMostly - Conference on Interaction with Sound"[8], which fostered the integration of game sound design and industry, was founded. Now being supported by ACM, it still remains focused on design and applications. In 2007, the COST Action IC0601 on "Sonic Interaction Design" (SID)[9] was launched, which encompassed all those fields, and included further areas such as interaction design and the arts (Serafin et al., 2011a; Franinovic and Serafin, 2013). .

In the following section, I will outline how the question of how to design and judge sounds for interactive applications was discussed in these communities. I will mainly focus on a few strong paradigms, which made their appearance early in the process, and I will discuss what the contributions, and limitations, of those paradigms were, and still are, for sound design in the context of this thesis.

2.1. Auditory Icons and Earcons as Design Paradigms

Historically, the discourse about research and design of sounds for interfaces and interactive artifacts, was marked by an early separation into two paradigmatic approaches to designing sounds for communications: Auditory Icons and Earcons. Paraphrasing the foundational (and still influential) work by (Gaver, 1988), Auditory Icons are defined as the auditory equivalent of the visual icons used in the desktop metaphor. They mimic everyday non-speech sounds that we might be familiar with from our everyday experience of the "real world". Hence the meaning of the sounds supposedly is self-evident, as they metaphorically draw upon our previous experiences. For example, deleting a document might be represented by the sound of crumpling a piece of paper; an application error may be represented by the sound of breaking glass. Gaver's (1988) interpretation and adaption of Gibson's (1979) ecological theory of visual perception to sound can be considered the argumentative foundation of this design paradigm. In a later article, Gaver emphasizes that

> "it is important to note that the notion of everyday listening came first, with Auditory Icons following as a natural application of these ideas." (Gaver, 1993b, p. 17).

Earcons, on the other hand, can be defined as non-verbal audio messages composed of usually synthetic, musical tones that can be used in structured combinations to create auditory messages. This approach is inspired by the notion of musical motives, and to some extend by the idea of the Leitmotif. Such audio messages can be used to provide the user of an interface with information about some virtual object or the status of an process (Blattner, Sumikawa and Greenberg, 1989; Brewster, 1994). The foundational texts show, that the term "Earcon" is meant to refer to visual icons in the graphical user interfaces (GUI), which emerged only a few years earlier[10].

Comparing Auditory Icons and Earcons, it was noted that the former require

> "an existing relationship between the sound and its meaning, something that may not always exist. In such cases, it may be better to employ Earcons. (...) The key difference between these and Auditory Icons is that there is no assumption of an existing relationship between the sound and the information that it represents. This relationship must, at least initially, be learned." (McGookin and Brewster, 2011, p. 339)

[8] http://www.audiomostly.com
[9] http://www.cost-sid.org; http://sid.soundobject.org
[10] The first commercial computer system with a GUI was the Xerox Star 1981, the Apple Macintosh then brought the technology to a wider market in 1984.

This need for learning, and the required training, may have contributed to the fact that Earcons, and musically inspired sound design approaches in general, have pretty much fallen out of favor in mainstream Auditory Display research and design over the last fifteen years, despite some successful applications, and a reasonable set of arguments in favor of their use, for instance provided by Vickers (1999), who used musical patterns for program auralisation, or Leplâtre (2002), who used Earcons to aid menu navigation). According to some studies, the difference in terms of learnability has been found to be statistically insignificant, and that the most important factor to improve the accuracy of recognition of the Auditory Icons and Earcons was the explanation and understanding of the rationale behind the sound design by the listeners (Lucas, 1994). Still, Auditory Icons turned out to be slightly easier to recognize than Earcons.

In the best case, Auditory Icons and Earcons are seen as having complementary strengths and weaknesses (McGookin and Brewster, 2011, p. 349), in the worst case, Earcons are considered rather useless because of their abstract and ambiguous symbolic nature and the required learning efforts which does not fare well in empirical comparisons of performance and accuracy (Dingler, Lindsay and Walker, 2008; Garzonis et al., 2009). McGookin and Brewster argued that “Earcons can be designed to be implicitly, rather than explicitly, learned; exploiting more musical properties of the sound to allow for more metaphorical mappings between the sound and data” (2011, p. 357), but such arguments did not seem to change the trend. More recent works usually do not use Earcons in the traditional sense anymore, but similar approaches, such as “tactons” or “musicons” (McGee-Lennon et al., 2011), may be used.

Despite the somewhat similar names, the two paradigms of Earcons and Auditory Icons seem mutually exclusive, and often are put in opposition to each other, at least regarding their use in applied and fundamental research and the related comparative evaluations (e.g., Dingler, Lindsay and Walker, 2008)[11]. These two paradigms have fundamentally defined a large amount of research. On some levels, the dichotomy comes down to sound “content” vs. sound “structure”, or a process of “translation” (e.g. of data into sound) versus “positing” specific auditory displays (Oswald, 2012). One aspect is the idea of meaning emerging from the single (sampled) sound and what it represents. The other approach is based on meaning emerging from how (tonal) sounds relate to each other and some given data.

There are few examples in Auditory Display literature that provide alternative approaches, and usually they are derivatives, such as modeling a language out of very short audio samples, which are used like Auditory Icons (Ma, Fellbaum and Cook, 2010), or combinations, such as “Spearcons”, which are produced by speeding up text-to-speech audio output until it is no longer perceived as speech, but retains some similarity to the original speech signal from which it was derived (Walker, Nance and Lindsay, 2006). Other crossover approaches have been introduced as “Parameterized Auditory Icons” (Gaver, 1989), or evolutionary Auditory Icons (Buxton, Gaver and Bly, 1994), and the “Earcon-Icon” hybrid (Dingler, Lindsay and Walker, 2008). A design example for this approach is the auditory information system for the iLAND environment at Fraunhofer, created by Müller-Tomfelde (2002). The most recent interpretation of the parametrized Auditory Icon features interactive, adaptive sonic interactions, sometimes called “closed-loop sonic interactions” (Serafin et al., 2011a), which feature naturalistic sounds that continuously respond to the gestures of one or more users. Here the sounds are usually procedurally synthesized, using physical sound models or imitating the sound generation of the natural counterpart, and follow the same design principles as Auditory Icons.

2.2. Ecological and Everyday Sound Perception

It is necessary, at this point, to have a closer look at some of the concepts behind Auditory Icons. From this specific conceptual setting a range of guiding concepts emerged, which rather strongly

[11] Interestingly, this dichotomy is not based on the foundational text. For Blattner et al. (1989) Auditory Icons were “representational Earcons” with a different name.

predetermine design decisions in Auditory Display, beyond Auditory Icons.

As mentioned, the design rationale behind Auditory Icons is based on the more or less intuitive notion of everyday sound perception which is supported by Gibson's theory of ecological perception[12]. In the view of ecological psychoacoustics,

> "(...) perception (of sound) does not pass through an analysis of the elements composing the sound event and their reconstitution into a mental image that is compared with a representation in memory. The perceptual system itself is hypothesized to be tuned to those aspects of the environment that are of biological significance to the listener or that have acquired behavioral significance through experience." (McAdams, 1993, pp. 147-148)

In relation to Auditory Display design, Walker & Kramer propose that the adoption of ecological approaches to perception brought about several benefits, such as the openness for more complex and less controlled – in other words more realistic – study settings, including dealing with more complex and dynamic sounds, but also a generally holistic view of interaction and meaning making, adopting metaphors and conceptual maps as relevant aspects (Walker and Kramer, 2004). The paradigm shift generally benefited from the increasing demand for "applicable" research, and the required "ecological validity", which motivated psychoacoustic research to move out of the laboratory[13].

A first outcome concerned the perception and cognition of complex sounds, such as those encountered during interaction with physical objects, which provided scientific evidence and a precise understanding of how our hearing is linked to artifact's physical properties (material, size, to some extend shape) through sound (see, e.g., the comprehensive overview provided by Giordano, 2003). Still, these studies usually take place in lab settings with controlled stimuli production using the relatively basic varieties of "complex" sounds, such as steel pendulums hitting metal plates (Kunkler-Peck and Turvey, 2000).

Building on the results of basic research on auditory perception from an ecological viewpoint[14] a general conclusions is, that everday sounds are easier to identify and understand, and thus design strategies should be based on such sounds. Giordano states:

> "[Gaver's] taxonomy is based on the simple assertion that sounds are generated by an 'interaction of materials', and it is inside this map that we should place the pieces of experimental evidence collected so far, synthesized in this chapter." (Giordano, 2003, p. 1)

These "everyday sounds" are not perceived as singularly, temporally isolated percepts based on simple stimuli, but rather as complex composites. Gaver uses the example of an approaching car, whose sound is a complex amalgam of a multitude of physical sound sources, but perceived as one single "sound event". Another example for such "everyday sounds" and their complexity is walking, which has recently come into the focus of Sonic Interaction Design researchers, exploring aspects such as material of shoe and floor, and the possibility to extract various complex parameters and qualities about the walking process just from listening to its sounds (Serafin et al., 2011a).

[12] Ecology is the study of organisms in relation to their environment. The study of perception investigates the ongoing awareness and adaptation to the environment by means of our senses and the processing of the data they provide in our cognitive system.

[13] I will not discuss here possible issues associated with ecological perception, or it's specific adoption in auditory perception and cognition study, as this is beyond the scope of this thesis. An excellent summary in this regard has been provided by Vicario (2003). For the present argument, I will only regard the influence that the concept had – and still has – on research and practice in Auditory Display.

[14] E.g., Vanderveer's doctoral thesis (1979) is an important starting point to the study of ecological perception of sound. Warren and Verbrugge (1984) investigated the recognition of breaking glass, revealing how procedural temporal patterns influence our perception and recognition of events: if the intervals between impacts increase, it is perceived as falling, if they decrease it is interpreted as breaking.

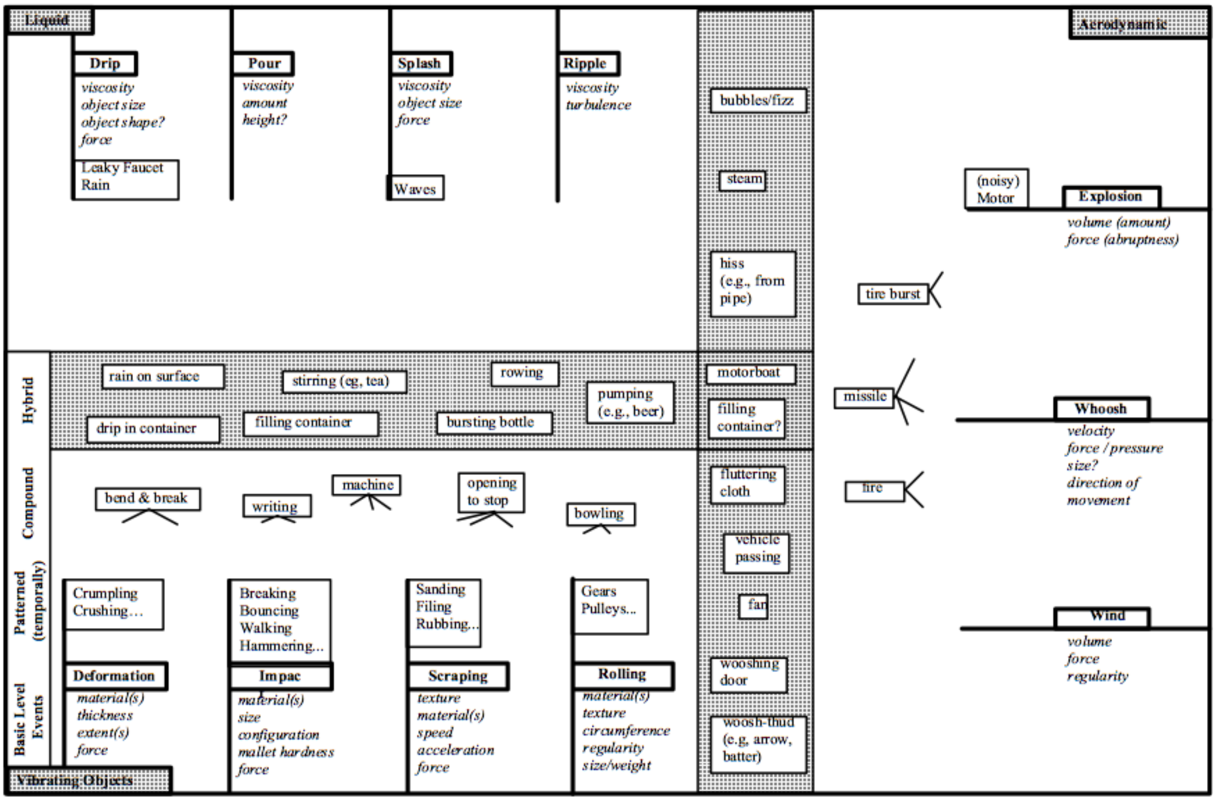


Figure 2.1.: Gaver's (1993) extended taxonomy of everyday sounds.

In an influential paper Gaver described a related taxonomy and outlined the main elements of a conceptual framework resting on the paradigm of ecological perception (see Figure 2.1): Sounds are described as composites of basic, physically produced vibrations, either from solids, water or air, which then occur in specific patterns, such as bouncing, scratching or whistling, and finally, can be composed between material sources, e.g. to result in the perceived event of raindrops on a metal roof (Gaver, 1993b). This model also implies that the compositional elements must be identifiable as natural, physical processes between natural materials, such as stone, metal or wood. As mentioned, this conceptual model has been, and is still very influential, grounding design (and the related research) that builds on the very notion of compositional ecological sound patterns, for instance work on certain temporal clustering of impact spectra to render the sound of a rolling ball (Rath and Rocchesso, 2005) or the design and evaluation of the Spinotron (Lemaitre et al., 2009b) as well as the associated development of the Sound Design Toolkit (Baldan, Monache and Rocchesso, in press, 2017).

2.3. Physics-based Naturalism in Relation to Sound and Mapping

All these efforts are ultimately motivated by the expectation that Auditory Icons and in general auditory signs which rely on "natural" and everyday sound experiences, are "intuitively and directly" understandable. The following statement is exemplary in this respect.

> "Therefore, the intention was that the rowers would not be expected to consciously "decode" the information conveyed by the sounds, nor to think about how modifying their action would modify the sound. The sound-action loop was supposed to be intuitive. After all, this is what happens in "natural" interactions through sound. A user filling a vessel with water does not need to understand the relationship between

> pitch and volume to fill a recipient without overflowing (Cabe and Pittenger, 2000)." (Serafin et al., 2011b, p.88)

The expectation that there are sounds which are so easy to understand, so ordinary and familiar, and still so flexible and adaptable that they would seamlessly intertwine with our activities seems very promising. A pivotal term is the notion of "naturalness"[15] from which everything else seems to follow.

Naturalness may refer to an isolated sound object and to its sonic behavior over time. In relation to isolated sounds, the dominant strategy of establishing naturalness is either using sounds obtained from recordings of real objects, usually obtained from sound libraries, with a reference to a real-world sound source, or presenting subjects selections of sounds and asking them to judge their naturalness. For instance, in (Susini et al., 2012) the authors propose a continuum of naturalness, from causal sounds (high naturalness) to iconic (medium naturalness) to arbitrary (little or no naturalness). The participants were asked to rate the naturalness of a defined set of sounds, before that they were presented a video showing a hammer hitting a ceramic tile, one version with the actual sound of the impact, the second with a synthetic, but similar sound, the third with a musical chord[16], and they were informed that this was to illustrate the three levels of naturalness.

The other line of thought behind construing naturalness in sounds is related to the mapping strategy chosen between some data or control pattern and the sound's development. Here, the natural, or in Walker and Nees' words, "ecological (i.e., naturally-associated) resemblance to the action or process" (Walker and Nees, 2011, p. 23) mapping is usually opposed to the notion of "symbolic" mappings. Coward and Stevens refer to this as "nomic" mapping[17].

> "Sounds and events that express consistent information regarding the source are termed nomic mappings, whereas symbolic mappings involve unrelated or arbitrary sound-event pairs. Gaver predicted that the redundancy of information expressed in nomic mappings results in efficient and rapid recognition." (Coward and Stevens, 2004, p. 350).

Coward and Stevens focused on the relation of object size and the frequency content of sounds emitted by said object, which, in the case of nomic mapping would be related and in the case of symbolic mapping unrelated. According to their study, symbolic mapping requires an additional step in recognition and learning. In their experiment, they confirmed, that nomic mappings are identified more easily than symbolic mappings, but also showed that after extended exposure, and the resulting learning effect, initially superior recognition of nomic mappings is equaled by symbolic mappings.

Particularly in Sonic Interaction Design, with its focus on continuous, action-related sounds, the understanding of "the natural" seems to be comprehensive, including both the sound object and mapping[18]. The motivation for, and definition of, "natural" mappings between sound and movement in continuous interactions is provided by Serafin et al.:

[15] It seems that the use of the term "natural" in Auditory Display and Sonic Interaction Design related literature is largely unaffected by any philosophical discourse in terms of what can be considered "natural" and is usually not explicitly defined.

[16] see video at http://Sonification.de/handbook/index.php/chapters/chapter5/, Example S5.2: "Marteau".

[17] This term seems to be used in very few publications. Essentially, Gaver (1988) introduced the term but replaced it with "everyday sounds" or "everyday sound-producing events" in later publications.

[18] In this case, the argumentation is often also supported with the theory and philosophy of "enactive perception" or "embodied cognition". See, e.g., the work of Dourish (2001) and Noe (2006), for two commonly cited sources. Also neuroscientific research concerning the processing of action related sounds in the brain has been used to substantiate the argumentation. See, e.g., the work of Pizzamiglio et al. (2005), cited by Serafin et al. (2011b). The approach proposes a primacy of the bodily in perception and meaning making which complements the notion of ecological perception. The projection of these conceptual frameworks on issues of sonic interaction design results in design approaches which includes a) some kind of bodily movement and manipulation (which may be extended to other body parts, such as feet (Visell et al., 2009)), which is b) linked, and continuously responds to a continuous sound, produced by a sound generating system simulating the sonic behaviour of

> "In other words, by using the sounds that users could commonly expect as a result of their gestures, the designer assumes that users will intuitively understand how their gestures influence the sonic feedback. Such commonly expected sounds which result from gestures (e.g., the sound of an impact arising from the striking of an object) are here referred to as 'natural'. The natural relationships between a sound and a gesture are those driven by the laws of physics". (Serafin et al., 2011a, p. 90)

Serafin et al. propose:

> "The design of sonic interactions based on the physical modeling of natural interaction seems to have two advantages. Firstly, the listeners find the interaction more pleasant, natural and engaging. Secondly, it seems that the interfaces are easier to use because the subjects already know, from their previous experience with everyday objects, how sound and gesture are related" (Serafin et al., 2011a, p. 90)[19]

But things may be more complicated. On the one hand, physics based mappings may or may not be the perceptually most efficient approach and mapping may or may not be related to physics based experience, for instance when participants interpreted an increase in the frequency of a tone not as an increase in temperature, but as a decrease in size (a common crossmodal congruency, see Spence, 2011), this may result in confusing inconsistencies within an interface (Walker and Kramer, 1996). In a similar study, sighted participants interpreted an increase in frequency as representing more money, whilst visually impaired participants interpreted it as less, which indicates their attribution of "less" with the higher pitches usually associated with smaller sound sources (Walker and Lane, 2001). This shows that in order for physics based patterns to work, some kind of preliminary interpretational path must be pursued by the users - the interpretation is not necessarily self-evident. For instance, mapping a parameter to pitch may be perceptually efficient, but, as Serafin et al. state, it can be "highly counterintuitive in the light of natural bindings, and this could increase learning time and even cause misunderstandings." (Serafin et al., 2011a, p. 105). Walker and Kramer (2004) and Walker (2007) provide insights into similar phenomena. And as Nees and Walker (2008) have shown, even very simple parameter mappings can work through a great variety of different strategies, such as assigning verbal labels to data points, imagining a visuospatial or picture-like representation of the data, using manual or pedal motor codes or attempting to remember and maintain a veridical or isomorphic representation of the sensory experience of the sound heard, and others. Also intentionally provided auditory context (e.g. in the form of reference tones) or simple counting of events seems to be used relatively often (Nees and Walker, 2008)[20]. These examples show, that it is potentially misleading

physical objects and is dynamically modulated by the bodily movement (Serafin et al., 2011a; Rocchesso, 2011).

[19] As consequence, the focus in several research initiatives lies on a series of sound synthesis techniques and tools that allow to synthesize sounds based on physical models or perceptual characteristics of sound events associated with physical processes. In particular physically informed sonic modeling are prominent and quite successful strategies (Cook, 2002; The S2S2 Consortium, 2007). Other approaches use a source-filter approach to produce rolling sounds using colored noise as input to a resonant filter structure (van den Doel, Kry and Pai, 2001). The aforementioned "Sound Design Toolkit", provides a modeling strategy that focuses on auditory perceptual relevance and a pragmatic simplification of underlying physics, in order to increase computational efficiency, perceptual sharpness and parametric temporal control, which ensures "appropriate, natural and expressive articulations of sound event sequences." (Monache, Polotti and Rocchesso, 2010, p. 2). These tools thus embody the underlying design paradigm of physics based naturalism.

[20] On a side note, in the case of Audification, which is the direct translation of data into sound by interpreting it as an audio waveform, it could be expected that the direct translation from one modality into another, or from data directly into sound waves, would reveal "natural" patterns, but this effect seems to be quite unreliable in practice. Hayward has shown that although seismic data could be readily understood, stock prices sounded like opaque noise (Hayward, 1994). One reason seems to be that they are not related to know patterns of physics. Another reason may be the absence of periodicity in the data, preventing the emergence of audible frequencies. But there is also another problem: The sonic phenomenon resulting from any kind of cross-modal translation is not straightforward. The resulting sound's energetic quailty, dynamics, rhythmicity may be

to assume, that mapping strategies built on "natural" laws and "everyday interaction experience" are per se and a priori more effective or intuitive to learn.

2.4. The Impact of the Scientific Method on Sound Design

On a closer analysis, it turns out, that the conceptual focus permeating the work in Auditory Display and Sonic Interaction Design may actually be also a result of the scientific method. While the debate about their relation of "scientific" and "artistic" approaches, and the integration of design in Auditory Display is already ongoing for a while[21], scientific approaches, and a focus on perception and cognition, are the de-facto standard in Auditory Display and Sonic Interaction Design research (Supper, 2012).

The impact of the scientific paradigm on sound design decision making becomes particularly visible in those reports, where authors explicitly discuss their sound design considerations. Often the related argumentation reflects a relatively limited perspective on sound, reducing the notion of "sound quality" to psychoacoustic parameters such as "sharpness" or categorizations such as "naturalness", or similar attributes. Such research may produce useful evidence for certain design related issues, for instance, the task-difficulty independend influence of sound's sharpness on the valence of the users' feelings, as reported by Lemaitre et al. (2009b). But the applicability in design tasks is limited. Leplâtre states:

> "This approach should be that of the sound designer looking for appropriate sounds; Psychoacoustics provides us with means to classify simple timbres; Gaver's ecological approach has led to a distinct but still meaningful classification of sounds regarding the properties of their source (Gaver, 1993b; Gaver, 1993a); the designer may use one of them to devise her own if the context requires it." (Leplâtre, 2002, p. 78)

Leplâtre further argues, that for his specific design problem (navigating menus on mobile devices),

> "(...) the classification of timbres devised by psychoacoustics should provide the designer with sufficient resources to undertake the design of semantically different sounds." (Leplâtre, 2002, p. 79)

This confirms the tendency identified in many publications related to Auditory Display design, to reduce the design space to a small amount of controllable, well-defined parameters.

A first issue associated with the scientific approach is thus its tendency (or need) to *reduce the level of complexity*, which has implications for issues concerning meaning making or aesthetics. A case in point are studies investigating meaning making based on isolated musical parameters, such as tempo, pitch, speed etc., usually arranged in binary opposites, and attributing them to specific informational or emotional dimensions, such as "fast = anger", or "slow = solemnity" (Polotti and Rocchesso, 2008). Such results certainly may account for a large number of cases, but certainly not all, and it is often relatively easy to falsify them through counterexamples: What, for instance, about the (relatively) slow, threatening aggressiveness of "Gangsta Rap"? What about the anger that manifests in tense, heavy, sonic movements of certain types of "Heavy Metal"?

foregrounded in listening, as aesthetic experience in its own right, and obscure - or rather: envelop - any other kind of information that might be hidden in it.

[21] According to Barras and Vickers, since the founding days of ICAD there was the attempt to introduce aesthetic and design related positions into Auditory Display research and design, with a particular focus on Sonification. Already the second ICAD included a session on deisgn issues with inputs about aesthetic, technical, and musical issues in commercial sound design, and Maribeth Back's introduction of a sound design theory of micro-narratives (Back, 1996). And the call for papers of ICAD 2002 included an art section "in the hope that future ICADs might continue to explore some of the arguably less utilitarian aesthetic implications of Auditory Display" (cited by Barrass and Vickers, 2011, p. 149).

A large amount of the research in the field of Auditory Display and Sonification is directed at finding ways to represent quantitative entities or relationships, or to investigate very clearly defined design concepts, relying for instance on scientifically substantiated "identifiability" of sounds, and their associated mental model. However - and this is acknowledged occasionally in the literature - the sounds we encounter, both in extraordinary and everyday situations, are hardly quantifiable, and the majority of research thus of limited ecological validity (Neuhoff, 2004).

The scientific reduction in research also results in a priori *limitations of possible mapping strategies*, and motivates the "mapping paradigm"[22] per se, as a clearly defined mapping function is the precondition of the scientific method. At some level of design, mapping usually takes place, if only because ultimately sensor data needs to control sound parameters. But on an experiential level we might deal with emergent, complex phenomena where a dynamic relationship, rather than parameter-based mapping is perceivable between the experiential quality (for instance the perception of kinetic energy) of a action or process and its sonic manifestation. The question of mapping in itself thus is relevant, but not necessarily at the beginning of the design process.

In general, the scientific method results in a *reduction of scope of design* to a small range of "testable" paradigms. Complex topics tend to be reduced to simple concepts. For instance, "aesthetics" often is reduced to "pleasantness" and causally linked to (psychoacoustically quantifiable) properties of sound, such as perceived sharpness, or harmonicity. This simplified definition in turn can be used to investigate assumed relationships of a sounds properties on emotions, another highly complex domain, as e.g. in (Lemaitre et al., 2012). This endeavor is often linked to the hope that emotional impact may be controlled or at least predicted.[23]

Another effect of scientific reductionism is the *thinking in categories*, which is often helpful or even necessary, but becomes a liability when the categories become too exclusive or contradictory. One of the strongest, paradigmatic categories is the dichotomy between "everyday" and "musical" sounds, which we have described in Section 2. But from a design perspective, the strict separation of musical and everyday listening cannot be maintained: The everyday soundscape has compositional aspects and, as in music, the sources of sounds are not always known. The following statement illustrates the emerging conflict between recognizing the complexity of sonic experience and design, while upholding established categories:

> "Now that we are no longer limited by piezoelectric buzzers in our products, the wealth of possible sound is great; which sounds should we choose? From which category? Musical sounds, speech sounds and everyday sounds all hold benefits." (Serafin et al., 2011a, p. 97).

An example of how the established categories frame otherwise very promising approaches to study design, is a study by Barrass et al. (2010) which compares sine wave based, vocal pattern based, wind metaphor based, "musicification" based , and "Gestalt stream" based Sonification

[22] Here understood as the reduction of mappings to simple, isolated sound parameters. In digital musical instrument design, approaches to mapping also include complex and nonlinear or even fuzzy strategies, see, e.g. Hunt, Wanderley and Paradis (2002) or Miranda and Wanderley (2006).

[23] Discussing emotion studies is beyond the scope of this work, but it seems clear, that the way the relationship between sound and emotion is investigated in current research does not acknowledge the complex nature of emotions, if it assumes, that emotions can be kind of "induced" into the listener, through sound or even isolated sound properties. This rests on an unspoken understanding of emotions as a response to a specific stimulus. A core problem with many studies about emotions and affect, is a common focus on the two-dimensional valence-arousal scheme, originally based on the affective circumplex model (Russell, 1980). As a model for grasping human emotion - also if only looking at its representation in language - this is an undue reduction, and at least four dimensions (evaluation- pleasantness, potency-control, activation-arousal, and unpredictability) should be regarded (Fontaine et al., 2007). In terms of sounds power to evoke emotions, Huron presented six components of emotions evoked by sound (Huron, 2002), which also relate to the concept of listening modes (Tuuri, Mustonen and Pirhonen, 2007). Despite the oversimplifications involved, many results are indeed very interesting, but, considering the contested state of the art of emotion studies, it seems problematic to derive normative design guidelines based on such work.

methods. Thus, while having a relatively broad scope, listening to the Sonification examples raises the question, what would have happened if there was an example that did not use either simple FM synthesized tones nor simple off-the shelve MIDI instruments. Again, sound design approach is predetermined to some extend by a fixed set of a priori categories in terms of how sounds are produced and become meaningful, which is also due to the epistemological ground of having to reduce the level of complexity in order to be able to derive correlations between specific variables, causes and effects.

To give another example, Leplâtre and McGregor propose that designers have to make clear, which aspects of a design are "purely functional", which are "purely aesthetic", and which ones involve both (Leplâtre and McGregor, 2004). This proposition is symptomatic for the dilemma between the need to identify individual parameters of control and the goal of a integrated solution, and is based on the assumption that there is in fact a line that can be drawn between those domains. It can be argued, that this distinction in itself is an artifact of the epistemological setup on which this - and many comparable studies - are based. What is "functional" is defined a priori by the designer, for instance, a mouse click in order to select a command in a word processor. But this, again, is only meaningful in the context of an interaction sequence, which results in an overall activity of writing a text. In everyday experience, aesthetic qualities are not an additive result of a multitude of more or less aesthetic components that are just "there". Instead we are confronted with a constant interplay between an intention to act, and the phenomena associated with executing this action. This process, ultimately, can not be fully understood by atomizing it (Suchman, 2007).

Last, but not least, the scientific method often establishes the justification of design decisions based on *user feedback.* On the one hand, a user centered design approach is unquestionable essential, as Frauenberger et al. point out in their study on common practice in Auditory Display design (Frauenberger, Stockman and Bourguet, 2007). But the problem arises from the procedures that are often employed in these user tests, more particularly their subjection to the scientific method. First of all, it is a relatively common practice to compile and collect sounds beforehand from off-the shelf libraries, or to create them cording to spectrotemporal templates which are derived from empirical experiments and then test them again with users against the initial selection criteria (Hug and Misdariis, 2011), rather than actually *designing* them. The question also is: to what extend can we let the users decide, and what is the consequence of this approach? For instance, Vogt and Höldrich (2010) built on metaphors which are developed with users of the intended applications' target domain, in this case particle physicists. Metaphors, if used correctly, are very accessible and powerful tools of communication (Pirhonen, 2005). But it is interesting to note, that most metaphors provided by participants were not different from common and rather trivial design approaches, such as using lower pitch to denote bigger size (Vogt and Höldrich, 2010). Furthermore the authors critically remarked that while facilitating the understanding and exchange about basic concepts, the use of metaphors also seemed to restrict the access to more abstract or complex notions. This relates to the discussion of advantages and disadvantages of using design strategies derived from familiar patterns and schemata. Another observation from this case is, that the metaphors were built around binary opposites such as "heavy - light", "matter - anti-matter", or isolated sound dimensions, such as "high - low pitch", "clear - noisy", "straight - vibrato", etc.. The reduction to a few selected option is one aspect. The other is the decontextualization of isolated sound events. If people are forced to rate a given body of sounds for preference, it can be expected that some will always be relatively preferable, although they might fail in an actual design application.

An example for a result of user-driven design decisions based on "forced" preference decisions is provided by Wersényi (2010). First users could select "suitable sounds" from ready-made sounds in a database. Associations made and rated by users were for instance coughing for virus killer, dog sniffing for file search and toilet flush for deleting a file, all of which received relatively good ratings by users. The applicability of this research is questionable, if we imagine a repeated confrontation with such sounds in our everyday life. It should also be noted that also in this case, the sounds were not designed, but off the shelve samples were cut together, and many sounds were based on "previous examples", which, from a scientific point of view, is even desirable.

As consequence of the orthodox application of "user centered design", "good", "successful", "acceptable" sounds are those, that are rated as such by the statistically significant majority, and the characteristics of such sounds are "hard linked" to their spectrotemporal properties, with little or no room for design, much less innovation[24].

2.5. The Natural, Identifiable, Familiar as Limitation of the Design Space

The aim of many design approaches in Auditory Display is, to enable the "user" to re-construct the metaphorical relationship, which the designer envisaged in order to convey a certain message, be it when the metaphor serves as an informational element or be it because the metaphor is supposed to guide a user's continuous interaction (e.g. the identification of a ratchet sound for understanding the interaction in the case of the Spinotron). As consequence, the sound source must be easily and unambiguously *identified*, and both the source as well as its metaphorical potential should be *familiar* to the listeners. This is reinforced by the scientific method which requires comparison quantifiable dimensions and known parameters. However, the list of "well identified sounds" is relatively short, often restricted to stereotypes. It is evident that resorting to some empirically "well identified sounds" also means to abandon the richness and diversity of the sonic world in favor of a statistical "average".

In general, there seems to be a lack of understanding of the potential impact of design decisions and sound design proper, which is often acknowledged in the community. Some authors raise concerns over the appropriateness of the existing body of theory. Coleman states:

> "...traditional cognitive and technology-lead approaches to Auditory Display research cannot fully deal with the effects of sonically-enhanced technologies entering our everyday lives." (Coleman, 2008 p. 269)

As a point in case, Lucas, who conducted a study comparing the learnability of Auditory Icons and Earcons, admits that there were only few cues, and thus the result could be fundamentally influenced by the actual sound design rather than the selection method for the sounds (Lucas, 1994).

In conclusion, it is certainly not sensible to ignore relevant scientific knowledge about the psychology of perception and cognition. For instance, studies of annoyance potential in sound (e.g., Steele and Chon, 2007) or quantifiable acoustic dimensions contributing to product sound quality (Lyon, 2000; Fastl, 2005), and the development of specific analytical frameworks (e.g. Susini et al., 2004; Lemaitre et al., 2007), and their application to specific design cases (Lemaitre et al., 2009c) clearly can provide a good understanding of the conditions, potentials and constraints of Auditory Displays. Also scientific methods of design evaluation (Bonebright and Flowers, 2011a) are of great value and should not be ignored by designers.

But care should be taken to not follow the sometimes premature and insufficient conclusions as to specific sound design strategies. And separating the complex sonic world into categories such as "musical sounds", "speech" and "everyday sounds", or "Sonification" "Auditory Icons", "Earcons" and "continuous sonic interactions" unnecessarily pre-determine design approaches.

[24] An alternative approach is presented by systems such as PART and AWESOME: While they provide means for selecting successful design approaches, they build on the contribution (and intuition) of expert designers by offer means to review a design and make comparative selections. (Fagerlönn and Liljedahl, 2009), (Liljedahl and Fagerlönn, 2010). However, the design options are strongly limited as well, and the designer is required to follow a relatively simple systematics, e.g.. by varying only the instrumentation or intervals of a simple Earcon.

Sound designers usually mix and blend sounds of all thinkable types together, if a design idea requires it (LoBrutto, 1994; Sonnenschein, 2001; Whittington, 2007). Evidence from scientific research may lead to the conclusion, that "natural" sounds are more usable, work better for interpretation and are in most of the cases more pleasant and generally preferred by users over "artificial" ones (see Section 2.3). But from a designer's perspective, reduction to indexical or naturalistic sounds is unnecessarily limiting (Brown, 2010; Chion, 1998; Hug and Misdariis, 2011) and leads to oversimplifications, such as the assumption that "soft" and "natural sounds" would turn out to be the ones with the highest ratings and resulting usability. Thus, while able to provide some decision making support, such "guidelines" are of limited help for a sound designer, who has to consider a multitude of other factors. As Serafin puts it:

> "Therefore the designer needs to balance various factors and adjust designs to find an optimal working point. Learnability versus effectiveness is just one example. There may be sound categories with very salient sonic parameters which are perhaps very intuitive, yet the sound would be less pleasant for long-term use, or even irritating or provoking an unwanted emotional reaction." (Serafin et al., 2011a, p. 105)

As a form of more fundamental critique, Chion criticizes the simplistic assumption of the (scientific) discourse about sound "naturally" representing a certain cause.

> "The naturalist conception of sound continues to infuse real experience ad critical discourse so completely that it has remained unnoticed by those who have referred to it and critiqued the same transparency on the level of the image." (Chion, 1994, p. 93)

From the point of view of sound design, there are many ways in which a sound can become "natural", "acceptable" and "familiar". From music and film sound we know, that thoroughly artificial sounds can sound "natural" and plausible. And, to begin with, a sound that is electroacoustically recorded and reproduced is never "natural". Electroacoustic technology has made it possible to detach a sound from its source, and relocate it into entirely new contexts. "Naturalisation", the notion of something *becoming* the "natural sound" of something, is the key, rather than assuming an apriori "naturalism"[25].

[25] I will elaborate this point in Part IV in Section 25.2.

3. The Schizophonic Interactive Commodity as Unknown Territory

Patsy: (sound of cell phone beeping)
"Oh Eddy!! Is it... is it a bee???"
(Later) "Is it a bee??? Kill it Eddy!!"
(Eddy pulls her cell phone out of her pocket)
"Oh it's a small shoe."

Absolutely Fabulous, Season 4 Episode 5, "Small Opening"

Considering the potentials of using sounds in design, and the issues associated with the a priori paradigms guiding a large part of the research and development in Auditory Display, the question arises, what possible alternatives exist. In this, we reach beyond the mere technicalities of how sonic parameters could convey specific information. I posit, that the nature of interactive commodities entails new, largely unstudied aspects related to sound and related interpretational processes. There are two main reasons for this:

- First, we are dealing with artifacts, which in themselves are, or will be, culturally and emotionally complex entities, embedded in socio-cultural processes. Thus the first step is to investigate the role of objects on various levels of our existence as individuals and social beings.
- Second, the sonic reality of such artifacts is essentially *schizophonic*, merging sounds originating from material processes with sounds produced by electroacoustic means. This transmedial merging is a new, largely unstudied quality in sound design.

In the next sections, I will elaborate on these two aspects[1].

3.1. The Material Relation between Objects and Their Sounds

On a very basic level, meaning around objects emerges from their materiality. For instance, in his dialogue "Hippias Maior" Plato proposes – through a dialogue between Socrates and Hippias – that certain materials like gold make ordinary things beautiful or that some materials are more functional and thus make an object appropriate. Materials like marble and (fake) gold suggest a royal or noble atmosphere in shopping malls, wood can signify closeness to nature, and so forth (discussed in Böhme, 1995).

Sounds are directly connected to an artifact's physical properties. In our everyday experience the acoustic properties of materials and objects provide us with information on their quality. We might see a transparent object, but we will only be able to tell whether it is glass or acrylic after tapping it with our finger. We can distinguish metals in the same way or determine whether a piece of wooden furniture is made of hardwood or plywood or whether it is in good or bad condition. Many studies have been concerned with the ability of detecting material properties, shape and size through sound, as well as processes of interacting materials (a comprehensive overview is provided by Giordano, 2003).

[1] Parts of this section are built on a previous publication (Hug, 2008a).

Also the intersensory link between audio and haptics is important. For example, Kayser et al. demonstrated somatosensory and auditory interaction and the conditions for its effectiveness, namely temporal coincidence and inverse effectiveness (Kayser et al., 2005). And Avanzini and Crosato (2006) have successfully demonstrated how sound can modulate the haptic perception of stiffness. Some studies deal with the audio haptic relationship in food consumption, for example the factors associated with judging apples to be mealy (Barreiro et al., 1998)[2]. Thus a sound of an object has the power of not only re-presenting the object, but give it presence.

On the other hand, through sound, matter can be present without object. Chion states, that we can find certain irregularities, frictions, traces of impacts in abstract sounds that can give it a material, bodily quality. He calls these notions of materiality "indices sonores matérialisants" (Chion, 1998, p. 102). Steven Connor (Connor, 2004) describes the dialectic relationship between sounds and objects as being an "immaterial corporeality":

> "One apparent paradox of hearing is that it strikes us as at once intensely corporeal - sound literally moves, shakes, and touches us - and mysteriously immaterial. (...) Perhaps the tactility of sound de- pends in part on this immaterial corporeality, because of the fact that all sound is disembodied, a residue of production rather than a property of objects." (Connor, 2004 p. 157)

Thus, the relation between sounds and physical is essentially dialectical: While objects are permanent and concretely graspable, sounds are temporary and evasive, yet still they often have an almost intimate relationship with the physical world, which is the basis for the naturalizing effect of sound in media. But the natural link between sound and causing physical event has to be questioned. Sounds also have an existence which is detached from their original source, ambivalent, sometimes carrying a rather vague notion of material in them, sometimes being totally abstract.

3.2. The Sociocultural Signification of Objects and Their Sounds

From a semiotic viewpoint, objects of everyday use are incredibly complex and difficult to theorize. Objects can either be the correlative of signs or they are signs themselves, and artifacts may have emblematic (meaning oriented) as well as have non-emblematic, "pre-semiotic" meaning dimensions (Nöth, 2000) carrying references to their practical use, as well as the determination to be used for something, "imprinted" in them[3]. Practical things can also be understood as referring to their value of use as indices. For instance, a rocking chair refers to its use-potential as a chair that allows a rocking motion and the related bodily relaxation. Such primary and denotative meanings can be accompanied by secondary, e.g. aesthetic or connotative, meanings (Nöth, 2000). Two other dimensions of understanding the meaning of objects are proposed by Barthes (1988), who discusses objects in terms of either their "existential" connotation, as obstinate, inhuman entities, or as as consumed, reproduced and functional products (the "technological" connotation). Baudrillard discusses a similar logic, by distinguishing a "functional system" from a "non-functional system" and a "metafunctional and dysfunctional system" of objects. He investigates society, culture, an all the artifacts of economy and consumptions as constituents of a system of signs which can be analyzed on the basis of semiological theories (Baudrillard, 1996). Examples of this could be the practice of collecting, the accumulation of objects as dowry, the expression of self in relation to society in bricolage, the rhetoric of the displayed artifact, shopping centers as super-objects and stages for objects and social actions, the mystification and commodification of culture through souvenirs, and the complex culture around jewels[4]. Baudrillard

[2] In the less scientific but nevertheless relevant domain of film and game design, sound often is used to substitute or denote haptic sensations of protagonists, and is essential for suggesting authenticity of objects on screen and suspending disbelief (Flückiger, 2001).

[3] This aspect relates to the notion of "affordance", mentioned earlier.

[4] An excellent collection of essays related to these questions has been provided by Riggins (1994).

finally points out the relationship between objects, production systems and society, describing the development of artifacts from a static role in a traditional pre-modern society to their emancipation to flexible, functional entities, and how systems of objects and their consumption reflect socio-ideological circumstances (Baudrillard, 1996).

Based on interviews with over 300 people, Csikszentmihalyi and Rochberg-Halton investigated the meaning of everyday artifacts from a pragmatic point of view, as artifacts of everyday use. They describe how objects become part and are the result of the process of cultivation, that is "the process of investing psychic energy so that one becomes conscious of the goals operating within oneself, among and between other persons, and in the environment" (Csikszentmihalyi and Rochberg-Halton, 1981, p. 13). According to Csikszentmihalyi and Rochberg-Halton things embody goals, make skills manifest and shape the identities of their users. Objects thus are embodiments of intentionality. They alter patterns of life, they reflect and define the personality, status, social integration etc. of both, producer and owner. In addition, things evoke emotions through interpretations in the context of past experiences, thus becoming signs or symbols of one's attitude. Moreover they can mediate conflicts within the self. Through the "objectivity" and permanence of objects such identities can be shared. This is the precondition for the socializing effect of things and of their ability to provide role models. Csikszentmihalyi and Rochberg-Halton also shed light on the role of the functional aspect of objects for culture, describing how even the use of things for utilitarian purposes is inseparable from the symbolic context of culture. Artifacts socialize people to certain habits or ways of life and represent these as signs (Csikszentmihalyi and Rochberg-Halton, 1981).

In terms of understanding the role and importance of artifacts for our lives, Joan M. Vastokas proposes a holistic view, beyond the strict semiotic viewpoint, taking into account the full spatial, temporal, and gestural dimensionality of the artifact. She proposes a narrative concept of artifact, understanding the procedural component of an artifact as being born through intentionality of its creator(s), going through a life of use and abuse as "meaningful and expressive object in itself, and as a ritual performer in social and cultural life", finally "dying" and being disposed, exhibited in a museum or recycled (Vastokas, 1994, p. 341). She outlines the following points to consider in the study of artifacts from a sociocultural perspective:

> "(1) The meaning of artifacts, including works of visual 'art', is constituted in the life of the objects themselves, not in words or texts about them; (2) the artifact is not an inert, passive object, but an interactive agent in sociocultural life and cognition; (3) the signification of the artifact resides in both the object as a self-enclosed material fact and in its performative, 'gestural' patterns of behavior in relation to space, time, and society; (4) the processes, materials, and products of technology, especially those of a society's dominant technology, function as cultural metaphors at many levels and in many sociocultural domains; and (5) theoretical insights derive, not from theorizing in the abstract, but from direct observation and experi- ence of the phenomenal world of nature and culture." (Vastokas, 1994, p. 337)

What role can sound play in this sociocultural system of objects and meanings? Barry Truax states that sound mediates the relationship between listener and environment (Truax, 2001). This includes also the sounds produced by the cultural-technological artifacts we create. For instance, Mark M. Smith describes how in travel accounts of antebellum America sounds became the signs of positively connoted, pre-industrial work, linking sound to an increase of wealth and population. He also reveals significant differences be- tween the industrialized North and the slavery dominated South. Both areas and cultures had a distinct soundscape with different keynote sounds and soundmarks[5] (Smith, 2003). The sounds of certain artifacts and machines

[5] The terms "keynote sound" (sounds that are heard by a particular society frequently enough to form a characteristic sonic background) and "soundmark" (a localized sound with a special meaning for a community) have been coined by R. Murray Schafer (1977).

thus contribute to the identification with a class, political orientation, etc.[6].

Through a comparative study of noise abatement campaigns from the early 20th century, Karin Bijsterveld points to class being an important element involved in definitions of noise and noise pollution. The cultural struggle about sounds is also a struggle between intellectual and working classes. Bijsterveld points out that

> ”the sound of technology is a key aspect of technological culture, because sound has been highly controversial and deeply invested with symbolic significance.” (Bijsterveld, 2003, p. 165)

The philosopher Theodor Lessing is reported being one of the first to organize an anti noise campaign. For him, noise (in the sense of “disturbing sounds”) was a weapon of the anti-intellectual power in humans. He writes:

> “Das Heraufholen und Verfolgen objektiver Werte wird zur Tortur. In jede geistige, jede theoretische Schöpfung bricht lärmender Pöbel ein und das praktische ’Interesse’ lärmenden Pöbels. Alle seelische Kraft wird zur Überwindung dieser ewigen Spannungen verbraucht. Der Mangel an gesundem, tiefem Schlaf zerrüttet unsre Nerven. Die Möglichkeit unsrer Arbeit wurde uns zerstört, bevor wir noch zu arbeiten begannen. Alle Augenblick ein neues unangenehmes Geräusch!” (Lessing, 1908, p. 15)[7]

Sound thus is a means of communication and expression, not only from artifact to user, but also from the user to other people through the artifact, which supports the artifact’s role in mediating and expressing personality, status, emotions and values. These examples show how the discourse about sound strongly reflected the societal structures and significant changes brought about by industrialization and technological changes in general. New technologies like the automobile, smartphones or the many manifestations of the Internet of Things bring with them new sounds that become symbols of progress for some and a primitive nuisance for others. Many comparable accounts could be found today, referring to ghetto blasters, iPods and mobile phones (Bull, 2011). Since the industrial age and the introduction of electroacoustic technology sound have become more pervasive than ever. And this trend will increase due to the technique of electroacoustic enhancement of commodities. The study of the sociocultural history of sound reveals that the importance of sound goes far beyond purely functionalist purposes of providing feedback in an interface.

3.3. Sound, Voice of Active, Animated Objects

Let us again turn our attention towards the object itself. When discussing the interaction with objects, we arrive at some point at the notion of the *object as actor.* Building on Activity Theory, introduced by Leontiev in the late 1970’s, Kaptelinin and Nardi propose, that Artifacts, as the product of cultural needs, embodying our intentions and desires, mediate between people and the world and in this sense have agency (Kaptelinin and Nardi, 2006). Going even further, Latour proposes in his Actor-Network Theory (ANT) that human beings and non-human or even inanimate objects are interlinked in mutual interactions. In this view, action is not limited to what intentional, intelligent “living” beings do. According to Latour any thing that does modify

[6] Attali goes even so far as to state: “More than colors and forms, it is sounds and their arrangements that fashion societies.” (Attali, 1995, p.6)

[7] In all fairness to Lessing, it should be noted, that he was fair enough to make a distinction between a more ore less background noises and rather sudden, attention grabbing noise events. He recognizes, that the first may even stimulate creativity (giving the example of Mozart, who worked in his small study while the children were playing in the same room, producing a constant stream of noise).

a state of affairs by making a difference is an actor. Artifacts thus are dynamic and equivalent agents in social networks, becoming a part of them (Latour, 2005)[8].

In the case of computerized artifacts, which are procedural and interactive, the attribution of agency becomes even more obvious. In the 20th Anniversary Edition of her book ”The Second Self” Sherry Turkle describes the computer as projection surface for our desires and fears and is often considered animate in some way, not only by children, exhibiting behaviors indicating some kind of reasoning and agency. The main criterion for aliveness, autonomous motion, is being replaced or extended by the notion of psychological autonomy. This also is a basis for anthropomorphisation often encountered in the interaction with computers. Turkle further states that these characteristics have become commodified, are part of our everyday experiences. But although computational technology has lost much of its uncanniness we still tend to per- sonify and project our self onto it. In the case of the increasing autonomy and complexity of computational artifacts this tendency becomes even stronger. And in some cases like wearable computers or computational implants the border between computer and human is increasingly blurring on a very concrete level (Turkle, 2004).

According to Daniel Chandler the quality of purposiveness and autonomy in artifacts arises from the whole being more than the sum of the parts when technology becomes too complex to control. Technological artifacts seem to have a will of their own and we tend to anthropomorphize them. The resulting technological animism credits an inanimate entity with consciousness and will[9] (Chandler, 1995b). From here the step to a notion of a magical quality in complex computerized artifacts can be easily made. According to Arthur C. Clarke's third law, “any sufficiently-advanced technology is indistinguishable from magic.”[10] and by consequence, complex interactive artifacts may be experienced or interpreted as “magical” or “enchanting” (McCarthy, Wright and Wallace, 2006). Beyond romantic techno-shamanism (Coyne, 2001), the black box of computerized interactive technology does indeed expose some experiential attributes associated with the supernatural and incomprehensible, in terms of complexity, unclear agency and sheer speed[11]. The “easy to use” and “simple” user interfaces contribute and emphasize this experiential quality by further detaching the user experience from the increasingly complex processes that make them possible.

In this context, we may remember the notion of sound being the “voice” of objects in an actual, immediate manner and not merely metaphorically. This notion, again, is quite complex. Connor states:

> “When we hear something we do not have the (...) sensation of hearing the thing itself. This is because objects do not have a single, invariant sound, or voice.” (Connor, 2004, p. 157)

At the same time sound rarely comes completely apart from its source, and can be experienced as intrinsically linked to it. Connor proposes

> “to think of a sound as the 'voice' of what sounds (...) is also to think of the sound as owned by and emanating essentially from its source, rather than being an accidental discharge from it.” (Connor, 2004, p. 157)

[8]Here lies a central difference between Actor Network Theory and Activity Theory: Instead of departing from a relational approach (between symmetric nodes in networks, ”actors”, that can be people, machines, or other things) Activity Theory proposes a primacy of human activity over both object and subject, originating in purpose, need and intentionality (Kaptelinin and Nardi, 2006).

[9]In our everyday myths and narratives this topic reappears often under a somewhat humorist veil, also referred to as ”resistentialism”. This term, coined by Paul Jennings, stands for a humorous theory in which inanimate objects display hostile desires towards humans, a ”fact” apparent in experiences such as cars not starting when one's in a hurry or the bread always falling on the side with butter on it.

[10]To be found in a 1973 revision of Clarke's compendium of essays, ”Profiles of the Future” (Clarke, 2000 (1973)).

[11]See Kuniavsky's (2010).discussion of this aspect in the context of user experience design.

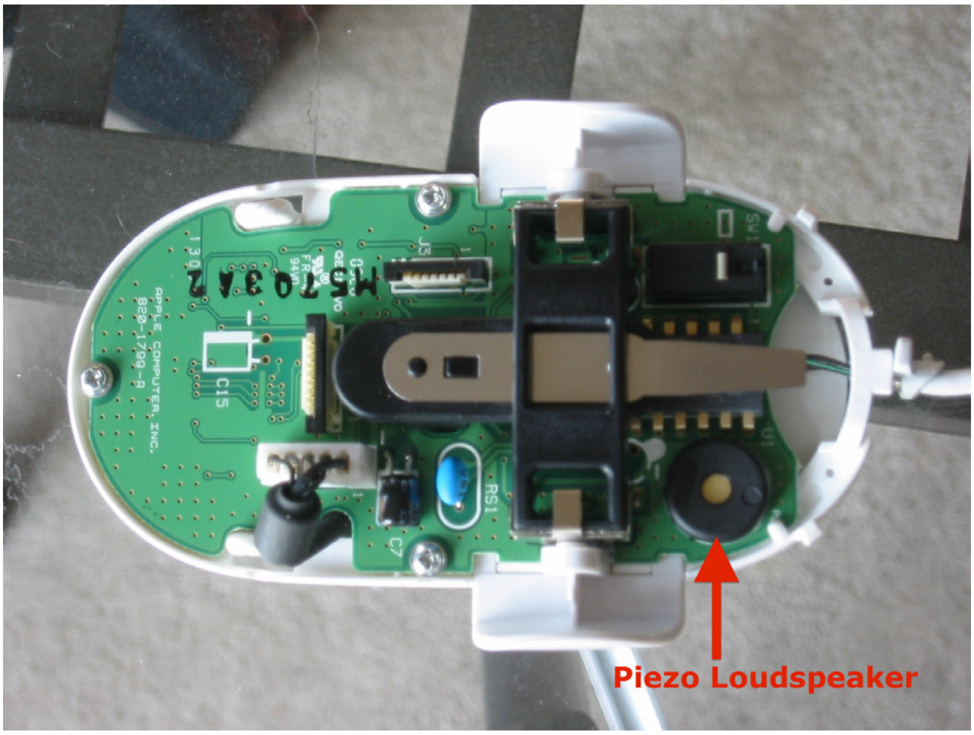


Figure 3.1.: The disassembled Apple "Mighty Mouse".
Image from https://arstechnica.com/uncategorized/2005/08/dissect/, label added by author.

Oskar Fischinger is reported to have stated that "sound is the soul of an inanimate object." (cited in (Flückiger, 2001), p. 330, author's translation). In Film, sound is essential to support the suspension of disbelief, and as a sign confirming a "proof of working", from beeping text on screen to spaceship engines. We encounter similar uses of sound in physical artifacts, where they are used on the one hand to confirm an input where natural physical sound is missing for instance on keypads of automated teller machines, phones, and buttons or switches of all kinds.

3.4. Goodbye Authenticity, Welcome Schizophonia!

As discussed above, mechanical, acoustic sound as a resource for meaning creation in the context of physical artifacts is always rooted in some sort of physical motion in time. This relates to the power of sound to be both "authentic" correlate of materiality and thus giving things a "voice".

But already through engineering of sounds for industrial products this relation of sound and the material world is questioned. Does the convincing sound of a car door really display its high quality or rather the ingeniosity of its engineers, who cleverly changed the resonance body or placed some additional piece of rubber (Lyon, 2000)? And are the engine sounds of tuned cars not perceived as authentic expression of their power, even though they may be just the result of an acoustic modification of the exhaust tube? What about the artificial addition of a mechanical scrolling sound to a mouse which is actually built from the cheapest parts possible, as it was the case in the "Apple Mighty Mouse" (Franinovic, Hug and Visell, 2007, see Figure 3.1)? In any case the sounds of objects are perceived as "natural" and authentic to some extend, which implies a certain ethical dimension in the discourse about sound design for artifacts.

Even more than the physical and mechanical engineering in product sound design, the possibility to integrate a practically limitless range of sounds into physical objects by means of miniaturized electroacoustic devices and to control them through computer technology makes the relationship between physical object and its sound arbitrary. The sounds that emerge in a process of interaction with such objects can originate both from the physical object itself, and its manipulation, and/or from an electroacoustic source. The electroacoustic sound, again, can mimic the sound of a physical artifact or process, or abstract, material qualities. In this way, a sonic index to another artifact or sonic process, and the related semantic implications, can be "implanted". Artifacts can be augmented with indexical sounds pointing to certain artifacts and thus to a range of potential meanings arising from them. On the other hand, entirely new sounds can be added to an artifact, sounds which either have lost their referential quality to physical objects, or sounds which are from a purely synthetic origin. Furthermore, in the electroacoustic enhanced commodity, the event or process causing a sound may be a complex manipulation, or just a button press, an intentional as well as unintentional movement, a mechanical process in the object or an action initiated by the objects "intelligence", generating electroacoustic sounds controlled by code. Each of these conditions suggest different interpretational dimensions. These sounds could be simultaneously a display of a function, or an information related to data changes in a process and the actual manifestation of the presence of a complex system at work.

In conclusion natural and artificial, acoustic and electroacoustic bodily action and (immaterial) agency mix and intertwine, the notion of authenticity is questioned. R. Murray Schafer was deeply concerned about the increasing Schizophonia resulting from the separation of sounds from their "natural" sources. The sonic augmentation of interactive commodities , The sonic extension of artifacts, and the resulting re-configuration and re-definition of the relationship between material, movement, function and sound, creates possibilities for a new kind of Schizophonic artifacts that even Schafer could not have anticipated. Opposed to Schafer's position, today, Schizophonia is not a pathological condition, but a cultural reality we live in and have learned to deal with (most of the time at least). The generation of teenagers, walking on the streets listening to distorted and filtered pop songs from their mobile phones will most likely have no problems at all with this notion. In a future of electroacoustically enhanced interactive artifacts, the differentiation between "natural" sound of an artifact and an added "schizophonic", electroacoustic sound may even become obsolete. The electroacoustically enhanced interactive commodity is not necessarily a object with an added Auditory Display, providing "user feedback" to "user input". Instead, artifact and sound of interaction can be potentially experienced as more or less unified, "naturally" related, artificial or "authentic". As designers we have to embrace this new aesthetics of the sonically extended artifact as a new field where expressive practices and codes, the understanding of how meaning emerges, and an understanding of conceptual approaches to their design, are still to be developed.

4. Objectives, Scope and Methodical Approach

> "The most exciting phrase to hear in science, the one that heralds new discoveries, isn't 'Eureka!' but rather 'hmm....that's funny'."
>
> *Ascribed to Isaac Asimov (probably erroneously)*

In the previous chapters I have outlined the application potential provided by the emerging "interactive commodities" with regards to the use of sound. I have discussed some central positions in the disciplines dealing with functional sound in interactive interfaces, namely Auditory Display and Sonification, in particular in relation to design concepts and strategies, and I have diagnosed the dominance of a set of paradigmatic design concepts which limit the scope and design space covered.

I also have presented challenges and questions in relation to the sonic design of interactive commodities, in relation to the sociocultural role of artifacts and the dialectic, even schizophonic nature of electroacoustic interactive commodities. The schizophonic artifact presents many ways of re-configurations between sound, artifact and interaction, and between artifact individual and society. Thus, as I have argued these kind of artifacts open up a vast field of unknown design territory. Specifically there are no studies about how meaning may emerge and on what grounds interpretations are built in this context. From a designers point of view, there is good reason to believe, that we face a large unexplored area of creative possibilities related to designing sound for interactive schizophonic commodities.

Therefore, the objective of this work is twofold:

1. Exploring the interpretation of sounds in the context of experiencing the related interactive commodities. This requires that they first be created in a suitable way, which also leads to the next point.

2. Exploring design motivations, considerations and hypotheses for sound for interactive commodities in emergent, creative settings, beyond scientifically controlled conditions[1].

The aim is not to apply and test, or to directly develop further, the work already done in the areas of Auditory Display and Sonic Interaction Design, but rather to approach the field from a different perspective. This perspective is explorative and grounded in common (design) sense, putting creative processes and a pragmatic, abductive generation of knowledge at the core. Its main interest lies in the discovery of the unexpected and unknown and its systematization. In doing so, the aim is not to formulate "truth based" rules. Instead, a systematic overview of design approaches and interpretational phenomena will emerge which complements current research in Auditory Display and Sonification, hopefully contributing to a more informed sound design practice in Sonic Interaction Design.

The setting in which this work has been executed is higher design education at three Universities of Art and Design. This made it possible to establish a research design process, which is systematic yet creative, and essentially replicable. Also, the perspective of (advanced) students

[1]Meaning: conditions where the design parameters are independent variables and thus predefined.

in art and design ensures a fresh, future oriented mindset necessary for such an exploration. It also means, that the aim is not to achieve a generalizable outcome, although the method ensures a high validity and potential applicability beyond the educational setting, through the generation of a large number of comparable cases and “thick descriptions”.

Further considerations concerning workshops as research labs are given below in Section 5.1. In the following sections I will give a detailed explanation of the research objectives, the motivations behind them, and the resulting considerations concerning method.

4.1. First Objective: Exploring Interpretation of Sound for Interactive Commodities

The first goal of this investigation is to “explore understanding”, to get an insight into people’s reflections, considerations, arguments and affects in relation to sounds emerging from interactions in “possible futures”. Therefore it is necessary to create actual instances of possible lived experiences by designing artifacts which can then serve as embodiments of conception and interpretation and thus as cases for further study (see Brix, 2008; Zimmerman and Forlizzi, 2008). This follows Wright et al., who state that

> “(...) the key to good aesthetic interaction design is understanding how the user makes sense of the artifact and his/her interactions with it at emotional, sensual, and intellectual levels.” (Wright, Wallace and McCarthy, 2008, p. 19).

In order to constrain the speculative scope of this endeavor, some criteria need to be fulfilled. First, the design scenarios, or specific elements of them, should deal with potential everyday situations by designing for, and demonstrating, plausible use cases. Furthermore, the designs need to represent “computational things”, which contain an element of actual interactivity of the artifact in an adequate way[2]. Finally, the participants should approach their interpretations with an open mind, not biased by a specific conceptual framework, only bringing their individual background, history, personality into the process.

My approach to interpretation rests on the concept, that sense and meaning are not simply “encoded” into an artifact, and then “decoded”, but that it emerges in the interaction with technology, and that the appropriation of an artifact happens in use (Kaptelinin and Nardi, 2006). As we go on about using our products and their function we constantly construct and modulate their meaning, also beyond what a designer might have intended, and this transformation happens in everyday use, often based on ad-hoc decisions and workarounds for problems (Brandes, Stich and Wender, 2009). In this, I am adopting Suchman’s understanding of situated action and situated meaning making to schizophonic artifacts: Both actions and experience are situated and negotiated rather than straightforward implementations of plans (Suchman, 2007). On a larger, societal scale, we subvert hegemonic systems of production and consumption and try to make them our own by developing our little tactics and workarounds (de Certeau, 1988). This is particularly true for products of “possible futures”, where there are no clear normative settings in terms of production and consumption yet.

My approach also aims at considering aesthetic experience, as it is inseparable from the process of “understanding” and “interpreting” and “functionality”. Petersen et al. explain this aspect, referring to “pragmatist aesthetics”, as based on Dewey, as follows:

> “Dewey insists that art and the aesthetic cannot be understood without full appreciation of their socio- historical dimensions. (...) Accordingly, aesthetic is not inherent in the artefact itself but rather a result of the human appropriation of the artefact. (...) According to the thinking in pragmatist aesthetics, aesthetic is not

[2]These two criteria were also a central part of the design briefs given to the participants. Further details and considerations regarding the design brief are given in Chapter 5.

> something a priori in the world, but a potential that is released in dialogue as we experience the world; it is based on valuable use relations influencing the construction of our everyday life." (Petersen et al., 2004, p. 271)

And, they continue:

> "What we stress here is that aesthetics has a purposeful role in the use of interactive systems, aesthetics is not only an adhesive making things attractive, and it is part of the foundation for a purposeful system. Aesthetics cannot be sat aside as an "added value". Emerging in use, it is an integral part of the understanding of an interactive system, and its potential use." (Petersen et al., 2004, p. 271)

Aesthetics, as it is understood in the context of this work, thus goes beyond the aim of creating "nice", or even "pleasant", let alone "beautiful" sounds. Instead, a sound's perceptual and affective quality is an integrated – or, rather, emergent – element of an overall stylistic, identity, expressivity, and socio-cultural situation of an artifact. This includes also a relation to the aesthetics of the interaction as potential or actual performative experience.

The resulting research questions thus are:

> *How do the participants interpret the sounds experienced during demonstrations and first-hand experiences of sounding interactive commodities?*
>
> *How do they explain those interpretations?*
>
> *How do they judge the artifacts and the sounds and what criteria and concepts do they use in the process?*

4.2. Second Objective: Exploring Design Considerations for Sound for Interactive Commodities

This second research goal can be seen as the other side of the same coin, therefore, the considerations mentioned above also apply. But the focus is on the actual process and act of creating new artifacts, the designerly enaction of interpretational beliefs, concepts, arguments and affects, and their embodiment into a specific aesthetic, sensorial form.

The aim thus is not to identify particular methods, solutions, let alone recipes for solving given problem. I follow Jonas Löwgren and Erik Stolterman who state that:

> "Since there can never be checklists or guidelines capable of determining what good design is, the designer needs highly developed *judgement* skills. (...) We believe that the design process is too complex and diverse to fully describe in any universal or general way." (Löwgren and Stolterman, 2005, p. 5).

Furthermore, Löwgren and Stolterman state that "a designer needs a description, model, or theory that can help her plan, organize, navigate, and evaluate her work" (Löwgren and Stolterman, 2005, p. 5), thereby signaling the benefit – and even need for – some sort of theoretical framework and systematics. In interviews conducted in relation to this work, sound designers generally agreed that all these points could be better addressed, if there was a comprehensive conceptual system available that would help them formulate and communicate sonic concepts adequately (Hug and Misdariis, 2011). The aim of this work is to contribute elements of such an analytic, descriptive and argumentative system by means of developing a better understanding of designer's decision making and design processes.

Therefore, the related research questions are:

> *What sound design solutions and specific realizations do people develop and how do they argument and justify them conceptually?*
>
> *What are the underlying assumptions, concepts and paradigms?*

4.3. Methodical Considerations

From above considerations, the following methodical consequences result.

4.3.1. Methodical Consequence 1: Open Dialogical Exploration of Interpretational Discourse and Aesthetic Experience

As argued above, it is pointless to think of both meaning making and aesthetic experience of artifacts as a kind of feature that is somehow "designed into" an artifact. Design rather defines an aesthetic and interpretational potential, and while its realization might depend on appropriation in use, careful attention to this aesthetic potential is indeed highly relevant, and therefore should be an important aspect of this inquiry. In order to investigate this, we have to set up our "laboratories" in a way that affords an open exploration of aesthetic experience and meaning making. The discourse emerging from this has to be equally open, allowing participants to bring their own experience, narratives and associations into the game.

An important aim of the method is thus to allow the investigation of interpretation and judgement of sounds not only on the basis of some ready-made sound, but actually in the process of creating it, including the real-time sound making during an interaction, and dialogue between spectators, users and soundmakers. I follow the considerations of Barras and Vickers to emphasize qualitative, interpretive exploration:

> "The emphasis is on meaning in use: how the user's talk about technology changes, possibly even how the artifact ceases to become a topic of conversation, is a valuable source of data. (...) Whilst one could measure the improvement on performance of auditory displays that have been designed to maximize their aesthetics, aesthetic judgment itself remains primarily experiential and so we can envisage using qualitative tools like IPA not only to gain more understanding of how users experience sonifications, but to evaluate the aesthetic dimension more richly." (Barrass and Vickers, 2011, p. 161)

If meaning and aesthetic experience of staged "possible futures" is at the centre of attention, the socio-cultural experience of participants and ad-hoc judgements have to be taken into account. This requires an "unbiased" approach to what and Auditory Display is and how it should be created. Given the early, exploratory nature of this research, reflected design intuition and introspection are called for. Normative, a-priori concepts should play a limited role. Rather, it has to be possible to reveal implicit a-priori paradigms, which could play a role in design and interpretation of sounding interactions.

In this early stage of development, where conventions are not set yet, it is therefore necessary, that the interpretational dimension is constantly observed from both perspectives, designer and "user" in a dialogical manner. This is elaborated further below in the discussion of the implementation of the research method in a setting similar to "research workshops", where students and researchers collaborate and exchange about a shared research interest[3].

This goal also calls for a prototyping method which affords real-time performance and improvisation. Enabling performativity in design methods has a long history in interaction design[4] and the method adopted follows such traces by adapting them to the needs of sound design. An inspiration in this regard has certainly been the area of sound in theatre and performing arts (Brown, 2010) and Foley (Ament, 2009), embracing liveness and "aural body" as both hearing and sounding, and the act of soundmaking as an actual dialogical investigation into design. I will elaborate on this in the sections about the implementation of the method below.

[3]Inspired by the notion of "Forschungswerkstätten" as described by Heimgartner and Hernandez (2005).
[4]See, e.g., (Laurel, 1993), (Macaulay et al., 2006), and related conceptual approaches like user scenarios (Carroll, 2000) and persona (Cooper, Reimann and Cronin, 2007).

4.3.2. Methodical Consequence 2: A Creative Process and Setting for Comparative Case Studies of "Possible Futures"

Building on these considerations, the design-research process has to fulfill two criteria: It has to be creative, building on established methods dealing with the generation of ideas, refining them to concepts and finally building prototypes. At the same time it needs to be structured in such a way that it can support the aggregation and comparative analysis of the data. Also it is required to make design hypotheses and intentions explicit as well as their experience and interpretation. In addition, the resulting artifacts of such a process need to be based on identical processes and aims, to allow for comparability. Also they need to be elaborate enough to stimulate proper discussions and critique, yet at the same time should remain "unrefined" enough to be understood as "design claims" and part of a discursive process, rather than "final products".

Thus, an important question regarding method is: How can design knowledge be developed in a way that is both structured enough to provide valid and relevant results and at the same time supports a design process open enough for ad-hoc inspiration and creative intuition? And what are the quality criteria to judge the value of its outcome? How can the core qualities of the design process, which includes both environments and processes to facilitate creativity (Kelley and Littman, 2001), ad-hoc brainstorms, iterative prototyping, and in general a certain amount of "creative mess", be preserved? It is clear that in any case, for the work to be relevant for designers, it has to adopt the designerly ways of knowing and acting (Cross, 2001), and to acknowledge the unique, "intrinsic logic" of design (Buurman and Rölli, 2015). The key to this seeming dilemma lies in Schön's call for "an epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict" (Schön, 1983, p. 49).

This philosophy has been methodically realized as "research through design", or "project-grounded research" by Alain Findeli (2004). The project-grounded approach understands research as being intrinsically embedded within an actual design project. The project corresponds here to the "field" in social sciences and the "laboratory" in the experimental sciences. According to Findeli, this kind of research is closely related to action research, grounded theory, participatory research and phenomenology. It is from these ares where project-grounded research acquires its methodical rigor, and the methodical question is thus relatively easy to answer (opposed to the epistemological issues, which are still hotly debated, mainly on the fundamental questions of qualitative vs. quantitative paradigms). In Krippendorff's proposition of a "science for design", the production of a "systematic collection of accounts of successful design practices, design methods and their lessons (...)" can be the basis of the data for this research, which at the same time "(...) [provides] methods for validating designs" (Krippendorff, 2006, p. 209). By defining a structured design process with clear goals and identical steps, it becomes possible to repeat the design process and establish a basis for comparability. The resulting artifacts, and the related experiences, can be discussed not only against their underlying design hypothesis but also against each other (Zimmerman, Forlizzi and Evenson, 2007). Phenomena encountered around those design cases, produced based on comparable design problems and conditions, can then be analyzed using an hermeneutic approach (Alvesson and Skoldberg, 2009).

4.3.3. Methodical Consequence 3: Enabling Sonic Exploration and Elaboration

In order to fulfill the aim of providing results which are of value for sound designers, it is necessary to explore the sonic potential as broadly as possible and to emphasize sonic refinement and care for detail. Therefore it is critical that sound remains at the center of the creative and reflective process[5]. Interaction designers deal with many different aspects in design, therefore,

[5] This focus also is connected to a limitation of the thesis with regards to the multimodal aspects of experience. The focus of both data generation and analysis was only on the sound dimension. But from there, occasional links to other modalities appear, such as material, form, etc. In any case, the impact of multimodality was not

the methodical framework has to encourage, and sometimes even enforce, a maintained focus on sound. On the other hand, the sound design process needs to be integrated into the interaction design process, making use of its methods of prototyping, mocking up and evaluating by testing and by design critique (Dix et al., 1998; Löwgren and Stolterman, 2005; Blevis et al., 2007).

An important goal in this respect is to enable and motivate sound design as activity of designing the very sounds themselves, rather than using prefabricated sounds from libraries or limiting design rules, such as imitation of a "natural" sound, or employing a simple tonal system. This may involve the use of sounds from a library or recordings, if necessary, but in this case, the goal is to transform them according to a given aesthetic principle based on the design task at hand (rather than an a priori rule). This relates to the understanding of sound design in professional practice (Sonnenschein, 2001; Whittington, 2007; Hug, 2008a; Hug and Misdariis, 2011).

As consequence, the design tools should afford as much sonic richness as possible, while remaining simple to use and accessible to all participants equally. Fundamental soundmaking skills are essential, and because the designers are dealing with interactive and to some unpredictable situations, soundmaking must happen in realtime, in an improvisational, performative setting. This is already necessary at the earliest "draft" stage. Therefore, in combination with the goal of "experience prototyping", an appropriate approach to "drafting" or "sketching" sounds[6] is needed (Buxton, 2008, Ekman and Rinott, 2010).

Also, the sound design process should support aesthetic openness. First, this leads to a reduction or even elimination of information related to established approaches to Auditory Display design. In addition to absence of these a priori design guidelines or principles, focus on sound and sonic experimentation is important and there should be minimal limitations in terms of aesthetic approaches to sound design. Design decisions should be left to the participants, so as to avoid a researcher-induced aesthetic bias. Therefore, during the design process, there must be minimal interventions from my side, and it was necessary for me to adopt a somewhat "naïve" position towards the participant's proposals. If help was necessary, it was aimed at stimulating and fleshing out the participant's own approaches, rather than correcting them.

a dominant topic. Excellent readings about multimodal design are (Luckner, 2004) and (Haverkamp, 2013).

[6] Drafting sounds is a challenge in itself. Pirhonen reports issues when presenting intentional draft-quality sounds in order to encourage the panelists to suggest changes, was not successful, as opposed to the design of visual layuts , in this study, such an analogy between visual and audio design is not strong enough to justify taking the same approach in sound design. When draft-quality sounds were presented to the panel, they were immediately criticised by participants. In the discussions it became clear that the main trigger for the negative reaction was not caused by the basic idea of each sound (formulated in the first panel). The negative reaction transpired to be an emotional one - the sounds were simply unpleasant to listen to (Murphy et al., 2006). Similar problems are identified by sound design practicioners being confronted with clients in early phase of a project (Hug and Misdariis, 2011).

5. Implementation of Method

In the follwing, I will describe, how the method was actually implemented and how the design process was structured, in order to reach the research objectives mentioned above, while adhering to the methodical considerations.

5.1. Using Workshops as Research Labs

Above, I have argued for a comparative exploration of design cases which emerge from a project based design process. Because of the reasons outlined above, this has to take place in the discussion of a series of comparable cases, which are themselves not perceived as finished products but rather as artifacts stimulating a debate. A goal was also to generate a sufficient number of cases, provided by a sufficiently large number of participants to allow for a comparative study of diverse phenomena. By going through a specific sequence of steps from analysis to evaluation with each group of participants, and by iterating the overall process, the reliability and validity of the findings can be increased.

These aspects can be well covered in a recurring design workshop format. Such workshops were conducted at the Zurich University of the Arts in Switzerland (referred to as "ZHdK" hereafter), at the University of Art and Design Linz, Austria (referred to as "UDKL" hereafter), and the Aalto University, School of Arts, Design and Architecture, in Helsinki, Finland (referred to as "TAIK" hereafter).

The educational setting is particular suitable for the purpose of this research, as it allows a open reflection-through-action about artifacts, which may become future products, but are not (yet) part of our everyday live experience, to take place. This would not be the case in actual design cases, where customers ultimately define the direction of the work Also, to work with students rather than design experts ensured a certain openness and desirable "naïveté" in terms of approaches chosen. Ultimately, in these workshops, the participants co-create the reality which we investigate as emerging phenomenon in a dialogical, discursive setting which is also in line with the learning goals of the workshop.

This approach also builds on the model of the "student research workshop"[1] which is a form of collaborative and discursive research practice in educational workshop settings, where a group of students collaborate and interact in the process of generating and interpreting "data" or phenomena[2]. In the design of the workshops, my aim was to follow the recommendations of Heimgartner and Hernandez (2005):

> "The basic idea of the research workshop as methodical arrangement is, to support, or optimize, research by communicative processes. Research workshops stimulate communication processes which can guide the research process and foster the generation of new knowledge. This way, knowledge is produced through discourse and interpretation in a group, and at the same time the participants are part of a collective educational process. (...)

[1] Not to be confused with the concept of the "research lab" in the anglo-saxon world.

[2] Comparable formats of participatory, research oriented workshop settings have also been found to be useful in order to deal with complex, design oriented issues like the one presented here, see e.g. (Schuler and Namioka, 1993; Franinovic, Hug and Visell, 2007; Droumeva and Wakkary, 2006 or Franinovic, Gaye and Behrendt, 2008).

> Essentially, this is not about approaches to validation, but about additional ways to generate knowledge, because the individual approaches will lead usually to diverging positions. It is important that the participants do no merely reflect the contributions, but have an interest in an active interpretation of statements. The discussion is not oriented towards consensus, but works out differing perspectives."[3] (Heimgartner and Hernandez, 2005 p. 184; author's translations)

In this framework, validity of results is essentially established based on a shared understanding. The aim is not to identify an "objective truth", which also would not be of interest for the research objectives stated above, but rather to provide analytic access to the specific phenomena and the related discourse that occurred in the workshops. Still, through the aggregation of phenomena across a number of comparable cases, it is possible to reach a relatively high confidence regarding the relevance and reliability of certain insights. To achieve this, altogether nine workshops (and one additional pilot workshop) were executed, resulting in 29 cases[4]. A total of 91 students[5] and about five expert guests who visited presentations (some of them several times), participated in the process. The following table gives an overview over the workshops and the participants.

Nr.	Institution	Year	Nr. of Cases	Nr. of Participants
1	ZHdK	2008	3	16
2	TAIK	2009	5	11
3	ZHdK	2009	1	10
4	ZHdK	2009	6	9
5	TAIK	2010	3	9
6	UDKL	2010	3	10
7	ZHdK	2010	3	11
8	UDKL	2011	3	11
9	TAIK	2012	2	4

Table 5.1.: Overview over workshops, number of cases and participants involved.

The workshop-based method has two major limitations. On the one hand, being actual workshops as part of an educational curriculum, there are didactical constraints and considerations to take into account. Ultimately, ensuring the learning outcomes is prioritized over adherence to the strict rules established in order to satisfy the research goals. On the other hand, the approach of integrating the research in curricular teaching also results in limitations regarding the sampling of participants. First, there is the limitation of the age group, as the participants were either bachelor or master students. Also, a detailed pre-assessment of sound and interaction design competences of the participants, beyond what their study curricula already covered, was not possible.

Common to all participants was their general background in design and arts. People with musical expertise were relatively rare in the classes taught at ZHdK and UDKL, participants

[3]"Ein Grundgedanke der Forschungswerkstätte als methodisch bedeutsames Arrangement ist, dass Forschen durch kommunikative Prozesse unterstützt bzw. optimiert werden kann. Es werden mit der Forschungswerkstätte kommunikative Prozesse in Gang gesetzt, die in der Folge den Forschungsverlauf lenken bzw. den Erkenntniszuwachs fördern. Auf diese Weise wird Wissen diskursiv bzw. interpretativ in einer Gruppe entwickelt und gleichzeitig findet für die Teilnehmenden ein kollektiv gestützter Bildungsprozess statt. (...) Es geht dabei im Wesentlichen nicht um Validierungsansätze, sondern um einen Zuwachs an Erkenntnismöglichkeiten, denn die individuellen Zugänge führen in der Regel zu divergierenden Positionen. Wichtig dabei ist, dass die Teilnehmerinnen und Teilnehmer die Beiträge nicht nur spiegeln, sondern dass sie an einer aktiven Interpretation des Gesagten interessiert sind. Die Diskussion ist dabei nicht primär am Konsens orientiert, sondern erarbeitet differente Perspektiven."

[4]Number of analyzed cases. Six cases were not included in the analysis for reasons given below.

[5]Total number of students, including those whose designs were not included in the analysis. Twelve more students were involved in the pilot workshop.

sound design experience were virtually non-existent in these two locations. On the other hand, participants from TAIK usually had a background in music or sound design. But the design brief was new for all participants and the tools and procedures used were new to all participants. In particular, the tools and the design methods ensured, that even participants with very little or no previous experience in music or sound design were able to actively contribute to design solutions. The results indicate, that this successfully prevented that previous knowledge and skills would have a significant impact on the results. If anything, it could be observed, that experience musicians tended to stick to approaches using tonality and harmony, and were often less open to "unorthodox" design solutions.

In the following, I will describe the specific design method and workshop procedure used and how data was generated and analyzed. A description of the workshops outcomes is presented in the next part of this thesis.

5.2. Design Method: Experience Prototyping with Electroacoustic Wizard-of-Oz Mockups

To enable the dialogical process I described above, a responsive, flexible design approach, which is able to deal with insights emerging during the interaction process. Also, the design method has to support the exploration of "possible futures" by making sure that the resulting artifacts are sufficiently "realistic". For this, we need to produce cases of "plausible experiences" that can be analyzed and discussed in the group. In Buchenau and Suri's words, researchers need

> "(...) to explore and communicate what it will be like to interact with the things we design." (Buchenau and Suri, 2000, p. 424)

They describe "experience prototyping" as being a design method particularly suitable for this purpose. In their words, experience prototyping is

> "(...) any kind of representation, in any medium, that is designed to understand, explore of communicate what it might be like to engage with the product, space or system we are designing." (Buchenau and Suri, 2000, p. 425)

In order to emphasize the collaborative and discursive exploration of possible futures, narrative framing (Kim, Lund and Dombrowski, 2010), and performative staging of such representations are particularly suitable[6]. A central point of performative approaches is to "open up informed dialogues between designers and an audience" (Burns et al., 1994, p.119), but also to deal with meaning as an emergent property of interaction which can only be fully explored through creating use experiences. Improvisation is an important aspect in this context, providing the possibility to come up with ad-hoc ideas about how to modify aspects of the design, but also to better understand the impact of the fact that actions in everyday life are situational rather than simply following pre-scripted steps of a plan, thus implementing Suchman's (2007) concept of "situated action". Thus the method needs to facilitate improvisation, and needs to build on an understanding of what constitutes it (Danzico, 2010). Based on (Pagel et al., 2009) the following key criteria of improvisation were considered to inform the methods and techniques presented here:

- Improvisation is *transindividual*. Only in a social setting, cultural practices and traditions can emerge. Also, the presence of other agents constantly provides cues for the improvisor to modulate the performance. As consequence, the project demonstrations always take place in a setting, which allows the audience to discuss, participate and interact.
- Without appropriate *skills* there is no improvisation, as it requires control, overview and fast decision-making. Therefore, the workshops ensure that all participants can use the tools available, and that they practice their performances sufficiently.

[6] Also see the concept of "staged research" ("Szenisches Forschen") described by Wentschur (2005).

- As adaptation is a catalyst of improvisation, the *change of circumstances* has to be enabled or even forced. This could be achieved by stimulating interventions by participants or by intervening myself.

- The creative play with sign systems can be fostered by *establishing rules* and a sign system or idiom. This does not negate the freedom of improvisation, but rather enables it. In the case of this project, the rules were the presentational setting, the tools, the design considerations that the demos had to answer (see below for a description of the activity brief of the workshops) and the general procedure and timeframe for the demonstrations.

A popular performative technique that builds on improvisation is "bodystorming" (Oulasvirta, Kurvinen and Kankainen, 2003), a kind of embodied brainstorming using early lo-fi prototypes, and an adapted version has been used in sonic interaction design (Franinovic, Hug and Visell, 2007; Franinovic, Gaye and Behrendt, 2008).

In response to the methodical aims of supporting performativity, improvisation, hands-on experience of mockups, while being able to focus on the sound design and aesthetics, I based the experience mockup method on the Wizard-of-Oz prototyping approach, where a computational system is simulated by an invisible human, triggering events in real time, while another person acts out the scenario or uses the prototype[7]. In 1977, Nigel Cross proposes human-behind-the-scenes prototypes for the simulation of a computer-aided design system, which describes the essential motivations for the approach:

> "There are two main problems which make investigation of the effects of new computer-aided design systems difficult. First, there is the probability that computer aids will so alter normal design processes that speculation based entirely on conventional practice cannot be reliable. Second, there is the prohibitive cost of setting up working experimental systems to provide the necessary experience and feedback. (...) The problem is, therefore, to devise a suitable simulation of a computer-aided design system. (...) Viewing the computer-aided design system in this way leads to an obvious suggestion for a simulation technique—one may as well fill the black box with people as with machinery. Doing so provides a comparatively cheap simulator, with the remarkable advantages of the human operator's flexibility, memory, and intelligence, and which can be reprogrammed to give a wide range of computer roles merely by changing the rules of operation. It sometimes lacks the real computer's speed and accuracy, but a team of experts working simultaneously can compensate to a sufficient degree to provide an acceptable simulation." (Cross, 1977, p. 107)

The method was further developed in the eighties by John F. Kelley to simulate natural language computing and he describes it as an

> "(...) experimental simulation which I call the OZ paradigm, in which experimental participants are given the impression that they are interacting with a program that understands English as well as another human would." (Kelley, 1984, p. 26)

An example of the use of a variation of the Wizard-of-Oz method in the context of Auditory Display research is provided by Droumeva and Wakkary (2006). For this research, the method was extended using Foley soundmaking methods combined with electroacoustic means of recording, processing and acousmatic playback with the goal to exploit the ventriloquism effect. This method is referred to as "Electroacoustic Wizard-of-Oz Mockup" in the following.

[7] Another motivation for choosing the Wizard-of-Oz method was to avoid the dominance of technology in the students' considerations. A more detailed discussion of the didactical implications and the issue of "technology-centered education" in particular in the workshops tought to interaction design students at ZHdK is provided by Hug and Kemper (2014).

The choice of tools for soundmaking was informed by the several considerations. First, they should enable performativity, improvisation and dialogical exploration. Second, they should afford the design of elaborate and rich sounds, while being as open as possible to sonic aesthetics[8], putting sound at the center of attention at any stage. Third, they should be easy to learn and accessible with a minimum of effort, also by participants with little or no experience with sound editing and processing, and offer the possibility to iteratively refine complex setups. Finally, the sound making techniques and tools should - in principle - allow to continue development beyond the mockup stage in the form of functional implementations[9]. In order to satisfy these requirements, sounds that participants worked with were based on recorded sound which could be used as "samples". This is a technology and workflow which is easy to learn and allows to work with existing, complex sonic phenomena, without having to learn about e.g. acoustics and synthesis. Students with the related expertise were free to use synthesis methods as well.

The software used in the majority of projects[10] was "MuLab"[11], or, more precisely, its built-in Multisampler tool, which offers all essential functions[12] for advanced (yet accessible) sample based sound design and live playback (Figure 5.1 on the following page). MuLab is available for both Windows and OSX platforms and offers a free demo mode, who does not restrict the functions required for the given task. Another software used was "Audacity"[13] for preparing sound files. Optionally, "Reaper"[14] (or any other DAW, depending on student's preference) could be used for creating complex samples for later use in the MuLab Multisampler. The Multisampler then could be triggered by a MIDI Keyboard, which also could be used to control the effects. In most of the cases, a Keyboard with large keys and knobs and sliders was used to ensure easy, and eyes-free playability (see Figure 5.2). For debugging MIDI data, "MIDI Monitor"[15] or "MIDI-OX"[16] were used.

In the following section, I will describe the concrete implementation of the workshops in more detail.

5.3. Workshop Structure, Content and Procedures

In order to establish and test the fundamental elements of the workshops, one pilot workshop was carried out at the Design Factory of the Aalto University in Espoo, Finland. Nine further workshops have been included in the data of this research. Each workshop had a comparable temporal structure which was mainly varied to accommodate the varying overall duration of a workshop. The duration was between a minimum of 4 and a maximum of 12 days. The workshops at UDKL had a duration of 4 days, and those at TAIK lasted 5 days. The first two Workshops at ZHdK (2008, 2009) had an overall duration of 12 days, spread over three weeks. The third workshop at ZHdK in 2011 (part of autumn semester 2010) had a duration of 10 days spread over two weeks. The additional days of the ZHdK workshops were usually

[8]Every tool affords a certain functional and aesthetic direction, thus biasing the design. The methods and tools I was using during the workshops are no exception, but there are several factors indicating that they are relatively neutral and open to change and modification, very much as a sketch in a visual design process (Buxton, 2008).

[9]These criteria and the related tools and design process also has been described by Hug (2010a) and Hug and Kemper (2014).

[10]Occasionally, students would chose to use the multisampling features provided by other software, such as Apple Logic or Ableton Live.

[11]http://www.mutools.com/

[12]Key Mapping, Loop Management, Pitch and Playback speed manipulation, ASDR envelopes and LFO's and a vast range of DSP effects, such as delay, reverb, distortion, etc..

[13]http://www.audacityteam.org/

[14]http://reaper.fm

[15]OSX; https://www.snoize.com/MIDIMonitor/

[16]Windows; http://midiox.com/

Figure 5.1.: Screenshot of MuLab (v4), hosting two multisampler units. Effects and mapping editors are visible.

Figure 5.2.: The "wizards" Monika Bühner and Kai Jauslin, performing their interaction mockup.

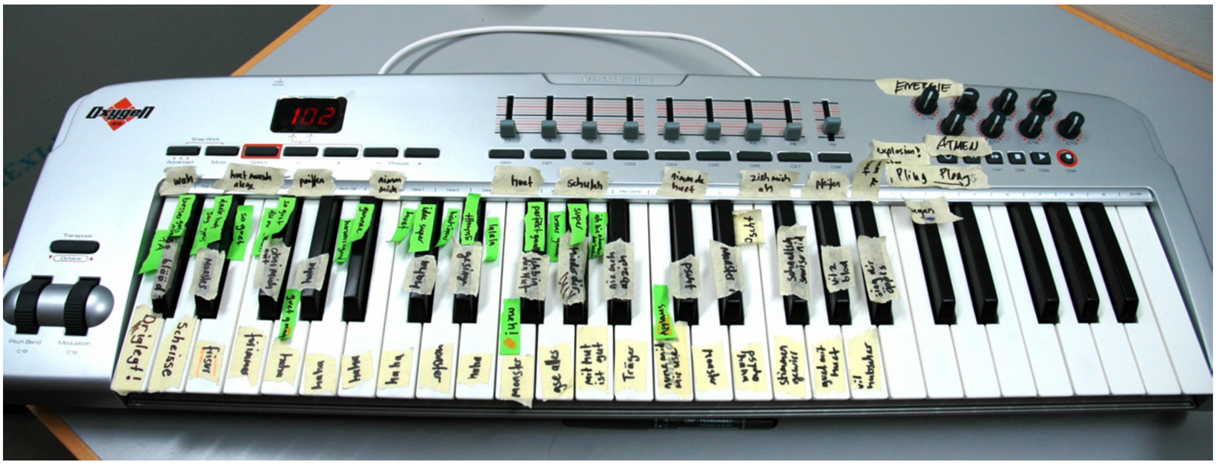


Figure 5.3.: The Workspace of a "wizard". The keyboard controller is used to trigger and control sound played back with MuLab.

used for additional inputs, e.g. related to sound studies, special visits[17] or additional teaching of basics, which the participants at ZHdK usually lacked. This also included extensive tutorials for the audio tools described above[18]. In the case of the second workshop at ZHdK, which was run in cooperation with Volkswagen, some time overhead was generated by the inclusion of a functional prototype framework in the form of a car equipped with sensors, and the need to build a functional version of the prototype[19]. The thorough documentation of each workshop made it possible to identify differences and their possible impact, thus ensuring accountability. The core components remained unchanged and are applied in every iteration. They are described in the following.

5.3.1. Establishing Fundamental Competences: Inputs and Tutorials

For the overall research strategy to yield the desired results it has to be assured that all participants share a comparable and sufficient level of sound related competence. This is necessary for both analytic and creative tasks. A series of inputs and activities were devised to satisfy this requirement. They consisted of the following elements, which were persistent over all workshops, but slightly varied, to accommodate circumstances and didactical considerations.

Introduction of theoretical and conceptual fundamentals (if not already provided in an earlier workshop): In the workshops at UDKL and at ZHdK, an introduction and practice of a suitable vocabulary to "speaking about sounds", including the analysis, description and representation of sonic objects and was provided. In longer workshops at ZHdK, this involved an introduction to sound studies and acoustic communication, excluding however Auditory Display and related design strategies, for the reasons described above. In all introductions, a general background on Sonic Interaction Design, the rationale for using sounds in the design of interactive commodities and the role of artifacts in sociocultural context was provided, including the presentation of a typology of interactive commodities (Hug, 2008b). The application potential of sound was illustrated with examples from industry and design research, e.g. (Aarts and Marzano, 2003) or (Oleksik et al., 2008) as well as interactive artworks, such as "Blendie"

[17]Such visits would usually be at the lab of the Institute for Computer and Sound Technology ICST of ZHdK and cover their ambisonics immersive sound systems, hence avoiding potential bias on design approaches of the workshops.

[18]Considering that participants in both UDKL and TAIK were master students (as opposed to bachelor students at ZHdK) an in particular students of TAIK were generally more experienced with sound, the additional time served to compensate for these differences.

[19]The functional version, however, was in fact only a small adaptation of the electroacoustic mockup.

by Kelly Dobson[20]. Also basic analytic competence related to the relationship of sound, object and interaction was conveyed. This included product sound quality and the analysis of action-sound relationships (Visell, Franinovic and Hug, 2007). This was combined with the creation of a ”Foley-box”, containing all kinds of objects with interesting sounds, to inspire creation and provide material for recordings.

Hands-on exercises were carried out in order to establish basic listening skills and analytic sensitivity for object sounds and action-sound relationships. This was designed as a scaffolding experience, providing a first building block for the sonic concept and mockup development. From the Workshop DD ZHdK 2009 onwards, the block was concluded by the “Semantic Foley” exercise: The participants were asked to form teams of two (sometimes three) and create a sound using “married foley” which was meant to convey both a process and its qualities[21]. The goal was then for the audience to infer the combination of process and its quality from listening to the Foley-sound acousmatically.

Introduction to performative and narrative dimensions of sonic interaction design. In order to stimulate interest and understanding of the potential of sound design, a systematic analysis of Film sound examples was conducted in the first editions of the workshops. This was also linked to research which aimed at distilling “Narrative Metatopics” and related sound design examples. For this purpose, a collection of up to 23 short extracts from movies and 5 extracts from video games were provided to the participants. Each clip contains a narratively closed scene, depicting either an interaction with an artefact, or changing internal states of objects or protagonists (provided the change is mediated by an artefact). The sound design should play an important role in the interpretation. The clips were divided in two sets and anonymised. The clips are provided together with an analytic protocol. The procedure and result of this analysis are described by Hug (2010a). This activity was carried out in all initial workshops, until and including ZHdK DD2009. In later workshops, the resulting narrative metatopics and related movie clips were presented to the participants as part of the introduction[22]. In some later workshops a “Foley Remake” of the sound effects of some clips from the clip analysis collection was performed.

Tutoring of the technical tools for soundmaking: In particular later development stages require some basic knowledge of sound editing and composition with simple effects. In order to fulfill this requirement, I put the focus on a range of soundmaking methods that originate in tape-based sound editing and basic signal processing methods, which can be understood and reproduced with relative ease.

5.3.2. Design Assignment

In order to ensure consistency and comparability between cases, the starting point of the project work has to be clearly defined, not only in terms of the overall setting, skills and tools, but also in terms of the assignment given to the students. Also here, the intention was to keep this so-called “design brief” as consistent as possible across all workshops, but also here some adjustments

[20] http://web.media.mit.edu/∼monster/blendie/

[21] Example processes were: charging, connecting, searching, dissolving. Example qualities were: determined, insecure, powerful, gentle, alerting, time-critical.

[22] The three conceptual elements of typology of interactive artifacts, situational categories and design space and narrative metatopics were integrated into a systematic conceptual framework that can inform the sound design process without predefining or biasing the actual design solutions Hug and Misdariis (2011). In later editions, starting with DD ZHdK 2010, this was presented to the participants as part of the introduction to the workshop.

were necessary occasionally. The following list provides an overview over the design brief and its variations[23].

- DD ZHdK 2008 & TAIK 2009: The assignment was to design sounds for object interactions in everyday situations. combination of everyday fiction as basis. The initial brief indicated as possible applications: shopping, smart home, smart office, toys, sportswear, kitchen, restaurant/bars, pervasive gaming artifacts.

- IAD ZHdK 2009: The design brief was to design an energy harvesting device.

- DD ZHdK 2009: Here, the brief was to design object interactions with sound for Smart Homes (e.g. Kitchen), Mobility (Cars, etc.), Cyborgs, or Wearables. Cars were at the center of attention, as this workshop was combined with another course at Interaction Design which was based on an assignment from Volkswagen to design auditory interactions for the process of entering a car.

- TAIK 2010: In this workshop the brief was to design for a) energy harvesting and management (was then omitted due to lack of participants); b) smart clothes and wearables as augmented identities in hybrid social spaces or extensions of self; c) the "smart kitchen"; or d) The "wise bathroom" as place of cleansing and health.

After three editions (including the pilot workshop) of the workshop, in 2009 , the design cases were analyzed a first time, and common design criteria, and a provisional related design space of situational criteria, was derived (Hug, 2013)[24] and shortly introduced in the workshop from ZHdK 2009 onwards. The categories which emerged cover a large spectrum of applications, but are likely not to be neither conclusive nor exclusive. The dimensions can be represented as semantic differentials representing the trajectories across situational categories that are related to the use of interactive commodities. Essentially, this design space consisted of the following dimensions: Social situation (between private and public situations, but also between personal and social concern), level of intimacy (the artifact can be seen as distant object, as something that can be put in a pocket, as a wearable or even as an implant), relationship to user and task (is the artifact an assistant or a tool?) and type of use (casual or professional?).

Based on this, the design brief was slightly changed. The application scenarios were still similar, but rather than freely exploring sound opportunities in the existing environment, a set of more specific interaction scenarios, or topics was provided. Each topic was designed to represents a certain profile in terms of design space as described above. This altered brief was first used in the UDKL 2010 edition of the workshop and proposed the following themes to chose from:

- Doc-o-Mat: A wearable or implant with a body related purpose ("quantified self"): e.g. health monitor for specific genetic dispositions, nutritional values, fitness... Monitors bodily activities such as eating or physical activity. Situational category: Rather intimate, private and public settings, usually casual use, but may have an "expert access" mode (e.g. by therapist or doctor).

- Matchmaker: A wearable or implant that manages social relationships in urban environments. Is part of the experience of a site-specific social situation. May be used as means for social expression / communication. Situational category: Mixes intimacy / privacy with sharing and public settings. Mostly "casual" use.

[23] For details about the design briefs, see the related description of the workshop in Part II of this thesis.

[24] The article was submitted on August 30th, 2009, and a slightly revised version was submitted 2010. However the publication was stalled until 2013.

- HomeMaid / KitchenMaid: An artifact or embedded system that helps managing typical processes at home (e.g. cooking, hygiene). Monitoring of processes, support in orchestrating a smart network of kitchen tools and home appliances. Tools for carrying out common activities at home. Situational category: Private space, intimate, but also social (with family or friends) interactions. Tools and assistants, casual and expert users possible.

In some workshops with a larger amount of participants, additional scenarios were offered:

- PlaySam: Focus on playful interactions or games, in particular for children. May support construction, movement, exploration, social interaction and communication, role play, but also retreat and hiding... Situational category: Hybrid between private spaces inside public spaces, and personal interactions which become negotiated as shared...

- MobilIT: This topic focused on aspects of spatial navigation and orientation, and applications in the area of traveling.

5.3.3. Design Process

After making sure that every team has a goal and there are no obstacles to the design process, the lecturer remained in the background, only intervening when problems with implementation of an idea occurred. The sound designs in particular should be kept secret by the teams. This served to assure a certain level of "ignorance" from the lecturer and the teams, which allowed them to participate in more or less equal position in the final interpretation and discussion.

The design process was separated in two stages: An initial first draft, in the form of a "sounding concept", and the final electroacoustic mockup. In order to encourage the dialogical process, at the end of each stage, the experience is discussed with all participants. The demonstrations and the discussions were recorded both as audio and on video (see below for details on the method of data collection and analysis).

Initial Design Stage 1 (WS 1-4)

As described above, the first workshops started with an analysis of selected sequences from movies, depicting specific interaction scenarios. The resulting "Narrative Metatopics" could then be used by the students as starting points for their design. After the clip analysis, participants are asked to document everyday interactions and objects using video recordings. These interactions have to be analyzed using the same steps as the movie clips (step 2). This helps to prepare the ground for the next step, designing sounds for everyday object interactions. In this step, the participants were asked to find narrative links between the fictional metatopics identified and the everyday experiences documented, and to redesign the sounds of the everyday experiences, using the available sound designs identified in the fictional scenarios of the clips as starting point. In the initial workshops, this first rapid prototype was achieved by overdubbing a video of the interaction ("everyday fiction"). Later on, starting with TAIK 2010, the first rapid prototype was implemented as *Foley Wizard-of-Oz mockup.*

Refined Design Stage 1: Foley Wizard-of-Oz Mockup (WS 5-9)

The first versions of the workshop used a overdubbed video or similar representations for designing the initial draft of a design. Later on, this was extended or even replaced by the Foley mockup stage, in order to explore the richness of sound while working on the initial concept in a form that can be directly implemented in the form of a live demonstration of a Wizard-of-Oz mockup. Afterwards, the demonstration is discussed with all participants, and ad-hoc suggestions might be tried out immediately, using the Foley technique. Thus, the Foley mockup stage served as both proof of concept and playful inspirational session.

Foley, the technique of creating sound effects synchronous to film[25], is ideal for heterogenous groups with varying soundmaking skills and can be easily learned through a set of simple exercises (e.g. “Semantic Foley”, and “Foley Remake”, see above). Combined with the possibility of making sounds with the voice and the body, it offers a vast amount of sonic possibilities with a very simple technical setup (Ament, 2009). In order to maintain a close aesthetic link to the subsequent stages, and to afford the detachment of sounds from their source, the sounds made were captured with a microphone. The microphone, and the projection of sound through a loudspeaker, provided an acousmatic listening condition, which further supported the understanding of sound transformation in the electroacoustic condition.

As the temporal and technical investment in creating the sounds for the Foley stage is relatively low, another requirement is fulfilled, which is the openness to change and the creation of design alternatives. Also, it makes it easier to abandon design directions, or to “kill your darlings”[26], if necessary. Finally, this method is also particularly open to improvisation that supports a dialogical form of design, where a sonic idea can be immediately adapted, based on the reactions of users and the audience, which, being unexpected, may often challenge interaction assumptions.

Design Stage 2: Electroacoustic Wizard-of-Oz Mockup (all WS)

Building on the results of the first drafts, the Everyday Fiction results, or the Foley mockup, the next step used recorded sounds that are played back via a multisampler setup. The use of multitrack editing allowed students to create complex sounds in a more controlled way than is possible with Foley. The resulting sounds were triggered with the multisampler software, and real time mappings were explored and performed by the “wizards” with a MIDI keyboard. These tools require a more structured approach already, in terms of defining mappings and producing assets, but are still easy to understand and handle and relatively flexible to modify[27].

The overall process of this stage was the same as in the Foley stage: The participants were asked to refine the initial ideas into a specific application scenario, considering the design requirements of the situational context, and to work towards a systematic approach to defining sound assets, modification parameters, and mappings to specific interaction elements. They were asked to perform their sonic interaction scenario, using MIDI controllers to explore the dynamic relationships of sound properties, action and artifact. Finally, again, the interactive scenarios were performed in a Wizard-of-Oz setting, and participants could try out the interactions themselves. Also at this stage, the participants were asked to consider designing for performative and expressive variation and adaptation and to stay open to improvisationThe stage was constructed in such a way, that it can be easily transferred to functional prototypes. This was the case in the workshop done in collaboration with Volkswagen (see description of DD ZHdK 2009 in Chapter 10).

[25] Realtime soundmaking practices in traditional film sound are almost as old as film itself (Gomery, 1985). At the core of these practices stands the art of Foley (Ament, 2009). Foley is used to support, enhance, replace or actually create a sonic ”reality”. For this purpose, the Foley artist performs sounds using objects and the own body and voice, whilst watching a screen with the film footage for timing. Foley is also used in video games or audio plays, where synchronization to a linear moving image is not required. Foley practice relies on a mixture of free exploration and elaborated, structured processes, the ingredients of successful improvisation. Usually Foley is produced in a ”Foley stage”, containing the ”Foley pit”, an area which offers different surfaces for walking. Around this surface, props of all kinds can be found. Usually there is a kind of ”Foley library”, in which hundreds of objects are stored in a more or less systematic way. An important technique to create more complex sounds is ”married” Foley, where two or more people perform the sounds simultaneously (Ament, 2009).

[26] Kill (or murder) your darlings is a popular recommendation in design education and practice. The phrase is originally attributed to Sir Arthur Quiller-Couch, who addressed it to authors: “Whenever you feel an impulse to perpetrate a piece of exceptionally fine writing, obey it - whole-heartedly - and delete it before sending your manuscript to press. Murder your darlings.” (Quiller-Couch, 1916)

[27] At the time of this research, tools like the Sound Design Toolkit (Monache, Hug and Erkut, 2010) were not yet easy to use and versatile enough for this purpose.

5.4. Data Generation and Explorative Analysis

In general, this work combines elements of the comparative case study method as described by Druckman (2005) and a setting similar to Focus Groups with a general Grounded Theory approach (Corbin and Strauss, 2008). According to Druckman, the case study approach is "not guided by an overarching paradigm or set of assumptions" and is based on establishing a "bound process that can be documented in time and/or space" (Druckman, 2005, pp. p. 163). My approach exhibits characteristics of both "Focused Case Comparisons" (FCC, ibid., p. 209) and "Aggregate Case Comparisons" (ACC, ibid., p. 217), without fully following these methodical models: As the former, it has a relatively thick description of each individual case, takes into account the context, and proceeds as qualitative inquiry but it attempts to generate a larger number of cases than FCC usually does and does not thoroughly analyze each single case, but rather looks at specific aspects. In this it resembles the Aggregate Case Comparison, which focuses on specific types of events and correlates them across cases, but this correlation is achieved by a Grounded Theory process rather than statistical methods as usually employed in the case of ACC. Grounded Theory also fits to the approach of Research Workshops:

> "The methodical understanding is open and explorative. The generation of theory is based on the empirical data. Sampling may follow the content analysis (theoretical sampling) and guided by the variation of the content."[28] (Heimgartner and Hernandez, 2005, p. 184; author's translation)

The Grounded Theory approach adopted here in general follows the Straussian variation (Corbin and Strauss, 2008) which recommends not to collect data wildly and interpret it at the end, but to adapt the sampling and data collection in an iterative process:

> "To make another point, theoretical sampling is cumulative. Each event sampled builds upon previous data collection and analysis, and in turn contributes to the next data collection and analysis. (...) It is kind of like fishing, for the researcher is hoping for something but does not know what will come out of that sea of data." (Corbin and Strauss, 2008, p.146)

Even though Grounded Theory is very open and does not build on a priori paradigms or hypotheses, it is not entirely free from bias, and the empirical data investigated is not "neutral" and "value free" (Alvesson and Skoldberg, 2009). However, it is compatible with the generally hermeneutic and pragmatic attitude adopted in this work.

During the design processes, my aim was to maintain an etic position, trying to not interfere with the design decision making and the interpretational processes as much as possible. Feedbacks to the project groups was restricted to helping them refine and realize what they proposed themselves. In the discussions, on the other hand, I participated as part of the group, which was also possible, because I would avoid getting too much insight into the developments of the final mockups, generally maintaining the level of knowledge of other participants.

5.4.1. Data Generation, Roles of Artifacts, Sounds and Language

In this case based exploration of experience and the discourse emerging from it, the artifacts themselves play a central role. In a certain sense, they embody design considerations and the inherent concepts and paradigms. They thus are manifesting insights and thus are also part not only of the "data" but also of the results of the research Artifacts are not just another form of text, but constitute epistemic objects themeselves, as proposed and discussed by Vastokas (1994), Buchli (2002), Brandstätter (2013) or Mersch (2015).

[28]"Das methodische Verständnis ist also ein offenes und exploratives. Die Theoriebildung gründet wesentlich auf dem empirischen Datenmaterial. Die Stichprobenentwicklung kann der inhaltlichen Analyse folgen (theoretisches Sampling) und ist an der Variation des Inhalts orientiert."

At the same time the focus of this work is not on the "objective", material dimensions of artifacts, but on the sounds and their related interpretations, as expressed in language. Therefore, I have restricted my analysis mostly on the level of spoken language as it emerged in the discussion of the projects and the related sounds. In order to maintain the link to the "actual" sounds and interactions, all related video recordings are made available online for reference[29], and I have provided descriptions of the sonic phenomena by myself as well as by participants. But it has to be taken into account, that the objective is not to establish some kind of comparison between talk about sound and actual "real" sound event as they occurred. Investigating objective causes for interpretational effects is not the scope of this work.

Each project was demonstrated twice in the process of the workshop. A first demonstration was done with the mockup of stage one and the scope and depth of the related discussion would vary greatly between workshops and cases. The second and final demonstration was carried out with the electroacoustic mockup, and it is these demonstrations, and the related discussions, that form the main data of this thesis.

The presentations always followed the same procedure:

1. Demonstration of the prototype, without explanations, except some information necessary to understand the setting and context.

2. Possibility for members of the audience to interact with the experience mockups.

3. Presentation of concept and design solution by the prototype authors.

4. Discussion, possibly revisiting the interaction using the mockup.

The discussion were moderated co-interpretations emerging from a dialog between presenters of a mockup, the other workshop participants (including occasionally visiting guests) and myself. These voices are indicated in the quotations provided in the Parts III and IV of this thesis by "Presenter", "Participant", and "I", respectively. The discussions were moderated by myself, using a series of "triggering questions", based on the research questions described above in Chapter 4. During the discussions, the aim was to illustrate statements about sounds and interactions as often as possible with the actual sound, using the Wizard-of-Oz setups. All demonstrations were video recorded and the discussions were audio recorded.

5.4.2. Procedure of Data Exploration and Analysis

For the explorative data analysis and interpretation, first all audio recordings of the discussions were transcribed using "f4transkript/f5transkript"[30]. I followed a simplified, "smoothed" procedure (Kittl, 2005; Desing and Pehl, 2011), as the text served as a navigational tool in the first place and the details of information in the discourse and speech acts was not of concern in this research. Rather the aim was to identify shared topics, patterns, references among individual statements and among the workshops.

For the analysis, the transcriptions were imported as Primary Documents (`PD`) into Atlas.ti[31] (Friese, 2012). In the following parts of this thesis, all source documents are referred by `‘‘PD’’` and the number associated with the document in Atlas.ti. An example of a view showing a Primary Document with the related codes in Atlas.ti is shown in Figure 5.4 on the next page.

[29] Available at http://people.zhdk.ch/daniel.hug/CLTKTYCLACK_data_Hug_2017/
[30] https://www.audiotranskription.de/
[31] http://atlasti.com

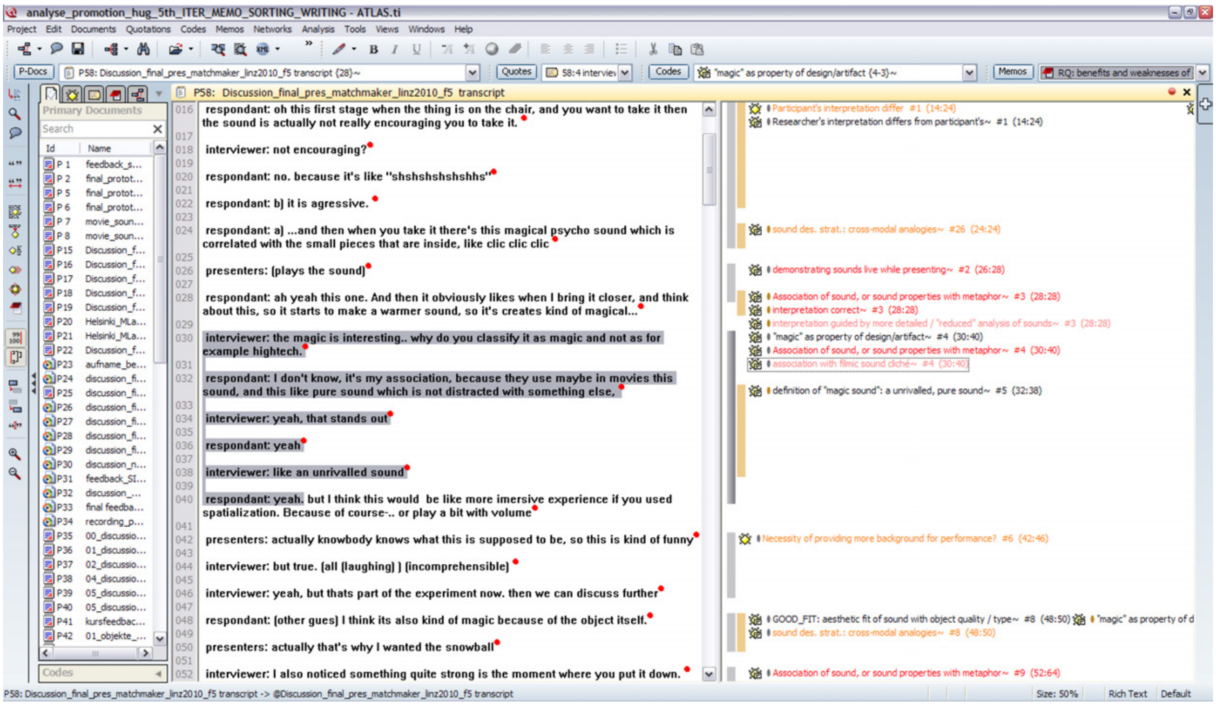


Figure 5.4.: Screenshot of a Primary Document with associated codes and quotes in Atlas.ti.

As mentioned, the analysis followed the general approach of Grounded Theory (Charmaz, 2006; Corbin and Strauss, 2008), abstracting phenomena in a comparative reading of the case discussions and developing them into types during the process (Kluge, 2000). A research diary was created to track reflections and insights along the way. This was also important to document the explorative – and hence not always linear and predictable – analysis process.

The process initiated with several coding steps, starting with open coding, then finding additional occurrences for existing codes. However it soon turned out that the heterogeneity of the discussions resulted in a rhizomatic code list. At this stage, less than 100 codes had more than three related quotations, which indicated a low, or even inexistent groundedness of the codes. Therefore, in several iterations, codes would be revised, deleted or merged, reducing the amount of codes to 297, but still a majority of codes was not strongly grounded. When further reduction was not possible anymore, a process of axial coding started in an attempt to relate codes to each other. This was achieved using the linking tool of Atlas.ti. These initial links were the basis to generate "network views" which could be then visually analyzed and arranged, exhibiting patterns, topical areas and new possible links between codes. Network views were generated by first viewing an initial set of related codes, and then gradually adding other related codes to the network, until a suitable thematic area would emerge, which would then become the name of the network view.

Codes with few quotations were again checked for their relevance, and if possible further cross-linked in the semantic networks with similar codes, or omitted from the network view. This helped to increase the "*density*" (the amount of network connections indicated by Atlas.ti) of the codes, and relevance of each code and topical area could be made more clear using the network view visualization, which turned out to be the main tool of analysis. An overview of an aggregate view of several thematic networks is shown in Figure 5.5 on the facing page.

Along the process, the network views were then extended and analyzed in memos. First only Research Questions were placed in network views, and could act as hubs for related codes and topics, then later the prominent topics would further evolve to actual elements of theory. Gradually, each memo was filled with an interpretation and discussion of the codes and the related quotations from the associated network views. Finally, all considerations were further condensed into 10 theory memos, which were gradually elaborated to become the actual building blocks of Parts III and IV of this thesis.

Throughout the Parts III and IV I will indicate the most relevant codes in relation to the discussed quotations, also providing information about groundedness and density, if applicable. Quotations from the workshop discussions are set in *italics* and their index number in the Atlas.ti database is indicated in brackets. The source data of the analysis can be accessed via the online repository at http://people.zhdk.ch/daniel.hug/CLTKTYCLACK_data_Hug_2017/.

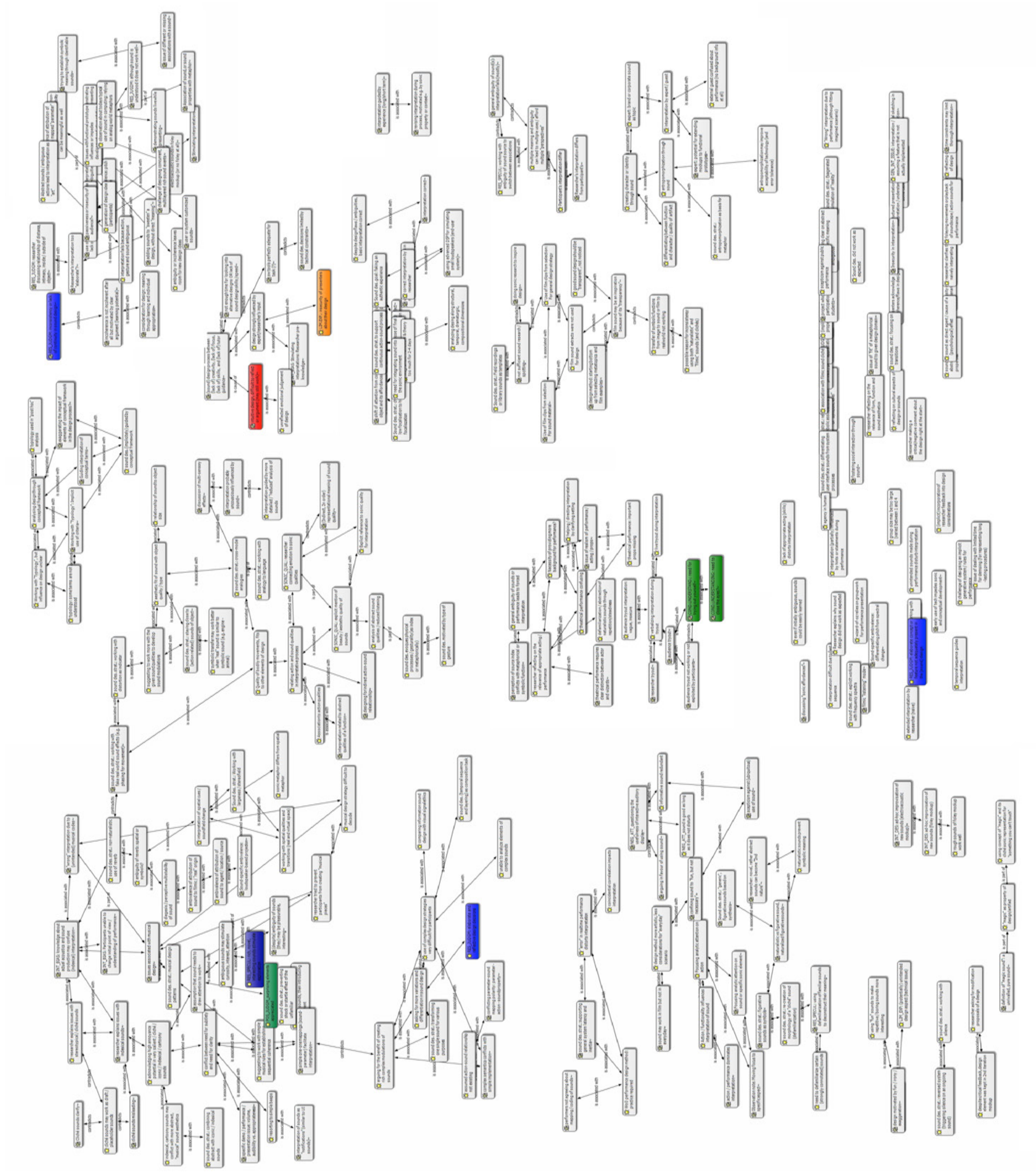


Figure 5.5.: Overview over aggregated network views (as of February 22, 2013) visualizing codes and their semantic linking.

Part II.

Documentation of Design Cases

Introduction to Part II

This part of the thesis provides an overview over all the cases that were used as "data" for this thesis. All cases are described based on the participants project reports. This description is complemented by my own observations from the demonstrations and the related video documentations. It is important to note, that the description does not discuss the designs, but stays as close as possible to the participants concept descriptions and the events as they occurred, as documented in the video recordings.

Each case description has one or several labels in brackets, indicating the original source documents, as they are indexed in the Atlas.ti database. The label is composed of the letters "PD" for "primary document" and the number assigned in Atlas.ti.

Also, each case description is accompanied by an illustration showing a typical moment in the interaction, and a reference to the video recordings from the Final mockup and - if applicable – the Foley mockup. All videos can be found on the online repository of this thesis at http://people.zhdk.ch/daniel.hug/CLTKTYCLACK_data_Hug_2017/.

6. Pilot Workshop at Helsinki University of Technology, 2008

The initial workshop was held on October 21st and 22nd 2008 at the "Design Factory"[1] of the Helsinki University of Technology (Now Aalto University of Technology) by invitation of Cumhur Erkut and Inger Ekman. Thirteen students attended, all of them had a background in audio engineering, some also in music. None of them had a formal education in design, but they had taken courses in which design-oriented methods were taught and used. The workshop was run to pilot the whole process. The duration was one and a half days, which resulted in a compression of the overall process. Namely the analysis of film examples and everyday interactions were carried out simultaneously in two separate groups and the overall number of clips was slightly reduced. Also only one iteration of the design was executed and the final discussion of the demonstrations was shortened. But all essential elements of the overall process were still contained in the program and it provided sufficient data to gain preliminary insights and to fine-tune the overall process. I have described the workshop and the resulting cases in previous work (Hug, 2009 and Hug, 2010a) and will not further discussed them here, as they were not included in the data analysis.

[1] http://designfactory.aalto.fi/

7. Zürich University of the Arts, Design Department, 2008 (“DD ZHdK 2008”)

This workshop was held between December 1st and 19th 2008 at Zürich University of the Arts (ZHdK) as a trandisciplinary module in the Design Department, meaning that it was open to students from interaction, game and industrial design, as well as visual communication, scenography, etc.. The workshop’s duration was 12 days. The longer time span allowed for more introductory exercises and for more time to be spent on both the production of sound designs and on the actual prototypes. Wizard-of-Oz techniques were used extensively for prototyping and for the theatrical performance. The clip analysis was extended, both in breadth and duration, and also included several clips created from video games in order to further saturate the data. The increased duration allowed also to create physical prototypes, either as novel constructions or by “hacking” and modifying existing artifacts. The workshop was attended by 16 students. Their background was Interaction Design (five students) Game Design (nine students), Scenography (one student) and Style & Design (one student).

The general process was to develop scenarios for novel everyday interactions using sonic narrative strategies derived from film analysis. Exercises included an object sound analysis, narrative film sound analysis and “Everyday Fiction”, an overdub of short video of an everyday interaction, using extracts from filmic sounds as first design iteration. Final prototypes were mocked up using the Wizard-of-Oz method, except for one case, which is not considered in the analysis here, as it was implemented as a functional prototype (and by consequence contained several bugs). One more case (out of five) were not included in this study. And another group developed design proposals for a sofa, a fridge and an office chair in the context of a “smart home” scenario and addressing three designs at once resulted in a lack of depth and elaboration for each single design[1]. For further details about the design brief, see Section 5.3.2.

7.1. TakeMeAway: Balz Rittmeyer, Daniel Lutz, Bruno Meilick (PD 2)

`Video file: PD2_DD-ZHDK-2008_takemeaway.mp4`

The starting point of this group was the constant self-representation in interpersonal communication in social networks or on the traditional telephone (Figure 7.1). Related to this was the notion of constructing oneself an “avatar”, a virtual alter ego. This was then adopted to the idea of the telephone as medium for conveying both information (by language) and emotion and the idea of being able to manipulate the informational and emotional qualities of a call, by creating an adhoc vocal avatar and also by manipulating the background sounds.

As result, the phone service proposed by this group allowed a callee to transport her- or himself sonically into an imaginary reality. This could be used, for instance, to easily get rid of a caller by providing an auditory excuse that corresponded to this virtual acoustic environment. Buttons on the phone activate virtual soundscapes and modify the voice of the callee to fit the scenario. For example, the callee might decide to pretend to be in a church, on a busy road or in the middle of a war, which would cause the respective soundscapes being played in the background. Also the voice of the caller would be modified in realtime, for instance, to make it sound scared.

[1] Descriptions of these cases can be found in (Hug, 2009 and Hug, 2010a).

It was also proposed that the phone itself could change its character based on the moral decay of the user, reflected in the amount of times the function was used to lie to the caller, or in the extremity of the chosen fake scenarios.

Figure 7.1.: Demonstration of the TakeMeAway prototype. The person on the right is the "wizard", controlling the sound events (video still).

7.2. Assembly Line: Philipp Lehmann, Julian Kraan, Didier Bertschinger (PD 5)

`Video file: PD5_DD-ZHDK-2008_assembly-line.mp4`

According to this group, in the near future assembly lines for car manufacturing will be entirely virtualized. The group's aim was to provide an auditory means of quality control in the manufacturing process. Robotic arms execute the precision work, remotely controlled through touch screens. The assembly takes place in three steps (car body, engine, tires), all of them associated with a different sonic configuration, which again is able to convey various degrees between low and high quality. The fine and expressive manipulative gestures of a car manufacturing expert on the touch screens are mediated by multilayered audio-visual representations that translate them into a superhuman robotic system (see Figure 7.2).

Abstracted synthesized sonic representations, for instance of the engine, represent different components of the car. This provides the basis for sounds which represent changes in precision, compatibility and overall quality by modulating consonance and pureness in the synthesized timbres. The sounds are constantly modulated until a closure is reached, for instance by resolving of dissonance. The scenario focused on conveying the transition and metamorphosis in the car's complex composition. The sonic representations become more than mere feedback because of the rich and complex nature of the resulting sounds. The overall result was a multilayered, atmospheric sound composition with a musical quality, turning assembly line work into an artistic performance. According to the designers, the aim was to create a direct dependency between movement and sound, and it requires manual skills to operate the machine.

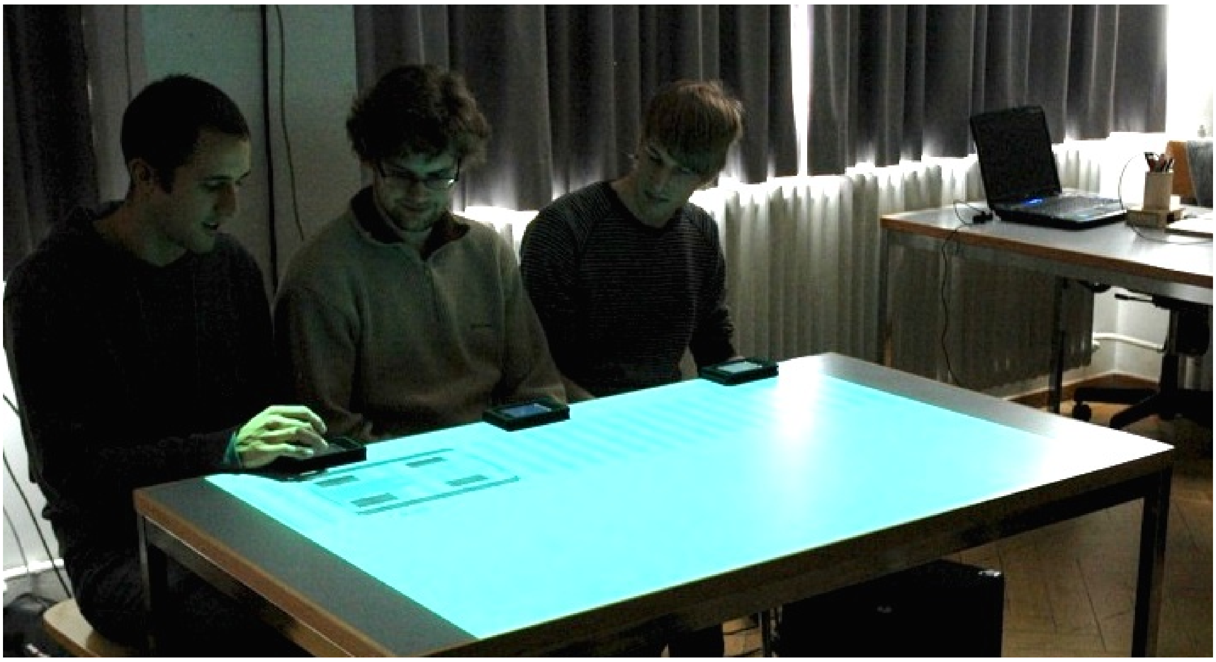


Figure 7.2.: Demonstration of the audiovisual assembly line (video still).

7.3. The Moody Hat: Kai Jauslin, Monika Bühner, Simon Broggi (PD 6)

`Video file: PD6_DD-ZHDK-2008_moody-hat.mp4`

(a) Touching rim... (b) ...struggling... (c) ...taking off.

Figure 7.3.: Expressive interactions with a moody, parasitic hat (video stills).

In their design, this group investigated the hat as both an functional and expressive piece of clothing. This starting point developed into designing the hat as sentient being with a parasitic lifestyle (Figure 7.3). The interaction and sound design was dealing with direct interactions with the hat (putting it on, touching it). While lying somewhere the hat attracts a potential wearer by whispering and making strange noises and breathing sounds. When somebody picks it up it attaches itself violently to the person's head, which is accompanied by a synthetic hum, oscillating with increased frequency towards a final outburst.

The hat can also enter a dialogue with its wearer. Depending on how the person touches it at the rim, it creates various sounds. Touching it in the "appropriate" way results in a tonal scale being played, "inappropriate" touching results in the sound reminiscent of breaking glass. The hat would also comment on the wearer, either insulting or praising him.

Overall, the hat was perceived as animated and emotional. In particular the initial phase of interaction marks a transition from dead matter to living being, which is expressed by sounds that convey a raise in energy level due to activation. The manipulative gestures are generic but could control various functions that the hat could offer.

8. Helsinki Aalto University, Media Lab, 2009 (“TAIK 2009”)

The second “full scale” workshop was held at the Media Lab of the Helsinki Aalto University of the Arts between March 9th and 13th 2009, by invitation of the head of the programme, Antti Ikonen. Eleven students of the MA for Sound in Media participated. Except for one student (the author of the “Barking Wallet” Project, see below), all students had a background in sound and music. Three participants (Cumhur Erkut, Antti Jylhä and Koray Tahiroglu) participated as visiting experts. This allowed to reduce the introduction section of the workshop significantly and also eliminated the need for extended tutorials for using sound design and mockup tools. Otherwise, the workshop followed the same procedure as the previous one from ZHdK, starting with an analysis of filmic narratives and using them as starting points for design scenarios. For details about the design brief, see Section 5.3.2.

8.1. The Elevator: Markus Bonsdorff, Ilkka Olander (PD 15)

`Video file: PD15_TAIK-2009_elevator.mp4`

The general design themes this group tackled was, to associate the movement of an elevator from bottom to top with a sonic transition and also to contribute to identification of the floors (see Figure 8.1). One proposed design approach relied on abstract sonic qualities associated with “earth” or “heaven”, and a transition from “heavy” to “light” sounds. Identification of a floor was provided by specific timbres, shaped through resonance and cutoff frequencies of a filter. Another design approach relied on stereotypical soundscapes associated with each floor. These were meant to be “iconic“ and were combined with sounds that convey a “feeling“, a mood or an atmosphere: For the floor where the so-called “Media Lab” was located, a “data stream“ sound was used. The floor where industrial design was residing was represented using humming, white spaces and some camera shots, thus combining indexical sounds (camera shots) with atmospheric sounds for ”white spaces”.

General movement was associated with a pitch transformation, combined with the crossfade between either filter settings of soundscapes. The elevator’s traveling thus resulted in a continuously changing sound composition, reminiscent of ambient music. The higher the elevator moved, the brighter the sounds became. The transition speed was adapted to the distance between origin and target of travel, creating more nuanced transitions between shorter travels and a more general change when traveling all floors in one go. Also a version for a very large elevator in a building with high ceiling was presented, which essentially focused on voluminous, boomy sounds and lots of reverberation.

8.2. The Barking Wallet: Su-Jin Hwang (PD 17)

`Video file: PD17_TAIK-2009_barking-wallet.mp4`

This participant presented a wallet which monitors the user while browsing shopping catalogs, and tries to prevent unnecessary expenses. When the user opens the wallet to make a transaction it may make a bark-like sound in disapproval. If the user insists and folds the wallet open to take money out, the wallet snarls, and if she nevertheless extracts a credit card, the wallet growls very

Figure 8.1.: Presenter pressing a button on the imaginary elevator (video still).

aggressively. The barking and growling noises are derived from the sound of the wallet’s zipper, which was slightly defamiliarized by cutting, changing pitch and playback speed. This design strategy helped to integrate the artificial sounds into the wallet’s sonic and gestural identity. The resulting ambiguous sonic identity prevents an overstated indexicality which would result in an undesired “cartooning” effect. Moreover there is an ambiguity of agency, as the sounds are impersonating the wallet’s animated character and personality while at the same time linked directly to the continuous gestures of the user (opening, taking out card, etc.).

8.3. Thermos Flask: Samy Kramer (PD 18)

`Video file: PD18_TAIK-2009_thermos-flask.mp4`

The aim of this project was to modify an essential, useful, yet unpretentious every day tool of the participant, a thermos flask (Figure 8.3). Samy Kramer chose to sonify the process of starting and ending a heating process to warm up the water inside the flask. Thus, the thermos flask is turned into a high-tech tool for both ritualized preparation and storage of tea.

The user touches the metallic can with the finger, which produces a fine “click”. The user then can move the finger vertically along the flask as on a touch ribbon interface. This produces a synthesized bubbling sound, mixed with an aerodynamic hiss and high-pitched chimes with a digital quality, conveying the “magic” of the interaction. As the finger moves up, the chimes pitch up and the amount of bubbles increases, representing higher energy levels and temperature, and a kind of metallic grain will indicate the current position sonically. After choosing the temperature by taking the finger off the flask, a short metallic plucking sound (containing a sample of an asian string instrument) which reminds of a switch sound, can be heard, which indicates the beginning of the cooking process. Now the normal sound of boiling water could be heard. After boiling, the water cools down and the cooker will sonically announce with the same initializing sound but with a descending string tune when the temperature is reached, that has been chosen beforehand.

Figure 8.2.: Carefully trying to take a credit card out of the barking wallet (video still).

Figure 8.3.: Controlling the temperature of a thermos flask (video still).

Figure 8.4.: Struggling with the robotic crocodile toy (video still).

8.4. Crocodile Tamer: Cumhur Erkut, Antti Jylhä, Koray Tahiroglu (PD 19)

`Video file: PD19_TAIK-2009_crocodile-tamer.mp4`

The aim of this project was to design an autonomous robotic toy with the shape of a small crocodile, which would communicate through nonverbal sound (Figure 8.4). The toy can be used to play a game, where the player is required to grab the toy, struggle with it and trying to find out how to tame it. The game starts by the crocodile lying on the floor, trying to lurk people into grabbing it by generating strange animalistic sounds and by indicating sonically that it is in a playful mode. Once a person has grabbed the toy, it would start to struggle to break free. Now the player needs to try out several movements with the toy. During this process the crocodile generates a sound which contains elements of a didgeridoo tone, and is modulated according to how the player swings the toy around. the sound modulations are supposed to help the player find out the motion pattern, which is swinging the crocodile around the head, which actually will help him to overcome the crocodile. After producing a sound indicating the player's victory, the crocodile then calms down, starts to purr like a cat, and lies on the floor again. It might then try to lure the player again, and can be shut down finally with a gesture.

8.5. Toilet Soundscape: Alexandra Jones, Dimitri Paile (PD 22)

`Video file: PD22_TAIK-2009_toilet-soundscape.mp4`

This team aimed at public bathrooms with several toilet rooms. This peculiar place protects privacy visually, but not aurally. Also, the individual toilet booth is very small, but sonically a feeling of being enclosed is overlaid with the reverb of the large toilet space. Reverb indicates the traveling of sound through the large space and the potential to being (inadvertently) overheard.

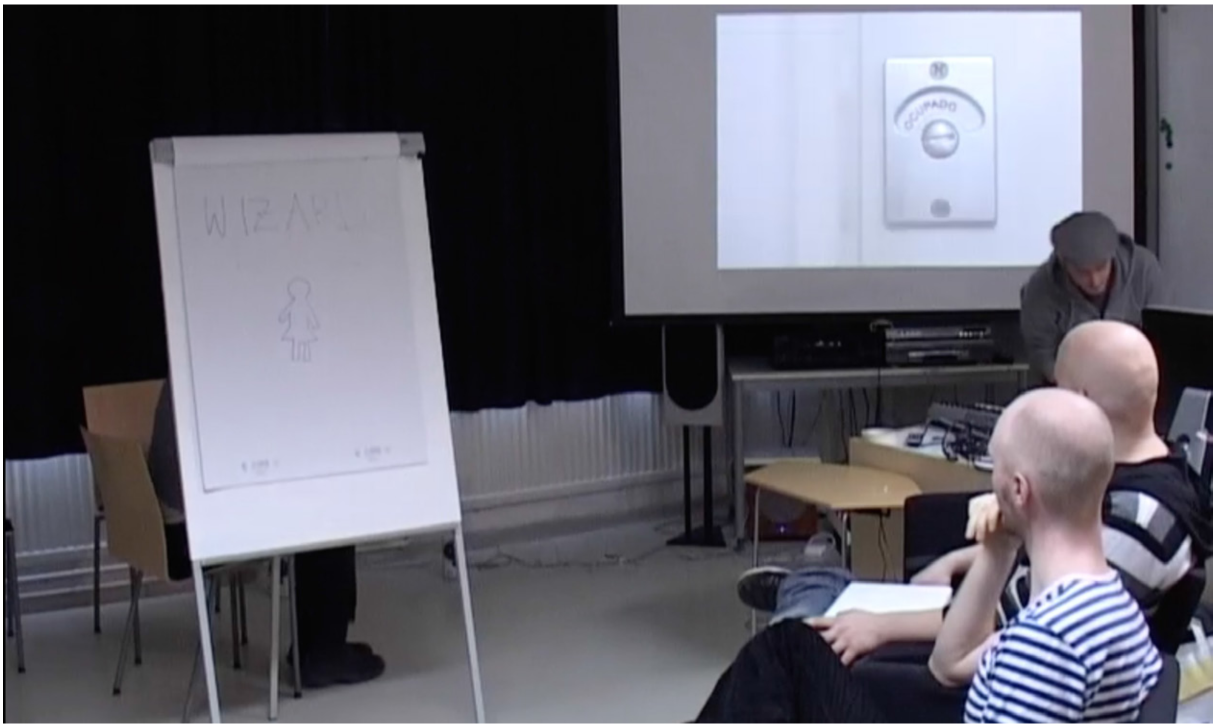


Figure 8.5.: Using the sonically augmented toilet, indicated by the whiteboard (video still).

The resulting design proposal (Figure 8.5) aimed at dealing with these aspects and the associated social (and sonic) taboos. There were two main objectives. The first objective was to mask the sonic taboos associated with using a toilet, and also creating a sonic distraction from them. The second objective was to counter the claustrophobic feeling of the toilet booth and extending the sonic largeness of the toilet room, turning it into an intimate yet spacious environment, thus contributing to relaxation, and to evoke nature and open space to communicate qualities of release, and relaxation in a pleasant flow. The design relied strongly on modified and enhanced sounds of nature, in particular water sounds drops and rain, embedded in a large reverberant space. The sound playback starts when a toilet booth door is locked, slowly build up and finally turn into a relaxing, releasing soundscape.

9. Zürich University of the Arts, Interaction Design, 2009 ("IAD ZHdK 2009")

This course took place in a different format than the others, as it was the only course which was not executed in a block week form. Instead, there were one or two days per week. Overall, the course lasted for seven days, between 8.10. and 20.11.2009. The participants were exclusively from the 3rd semester BA of Interaction Design. Also the course was part of other courses of the module "Embodied Interaction Basics" sharing the common topic of designing solutions that support a more sustainable energy consumption.

The general blocks of the course, resembled the other courses, but some modifications had to be made, due to different circumstances. The narrative analysis of film clips was focused on finding relevant indications of how to communicate processes and qualities of energy through sound. More particularly, participants were asked to identify general "energy narratives" (not necessarily associated with devices), collect "energy sounds" and describe the sounds of devices actually using energy. The concept development still resulted from an analysis of typical everyday situations in the light of the analysis of the filmic stagings of energy. The design brief was to "Define a short scenario of energy consumption / production in the household" and to design a related auditory display and sonic interaction.

Except for one, all final mockups were presented using the Wizard of Oz method. However, due to the unusual format and thus limited comparability, only one design case was considered in the analysis for this work.

9.1. Energy Harvesting Office Chair: Dinis Meier, Jan Huggenberg (PD 25)

`Video file: PD25_IAD-ZHDK-2009_energy-harvesting-office-chair.mp4`

The project demonstrated by this group presented a box containing energy and an office chair (Figure 9.1). Both are connected to a computer or any other power consuming device. By siting down, swiveling or moving the chair on the floor while sitting in it, the user produces energy which is stored in the energy box. All movements performed with the chair produce a sound indicative of energy production. Furthermore the energy box produces two different sounds associated with either (positive) self-produced energy or (negative) electricity generated by nuclear power. The two sounds are merged and crossfaded according to the energy mix used.

The design relied on humming drones and resonant noisy sweeps, evoking a futuristic, somewhat digital, dirty and scratchy high-tech atmosphere, inspired by dystopic science fiction films and games.

Figure 9.1.: Swiveling the office chair to generate some more energy (video still).

10. Zürich University of the Arts, Design Department, 2009 ("DD ZHdK 2009")

As the first course at ZHdK reported in this study (and opposed to the course reported in the previous section), this course was an interdisciplinary module of the department Design, was targeted at bachelor students of the 5th Semester. Five students from Interaction design, three from Game Design and one from industrial design participated. The course lasted from 1.12.2009 - 18.12.2009, with a duration of 12 days

The course was linked to a visual interface design module organized by Jürgen Späth, as part of a cooperation with Dr. Stefan Henze from Volkswagen. Therefore, some of the projects emerged from the design brief provided by Volkswagen, while another one was more loosely connected to the context of driving a car. The Volkswagen design brief was to explore ways, how sound could be used in the process of boarding and exiting a car. The focus was put on three stages: Opening the door, entering the car and sitting down, and putting the belt on. Volkswagen supplied a car for testing purposes, which was equipped with sensors in the door, the seat and the seating belt. However, the same design strategies as in the Wizard of Oz prototypes were used for the preparation. Also other interactions with the car than just the boarding process could be explored. The students of Interaction Design were requested to focus on this brief in their work, students of other subjects could chose from more general applications related to smart home, cyborgism and wearables.

The main components of the workshop were identical to the previous editions. As new element, the "semantic foley" exercise was carried out. Also a narrative film sound analysis was conducted, again with the same example clips as in the previous workshops. Also in this course a first mockup stage included the use of sounds found in these movie clips in the "everyday fiction" stage. Inspired from the analysis of previous workshops and recent publications, the focus on "narrative" and "performative" aspects in the design were more obvious, and the situational categories were introduced for the first time. For details about the design brief, see Section 5.3.2.

10.1. Sonic Car Boarding Project 1: Nino Cometti, Florian Wille (PD 35)

`Video file: PD35_DD-ZHDK-2009_sonic-car-boarding-1.mp4`

The target group for this project were the so-called "LOHAS", people living a "Lifestyle Of Health And Sustainability", a demographic term defining a particular market segment related to sustainable living, „green“ ecological initiatives, and generally composed of a relatively upscale and well-educated population segment.

The design proposal presented a car with an "aura" (see Figure 10.1). Upon entering this invisible sphere, its doors would unlock automatically which would be expressed in a welcoming sound, composed of a high crystal timbre, signaling the car's awareness, and a thud reminiscent of heartbeat, expressing the connection with the car. After opening the door, the driver would sit down and fasten the seatbelt, which further strengthens the connection with the car. Sounds constantly accompany this process, resulting in a flowing melodic composition from entering, sitting and using the car belt, finally ending with starting the car. The high ethereal sounds used express how the driver enters the cars clean and environment, and the composition of the

Figure 10.1.: Remembering to fasten the seatbelt (video still).

sequence indicates the steps of the interaction and thus indirectly inform of a missing step, e.g. when the seatbelt has not been put on.

10.2. Sonic Car Boarding Project 2: Liliane Krauss (PD 36)

`Video file: PD36_DD-ZHDK-2009_sonic-car-boarding-2.mp4`

This second proposal for the car boarding brief from Volkswagen based on the idea of an anthropomorphous car as a friendly, animate character (Figure 10.2). The design used sounds associated with wild cats and mechanical, robotic elements. The car "wakes up" with a mechanical sound as the user approaches it. When opening the car door, a sound composition containing a tiger growl evolved synchronous with the door movement and changed depending on the speed, thus adding a perfomative element but also intended as a friendly salute of the car's "animal spirit". Fastening the seatbelt is accompanied by a gentle purr. When leaving the car and closing the door, again a tiger growl is heard. In general, the user's actions were meant to be associated with the mechanical sound timbres, and the car's autonomous actions with the organic or animal sounds.

The overall aim was to evoke the feeling of a friendly and safe environment, and a protection by a gentle but powerful predator cat. At the same time, it aimed to convey the electric vehicle-quality of the car. The sounds were intended to convey power, safety, mystery, and the warmth of a pet rather than cold machinery.

10.3. Sonic Car Boarding Project 3: Christoph Brandin (PD 37)

`Video file: PD37_DD-ZHDK-2009_sonic-car-boarding-3.mp4`

This project proposed a sound design for entering a powerful SUV, as opposed to a smaller, more pragmatic car model (see Figure 10.3). It relates to the car's role in contributing and expressing

Figure 10.2.: Listening to the car being remotely unlocked (video still).

its owner's identity. The approach covers to viewpoints: The outside view is the extrovert side, what a car expresses to people around it. In this case, also the owners actions on the car, such as opening its door, become extrovert, communicative acts. This outside perspective is generally aggressive.

This is complemented by an inside view, an introvert design aimed at the owner, sitting inside the car. Here, the the car conveys intimacy, safety, privacy, calmness, which is expressed in a clean, harmonic sound environment. Furthermore, the design differentiates between actions, which the user can influence, and those which he or she cannot control. Finally, the emotional and expressive sound design is complemented by a sound notification in the case a door is left open, which presents a windy flutter sound instead of the usual alarming beep.

10.4. INTERACTIVE CAR : Tobias Koller (PD 38)

`Video file: PD38_DD-ZHDK-2009_interactive-car.mp4`

This scenario presented somebody driving curves in a tireless, hovering electric car (Figure 10.4). The function was inspired by rumble strips used to alert a driver when leaving a lane. The sonic design was inspired by the sounds of squeaking tires, which convey sonically the loss of grip in a curve. Using modulations of the blinker sound, different ways of driving through curves were expressed, combining the information of the blinker with the joyful experience reminiscent of hearing squeaking tires. When setting the blinker, a usual tonal blinking sound can be heard, which starts to distort slightly, as soon as the driver starts to take the curve. When a curve is taken very fast the distortion is stronger. When driving in a curve without the blinker, a similar sound is played automatically, and distorted in the same way. The blinking sound was gradually "destroyed", creating an unexpected defamiliarization. This turned out to be very efficient in providing a warning, without having to resort to ordinary and annoying beeps. The design thus aimed at conveying the notion of "going over a limit" intuitively. An important aspect of the design was to convey gradual changes between a simple information (blinking) and a warning with increasing urgency.

Figure 10.3.: A participant explores the car's response to opening and closing the door (video still).

Figure 10.4.: A participant tests the sonic curve driving assistant (video still).

Figure 10.5.: Live tryout and exchange with AcuPot designers (video still).

10.5. AcuPot: Gregor Falk, Christian Knuchel (PD 39)

`Video file: PD39_DD-ZHDK-2009_acupot.mp4`

The idea behind the project was to give plants a voice that would help to monitor their health. The result, AcuPot, is a smart pot for indoor plants (see Figure 10.5). It can be switched on and off by touching the rim with a discreet gesture, resulting in a gentle tonal sound. The sound of switching on and off, on the other hand, was smooth and more technical, supporting the experience of the pot as a gentle smart system. The pot helps the owner to find the best spot for the plant. This searching process is accompanied by humming, static noise and scratchy sounds which finally turn into a tonal resonance when a suitable spot is found. In general, warning sounds and sounds of "misfit" are associated with rough, scratchy and booming timbres. The radio noise was intended to work as a metaphor for "finding good reception" and also reminiscent of general sound of disturbance of a technical system. Also, the distorted nature of the sounds suggested that the system was rather rough and solid, which was in correspondence to the clay material of the pot.

As additional function, the AcuPot helps to manage the watering process. In the case of lack of water, the pot would make scratching sounds by itself, which sounded like a variation of the movement sounds. Watering the plant would result in sounds reminding of swallowing fluids being played, emerging gradually from the pot's own sound. When the plant was drying out, a higher distorted sound would be played, together with some scream-like timbres.

10.6. Sonic Paper: Angela Gebenroth, Beat Keller (PD 40)

`Video file: PD40_DD-ZHDK-2009_sonic-paper.mp4`

This group was fascinated by paper's omnipresence. While still important, even in the digital age, paper is hardly valued anymore. Their scenario is about a living, self-conscious high end paper, which is able to store data (see Figure 10.6). The sound of an individual sheet is meant to convey that it is an energetic part of the whole. It should also convey the joyful expectation

Figure 10.6.: Folding and crumpling the sonic paper (video still).

and a certain magic. Initially, the note pad with the smart paper is empty and sonically very subtle. The sounds are intended to signal readiness and openness for input. Then the user can browse through the leaves. This makes the individual leaves audible and the sound conveys their aliveness and joy of being interacted with. Pulling out a sheet results in a short sound of pain, which is transformed into relief and finally joy in the prospect of being used. The user then starts to write, maybe also fold the sheet. These interventions have a strong impact and are not (entirely) reversible. Also the value of the sheet is transformed. Through use the paper may get wrinkles and other signs of wear. This is associated with scars and results in fragmentation of data, which is reflected in sonic distortions, with the sound further losing quality. Finally, the user is fed up and crumples the paper to a ball, which results in the paper losing data and energy. Then the paper ball is tossed into the trash bin, the sound expresses how it is losing data, and how its energy literally evaporates. Once in the bin, there is a whimpering sound and finally the shutdown can be heard.

11. Helsinki Aalto University, Media Lab, 2010 ("TAIK 2010")

This second full-scale edition of the workshop lasted from 8.2. - 12.2. 2010. Nine students attended, six from the Sound in New Media program, two from new media and one from industrial design.

The workshop contained all elements of previous workshops. However, the movie analysis was not carried out in an in-depth group assignment, but was discussed as part of the introduction. For the first time, a "Foley Mockup" had to be presented as first iteration of the design.

The design assignment proposed three topics, one per group: wearables, smart kitchen, and a smart bathroom. For details about the design brief, see Section 5.3.2.

11.1. BAG TO THE FUTURE: Simon Morris, Irene Poutanen, Jari Suominen (PD 44; PD 47)

`Video files: PD44_TAIK-2010_bag-to-the-future.mp4; PD47_TAIK-2010_bag-to-the-future.mp4`

The bag presented by this group (see Figure 11.1) has a sonic identity and helps the user to remember what to take along and to casually check its contents.

Moving it produces various sounds associated with the importance of the objects inside. The bag thus is "intelligent" and has an animated character, but in general is passive, reacting to the user's movements. Precious, public and private items have different sonic qualities. Shaking, stretching and rotating the bag changes the parameters of each sound. Various jingling sounds, with elements of bells, chimes and tambourines, were used for the objects inside the bag, joining a physical notion of objects colliding with the sonic stereotype of positive magic and preciousness. The sounds were meant to be familiar, but at the same time were not the sounds that the user would typically expect from content inside a bag.

Private and public sounds are revealed to the owner of the bag, but in public spaces, some private items may be sonically hidden. The approach thus dealt with both casual and private use scenarios, where the users monitors the objects in the bag casually, from the jingling that occurs through normal movement and use, and intentional public use, where putting the bag down could become an expressive act, showing off the "cool stuff" in it. Additionally, a high-pitched metallic, shimmering sound is played when an object is removed from the bag. This would attract attention, providing another opportunity to show off one's belongings. Finally, dropping the bag to the floor created a purring sound, which was meant to underline the material quality of the leather bag and its animated character, and serving to gently remind the user to take care of it.

11.2. INTERACTIVE FRYING PAN: Ranjit Menon, Iris Tomaszewski, Tero Vänttinen (PD 45)

`Video file: PD45_TAIK-2010_interactive-frying-pan.mp4`

The project of this group[1] focused on smart kitchen equipment for tomorrow's kitchen, propos-

[1] Of this project, only data about the Foley mockup is available, as the audio recording of the final presentation was damaged due to a technical error.

Figure 11.1.: A participant is closely observed by the "wizards" while interacting with the bag (video still).

ing a sonic interactive frying pan (see Figure 11.2). The sound was intended to inform about energy consumption, the pan's lifecycle, and related health issues (e.g. from damaged coating or overheating) and the cooking process itself. In order to achieve an intuitive user interface the sounds are controlled by gestures naturally occurring when cooking. When the user moves his/her hand near enough, the pan's sound becomes audible. The closer the hand gets the louder the sounds become.

The pan had three different categories of sound: temperature sounds, warning sound and lifecycle sounds. The temperature was indicated by an organic clicking sound that would rise in pitch in relation to the temperature. The clicks would also increase tempo the hotter the pan became. For the overheating sound, instead of using a conventional "warning" beep, it was decided to create a sound different from the soundscape of other sounds so it would still stand out. For this purpose, a viscous and gooey liquid bubbling sound was mixed with some metal scraping to create a feeling of emergency and urgency for the user. For the third category, sounds that tell about pan's lifecycle, more alarm-like tonal sounds were used because these sounds were supposed to occur only rarely. The warning sounds would get more noticeable little by little and eventually would cover completely the temperature/heating sound.

11.3. Intelligent Shower: Kalle Jokinen, Lasse Kaikkonen, Janne Laiho (PD 46; PD 48)

`Video files: PD46_TAIK-2010_intelligent-shower.mp4; PD48_TAIK-2010_intelligent-shower.mp4`

The concept behind this project (see Figure 11.3) was to develop a water-conserving shower, which would be enjoyable to use, and where users would get sonic feedback from the system,

Figure 11.2.: Sensing the response of the frying pan (video still).

allowing them to keep the eyes closed when showering. Two different scenarios were presented: A “refreshing” quick morning shower, with a duration of a few minutes and a “relaxing” shower, with a duration of approximately 15 minutes.

After the user has selected the preferred mode, the shower plays a suitable sound ambience. The purpose of this sound is to ease the user into the mood of the selected preset. After a voice command, the shower starts with an intensified sound ambience, according to the selected preset. Then, a series of sounds indicate the best time to use shampoo and soap in relation to the overall duration of showering. Towards the end of the assumed session length, the ambient sound composition slowly is reduced in intensity, becoming increasingly dull. The aim is to gently encourage the user to stop showering.

The ambient sound background serves both to monitor water consumption and overall duration of the shower, through a constant change of the composition.: from the change in the soundscape the user will know approximately how much time they have spent in the shower, and to establish and maintain the relaxing or refreshing mood. As consequence, the ambient sounds are composed of two main layers, a sound layer that will sound throughout the showering session, setting a general atmosphere and providing an idea for the overall duration of the process. Another layer is played whenever water is flowing, also helping to maintain the sonic aesthetics even when the “normal” water sound can be heard.

Figure 11.3.: Setting the shower mode to "refreshing" (video still).

12. Linz University of Art and Design, 2010 (“UDKL 2010”)

This workshop in Linz, held between Monday 15.3. and Thursday 18.3.2010, is comparable to the versions taught in Aalto University Media Lab in terms of duration and target group, which are Master Students of the Interface Cultures program of the University of Art and Design Linz. The course lasts four days and the students are media artists. Opposed to the workshops in Finland, their sound design skills are relatively limited, but, as mentioned earlier, the design method made sure that everybody could participate in the process.

In order to compensate for the lack of knowledge in sound theory, a short introduction to ways of listening and describing sound of objects and actions was given, comparable to the workshops taught at ZHdK. As opposed to the Helsinki edition of the workshops, tutorials in sound editing were necessary. Also, a film sound analysis in groups was performed, again with the same clips as in previous workshops, but in a temporally more condensed format. Due to the short timeframe, the “everyday fiction” activity was omitted, and instead the development was focused directly on Foley mockups from the beginning. For details about the design brief, see Section 5.3.2.

12.1. MATCHMAKER: Tiago Martins, Veronika Pauser (PD 52; PD 58)

`Video files: PD52_UDKL2010_matchmaker.mp4; PD58_UDKL2010_matchmaker.mp4`

This artifact (see Figure 12.1) is able to remember of the last person who held it and wether (s)he was male or female, old or young. The Matchmaker is also aware of social connections or compatibility between users. Two aspects come into play: the amount of social connection/compatibility between the current and the previous user at first; and, in the case of a sufficiently strong connection, the gender and age of the last user. The object also has the ability to communicate this memory and to characterize this quality using sound.

The object would use sound not only as the means to convey information but also as a manifestation of its sentience. When the object is lying idle somewhere, strange subtle sounds encourage people to interact with it and try to understand it. As a person picks up the artifact, the sound expresses how it becomes active and attentive. The artifact signals sonically whether the current user is connected or compatible to the previous user. In the case of a connection, the user can pull the artifact closer. The artifact becomes more focused and reveals age and gender of the previous user through sound. At any point, the user can put down the artifact, which thereupon reverts to its idle state, and the sounds are “swallowed” by a filter effect.

In its “idle” state, the artifact produces a steady broadband noise. Those who know it would register it’s presence, for the others the noise would be just a meaningless sound which can be easily ignored. However the Matchmaker completely changes its sonic behavior when it is grasped and moved close to the body, resulting in a performance of the transition from a public, social space to intimacy. On the sonic level this is expressed by a transition to more focused, granular and fine sounds, which relates to performing gentle movements near the body. A relative low sound level additionally affords holding the artifact close to the upper body or even cheek and ear.

Figure 12.1.: Social interaction with the Matchmaker (video still).

12.2. The Fridge: Myrssini Antoniou, Ulrike Gollner, Onur Sonmez (PD 50; PD 56)

Video files: PD50_UDKL2010_fridge.mp4; PD56_UDKL2010_fridge.mp4

The theme chosen by this team was the smart kitchen environment, focusing on the fridge that could communicate the state of its content and whether the food in the fridge is healthy or not and how fresh it is (Figure 12.2). First, when food is put into the fridge, a crunching sound is played. The information sounds that are related to the food state are activated by opening the fridge and deactivated when closing the door and are played differently according to the overall state of the fridge at every point of use. If the food in the fridge was (mostly) healthy, a laughing sound could be heard, if it was unhealthy, a disgusting, slurpy, gooey sound can be heard. When the food was fresh, the sounds would be watery-fresh, and rotten food would sound muddy with the sounds of flies. In order to place the naturalistic sounds in a virtual environment, a reverb effect was added to most of the sounds. Finally, there is an yodeling alarm when the fridge door is not closed properly.

12.3. Doc-O-Mat: Ana Čigon, Bager Akbay, David Brunnthaler, Anca Stirbacu, Vesela Mihaylova (P 54; PD 60)

Video files: PD54_UDKL2010_docomat.mp4; PD60_UDKL2010_docomat.mp4

The project (see Figure 12.3) created the sound landscape for a small implant device which connects doctor and a patient. The related scenario is about a person who is unfaithful in a relationship, so the device is constantly monitoring the person’s emotional state. If the heartbeat

Figure 12.2.: A reaction to the fridge's sonic expressions (video still).

Figure 12.3.: Trying to resist the temptation (video still).

and breathing are not within certain default values, the system sends a signal to the doctor so he can remotely connect to the "patient", observe the situation and take measures necessary in order to prevent further undesirable actions.

There are several stages in the interaction which are reflected by sound. First the general state of arousal between the patient and a stranger is reflected by (artificially created) heartbeat and breathing of varying intensity. The doctor's login is audible as metallic, accelerating sliding noise. When arousal levels get too high, the doctor intervenes, which is audible as scratching, combined with squeaky tonalities and picking of strings, which change pitch and intensity.

After the interuption and the successful breakdown of the erotic interactions, a calming sequence starts, which is accompanied by water sounds and subtle tinkling bells. Finally, after conclusion of the successful intervention, the doctor logs out, expressed by the metallic sliding noise again, this time with a decelerating quality.

13. Zürich University of the Arts, Interaction Design, 2010 ("IAD ZHdK 2010")

This workshop was carried out between January 10th and 21st 2011 but belonged to the autumn term 2010. The workshop was directed exclusively at students of interaction design. Eighteen students participated.

Apart from the general introduction, the workshop contained a Semantic Foley activity and a Foley Remake of the sound effects of a film clip. Also the Everyday Fiction assignment was again executed. The projects were developed using a Foley Wizard-of-Oz mockup as first iteration. For details about the design brief, see Section 5.3.2.

13.1. DAS SYSTEM: Sabrina Brunner, Lisa Müller, Daniel Schmider, Riccardo Lardi (PD 68)

`Video file: PD68_IAD-ZDHK-2010_system.mp4`

The concept of this team is situated in a dystopic future, where citizens are constantly supervised by a totalitarian state. This is achieved by earplugs which everybody is required to wear. The system also reproaches and sanctions "bad" behavior and generally controls the individual, all by means of audio signals transmitted by the earplug (see Figure 13.1). One the one hand a warning sound can be emitted from the device. But the audio signals can cause even physical pain and are used to punish citizens directly. In the case the user would then to try to remove the earplug in order to escape either control or pain, alarm sounds are emitted by public loudspeakers, to ensure everybody takes notice of this criminal act, thereby leveraging the power of social control. The earplug also acts as a key, controlling the access to certain places. In some particular places a scan of the person takes place. The scan is prompted by a sound signaling the person to stand still, then the scan is executed, which is also an audible process.

The wakeup sound is dominated by loud beeps, whose intensity is increased by adding nervous impact noises and then a rough alarm tone sequence, and finally, a very high pitched constant tone. The observation system makes itself noticed as "ding sound" reminiscent of older Microsoft Windows operating system sounds. The scanning device uses a pitched sound to help the person standing in the right spot. The scan itself is accompanied by rough, mechanical noises. During the scan, a fast oscillating modulation of the machine sound, combined with a constant beep is used to indicate that an error is detected. After successful completion of the scan, the "standard" beep is again played. Whenever the user is doing something illegal, such as trying to leave class early, the same alarm sound and high pitched tone can be heard, and finally, an additional tone combination is played to punish the person painfully.

13.2. SONIC PUZZLE: Janine Iten, Stefan Wanner, Rouven Bühlmann (PD 70)

`Video file: PD70_IAD-ZDHK-2010_sonic-puzzle.mp4`

This sound game offers a multisensory exploration of building with lego bricks (Figure 13.2). The bricks themselves do not have a sound, but their configuration on a base plate defines and

Figure 13.1.: A citizen is scanned by the "System" (video still).

influence the sound produced. A basic, continuous sound represents the weight of a specific state of a construction. A sonic representation of chaos emerges more or less, depending on the amount of regularity and balancedness of the configurations. Finally, there is a sound layer representing compactness, when the bricks are located further apart. The sounds are composed from synthetic constant tones with changing pitch and an arpeggiated sound indicating level of chaos. The placing of bricks produces a wooden sounding "clack". Each brick color is associated with a slightly different timbre.

13.3. Interactive Cookbook: Cédric Steiner, Martin Feigel, Sibylle Oeschger, Sven Weber (PD 72; PD 74; PD 76)

`Video file: PD72-74-76_IAD-ZDHK-2010_interactive-cookbook.mp4`

During cooking by recipe, there are two basic activities: On the one hand actions related to the actual cooking, such as handling the pans and cooking utensils, the ingredients, and handling the settings of the various appliances. On the other hand there is the reading of the recipe itself, maybe even with ad-hoc calculations of amounts or substitution of missing ingredients.

The system proposed by this team[1] (see Figure 13.3) integrates both aspects and makes reading and tracking the recipe redundant. Also, the system supports and guides the cook by recognizing and judging his or her actions and proposing suitable next steps. The system uses acoustic indicators for getting the user's attention and then clarifies the actions by means of a visual icon.

The sounds are designed to be rather subtle and are composed according to a hierarchical system. Warning signals are more prominent than standard indicators. Some special indicators

[1]In this case, there are three primary documents because the recording was interrupted twice. All documents cover the final presentation.

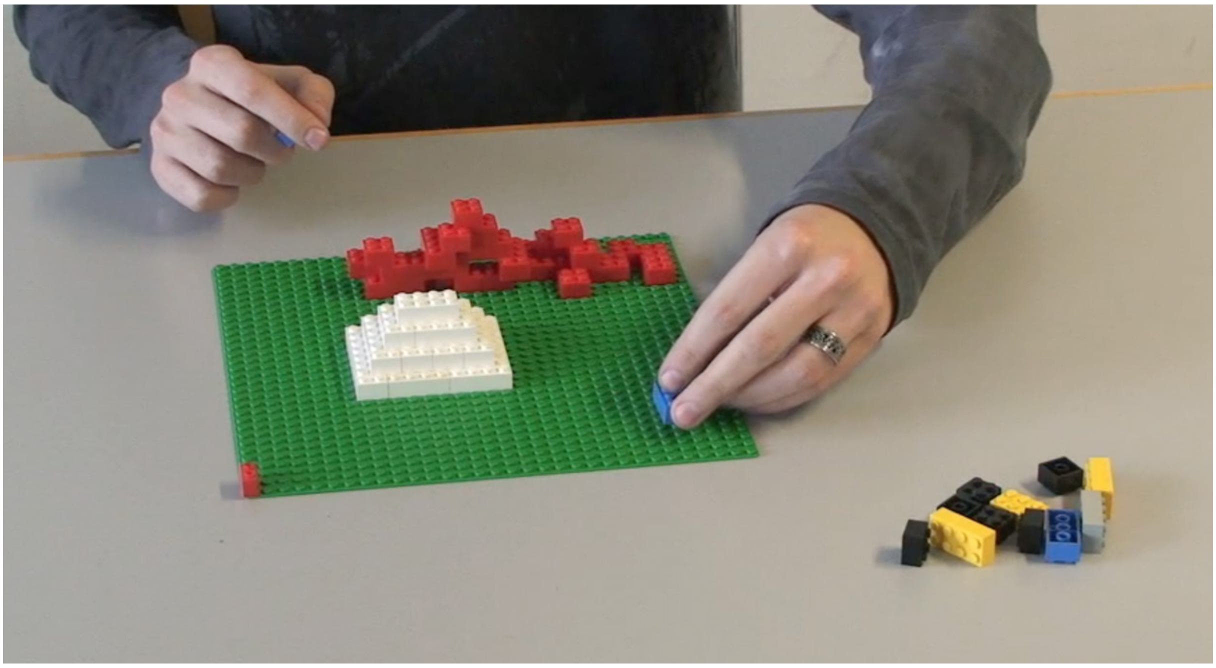


Figure 13.2.: Playing the sonic puzzle (video still).

were used for indicating the system start, that something was forgotten or wrongly executed, and finally that the meal was ready. The indicators and action related sounds were accompanied by a continuous synthetic sound background, which originated in the action being executed at the time. For instance, the sound of frying was accompanied by a transformed, synthetic version of the same sound. This background sound was used to indicate the cooking phases. In their demonstration, this group also foleyed the sounds of physical actions such as slicing, pouring water or using a pepper mill.

Figure 13.3.: The interactive cookbook prompts the user to using the frying pan (video still).

14. Linz University of Art and Design, 2011 ("UDKL 2011")

The second edition of the Linz workshop took place from Tuesday 17.5. until Friday 20.5.2011. It was largely identical to the first version, but in addition it included the Semantic Foley exercise. Eleven students from the Interface Cultures MA program participated in this workshop. For details about the design brief, see Section 5.3.2.

14.1. MACHINA OBTURANTIS: Maša Jasbec, Ioan Ovidiu Cernei, Fabrizio Lamoncha, Jaak Kaevats (PD 78)

`Video file: PD78_UDKL-2011_machina-obturantis.mp4`

Following the Doc-O-Mat design assignment, this group decided to produce an interactive installation which consists of a container inviting users to interact with it through unplugging its power cable in order to kill it (Figure 14.1). By using iconic sounds of heart beating and breathing. Employing the metaphor of basic bio-feedback systems as breathing and heart beat, and using related iconic sounds, the machine becomes anthropomorphized and thus is presented as a living entity. With the repetitive and simple sonic pattern, the device becomes a stoic sculpture similar to clocks which are constantly making a repetitive sound. We can choose to pay attention to them or not. The sounds as well as the performance would only stop once someone from the audience would turn the device off. One minute after the power-cable is unplugged the machine turns silent and stops functioning.

14.2. THE TOASTER: Andrea Suter, Miha Cojhter, Javier Mayáns Martorell (PD 80)

`Video file: PD80_UDKL-2011_toaster.mp4`

Toasting bread right is a difficult endeavor: some like the bred browner, others more pale. The toasting degree depends on the time the bread has been toasted. This group thus focused on the temporal aspect and the experience of time, and waiting, in their design. The waiting time can be of varying duration, both in subjective experience and objective, measured time. Waiting time can be everything between monotonous, lengthy, boring, exciting, relaxing. The clicking of the clock is a reminder for time, and at the same time for forgetting about it, or it can be a thinking rhythm. The end of the toasting process is always a surprise.

The sounds designed for this experience of waiting (see Figure 14.2) were supposed to represent the processes happening inside the appliance, both diegetic and non-diegetic or imagined, evocative. The sound design of the first part of the sequence, where the protagonist is still focused on the toaster and patiently waiting for it to end its process, featured a ticking sound and a gentle, continuous flow of noise, fine whistling and scratching. Later, when the thoughts of the protagonist started to wander, lost in time, the ticking becomes more dominant, and distorted and strange vocal sounds and various clicking and rattling noises can be heard, sometimes amounting to a soundscape reminiscent of a construction area. The end of the toasting is always an identical, yet surprising, sudden ceramic impact sound, modeled after a more trivial notification beep.

Figure 14.1.: The mysterious Machina Obturantis, shortly before being switched off (video still).

Figure 14.2.: Setting the time on the toaster (video still).

Figure 14.3.: Three “wizards” controlling the sounds in interaction with the searching participant (video still).

14.3. Explorations: Ulrich Brandstaetter, Lenka Klimesova, Roel Roscam Abbing, Florian Weil (PD 82)

`Video file: PD82_UDKL-2011_explorations.mp4`

This group started from the Matchmaker assignment and turned it into an “audio based interactive performance” reminiscent of the hot-cold game. The performance is a two-way improvisation between performer and musicians or an interactive system (Figure 14.3). The goal is for the player to find and navigate to a “nice person” in the environment, while avoiding “negative” people.

The target person is represented by clean harmonic sounds, derived from “singing” wine glasses, which were layered in various pitches to create dense harmonic overtones. Several real-time modifications such as tremolo effect, change of the tuning, and an echo, helped to create eery, yet positively connotated sounds, while at the same time, the same modifications could be used to create disharmonic effects. Using pitch, echo, rhythm and melody, the player is guided to his or her goal.

The negative positions in space are represented by various natural sounds that signify danger: A combination of geiger counter sounds, as well as humming sounds of insects were used. The negative intensity could be changed by layering and detuning.

The group also used samples of city and street sounds as background in order to virtually place the demonstration in a city environment.

15. Helsinki Aalto University, Media Lab, 2012 ("TAIK 2012")

In this workshop, which was held between February 6th and 10th 2012, four students from the Sound for Media MA participated. Due to the small amount of participants, only three design topics were introduced in the brief: "Doc-O-Mat", "Matchmaker" and "Kitchen-Aid". The two groups both chose the Matchmaker scenario.

The introduction contained again the "Semantic Foley" exercise and the a condensed form of the "Narrative Clip Analysis", as well as the "Foley Remix" activity. For details about the design brief, see Section 5.3.2.

15.1. "Party" Matchmaker: Simon Lysander Overstall, Juan Carlos Duarte (PD 84)

Video file: `PD84_UDKL-2011_party-matchmaker.mp4`

This version of the Matchmaker was aimed to help people connect in a casual social setting, such as a party (Figure 15.1). The matching is based on previously connected profiles of interests, including indications of what kind of person one would like to meet.

Once at a party, the product indicates the direction, in which potentially interesting people are located. The user then is supposed to join this group and starting to chat to its members. During a conversation with a group containing a "possible match" a subtle sound indicates when the potential match is in the user's focus. Also the product indicates if it thinks a current group of persons is not worth talking to anymore and encourages the users to establish a connection with other people. But in order to cheer the user up, the device notifies the user that there might be a potentially better connection in this group of people than the one he or she is currently focusing on. After some conversation, the device may produce again a sound multiple times to indicate that an even better match was found.

The sound design builds on biologic pulse such as heartbeat as a metaphor related to human emotions. The tempo of the pulses is modulated between 60 and 80 beats per minute, as the rate should not bee too excited, nor overly calm. There is a separate stream of short and repeated sounds for each possible positive match. Each stream would indicate proximity to it's associated match by the nature of the sound such as faster repetitions and or higher pitch closer to match. Volume of playback is low and discreet or earplugs are used, since you don't want others to be aware of your matching process status and the implied social messages.

15.2. "Dancing" Matchmaker: Tommi Koskinen, Mikko Mäkeläinen (PD 86)

Video file: `PD86_UDKL-2011_dancing-matchmaker.mp4`

The "Dancing MatchMaker" is a smartphone application that helps people to find matches among people around you. Whenever a possible match is near you MatchMaker sends a message to your phone, which is indicated by a minimalistic playful melody similar to bird chirps and a nocking sound. This reveals the personal profile of the matched person, but in order to find out if you

Figure 15.1.: Trying to find a potentially interesting group of people to talk to during a party by ear (video still).

are really made for each other, you will have to proceed in the matchmaking process which is a playful dancing game (Figure 15.2).

The game requires the two potential matches to get close to each other and improvise a dance. For this purpose, the smartphones play an abstract music track over the user’s headphones. As the people start to dance, the music changes depending on how well they synchronize and interact with each other, becoming more intense as the dancing progresses. Also, the gestures of the dancers have an influence on the music, adding an expressive quality to it. If the two people mach up, three versions of sounds can be heard, depending of how well they match: For average matching, a short bass sound with ascending pitch is played, for a good match, the ascending bass sound is a bit longer and hints of chimes and electricity can be heard. Finally a perfect match results in a spherical synthetic pad sound. All the bass sounds are modulated to resemble bird chirps. However, if the two people do not match and their dancing is not corresponding, the music will not develop and eventually a bassy, atonal “failed match” sound will be played. Slightly different sounds for male and female persons were used in order to be able to differentiate the origin of a sound. The sounds are designed to belong in the same “sound family” sharing similar sound elements (such as chirps or the bass sound) across the information sounds and the dancing music.

Figure 15.2.: Dancing away with an "almost perfect" match (video still),

Part III.

A Systematized Conglomeration of Design and Interpretation

Introduction to Part III

The following part of this thesis sets out to provide an overview over the many types of design elements and reference points that emerged in the design cases and the related discussions. It thus constitutes the core part of the result of the data analysis, and dives down to the details of the data available. Therefore, this section is very strongly built around individual statements, trying to put them into context, and perspective.

As I mentioned in the introduction, the categories and topics collected here are not meant to form a comprehensive and unified taxonomy. Rather they are an attempt to make the rhizomatic diversity encountered in the design cases and the related discussions into a kind of systematized conglomeration of design and interpretation, carefully releasing the underlying concepts and paradigms. At the same time, they are meant to provide an insight into the otherwise ephemeral and transitive processes of design and interpretation, thereby serving as inspiration for other designers and researchers in the area of sound.

Throughout this part of the thesis, quotations from the workshop discussions are set in *italics* and their index number in the Atlas.ti database is indicated in brackets.

16. References to Basic, "Non-Mediated" Sound

A first category, which emerged from the design related discourse, was related to sounds and their interpretations which were based on some kind of template of sound known from previous experience. Quite often the sounds are composed partially or entirely based on a very common pattern, or sonic stereotype. In this case, these sounds experiences were "non-mediated", this means, the referred contexts of these sounds were not from audiovisual media[1]. Such sounds can get their meaning through the common everyday situations in which they occur, sometimes they are even archetypal, pervading cultures and ages. Our everyday interactions with many objects result in sounds which are very typical of specific applications, activities and situations.

In the following, I will discuss design and interpretation phenomena related to these types of sounds.

16.1. Water Sounds

Water sounds, or more precisely: the sound of flowing water, can be counted among sonic archetypes. As opposed to heartbeat, which is discussed further below in the context of sound stereotypes inspired by films (see Chapter 17), we do actually encounter the sounds of water in many situations which can be very significant in our everyday life. In the design cases studied in this research, water sounds were explicitly referred to in six cases, three of them having to do with actual water (e.g. shower or toilet scenarios). Only in three cases water was used as a symbolic or metaphoric element.

For instance, the designers of the final version of the prototype Doc-O-Mat UDKL 2010 (PD 60, on page 86) used water sounds for expressing (or inducing) relaxation. The sounds here did not only work as symbols, but had an evocative effect for a specific location:

> *Participant: "Yeah, it's like being on a mountain, and hear it somehow in the background, sheep..."*
>
> *Presenter2: "And water, we all know that water is... water. So more like natural elements. It's back to sanity, more natural."* `(>60:21)`

The water worked not only as a sign for nature, but aurally transported the listener to mountains and meadows, which is consistent with the associations evoked by the bell sounds, which were also audible (I will discuss location and spatial situation in Section 20.2). But at the same time water was heard as representing "sanity" in a process which started with a situation of excitedness and gradually calmed down. Also in the preceding Foley mockup of Doc-O-Mat UDKL 2010 (PD 54, on page 86) water sounds, such as waves and some generic flowing water, were audible at a later stage in the interaction process. In this case, an association with the generic water sounds was "moisture" which, in the context of the erotic content of the performance, was associated with sexual activity. On the other hand – and somewhat contradicting – the association with "cooling" emerged, which was supported by the sound of water being still clearly perceivable in the phase of the interaction process, where the initial excitement of the protagonists had already faded substantially. According to the designers, the wave sounds were indeed meant to be associated

[1] It turned out, that many seemingly "everyday" sound references actually originated in audiovisual media, in particular film. This is discussed in the next Chapter (17).

with the erotic, but not necessarily through the notion of moistness, but rather through the temporal wave-like movement, which would make this association base on cross-modal analogies to which we will return in Section 18.2. But the other water sounds were supposed to be associated with water as such, and its cooling effect. This indicates, that the identification of a categorial, generalized sound source, such as "water" is not sufficient for explaining the interpretation, the specific spectrotemporal morphology is also important.

Also the project Matchmaker UDKL 2011 (PD 82, on page 95) used water sounds, but for indicating a fountain in an imagined diegetic urban space. However, this index was not recognized by all members of the audience, instead it was heard by some as symbolic or metaphoric sound. A guest stated:

> *Participant: "Maybe the water stands for health (...). (...) Geiger counter and disease an then it goes to a clear room where there is no threat anymore, and then you have water and these clear atmospheric sounds, this is a healthy region or something."* `(>82:18)`

This participant associated the water with "health" which also opposes the sounds of flies and geiger counter, which were audible during the demonstration as well. In this case a sound was interpreted through associations with the actual sound source, water, and the associated concept of "naturalness", instead of a sound of a concrete object (fountain) in space.

16.2. Sounds of Cooking: Frying and Boiling

Cooking is a particularly interesting example of a relatively standardized everyday activity, and some of the associated sounds are very established and familiar, partially because of their dominant sonic properties, partially because of their prominence and importance in the cooking process. A good example from the cases analyzed is the sound of frying, which was used in some cases related to the kitchen setting, with the aim to represent "cooking"[2] in general. The following quote is from the discussion of the mockup from the Interactive Kitchen VID 2011 (PD 74, on page 90):

> *Presenter: "(...) [it tells you that you] have to do something with this part of the menu."*
>
> *I: "I see, so it is a kind of selector, telling me that now we continue with the sizzling."*[3] `(>74:1)`

The sound of frying seems to be a good solution to work as "pars pro toto" in this case, as it is probably the most prominent sound event during cooking, and covers a frequency area which is well perceived by humans. In the same mockup, also the sound of boiling water was used for a similar purpose, but was not so clearly audible[4]:

> *I: "This reminded me of boiling, the boiling of water, I would probably, if I see a pan here, and a pot, I would rather associate this with the pot than with the frying, wouldn't I."*[5] `(>72:4)`

[2]It should be noted that in German the term "Kochen" is used for both the general activity of cooking a meal and for the specific action of boiling water, hence, some ambiguities arise from language.

[3]*Presenter: "(...) (dass man) halt mit diesem Teil des Menus etwas machen muss."*
I: "Aha, das ist eine Art Selektor, der sagt, jetzt gehts mit dem Brutzeln weiter."

[4]In both cases there was an interpretational issue, as the sound would still be heard as frying or boiling, and not as general indicator of cooking.

[5]*I: "Das hat mich an Kochen erinnert, an Kochen von Wasser, also ich würde das eventuell, wenn ich hier eine Pfanne sehe und ein Kochtopf, würde ich das eher mit dem Kochtopf asoszieren als mit dem Frittieren, nicht wahr."*

Boiling is not only sonically less perceivable (in terms of salience), as the sound is much less sharp with less high frequency content, but also is associated with a different function in the process, usually less time-critical, and less "dangerous" than frying.

16.3. Clicks and Beeps

A similar sound cliché is the "click", which is a sound generated from a mechanical element snapping into place. Several cases show that click sounds can be useful and are understood and judged to be helpful. For instance, the following statement drawn from the discussion of Sonic Car Boarding Project 2 from DD ZHdK 2009 (PD 35, on page 75) propagates the use of click sound to give security:

> *Participant: "I think, this other sound, in the first example, where you sit down, and you are there, where this bass sound appears, this is pretty well made. You are not sure yet, you are just there. But the security of the click should be there in any case. I think, combining both would be super."*[6] `(>35:18)`

The "click" is peculiar because while it is a very short, almost negligible, sound, it is still very established and potentially accepted, as it usually relates to positive events, such as doors closing properly or buttons working. The click sound is the prototypical Auditory Display sound, as it became widely used to replace all kinds of mechanical sounds when relays and switches were replaced by purely electronic circuits. Also it has become widespread through mouse pointer and touchscreen interfaces.

Another, much more problematic example is the occasional occurrence of the beep, used as reference to an everyday object which produces beeps, such as the analog telephone, as in the case of the mockup TakeMeAway, DD ZHdK 2008 (PD 2, on page 63):

> *Participant: "When this 'dooo' comes out of the loudspeaker, you immediately understand."*
>
> *(...)*
>
> *I: "it's marking that this is meant to be a telephone sound."*[7] `(>2:7 & 2:8)`

The sound here is not chosen based on aesthetic or informational criteria, but rather in order to establish an association with a familiar object, the telephone, contextualizing the interaction.

16.4. The Computer "Startup" Sound

Somewhat associated with click and beeps is another, relatively new category of everyday sounds, created by computers or, more precisely, their operating systems. Besides all the sounds produced for notification and warning purpose, boot or startup sounds deserve particular attention[8] and also emerged as relevant category in the case study. Besides asserting the user of the product's functioning and / or readiness for input, startup sounds play also an important role in

[6] *Participant: "Da finde ich eben der andere Klang, im ersten Beispiel, in dem man hinsitzt und man ist da, wo dieser Basssound kommt, das ist ziemlich gut getroffen. Man ist noch nicht sicher, man ist einfach mal da. Aber die Sicherheit mit dem Click die sollte man auf jeden Fall haben. Wenn man die beiden mischen könnte, das fände ich super."*

[7] *Participant: "Ich glaube wenn dieses 'düüü' aus dem Lautsprecher kommt, dann begreift man es sofort."*
(...)
I: "[es ist da,] um zu markieren, das ist jetzt eigentlich ein Telefongeräusch."

[8] Sonic startup sequences are often accompanied by sounds, be it at the beginning of the process, deeply embedded in the system's core and unchangeable (Apple Computers, but also some TVs, mobile phones or electronic cars) or at the point of the first possible user interaction, and customizable by the user (as in Microsoft's Windows Operating System). A special variation are sounds that accompany the entire boot process (as in Microsoft's first XBOX console product line).

corporate branding and communication. Again, the fact that they are both widespread, part of our everyday experience with computers, and designed to be clearly perceived, results in a sonic design stereotype, which also made its appearance in some of the cases studied here. It was somewhat surprising, that startup sounds were used more often than other common functional sound stereotypes, such as the sounds commonly associated with deleting a file, or shutdown sounds[9].

One example for this transfer from the everyday experience of startup sounds to the proposed designs is the interpretation of sounds which were played at the beginning of an interaction sequence with an artifact. In the following dialogue related to the Project 3 of Sonic Car Boarding ZHdK DD 2009 (37, on page 76) a participant states, that a sound signalizing the beginning of the interaction would be desirable in the case of a smart car:

> *Participant: "This would be good when you board the car, when you sit in it. Like, 'ding', like a PC which has booted. That's how it seemed to me."*
>
> *I: "Just because it is maybe closer to those familiar PC or Mac confirmation sounds? Is this required sometimes? Maybe sometimes it is required..."*
>
> *Participant: "Yes, it is some kind of sign, the car is now awake, it is here, it is... ready."*[10] (>37:12)

As we can see from this case, the "startup sound" stereotype indicates not only the beginning of an interaction process, but also as an expression of the duality of some computerized systems, such as smart cars. The startup sound communicates that the device in question is also a computer, with additional functions (i.e. information and entertainment systems, security related functions) that do not directly relate to the execution of the devices primary function (driving). More generally, the startup sound design pattern works based on the expectation of sound related to devices which require some kind of "switching on" or activation to work. Through the experience of machines, from lawnmower to car, we are used to the notion that the use of such devices is initiated with a clearly distinguishable starting sound - with no regard to whether or not there is sound emitted afterwards during the process of using the artifact. Some software, such as instant messengers, and many computer games, employ similar strategies. This collective experience is the basis for said expectation, and also the interpretational approach, in the context of interactive commodities. There are indeed several parallels which foster the transfer of meaning: in all cases mentioned here we are dealing with machinery with a certain degree of complexity, with computing technology being the most complex to the degree of being a "black box". At the same time it is a sign that the car *"is now awake, it is here, it is... ready"*, as the participant states. This case thus shows how the border between the experience of a complex computerized system and the techno-mythical narrative (Coyne, 2001) of the high-tech car as sentient, intelligent being, as anthropomorphized assistant for its driver, is blurring.

Another example for the use of a startup sound comes from the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97). Here, the related discussion points at different aspect, which relates to the stereotyped nature of such sounds:

> *Presenters: "We argued about this sound today, this is some kind of retro stuff sci-fi sound, should we discard it, or adapt at least some kind of bird song type element at the end. And these bird song type of sounds are actually present in many other samples."* (>86:21)

[9] A large majority of sounds encountered in the workshops were "notifications" from a functional point of view, but their design usually was not built on sonic stereotypes of familiar notification sounds.

[10] *Participant: "Also das wäre vielleicht gut wenn man einsteigt, wenn man drinsitzt. So 'Ding', so wie der PC der aufgestartet ist. So hat es mir geschienen (sic). (...)"*

I: "Gerade weil er vielleicht näher bei so einem bekannten PC oder Mac Quittierungsklang ist? Braucht man das manchmal? Manchmal braucht man das vielleicht..."

Participant: "Ja es ist auch so ein Zeichen, das Auto ist jetzt wach, es ist hier, es ist... bereit."

In this case, the designers decided to employ a startup sound in order to inform the user about the start of the interaction process, but they were insecure about how to actually implement it sonically without ending up with a stereotypical startup-sound. This shows the related design challenge, if the obvious association with starting a PC or a reference to cinematic Science-Fiction is to be avoided[11].

16.5. References to Humans or Animals

The qualification of artifacts and processes as technical or mechanic, organic, live and human are important functions of sound, in particular in audiovisual media[12], but also in the "real" world, as sound is strongly defined by the material and energy involved in its production. The use of sounds that relate to living organisms was not a very common design strategy, but appeared in a more or less prominent form in all workshops. In the following, I will describe cases of anthropomorphization and zoomorphism[13].

A good example of this design strategy comes from the Machina Obturantis, UDKL 2011 (PD 78, on page 93):

> *Participant: "The time makes a reference to the machine actually. It's quite ... it's quite ... it's squeaking, it's mechanical, and this makes a reference to the machine, whereas the breathing makes a reference to something that is human."* `(>78:5)`

In this case, the creators combined (stereotypical) sounds for mechanical processes with the a recording of breathing.

Another example comes from the Foley mockup of The Fridge, UDKL 2010 (PD 50, on page 86), featuring a smart fridge, which was designed as "living being" that is relieved when rotten food is taken out and thrown away. The designers used sounds with obviously human origin. The sounds were based on the nagging, gnarling sounds that supposedly elder women might produce and were meant to express the fridge's *"friendly, fantastic character"* (`>50:7`).

But instead, these vocal utterances were mistaken as *"angry at people"* (`>50:7`). This misinterpretation also was caused by a lack of contextualizing elements in the design. The fridge also produced a sound like "haaa" which was interpreted as sign of relief of the fridge when rotten food was taken out of it and thrown away (`>50:8`), an interpretation obviously based on the anthropomorphizing function of the sound. As soon as the anthropomorphisation was established, the discussion turned towards the fridge itself:

> *Participant: "Does it show any level of information? Like the more full it is the less it eats? Or the less 'bch bch bch' it makes?"* `(>50:14)`

Anthropomorphization, in combination with the fridge's function to store food, thus leads to the narrative, that the fridge "eats food", which turned also out to be the idea behind the sound design.

During the discussion of this case, a potential pitfall of using sounds derived from human voice also emerged, which was related to their comical potential:

> *Participant: "They were very convincing, and obvious, as you said."*
>
> *I: "Yeah but maybe they were obvious and funny, comical, so the question is, how comical can it be?"* `(>50:10)`

[11] The idea to work with a sonic element, which is also present in other sounds during interaction, anticipates the discussion about systematic sound design, which provides semantic relationships between individual sounds, later in this thesis.

[12] The role of film in establishing and "naturalizing" these meaning potentials with sound will be further explored in Chapter 17.

[13] The related codes, "anthropomorphization through sound" and "anthropomorphization as basis for metaphor"contain 7 quotes from 5 cases.

This shows that a sound may “work” but still be problematic. A general problem of this approach is that it can easily flip over to parody[14].

Anthropomorphization can go beyond the metaphorical, when the aim is to convey that the artifact might exhibit some kind of “human” behavior or is capable of subjective experience. This design goalcan be traced back to the discourse originating in the turing test, which aims at telling the difference between a human and a machine. For instance, in the presentation of the Sonic Paper DD ZHdK 2009 (PD 40, on page 79) a smart interactive paper is crumpled and thrown into the trash. One of the designers describes their use of sounds:

> *Presenter: “(...) it is a painful process for the paper. Then in the trash bin it is whining, it is sad.”* (>40:21)

The sound design here used a sound sample which reminds of a zipper but was pitched down to mimic a human utterance of disappointment. A bit later, the presenter describes the interaction of browsing through the book containing smart paper sheets:

> *Presenter: “And several pieces of the smart paper together are a bit excited, and when you browse through the pages, then you hear the individual leaves as alive and joyful, (...) because they are still blank. Then tearing out is a short pain, then relaxation and joy of being used.”* (>40:22)

The “joyful aliveness” in this case came out of a chirping quality of the sound sequence, which also exhibited a similarity with spoken language.

As these examples show, anthropomorphization is used to establish the basis for a playful relationship between human and artifact rather than only being informative[15]. The point was not to create humanoid machines, but rather to establish a setting, where the interaction would obtain a playful, even humorous note, and where elements of human (nonverbal) expression could be used to establish understanding. This can be underlined by the following statement from the demonstration of the Sonic Car Boarding Project 2 DD ZHdK 2009 (PD 36, on page 76):

> *Presenter: “When you make something human, (...) when you can give it a character, it is more likely to become my friend, my colleague, my pet if you want. And then I have a relationship to this object.”* (>36:26)

Another anthropomorphizing aspect is associated with *sound pitch*, in particular in scenarios which are not concerned with the representation of simple numerical values. In the Matchmaker UDKL 2010 (PD 52, on page 85) the perceived pitch of the frequency spectrum is used to indicate a gendered character in the artifact, or to represent the gender of the user.

> *Presenters: “We wanted to make (...) the male more bassy and the female more trebly.“* (>52:18)

This code is rooted in an anthropological universal, which is that the spectral centroid of the male voice in general is lower the female’s. But also it is based on a stereotyping, which reduces the difference to pitch rather than spectral distribution.

Closely related to sonic anthropomorphism is *zoomorphism*. Again returning to the Sonic Car Boarding Project 2 DD ZHdK 2009 (PD 36, on page 76), the designer mixed animal sounds together with other sounds and in synchrony to opening the door. The author of the design states:

> *Presenter: “It just isn’t an angrily growling panther or tiger, but it is just grumbling a bit. That’s why it sounds like that. I just thought (...) this suits me better, when*

[14] This aspect will be discussed in more detail in Section 27.7.3.

[15] One related code was “using sound as expressive, personal channel (rather than conveying information)” with 2 quotes from 2 cases.

> *I was browsing those sound files. I really wanted this and not the one, that behaves angrily. After all, it is my car."*[16] `(>36:9)`

There is an interesting ambivalence between the symbol of power and potential danger and the symbol of a gentle, large predator, which represents also a narrative cliché, but also is inherent in the culture of pet predators, such as house cats. In any case, the designer's intention was to use the animal sound as a symbol for power and potential danger, without being scary, and with a metaphorical note (the car is *like* a large, gentle predator).

But the designer of this case also intended to transform this growl into a prominent alarm, which combines the "vocal" dimension inherent in this type of sound, with the potential startling effect of a sudden unexpected raise.

> *Presenter: "What I considered, was to use the growl as an alarm, if an unauthorized person pulls the lever (...) and when you open yourself, it is more like a tame 'hoo hoo'."* `(>36:15)`

Thus we have a combination of a metaphoric, narrative function of the sound, with a perceptual, affective change towards a more aggressive sound[17]. It should be noted that in this case, the sonic reference is not only established based on the archetype of predator sounds, as the designer also refers to a filmic character as motivation for the anthropomorphization:

> *Presenter: "Well, my idea was, (...) I thought a bit about (...) Marvin*[18]*, this is somehow a machine with the character of a human, a depressed one, although the car is not supposed to be depressed."*[19] `(>36:32)`

The leather purr of the Bag to the Future TAIK 2010 (PD 47, on page 81), is another example of using zoomorphism, but in this case, the sound was sonically more embedded in "material" dimensions of the artifact:

> *Presenter: "The breaking thing... we wanted to have an element of something breaking or like it's not whole it's not like a clear sound of something and not like too much... like (...), one impact. Trying to make it suitable for a bag."* `(>47:10)`

Another example case is a sound design solution from the Barking Wallet TAIK 2009 (PD 17, on page 67):

> *I: "Why did you think that for example the wallet was (...) angry (...)?"*
>
> *Participant: "No, I said (...) it is like to prevent me from [taking the] credit card."*
>
> *I: "(...) Exactly, preventing from. How do you come to this idea?"*
>
> *Participant: "Because you have this, like, dog, like guard dog, like sound, 'wuarr, wuarr!', keep away, you know, (...) maybe a credit card company made it, I don't know, because you are over your limit, I don't know."* `(>17:1)`

Here the sound evokes the image of a guard dog - which is supported by the wallet resembling a mouth when opened, and the user having to put her hand inside this "mouth". The bark

[16] *Presenter: "Es ist eben nicht ein böse knurrender Panther oder Tiger, sondern er grummelt ein wenig vor sich hin. Daher tönt das so. Aber ich habe eben gefunden (...) das passt mir besser also als ich in diesen Soundfiles herumgewühlt habe. Habe ich wirklich das gewollt und nicht der, welcher Böse tut. Es ist ja mein Auto."*

[17] It is likely, that the design was inspired by filmic use of sound. I will elaborate on the impact of filmic sound design in Chapter *17*.

[18] Marvin is a depressed robot from the audio play and novel "A Hitchhiker's Guide to the Galaxy" (Adams, 1979), the presenter here is referring to the character from the eponymous movie (Jennings, 2005).

[19] *Presenter: "Also meine Idee war gewesen, (...) ich habe ein wenig an (...) Marvin [gedacht] , das ist irgendwie eine Maschine die den Charakter eines Menschen, eines Deprimierten, hat, wobei das Auto ja nicht deprimiert sein sollte."*

of a dog is a good example of a sound which often is associated with "danger" or "aggression". Therefore, the association of a sound with it will influence the interpretation in this direction. In this specific example, the sound worked metaphorically, but at the same time sounded somewhat strange. In this context it is relevant to note that the actual sound was not based on a recording of a dog bark, but the recording of a zipper:

> *Presenter: "My sound design, this sound is pretty similar to the bark of a dog sound, but I didn't use a dog sound. I used this (opens a zipper). (...) It's very interesting for me, it was just a coincidence, so... [it also makes an] original sound. So... I want to use a sound that changes based on defamiliarization."*
>
> *I: "Defamiliarization, yeah. You (...) didn't want to take an actual dog sound to actually defamiliarize it, because otherwise it would be maybe silly. A barking wallet. Like obviously a barking wallet would be... maybe in a cartoon movie it would work but... mhm."*
>
> *Presenter: "Yes, that's [it]..."* `(>17:4)`

Thus the sound worked with a relationship between a referred sound (dog bark) and the actual sound, which required the zipper sound to be defamiliarized. The naturalistic sound of a dog bark is assumed to be unsuitable for the object being designed, as it would most likely perceived as "cartoonish" because of its clear iconicity[20].

Another approach to using animal sounds was present in two prototypes which used the sounds of flies. One case was The Fridge, UDKL 2010 (PD 56, on page 86), where the sound of flies are used to signify rotten food. The other case was the project Explorations UDKL 2011 (PD 82, on page 95), where flies in combination with the sound of a geiger counter were meant to signify areas where one was not supposed to go:

> *I: "But the flies, of course I associated them, through clichés again, with dead bodies, with disease, with a specific scene from 28 Days Later... and the geiger counter, Fukushima and so on, right..."* `(>82:9)`

These sounds worked as symbolic signs, supporting specific associations to rotten food, rather than working as zoomorphic "utterances" of the artifact. The sound of flies may be considered a special case of culturally connotated natural sounds, where both evolutionary reactions and their narrative power from mass media like film, can be seen as the force behind the interpretation. The naturalistic sounds are framed in their stereotypical filmic narrative context, at least by those who are familiar with such films, and the related codes may even "override" the meaning emerging from first-hand experience.

An interesting version of zoomorphism emerged from the AcuPot DD ZHdK 2009 (PD 39, on page 79). Here, the designers aimed for something "insectoid, corroded" to express the process of the plant dying due to insufficient light and water. They used synthetically produced crackles which were abstract enough to work as a symbol, but also exhibit the crossmodal quality of a scratchy surface, or the sounds of insects crawling about, which contributed to the interpretation by biasing it towards rather unpleasant experiences[21]. While this association, just as the predator roar, relies to some extend on a sonic archetype it still requires the familiarity with the experience of foregrounded insectoid sounds established by audiovisual mainstream media.

Also in the context of the Crocodile Tamer TAIK 2009 (PD 19, on page 70) I propose to use insectoid sounds to convey danger when the object, from which the sound emanates, is small:

[20] This relates to the code *"sound des strat. re-creation of morphology of a 'cliché' sound (defamiliarization)"*, which contains 4 quotes from 4 cases.

[21] This series of different, but related, associations are an example of productive ambiguity, which will be discussed in Chapter 25 in Part IV.

> *I: "...in cartoons of course you have small animals with huge sounds, but if you're in the physical world, (...) and you want to convey danger, you have to maybe look into domains of sounds where dangers comes from something small as well. Then you have a better unity and there are examples like, again, clichés like snakes and scorpions."* `(>19:38)`

The statement shows how the use of this type of sound is strongly related to filmic auditive experience. In film, sound is often used to convey danger or enunciate the protagonist's disgust. It also may be used to convey that something is corroding or dying, and profit from their ambivalence with technically produced sounds such as static noise. Also these sounds often allude to archetypal sounds, such as insects, combined with the nature of related sonic experiences, where one hears, but does not see, the origin of the sound. I will explore this influence of *sound as experienced in audiovisual media*, in particular film, on design considerations and interpretation in the next chapter.

17. References to Sound in Audiovisual Media

> Michael Jarrett: Has film sound led us to hear the world differently?
>
> Walter Murch: Yes... sure. (...) In the same way that painting, or looking at paintings, makes you see the world in a different way, listening to interestingly arranged sounds makes you hear differently.
>
> *Jarrett and Murch, 2000*

In the following, I will report on interpretational discourses and designs which exhibit an obvious relation to filmic sound and mediated sound narratives in general. A general observation is, that this relation might in many cases only be implicit in the discussions, through references to sonic phenomena which do not exist outside of the interpretative framework provided by filmic narrative, because the people who are not trained in analytic listening to filmic sounds in most of the cases were not aware of the referential and aesthetic system they are employing. In fact, the border between filmic or non-filmic sound phenomenon as reference was often blurred.

17.1. References to Specific Films or Film Sounds

In some cases a sound design would evoke actual films or specific familiar sounds from films. An example for this type of "filmic listening mode" is evident from the following statement from a participant, in context of the presentation of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *Participant: "Well, I associate it rather with Spaceship Enterprise, the door of the elevator."* `(>25:9)`

This refers to a sound which was associated with the interaction with the office chair. The designers chose a sound, which resembled the sounds of the doors in the Star Trek series. The sound's synchronicity with the movement of the chair may have supported this association although the movement patterns (chair swiveling, doors sliding) are different. The general aesthetics of the sounds of the Star Trek series, representing refined and subtle smart high-tech, would indeed fit the presented artifact and interaction. The problem is, however, that the associated elevator door has no particular narrative purpose or meaning in this context, except for being an example of reliable and functional technology of which the Star Trek universe is composed. This seems to prevent the listener from listening for potential meaning beyond this initial point of reference.

There was a similar case of association with a specific sound from a movie, and the related implications. During the discussion of the Crocodile Tamer TAIK 2009 (PD 19, on page 70), a participant stated:

> *Participant: "For me it was definitely alive, since there was this Chewbacca sound."* `(>19:8)`

Chewbacca is a heroic protagonist from several Star Wars movies (Lucas et al., 1977-) who speaks with a very characteristic, guttural-raspy voice. In this case, there is an element in the sound, which is the hint to a (metaphorical) liveness of the object, but the sounds similarity to this popular film character is misleading in the context of the prototype presented here. It also should be noted, however, that the statement is not actually referring to the film or the character as element of interpretation, but was an ad-hoc means to describe a the sonic quality by a reference. The fact, that the protagonist refers to the sonic memory of a film character to describe a sound is an indication of the power of the shared mainstream film sound vocabulary.

Another example, which relates to the sonic memory of a memorable film character was discussed after the demonstration of the SONIC PAPER DD ZHdK 2009 (PD 40, on page 79):

> *I: "This is great, there is a Gremlin in the paper ball! Yes, what is this?"* `(>40:13)`

The actual sound that I refer to here, is not very prominent, but the sound produced by interacting with the paper has a shared quality to the characteristic Gremlin sounds, the creatures of the eponymous movie (Dante, 1984). As the interaction scenario presented relied on the metaphor of "living paper", this association made sense and could be accommodated into the general context of a "smart paper" and the playful character of the interaction scenario. But while the general association was correct, a potentially intended specific information was not necessarily understood. The designs triggered listener's interest and raised attention, but remained ambiguous (see Chapter 25 about the topic of ambiguity).

In conclusion, some sounds were strongly reminding of more or less known film sounds. It seems that it was not always necessary to remember exactly how a specific film sound actually sounds, also general sonic properties seemed to be well memorized and associated with certain films. In general this requires the sounds - or sonic qualities - to be well established in the collective auditory memory. In this respect, several levels of association are possible. For instance, the sound I associated with the Gremlins could be associated by someone else, who has not seen the film for a long time, with "small monsters", thanks to the fact that many of these sounds are somewhat stereotyped and used in many different films.

In all these cases the sounds were not an exact reproduction of the original filmic example, but rather shared certain spectro-morphological qualities. This shows the strength of these filmic sound designs. However, not necessarily in terms of a specific sound being associated with a specific object or event, but rather with a class of objects or events (such as "doors in sci-fi movies à la Star Trek"). Still, the timbral quality alone may not be sufficient, as the association emerges in interaction with the application functionality, properties of the artifact and setting, or the movement involved in the interaction.

17.2. Association with the "Filmic"

One of the main motivations of mainstream film is to be "bigger than life", and this translates also to the way filmic sound is staged, in particular in relevant narrative moments. An example of such a filmic sonic aesthetic can be the use of boomy, or bassy, sounds, or sounds with a large perceived spatial extension[1], or ubiquity[2], to make something "feel" big and massive. A similar strategy was used in one of the sonically augmented car prototypes from the SONIC CAR BOARDING PROJECT 3 DD ZHdK 2009 (PD 37, on page 76), where the closing of the door was followed by a powerful low-end boom. In fact, the presenter's explanation confirms his attempt to transfer a narrative about identity and self, as conveyed in advertisement, to the real world object, using related sonic means:

> *Presenter: "I took on their character actually by means of advertisement, as it is attributed to them by advertisement, I took that on and said: I am going to intensify*

[1] Flückiger uses the term "extension" to describe the perceived spatial dimension of a sound or a sound source (Flückiger, 2001).

[2] This term is used by Augoyard and Torgue to describe the sonic effect associated with a sound that seems to come from everywhere, encompassing the listener (Augoyard and Torgue 2005).

> *this now, as it became clear to me, OK, so everyone of us has their identity, and in particular in the western world you want to identify with your car. It's some kind of expression to the outside, quite strongly. It goes even so far that you can imagine that people feel ashamed for their car."*[3] `(>37:17)`

Another strategy that can lead to an association with the "filmic" as such is the use of animal sounds in the mix. I discussed xenomorphism as sound design strategy above (Section 16.5), and it can be assumed, that the approach is often inspired by the filmic use of animal sounds. One stereotype is the mix of animal growls into car sounds, to make them seem more organic or powerful and aggressive. The sounds of animals were used in several projects. For instance, the roar of a predator cat from aforementioned Sonic Car Boarding Project 2 ZHdK DD 2009 (PD 36, on page 76) may well have an archetypal function due to evolutionary emotional processes (fear of predators), but its expressive potential is most likely strongly supported by its use in film, where such sounds may be used to augment (or "sweeten" in film sound jargon) a sound design. This filmic use of sound relies on subtle mixing, literally "hiding" a sound within another one. The designer argued for the use of recordings of animal predator roars:

> *Presenter: "The car indeed expresses power and speed, and I thought, this fits, yes."*[4] `(>36:18)`

Regarding the applicability of this design beyond audiovisual media I stated:

> *I: "It maybe fits in a way, that (...) the whole image language that we know from advertisement, panthers and tigers and so on, that this is really very much an image language, (...) or also a very symbolic language, which in the everyday context loses the symbolic and becomes too concrete."* `(>36:24)`

Here, I was referring to the normative power of advertisement, and mainstream film. In fact, one participant mentions that the roar could fit well to turning the car on, which suggests, that this particular strategy of blending and augmenting sounds familiar from film may be at least considered also for everyday interactions. In this particular application of the design strategy, however, some issues emerged. In particular, the sound was perceived as being "too concrete", to clearly audible in terms of its source (the animal). At the same time, if emphasized, such sounds may evoke an association with "advertisement", which again would disrupt the experience.

17.3. Associations with a Filmic Genre Through Sonic Style

Flückiger (2001) describes how a sonic style can be fundamental for establishing the identify of filmic genres such as horror, western or science fiction, and sonically conveyed filmic style had an effect on the way sounds were classified and interpreted in the workshops. For instance, sounds that were simplified and strongly foregrounded, as we know it from animated cartoon sound effects, in addition to cartoon sound stereotypes, have the tendency to evoke the cartoon genre as interpretational reference[5]. Another example are sounds, or spectro-morphological qualities, which triggered associations with mainstream horror films. Often films from this genre make use of abstract sound design inspired by avant-garde electroacoustic music and of denaturalization strategies (Flückiger, 2001; Hentschel, 2011).

A first example are abstract, screeching sounds of The Elevator TAIK 2009 (PD 15, on page 67) which were judged by participants to be "scary":

[3] *Presenter: "Ich habe deren Charakter eigentlich durch die Werbung, der ihnen durch die Werbung zugeschrieben wird, habe ich aufgenommen und gesagt: den intensivier ich jetzt, weil für mich einfach bewusst geworden ist, ok, also jeder von uns hat so seine Identität, und gerade im westlichen Raum will man sich mit seinem Auto identifizieren. Ist es so ein Ausdruck nach aussen ganz stark. Es geht soweit dass man sich vorstellen kann, dass sich Leute schämen für ihr Auto."*

[4] *Presenter: "Das Auto strahlt ja doch Macht aus und Schnelligkeit, und ich habe gefunden, das passt, ja."*

[5] See also Section 27.7.3 on the problem of (unwanted) sonic caricature.

> *Participant: "They were quite scary... for me... I might decide, like, 'oh, I think maybe I take the stairs'." [laughter]*
>
> *I: "Yeah, for me especially when there is this screechy sound. And I thought: is this the movie 'the elevator', or what is it called..."*
>
> *Participant 2: "...where it just drops..."* `(>15:21)`

Another means to establish the style of horror is the use of specific sonic archetypes which are associated with danger, fear or sickness and death. The case with the sounds of flies discussed earlier could be counted as an example, but also in the case of The Toaster UDKL 2011 (PD 80, on page 93), where I state that the sounds reminded me of horror films:

> *I: "And (...) this was different, it was much more with animals, with screams, with human voices, somehow (...). The quality was different. It was again maybe a little bit more filmic, or you know, horror movie like."* `(>80:15)`

Synthetic sweeping sounds, on the other hand, may evoke the sonic style of Science Fiction films of the sixties and seventies, as the example from the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73), discussed also above, in the context of the sonic association with specific films, shows.

An interesting observation was, that even within the non-filmic situation of interactive artifacts demonstrations, there was the notion of sonic style, and the associated expectation of stylistic consistency. For instance, in the demonstration of the Crocodile Tamer TAIK 2009 (PD 19, on page 70) a chimes sound could be heard, and was associated by the audience as expressing a "magic" quality. An expert visitor then stated that such a sound is *"slightly out of genre"* – an action game based on a wildlife metaphor – and that this discontinuity may result in suggesting *"that you are performing something for an audience"* `(>19:31)`. Also, just as in films, when the sound is not part of the stylistic ensemble, it can be understood as an extradiegetic "comment" to the interaction displayed, which is a common narrative device in film sound (Flückiger, 2001). We will have a look at such sonic narrative devices in the next section.

17.4. Association with Sonic Narrative Devices of Film

Film sound contributes to the filmic narrative in many ways, and in mainstream film we encounter an abundance of related sound design strategies, which are well established and familiar to a large audience (see Flückiger, 2001). For instance there are sonic symbols, such as the scream of the red-tailed hawk, which is a common symbol for deserted areas, wilderness and loneliness[6] or non-diegetic enunciations, often in the form of abstract or unidentifiable sounds, that help us to understand the subjective experience or state of a protagonist[7].

It was interesting that in several instances of interpretational discussions during the workshops, the interpretation followed such filmic conventions, as if the presented interaction was a filmic narrative. I will discuss these aspects in the following sections in more detail.

17.4.1. "Off" Voices and Commentary

Another example is the filmic representation of a protagonist hearing voices in his or her head. A related example from the design cases is the use of distorted voices from inside the artifact in The Toaster UDKL 2011 (PD 80, on page 93):

[6] See http://www.filmsound.org/cliche/ for an overview over common film sound clichés, including the red tailed hawk.

[7] According to Flückiger (2001, p. 395), common strategies in film to enunciate the subjective state of a protagonist include the disassociation of sound and image, the disappearing of noises, reverberation, unnatural selection or enlargement of sounds, and sounds such as breathing and heartbeat.

> *Participant (visiting guest): "The rest, I just kept imagining (...) little gnomes inside the toaster, in some expanded alternative space, working (...) the way of making toast. And they are kind of getting pissed off at too much work (...)."* `(>80:5)`

Distorted screams and (still recognizable) human voices are typical filmic sound material. Related to the topic of extradiegetic voices in the head of the protagonist, a common filmic association may come from the use of spoken language without visible source, which could be associated with filmic off screen voice, which was actually the design idea behind the whispering voices in this project:

> *Presenters: "The voices that you imagined to be the toaster was more like a thinking person."* `(>80:18)`

Here, the sound of voices clearly are not meant to be seamlessly integrated into the artifact, but are understood as an element of a meta-narrative of the scenario, where the artifact is literally a manifestation of the users mental state:

> *Participant: "The sound comes from the toaster but is was reflecting you, somehow?"*
>
> *Presenters: "Yeah"*
>
> *I: "This is also very filmic you know, if you remember... it's like what you saw in some movie examples I showed, that the sound oscillate between embodied in the artifact, but also of course they are expressions of the subjective inner state."* `(>80:20)`

This corresponds to the filmic use of inner monologues, where we can hear a protagonist's reflections, or an extradiegetic commentary, as off screen voice. In this case this resulted in the disruption of the diegetic continuum, by blurring the border between actual artifact sounds and some kind of imagined narrator. Non-diegetic voice and narration is thus a filmic narrative device which probably can not be transferred to interactive commodities directly. It might be interesting to see, if the increasing popularity of speaking assistants in smartphones and appliances might change this.

17.4.2. Breathing, Heartbeat, Ticking Clocks

Other sound stereotypes which were employed in some prototypes were heartbeat and breathing. Heartbeat is a sound which me might have heard only when playing with a stethoscope as a child, and as diffuse audio-haptic perception of a heart pounding in our body after a physical effort or stressful situation. Despite its rarity in terms of everyday sound experience, heartbeat has an archetypal quality. I would argue, however, that this relevance is strongly supported by the experience of the stereotyped heartbeat from media, where it is a common device to convey subjectivization. Just as extradiegetic voice, these sounds belong to the narrative devices associated with filmic "subjectivization" (Flückiger, 2001). As heartbeat and breathing sounds (or sounds imitating them) are often used as representation of living beings they were also used for anthropomorphizing purposes

In the Foley mockup of the Doc-O-Mat UDKL 2010 (PD 54, on page 86) which was already an example of using voice for anthropomorphizing purposes, these sounds were used in a very prominent way, as clearly audible sounds emanating from the fridge. The designers stated:

> *Presenters: "We wanted (...) that the first part with the breathing and heartbeat was more close to a human, and afterwards when he injects her with medicine there is more like fluid and (...) so scratchy..."*
>
> *Participant: "...it's not natural."*
>
> *Presenters: "...it's more like chemical fluids they put in your body."* `(>54:12)`

In this case the breathing and heartbeat sounds are both meant to denote a specific process state as being associated with a human, or the actual protagonist. Another example from the same case points to the problem of adopting the signification of heartbeat with the scenario at hand:

> *I: "Of course for example the heartbeat is a cliché in some ways as well, so maybe the idea of tension rising or something more organic, more human-like could be transferred by using the idea of accelerating rhythm but maybe with another sound (...) because the association with the system is not yet working at this stage, but what worked was the increased tension, the sense of increasing."* `(>54:14)`

In The Toaster UDKL 2011 (PD 80, on page 93) we encounter the heartbeat sound again. In this case, it caused some confusion:

> *Participant: "I didn't quite know what to do with this, but its kind of weird that the toast inside of the toaster was some kind of living thing and the heartbeat stopped at the time and so the process of the cooking of the toast died."* `(>80:7)`

It is striking that the code associated with the heartbeat sound as signifier for *"living thing"* is guiding the interpretation, which results in the insecurity, because the heartbeat sound would have to be attributed to a source which could not be plausibly interpreted as "living" (in this case, the toast inside the toaster). This is an indicator for an issue concerning the interpretational inflexibility of indexical sounds, which is discussed in Section 24.1 in Part IV.

But the strategy of using such sounds in a clearly identifiable way does not have to fail necessarily. During the same discussion, I stated:

> *I: "It worked. I mean the heartbeat is a cliché, it's a filmic cliché, (...) a symbolic sound, and often associated with fear, or live in general."* `(>80:8)`

Both of these cases are also good examples of the temporal structure of a sound becoming meaningful in itself, independent from a source it may be representing. The heartbeat, at some point, is also simply a steady beat, a temporal phenomenon which itself is informative. I will discuss this phenomenon in more depth in Section 20.1.

An example of this "temporal abstraction" is the Machina Obturantis, UDKL 2011 (PD 78, on page 93), where a ticking sound was explicitly related to *"heart beating"*:

> *I: "So the live sustaining element is the ticking, or the ticking represents that the power is flowing."*
>
> *Presenters: "Yes, the heart is beating."* `(>78:2)`

This case also was a case of a combination of both stereotypes, breathing and ticking, in one narrative:

> *Participant: "The time (author's note: here refers to the clock ticking noise) makes a reference to the machine actually (...) whereas the breathing makes a reference to something that is human. (...) It's the idea of living."* `(>78:5)`

The sound of ticking clocks is another filmic narrative stereotype, marks the passing or stalling time, or waiting, but also as suggestion of tension or symbol for live and death (Flückiger, 2001). My statement shows, that the combination of ticking and breathing sounds with an abstract metal box changed the basis for the interpretation. The breathing, as sonically dominant element of the narrative, became the basis for interpretation. The ticking was representing time as important element of the process, but the designer's statement reveals that there was an underlying metaphor of the box as a living entity. This conflicts with the "interpretational message" of the ticking, which was even overemphasized and foregrounded in the mix.

17.4.3. Sonically Dramatized Actions and Processes

In the presentation of the project Bag to the Future TAIK 2010 (PD 47, on page 81) the movement of taking something out of the "smart bag" was accompanied by a metallic, resonant sound, which I commented as follows:

> *I: "I would guess that the sound with the afterthingy is something more precious. And the simpler sound is something not so important."* `(>47:20)`

The profane action of taking something out of the bag was emphasized, even ennobled by the sound quality. The perception of the sound was focused on the fine metallic tone, standing out in the soundscape and not clearly identifiable as indexical/iconic "sound of", which supported its expressive function in correspondence with its perceptual quality. This kind of sound use is similar to the filmic narrative sound stereotype associated with a sword (or similar weapon) being pulled out of the sheath, emphasizing a tonal high pitched resonance, which in particular is associated with the dramatized depiction of a heroic protagonist's action, or even enunciating a particular preciousness of the sword itself. More generally, resonant metallic or glassy sounds are associated with sharpness, preciousness and perfection. The "bling" sound associated with visual highlights in toothbrush and cleaning agent advertisement come to mind.

Another variation of this topic is the stereotypical enunciation of important, powerful processes or events. A typical example is the process *charging - exploding*. In reality, explosions happen unannounced, suddenly. In films, however, we often hear a sonic build-up in the form of a "whoosh" just before explosions, or strong impacts. This filmic use of sonic anticipation is referred to in the following discussion from the presentation of the Crocodile Tamer TAIK 2009 (PD 19, on page 70):

> *I: "Yeah its like something is charging and then exploding in a way, a small, how do you say..."*
>
> *Participant: "Releasing?"*
>
> *I: "Releasing, yeah thanks. And then resonating of a magic thing... So it's really a cliché structure, and it goes with the gesture. So what could that be? I don't know."* `(>19:7)`

The charging-exploding sound pair gets its meaning potential from a "physical" suggestion, such as acceleration, increase of force, or sudden breakout.

17.4.4. Filmic Enunciation of "Goodness" or "Badness"

The case Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73) uses specific sound qualities to convey whether the energy used by the system is "good" or "bad":

> *I: "Why should we think one energy is good and one is bad?"*
>
> *Presenters. "The bad sound should be very deep, industrial, powerful, you should hear the atomic energy generator in this sound. In the good sound there is a natural thing, I had the sound of water in the sample, it should be light energy, happy."* `(>25:18)`

We may notice the multilayered meaning projected into the sound. It refers to its perceptual property of "deepness" which often was associated with "badness" or threat, but also a sonic quality which was associated with a powerful energy source, in this case an "atomic energy generator". The good sound is a "natural thing", the "natural" is represented by a "natural sound" of water, which is also expressing "happiness" for the designers[8]. Note that in this case,

[8] This design also shows how the designers blend indexical with more abstract sound qualities, which will be discussed in Chapter 19.

the water sample was used as continuous loop with changing pitch, thus reducing or eliminating the explicit reference to water, but still the timbre was bright and rather organic. In film and audiovisual media sound is often used in similar ways in order to enunciate the positive or negative character of artifacts or actions (Hug, 2010a). ”

17.4.5. Enunciation of “Magic”

As a property of artifacts, forces and protagonists, “magic” is a common attribute to classify objects, protagonists or actions in filmic (fantasy) narratives. Similar to the sounds used to enunciate the character of artifacts or actions, particular sounds are used to express, or denote, an invisible, hidden quality of entities, which usually is related to agency and “intelligence” of the artifact[9]. As described in Section 3.3 in Part I in the context of digital, interactive technologies, the notion of “magic quality” has gained new momentum.

Magic per se was usually not explicitly mentioned as intended design quality in the cases studied here. Rather, it emerged in the discussions in relation to specific sounds, or types of sound use. For instance, during a demonstration of the gesture which concludes the interaction with the Crocodile Tamer TAIK 2009 (PD 19, on page 70), a participant spontaneously stated:

> *Participant: “Yeah, magic again!”* `(>19:9)`

And the discussion went on, trying to dig deeper into this spontaneous interpretation:

> *I: “I think I understand, because this clingeling sound is an enunciation of magic power in a movie, directed towards an audience.”*
>
> *Participant: “It’s a kind of fantasy sound.”*
>
> *I: “It’s not a diegetic sound that Harry Potter hears.”* `(>19:33)`

So on the one hand, there seems to be something that tells us that a specific type of *“clingeling sound”* enunciate magic powers, or to *“fantasy”* as film genre. Being classified as such, it serves to “color” the whole interaction as “magic”. Similar to the enunciation of preciousness described above, chimes or similar, tonal, high-pitched sounds with a metallic or glassy impression are often associated with the film sound stereotype for “magic”. There might even be an association with a specific movie - in this case, Harry Potter was mentioned.

Another discussion, from the Matchmaker UDKL 2010 (PD 58, on page 85), shows, that the notion of “magic” does not only rely on recognition of a sonic stereotype:

> *I: “Why do you classify it as magic and not as, for example, high-tech?”*
>
> *Participant: “I don’t know, it’s my association, because they use maybe in movies this sound, which is not distracted by something else.”*
>
> *I: “That stands out.”*
>
> *Participant: “Yeah.”*
>
> *I: “Like an unrivaled sound.”*
>
> *Participant: “Yeah.”* `(>58:4)`

This confirms that the classification of a sound as expressing a magic quality is on the one hand learned from filmic examples. But, the association of “magic” quality may also emerge from a not-filmic association or without an obvious stereotypical template, as the description of the magic sound as *“a pure sound which is not disturbed by something else”* shows. “Magic” as classification of a sound also relies on a contextual quality of the sound: *“Standing out unrivaled”.*

[9] I have investigated this phenomenon, and the related filmic “narrative metatopics” also together with workshop participants in earlier editions of the workshop (Hug, 2010a).

The emergence of the notion of "magic" is then based on a metaphorical interpretation of the contextual (or compositional) sonic quality.

As a consequence it was not always clear in the interpretational processes, whether the attribution of "magic" was based on the identification of the sonic stereotype, or on a perceptual quality of the sound. In the case discussed here, the classification as "magic" was supported by the artifact itself:

> *Participant (visitor): "It's also kind of magic because of the object itself."*
>
> *Presenter: "That's why I wanted the snowball."* `(>58:7)`

In this case, both designer and interpreting participant refer to the snow globe, which was used as demonstration prop by the presenters. The snow globe is a culturally connotated artifact, whose miniaturized landscape and snowfall are associated – among others – with magic and enchantment.

The association with "magic" also can emerge from the gesturality of interaction, and the **r**elationship between gesture and sound. Consider the following quote from the Thermos Flask TAIK 2009 (PD 18, on page 68):

> *I: "There was this gesture from bottom to up, very slowly, carefully... somehow for me it was a magic gesture, because magic gestures are sometimes [made with] fingertips. You know, touching something slightly and doing something quite complex from that."* `(>18:7)`

The gentle touch in this case requires a perceivable effect of the movement, in order to convey the experience of controlling something through the gesture. The connotation with "magic" can thus not emerge from a gesture alone, but in relation to a gesture's effect. This observation relates to the concept of sonically expressed "power differential" (Hug, 2010b) and can be generally associated with complex effects emerging from simple actions.

Finally, and related to the question of gesture, magic was associated with something *"you can't touch"*, as discussed in relation to the Crocodile Tamer TAIK 2009 (PD 19, on page 70):

> *Presenter: "We can't touch it. How do you interact with something you can't touch. And the magic was one way of doing it."* `(>19:30)`

In this scenario, the user is required to make a control gesture from a distance, and the resulting "supernatural" quality is expressed with a "magic" sound. In this case, the "magic" quality again was rooted in the sound design, which employed sounds of high pitched chimes.

18. Analogy-Driven Design and Interpretation

A very common type of approach to design and interpretation can be attributed to the perception of "analogy" between various sensory stimuli and the related subjective experience. Based on the discussions during the workshops, two types of analogies can be identified, which share certain properties, and thus cannot be alway clearly separated. One type refers to formal, or procedural analogies, and the other to the more narrowly defined notion of "crossmodal analogies" and - as slightly different understanding of the same principle - "crossmodal correspondences"[1]:

- *Formal or procedural analogies* can be defined as sounds, or sound effects, which are similar to, or reminiscent of, sounds, or sound effects, associated with another process, or a sound producing process. This concept can be contrasted to the notion of Auditory Icon where a sound's simplified version is used to create a – usually – metaphorical relation.

- The other group of phenomena can be addressed as either *crossmodal analogy* or *crossmodal correspondency*. The concept of crossmodal analogies "refers to the capability of each person to detect correlations (congruence) between the properties of objects above and beyond the boundaries of the senses" (Haverkamp, 2013, p.136). According to Haverkamp, crossmodal analogies are not necessarily "natural" but can be culturally conditioned. A more narrow but related concept is the one of crossmodal correspondences, "nonarbitrary associations that appear to exist between different basic physical stimulus attributes, or features, in different sensory modalities" (Spence, 2011, p. 972). Examples of crossmodal correspondences would be the association of auditory pitch with visual elevation, size, or lightness. Furthermore, crossmodal correspondences can be mediated by statistical, structural, and semantic relations. Perceptual continua emerge on the basis of quanitites and magnitudes, the latter is based on the arrangement of stimuli in qualitative terms (i.e. "what kind of", or "where").

In the following sections, I will provide examples of analogy-driven interpretations below based on the cases from the workshops.

18.1. Formal or Procedural Sonic Analogy

The following types of referentiality build on analogies between a designed, electroacoustically added sound and another (naturally occurring) sound, or sound producing process. Thus the meaning potential is not resulting from the use of "natural" or "everyday" sounds, as is the case of Auditory Icons, which are supposed to replicate the sound of the event or object they refer to, but reminds of them by means of an analogy in terms of shared formal or procedural features.

The analysis of the cases allows us to diversify this general structure, and uncover eventually other phenomena that serve as basis of interpretation of sounds in schizophonic interactive commodities.

[1] According to Haverkamp (2013), several types of correlations in audio-visual perception exist, from mathematical or physical connections, symbolic or metaphoric connections, concrete associations and iconic connections, crossmodal analogies and finally, genuine synesthesia. Crossmodal analogies are not to be confused with the use of real world sonic effects (such as phasing, reverb, doppler) where the effect has a property which itself becomes meaningful.

18.1.1. Sonic Analogy to Audible Processes and Sonic Behaviors

In the Matchmaker UDKL 2010 (PD 58, on page 85), we encounter a broadband noise is subjected to a filter sweeping downwards, which makes the sound perceptually "thinner", or "smaller". This would in fact be an example of a crossmodal correspondence which relates narrowband sounds with comparatively high spectral centroids to be associated with smaller objects. But the following statements show, that also other types of analogies can emerge:

> *I: "I also noticed something quite strong is the moment where you put it down."*
>
> *Participant (visiting guest): "Yes."*
>
> *I: "At the moment when everything is 'shhhshshshs' - swallowed."*
>
> *Participant: "Yeah."*
>
> *I: "I find it quite nice. There is something, some narrative or dramaturgy that builds up again, a bit like in the one before, but then you have an influence by saying ok now I've got enough of this and you put it down and this moment is where the sound don't just stop, but they're kind of are swallowed into this little thing."*
>
> *Participants [several together]: "Yeah."*
>
> *I: "I could even imagine that you could put a lot of evil, evil energy inside and clean your soul."*
>
> *Participant: "Yeah."*
>
> *Presenters: "It should be taking a piece of you , something from you when you put it down. (...)"*
>
> *Participant: "I gathered, when you did this, I heard it twice of course, I got the picture of a box where some kind of ghost or some kind of... immaterial..."*
>
> *I: "Yeah the jinni in the bottle or something..."*
>
> *Participant: "...is going back, yeah."* `(>58:9)`

One exemplary excerpt is: *"everything is (...) swallowed"*. Here the sound becomes a virtual, spatially extended entity, whose perceptual shrinking is the precondition of "swallowability", which then is executed by the subsequent muffling and disappearing of the sound, which again is a natural acoustic consequence of a sound source being put into a container. This approach was extended by another participant to a narrative reference: a *"jinn in the bottle"* , which emerged from the context of the artifact being a handheld, small transparent object. Another interpretation was, that a *"piece is taken from the user"*. Here, the interpretation refers to the notion of a larger entity, from which a smaller element is detached. Thus, throughout the varying perspectives, the transition large to small is always present. Also we can observe, how these analytic reflections of basic sonic properties contribute to more imaginative interpretations, such as the absorption of *"evil energy"*.

We see also from these examples, that analogy does not work independent from other signification aspects. In these examples, we can see, how elements of analogy are mixed with perceptual qualities of sounds, or their narrative associations, and even references to filmic clichés.

A different example comes from the Sonic Paper DD ZHdK 2009 (PD 40, on page 79) where a surprising association emerged:

> *Presenter: "... this comes to the sound of the page, like a car that is not starting."* `(>40:19)`

This is a good example to demonstrate the difference between an Auditory Icon and a more abstract sonic analogy: The sound of a starting car would strongly conflict with the interaction with paper. The sound used here was thus not a recording of a stuttering car engine, but a stuttering sound, the stuttering itself, as a manifestation of a problem to start an "engine", became the foundation for the association.

18.1.2. Sonic Analogy to the Sonic Manifestation of Physical Processes

In some cases, specific properties of sound were the basis of interpretations, if those properties resembled familiar sonic properties from physical or mechanical processes. An example comes from The Elevator TAIK 2009 (PD 15, on page 67), where a shift of spectral centroid[2] is associated with the feeling of movement and acceleration:

> *Presenters: "You move more frequency wise than pitch wise, I think we also have this pitch shift to kind of enhance the... You get the feel of movement and acceleration and little bit of that."* `(>15:31)`

This relates to a typical shift in the frequency spectrum as it occurs when an object is moving with increasing speed over a surface[3]. Thus, in this case we are dealing with a transfer of sonic phenomena associated with movement.

Some interpretations are built on analogies of an interaction process with mechanical processes, as we can see from the following statement from the Thermos Flask TAIK 2009 (PD 18, on page 68).

> *I: "This is a very springish, elastic sound, seems to me. Also something that is releasing from a tension. (...) Why did you choose this sound?"*
>
> *Presenter: "Because it's somehow physical in a way, like, I don't know, it's like a lock."* `(>18:17)`

The continuous process is coming to an sudden stop, which is illustrated by a metallic clicking sound. The presenter argues for a "physical" quality of the sound. There is the immediate notion of a (metallic) mechanical process of clicking and detaching. A lock might well be a possible source, but does not seem to be the primary point of reference here: the interpretation is not that something is literally locked or unlocked, but more generally, a tension is abruptly released.

The following example shows, that we indeed may understand sounds of mechanical processes as representations for a quality of a state, for instance related to structural conditions, and not just as manifestations or representations of the specific mechanical process: During the demonstration of the Assembly Line DD ZHdK 2008 (PD 5, on page 64), a participant states:

> *Participant: "Maybe this shows somehow the (stability) of the engine?"* `(>5:17)`

Here a change of the sound from clattering to something more smooth was associated with increasing stability. The reference was not made to the clattering object, but to the sonic manifestation of the process this object is undergoing.

But we have also cases where the actual sonic quality is not based on a sonic manifestation of a mechanical process directly, but to a more generic abstraction of the sonic pattern. For instance, we have the association of the distorted blinker sound of the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77), which was associated by me with *"squealing, screaming wheels"* `(>38:8)`. In this case, the sonic property of distortion, which shares a perceptual similarity to the sound of squeaking tires, allows the transfer of a sonic property of one sound event to a new sound: the blinker is squeaking like tires in the curve, the blinker becomes expressive of the physical phenomenon associated with the rubber slowly losing contact with the ground. At the same time, the distortion is a meaningful expressive device in itself[4]: the clean sound gets distorted as a consequence of some kind of overload, and sounds "unpleasant" (we might enjoy the sound nevertheless). We have thus a combination of the various properties of the sound as such, in addition to the analogy of the know process from physical and mechanical world.

[2] A measure which indicates the perceived "center of mass" of a spectrum, which is closely connected to the impression of "brightness" of a sound.

[3] Not to be confused with the doppler effect.

[4] See also Section 20.3.2 for a more detailed discussion of this aspect.

Another interesting example comes from the presentation of the Foley mockup of the Matchmaker UDKL 2010 (PD 52, on page 85). Here, a sound was heard as something "snapping". This conveys an association with a physical process, such as a clasp lock. Yet the sound does not sound like a mechanical kind of snapping. Rather it seems to rely on a certain time-frequency morphology that we find figurative of a snapping event . Something seems to *"snap over"*, or *"pop out"* (>52:12). This understanding is reinforced by the observable action (concentrated facial expression, firmly holding the object).

18.1.3. Sonic Analogy with Sonic Manifestation of Natural Material States

Another use of analogy was based on the conceptual abstraction from specific physical conditions which result in certain sonic phenomena. More precisely, the aesthetic reference here is not to a mechanical process, but rather to sonic patterns associated with material phenomena found in nature. One example is the degree of dryness of organic material, such as leaves, which is correlated with the rustling quality of the sounds they produce when moved. An application of this principle appears in the AcuPot DD ZHdK 2009 (PD 39, on page 79):

> *Presenter: "The thirstiness, then the dying (...) when the pot is really doing bad, something insectoid, corroded..."* (>39:18)

The statement shows, again, that the interpretation is not linked to a single point of reference, but establishes a network of references, that are in one way or another related to the sound. The "insectoid" refers to noises associated with insects moving about. The sounds of insects convey the "fragile hardness" of their chitin shells, but at the same time allude to evolutionary associations and cultural codes (see Chapter 16.5). The notion of "corrosion", then, is related to the imminent consequence of dryness in fragile organic matter, which ultimately leads to its disintegration. A similar phenomenon was identified in the design of the Doc-O-Mat UDKL 2010 (PD 54, on page 86):

> *Participant: "There is the crumbling of paper, everything is like very dry, very crisp."* (>54:7)

In the context of the erotic scenario of this project, dryness as perceptive quality of a sound becomes both a metaphor for the drying-out of something living, and also the more literal absence of moisture and fluids. Therefore, this case represents a conceptual transfer, from the dryness associated with crackling of crisp (dry) materials to the experience of sexual contact.

Another natural state which has been represented sonically was heat, as manifested in the sound of boiling water. In the prototype of the Thermos Flask TAIK 2009 (PD 18, on page 68) participants stated, that the (figurative, synthetic) bubbling sound could be indicative for boiling water and thus indicative of high temperature.

18.2. Crossmodal Analogies and Correspondences

Let us now turn our attention to those phenomena, which can best be subsumed as crossmodal analogy or correspondence. These were relatively common in design and interpretation[5].

18.2.1. Mapping Pitch and Height

One discussion in the context of sound and meaning has been related to the question, whether there are actual sonic universals, sonic phenomena that are perceived, experienced, judged or interpreted identically, or that have the same effect on people, across all cultures and populations.

[5] A related code, "sound des. strat: crossmodal analogies" relates to 10 quotations from 8 cases.

Regarding the data derived from the workshops, sonic universals were not a very prominent issue. However, pitch related designs often referred implicitly or explicitly to the assumption of a pitch related universal namely the association of pitch with elevation (Walker and Kramer, 2004; Spence, 2011), or "height" of numerical values (Walker and Lane, 2001), whereby a positive mapping (higher pitch representing increased height or value) seems universally adopted, also in Auditoy Display design. In the cases analyzed in this study, however, pitch was used rarely as isolated dimension, even when associated with simple dimensions such as height or numerical value.

Consider for instance, The Elevator TAIK 2009 (PD 15, on page 67). "Height", in this case, is an intrinsic component of design, although not necessarily perceived as continuous movement in space, but rather in discreet stages (floors) with more or less accentuated transitions between them. It could be even argued, that the floors an elevator travels are not neutral in terms of value: the basement has different connotations than ground floor or executive floor. This is also reflected in the following statement:

> *Presenters: "You go from up and down (...) kind of symbolically (...), we were thinking how cultures (...) associate different things to up and down (...), so you could kind of symbolize (...) down is like the profane or natural and high up is sacred and supernatural."* `(>15:28)`

And, in the same project:

> *Presenters: "You kind of start from the organic (...) you're attached to the ground and your roots and it's kind of the low frequencies that have kind of solidity and mass, and then the high frequencies which are kind of airy and spacy."* `(>15:30)`

In this design, the symbolic is supported by some basic perceptual properties based on natural phenomena associated with height, or closeness to the ground. It certainly is not a trivial mapping of higher elevation to higher pitch, but rather a metaphorical one: The organic is the bottom, the ground, on which everything stands and grows, the upper levels are literally elevated, into some kind of immaterial, even heavenly, domain[6].

In the demonstration of the Moody Hat DD ZHdK 2008 (PD6, on page 65), a sound of raising pitch was used to accompany the successful execution of a control gesture on the hat's rim. I asked the designers if it could be possible that the sound would progress downwards. They replied:

> *Presenters: "It's supposed to show success, success goes always up, it could go to another direction but the it wouldn't be so successful."* `(>6:28)`

The association of "success" and "up" is certainly rooted in a culturally coded symbolic quality, as well as metaphorical dimensions, for instance from the image of the pedestal in sports, or the executive floor in a corporate building. But, following van Leeuwen (1999), meaning potential is also grounded in universyl bodily experience, such as the joyful jump, as opposed to the falling to the ground when losing[7].

I will return to pitch later in the Chapter about anthropomorphism (Chapter 16.5).

[6] During the discussion about the possibility of using a more simple pitch modulation to communicate the movement of the elevator, a participant notices the need for a reference pitch `(>15:10)` which is also proposed in Auditory Display literature (Walker and Nees, 2011).

[7] Again, we might object, in sports like football throwing yourself on the knees or even on the stomach is also associated with success, but in this case the movement is executed in a controlled way, under bodily tension. This diversification again is an indication of the impossibility to reduce human communication and expression to simple, one dimensional parameters.

18.2.2. Analogies in Relation to an Object's Visual Quality

The investigation of possible correspondences between visual and auditory qualities is certainly more common than the study of other modality combinations. Gestalt theorists, for instance, found that participants would associate the word "maluma" with a rounded shape, and the word "takete" with a polygon with sharp inflections (Köhler, 1929). It is somewhat surprising, however, that the audio-visual correspondence was relatively rare design or interpretation strategy. One case that can be investigated in this context is the Intelligent Shower TAIK 2010 (PD48, on page 82):

> *Presenter: "Yeah we searched kind of electricity like sounds or sounds that remind somehow from the bright light situation. From this picture [refers to projection behind the stage] you can't see the light changes (...)"* `(>48:22)`

The designers here use the word *"remind"* which indicates that they were not consciously looking for an actual crossmodal correspondence in the sense of a "immediate" sensorial relationship, but rather a cognitive approach. In fact, their actual design intention was to work with sounds associated with electricity. The result however uses high pitched tonal sounds, slight dissonances and glassy notes rather than sounds of actual electricity (such as the recording of a static discharge). This shows that a crossmodal correspondency was at play at least intuitively.

In the same quotation also an analogy to mental state and light emerges:

> *"(...) for the refreshing one it would be nice to have bright light walls and then it darkens a bit for the relaxed shower."* `(>48:22)`

We see – again – that the conceptual approaches and design strategies, as well as interpretation, emerged from a complex interplay of references. In this case, concepts like "relaxed" are interpreted in several modalities (vision and audition), we could say that it is the experience of relaxation which contributes to the cross modal design, as much as the sensorial correspondence.

18.2.3. Analogies Based on Object Size

Another well explored crossmodal analogy, which is based on actual acoustic phenomena, is the relation of smaller size with higher pitch (Spence, 2011). An example case, using crossmodal analogies based on overall dimensions of the artifact, comes from The Elevator TAIK 2009 (PD 15, on page 67):

> *Presenters: "It ended up to be this kind of sounds for a huge elevator for a huge enterprise in Dubai or something."* `(>15:34)`

First, there is the size and weight of an elevator. This is emphasized by contextualizing the artifact in a extraordinarily rich setting of an oil state which makes exaggeration a plausible design strategy. This is reflected in boomy sounds and the use of reverberation[8].

A strongly contrasting example comes from the Sonic Paper DD ZHdK 2009 (PD 40, on page 79). This scenario focused on subtlety, and fine, small objects. The following quote illustrates a relationship of less information and smaller size with a "thinner" sound:

> *Participant: "(...) when you fold it, the surface of the information decreases, the sound becomes thinner."* `(>40:2)`

The design works not only from the point of view of metaphorical "amount of information", but in fact also corresponds to the small, fine character of the object (paper) itself. Again, referential systems interact and integrate in the interpretational process.

[8] This could be compared to the use of boomy bass sounds in the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37), but in the case of the "huge" elevator, the actual physical size of the object becomes more important than the demonstration of status alone.

Finally, in the SONIC PUZZLE IAD ZHdK 2010 (PD 70, on page 89), the pitch of the sounds was associated with heaviness in a seemingly unintuitive way: Higher pitched sounds were played when the overall volume of the construction and thus, according to the creators, the imagined weight increased (>70:9). This mapping does not build on a "natural" phenomenon and the associated crossmodal analogy, but rather on a narrative paradigm: the progression from low to high underlines the progression of the construction. This mapping lead to confusion, also because the narrative – or dramaturgical – aspect was not communicated.

18.2.4. Analogy Based on Physical-Material Movement

Relationships between artifact properties and sound design can also be built on the grounds of physical behavior, which in the case of sound, with its intrinsic relationship to physical processes, is not necessarily a metaphor. The designers of the ASSEMBLY LINE DD ZHdK 2008 (PD 5, on page 64) state:

> *Presenters: "(...) we discussed (...) what does the screen not do in this moment, it is not shaking, has a continuous movement, and then we transferred this to the sound."*[9] (>5:36)

In this case, the sound design strategy was inspired by the object's properties, more specifically: its moving behaviour. In this case, the movement is defined as "steady, continuous", and is both including a possible movement of the windscreen, or its shape.

18.2.5. Analogies on Formal-Aesthetic Levels

Analogies were not only built on concrete objects, or their behaviors, but also on more general, and abstract, properties or concepts of abstract phenomena. Consider the following quote from the SONIC PUZZLE IAD ZHdK 2010 (PD70, on page 89):

> *Participant: "This from the beginning I liked, it seemed clear to me, in the beginning one built just chaos with the white bricks, the music thus sounded chaotic then, when they built this beautiful white pyramid, it sounded beautifully clean."*[10] (>70:2)

The participant associates between *"building a chaos"* and *"chaotic music"* which becomes *"beautifully clean"* when a *"beautiful pyramid"* is built. In this case we have an analogy between the experience of a form, or structure, qualities and a sound rather than the concrete form itself. The property of the form are abstracted as being "chaotic", which is reflected in the sound. In a later stage of the interaction, a monochrome geometrical form emerges, which also was reflected in the sonic quality. The two qualities of the design, form (or structure) and sound are complimentary, redundant, and thus perceived as a consistent whole. The following statement can be understood in a similar vein:

> *Participant: "I suppose this was clear, more complex, more moved, somehow. (...) what I certainly did hear now, there is more movement and more beeping when it is built irregularly, and when it is built more regularly it becomes rather static."*[11] (>70:12)

[9] *Presenters: "...haben wir diskutiert (...) was macht eine Scheibe jetzt nicht, sie zittert nicht, hat eine durchgehende Bewegung, und das dann auf das Geräusch übertragen."*

[10] *Participant: "Das vom Anfang habe ich schön gefunden, also es hat mir noch eingeleuchtet, am Anfang hat man mit den weissen Steinen einfach ein Chaos gebaut, die Musik hat da so chaotisch geklungen, als sie dann diese schöne weisse Pyramide gebaut haben hat es schön sauber geklungen."*

[11] *Participant: "Das war glaub ich klar, komplexer, irgendwie auch bewegter. (...) was ich jetzt sicher gehört habe, es hat mehr Bewegung und mehr Gepiepse wenn es unregelmässig gebaut ist und wenn es regelmässiger gebaut ist wird es eher statisch."*

From this statement we see that the formal properties were associated with temporal properties of the music, and the quality of the perceived "movement" in sound. There is a relation between complexity and increased movement in the sound, when the construction becomes more complex. If it was built more regularly, the pattern would become more static. This aspect relates also to the discussion of using musical codes and conventions in the design (see Section 20.1).

18.2.6. Supporting Common Classification Through Crossmodal Analogies

In general, crossmodal analogies could contribute to coherence in design by establishing common classifications of the artifact's (sensorial) properties and by supporting consistent characteristics. The MATCHMAKER UDKL 2010 (PD 58, on page 85) is a good example of the importance to carefully deal with sonic references to stereotypes and the interplay between an object's identity and a sound's characteristics. Again, we encounter the notion of "(techno-)magic", which is discussed also in relation to the impact of filmic stereotypes in Section 17.4.5:

> *Participant: "I think it is also some kind of magic because of the object itself."*
>
> *Presenter: "Actually that's why I wanted the snow-ball."* `(>58:8)`

In this case, the association to the concept of "magic" (and the related stereotype) was much less problematic than in other cases. This was, on the one hand, due to the fact that the sound design was not built on too prominent filmic sound clichés. Another important reason was, that the design was motivated by the object itself, as well as the interaction scenario. The snowball is an object that offers us a virtual miniature reality, it simulates the experience of snowfall in a winterly landscape in a miniaturized way, but with a surprising physical accuracy. From the point of view of narrative and cultural codes, snowfall is often associated with fairy tales and magical settings. Furthermore the object has a very contemplative side. Going on in the interpretational discussion, a participant states:

> *Participant: "... and there when you take it there's this magical psycho sound which is correlated with the small pieces that are inside, like clic clic clic."* `(>58:26)`

This quote is another good example of cross modal analogy as the basis of establishing a relation between sonic and more general formal aesthetics. The granular sounds of the prototype, called *"magical psycho sound"* by the participant, was inspired by the object as well, or more precisely, to the granularity of the snow particles. Also it was not identifiable as sound of a specific source, thus disembodied. This was emphasized by its looping, almost mechanical texture, combined with sounds which were too tonal to be "natural", and the metallic impacts. Together, these qualities contributed to a sound which was familiar and alien at the same time, and lead to the "magical psycho" attribution. Also, the modulations of the sound were related to the gesture of the interaction (moving object from and to body) and functionality (activation, deactivation) and this relates well to the narrative "standards" we are familiar with: "Magic powers" are executed through touchless gesture.

19. Simultaneity of Abstract and Concrete, Indexical Qualities

The following sections report about interpretational phenomena and design decisions building on abstract sonic qualities as their main expressive means. It soon turned out, however, that there is no clear line between the abstract and the concrete (indexical): The amount of quotations collected under the related codes[1] suggests, that abstract and concrete qualities of sound were both effective and quite widespread in design and interpretational discourse. While the two codes sound similar, the describe different phenomena: while the former focuses on the sounds themselves, the latter focuses more on the concepts associated with sounds.

19.1. Abstract Sonic Qualities as Interpretational References

In many cases it turned out, that abstract sonic qualities, as opposed to concrete, identifiable, indexical sounds, played an important role in the interpretational process, providing "interpretational hints" or a specific impetus[2]. This could be the case also, when interpretation seemed to rest mainly on indexical or metaphorical aspects of the sound design. Also affective qualities were intentionally looked for in the design process of several projects[3].

A sonic quality on its own could lead to a correct interpretation, as in the case of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73). The interpretation process first started with a certain degree of confusion:

> *Participant: "There was a dull rumbling which I could not attribute."* `(>25:2)`

The participant describes the sound based on its perceptual quality, and the attribution is not obvious. But in this case this was not a problem, because the sound was not meant to be clearly attributable to a specific source or information, but was meant to indicate the basic activity of the system. The interpretation went on:

> *I: "Could you find the connections?"*
>
> *Participant 1: "With movement."*
>
> *Participant 2: "With energy."* `(>25:4)`

Participant 1 refers to the movement of the presenting person. The movement indirectly affected the pitch of a steady tone, and this steady tone was interpreted as "energy". Thus the association with energy was based on the sounds quality, but also to our listening experience of electric devices such as fridges. While such interpretations are rather general, they can serve as a good basis for an sustained interpretive process.

> *I: "Do you have an idea what these sounds could express in relation to movement and energy, and why?"*

[1] The code "sound des. strat: combining abstract with iconic/indexical sounds" contains 10 quotes from 9 cases and the code "sound des. strat: trying to link abstract concept to sonic properties" contains 12 quotes from 9 cases, both codes having two overlapping quotations.

[2] The related code, "explicit reference to sonic quality for interpretation", contains 11 quotes from 7 cases.

[3] "Affect" as such did not emerge as coding category, but a similar code, "sound des. strat.: trying to link abstract concept to sonic properties", contains 10 quotes from 9 cases.

> *[silence]*
>
> *I: "Did it remain unclear? Did you hear maybe stuff like energy raising or lowering?"*
>
> *Participant: "Only when he moved."* `(>25:5)`

After the silence I am giving a hint to the participants that it could represent "energy raising or lowering", which a participant then implicitly confirms, relating it to the demonstrator's movement. The formulation of the statement however makes it clear, that he immediately got the idea of lowering or raising energy, so that was clear, but the "cause" was not, but it seemed almost obvious after the hint[4]. This is encouraging, that such a design may work indeed very well after a very short learning period.

In some cases, the participants refer explicitly to designing the frequency spectrum. This was sometimes based on rather technical considerations of working with the spectrum, as in the Toilet Soundscape TAIK 2009 (PD 22, on page 70):

> *Presenters: "We needed to fill in the higher frequencies because a lot of the sounds we used were very low and sort of deep and if you are peeing it's that very high sort of tinkling sound."* `(>22:17)`

Apart from the technical goal of making the sounds perceivable in the mix, the design aims at masking the embarrassing sounds produced on a toilet, with sounds that are in a certain aesthetic proximity, without having the actual indexical quality.

The affective quality of certain timbres and frequency spectra also was discussed. In the demonstration of the Doc-O-Mat UDKL 2010 (PD 60, on page 86) the doctor intervenes with the lover's interactions, which produces a fine, high pitched metallic sound. I state that:

> *I: "It's exactly this very fineness but still perceivability of the sound, and this pure quality, that distracts. You get the attention away from the physical experience of love to this 'what's that clinging thing'? And this again helps the case of the doctor, to get you away from there."* `(>60:24)`

Also, in relation to the demonstration of the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97):

> *I: "There was a very bassy full thump. I interpreted that as the system kind of says 'no its enough, enough events happened, I can judge or help you judge each other', kind of this, 'whoommp'. Also it related to me with the starting sound."* `(>86:16)`

Here, the abstract spectral sound quality is final, confirmational, but also provides a semantic link to the start of the interaction.

One approach to work with abstract sonic qualities was the deliberate use of (referential) sound qualities and the search for abstract affective qualities in physical materials at hand. The following quote from the final presentation of the Bag to the Future TAIK 2010 (PD 47, on page 81) shows how participants were looking for abstract sonic qualities. The presenters reported about their attempt to explore the "natural" sounds of the object as a possible starting point for finding a suitable (abstract) sonic language:

> *Presenters: "We recorded the sound of the bag as well, leather (...) We worked with reverse, (...) it was interesting to play with the actual object, placing a microphone and just record the sounds. Because we managed to get some funny sounds out of it. Really surprising wet sounds and you [didn't know that it's] leather."* `(>47:11)`

Evocation of emotion and affect contributed to the interpretation in the following example from the same demo case:

[4]The dialogue also suggests that the participant had this association already earlier, but was not quite sure about it, or did not state it openly.

Participant: "(...) because there was this like this kind of 'kchchchch'."

I: "'brrrrrr', did you fee this was aggressive?"

Participant: "A little bit like..."

I: "Ok.. scary maybe also, I mean, the scariness here came also maybe from the... it's strange, it's unexpected."

Participant: "And the other ones are like clinging sounds like clearly like objects, adding more objects but then when I dropped it there was something like an animal, something more alive. So it was like the bag was telling you don't drop me. But the object when they go it's sort of like the objects telling (...)." `(>47:1)`

The interpretation refers to several dimensions experienced through or expressed by sound. We find associations with vocal expression, sonic quality (roughness) and the sound's strangeness and unexpectedness, which again could be related to the systematic and aesthetic contrast to the more indexical, source oriented sounds of the design. These interpretational dimension are not constituting a fixed set of criteria in an interpretational matrix, but rather work as interpretational affective force field, affording certain interpretational tendencies.

In the demonstration of the ASSEMBLY LINE DD ZHdK 2008 (PD 5, on page 64), a notion of instability and various levels of "quality" were apparent:

Participant: "...you are controlling it and it rattles and clatters and then at some point there is this full-bodied sound with high quality, and then it is being forwarded to the next step." `(>5:25)`

Rattling and clattering are both intrinsically associated with low build quality, and in this sense has an indexical quality. The designers chose to introduce a new sonic dimension for the "high quality" state, which conveys a final state of completion and high quality through its full-bodiedness and rich timbre.

In the case of the MOODY HAT DD ZHdK 2008 (PD 6, on page 65) both the rather abstract sounds and their sonic staging contributed to the interpretation:

Participant: "First the sound came from outside of the object, I think? (...) First there was this surround and then the rest developed inside the hat. (...) The hat presented itself (...) very inviting, but also alive, with its own dynamics, thats how I understood it." `(>6:5)`

The scenario is comparable with the following one from the MATCHMAKER UDKL 2010 (PD 58, on page 85), where a sound discourages to take an object, but the means of sound design are different:

Participant: "(...) this first stage, when the thing is on the chair, and you want to take it then the sound is actually not really encouraging you to take it."

I: "Not encouraging?"

Participant: "No. because it's like 'shshshshshshhs'."

Participant 2: "It is aggressive."

Participant: "...and then when you take it there's this magical psycho sound which is correlated with the small pieces that are inside, like 'clic clic clic'." `(>58:1)`

This example shows a relatively immediate effect of the sound on the listener, in the sense that it has an *affective quality* that informs meaning making. Through its sonic expression, the object is perceived as suspicious, even aggressive. The affective quality most likely biases the interpretation of subsequent sounds, as being both "magical" and "psycho", as discussed above.

During the presentation of the Foley mockup of the Matchmaker UDKL 2010 (PD 52, on page 85), when the artifact was held close to the person, the sounds transformed into very fine granular structures, evolving over time. This was perceived as "melting with your person", but not in the sense of melting due to heat, but more in the sense of utmost proximity, expressed by an intimate, gentle whispering. Two exemplary interpretations of this mockup were:

> *I: "Ah that was nice. Then it disappears into something smaller. I think it is now in the can."*
>
> *Participant: "Yeah it's kind of there."* `(>52:5)`

This can be read as: I don't perceive the disappearing in the can directly, only the shrinking and disappearing, and then allocate this to the can. Another interpretation was:

> *Participant: "(...) it's the contact between them."* `(>52:5)`

Both interpretations are valid for the given interaction scenario. They express the two inherent design qualities: a sound that gets "smaller" and disappears[5] and a sound that reminds of whispering. It also shows that such an abstractly narrating sound can be very enjoyable and interesting to listen to, by exhibiting sonic features that makes the sound pleasurable to listen to. Many examples indicate, that this pleasure is not (only) a result spectrotemporal feature of a sound as such, or based on indexical qualities, but can emerge from a certain temporal process and compositional development. The whole project is actually a good example of the attempt to sonically convey abstract processes and concepts rather than using referential sonic indicators. In particular the finish of the interaction was discussed, where a noise-like sound, combined with metallic buzzing and crackling was "swallowed" in a filter sweep:

> *I: "There is some narrative or dramaturgy that builds up (...) but then you have an influence by saying, ok now I've got enough of this, and you put it down, and this moment is where the sound doesn't just stop, but is kind of swallowed into this little thing."*
>
> *[Several Participants]: "Yeah."*
>
> *Presenter : "It should be taking a piece of you (...) when you put it down."* `(>58:9)`

Finishing the interaction process is not achieved by simply muting its associated sound, but as expression of the narrative of "swallowing", achieved with a sound of something emitting a sound being gradually encased. Thus the sound design was rooted in a "real world phenomenon" (see Section 18.1), but using a relatively generic sonic component of this process, which is a filter sweep, instead of representing a literal process of putting something into a box.

In the context of the final Doc-O-Mat UDKL 2010 (PD 60, on page 86), an additional mode of affectivity emerges:

> *I: "It's exactly this very fineness, but still perceivability of the sound, and this pure quality, that distracts. You get the attention away from the physical experience of love to this 'what's that clinging thing?'. And this again helps the case of the doctor, to get you away from there."* `(>60:24)`

We encounter here a sound "standing out", contrasting to the remaining sounds. The sound does not function to illustrate or express an attribute of an object or an interaction. It rather works as foregrounding device, which also has a disruptive effect, "distracting" the listener from a previous process. The sound itself was based on the recording of a bell, but this potential causal index was quite irrelevant in the interpretation. The sounds thus exhibit an affective quality based on their sonic qualities, such as sharpness, salience, or disruptiveness.

[5] This example relates also to code "interpretation related to abstract quality of function", which is that something is stored inside an artifact.

As these examples show, the affective power of sonic qualities would often work in context of other interpretational dimensions, e.g. source-identification based metaphors, but also gestural qualities of sounds. The sound for the login of the doctor into the patient's body monitoring system is a good example:

> *I: "It's not just a gesture of sliding in and intruding, but also it's a noisy sound, it's not a tonal sound at all, but It'a also not a rhythmical sound, it's kinda going in."* `(>60:25)`

The sound does not fit neither in a musical category (e.g., tonality, rhythm) nor an indexical category, and thus worked only on a gestural-affective level. The timbre contributed to this as much as the temporal structure as a dynamic spectro-temporal development.

The next example, originating from the discussion of the Intelligent Shower TAIK 2010 (PD 48, on page 82), relates the (intended) effect (a refreshing experience) to sonic qualities, both in relation to material properties and musical notions.

> *I: "The morning sound was supposed to be refreshing and I noticed a lot of metallic high-pitched sounds there and less extended tonalities, the second sound had more of these, also more tonal sounds (...)."* `(>48:3)`

My listening identified both metallic qualities and the "pitchedness" or the sounds, and a change in "tonality" or amount of tonal components. The attribution to "refreshment" emerges based on the sonic quality, and also in the difference to the sonic quality of the "relaxing" version of the shower.

The prototype of the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77) used distortion of a given sound to express a transformation or give an information about a continuous change.

> *I: "(...) it is not traditional anymore [in terms of being an Auditory Display] that you use distortion on various levels as form of representation, which is not very parametric, but it can also be felt intuitively what it could mean (...) it is not simply parameter mapping, but you work with (...) sound qualities to express something."*[6] `(>38:16)`

In this example, the distortion effect conveys the abstract concept of a process getting somewhat pushed to a border with the danger of "losing grip".

Similarly, in the AcuPot DD ZHdK 2009 (PD 39, on page 79) works with sonic qualities and their transformation in the process:

> *Participant: "It has a digital feel..."*
>
> *I: "... something distorted, electronic, not so much digital, rather analog, distorted..."*
>
> *Participant: "... the noise."*
>
> *I: "... has something brute, it is certainly not a plant for a sophisticate."*[7] `(>39:4)`

In this case, the sonic quality – despite a disagreement if it was "analog" or "digital" – is an aesthetic attribute of the product itself, rather than related to an isolated functional design element, but still stands out sufficiently to be noticed in the interpretational process.

Transition is also an important element of the interaction in the Matchmaker UDKL 2010 (PD 58, on page 85):

[6] *I: "(...) es ist insofern nicht mehr traditionell, dass man Verzerrung auf verschiedenen Ebenen als Darstellungsform nutzt, die nicht sehr parametrisch ist, sondern sehr intuitiv auch gespürt wird, was es bedeuten könnte (...) es ist nicht einfach Parmeter Mapping, sondern es wird mit (...) Klangqualitäten gearbeitet, um was auszudrücken."*

[7] *Participant: "Es hat eine digitale Anmutung..."*
I: "... etwas verzerrtes, elektronisches, weniger digital, eher analog, verzerrt ..."
Participant: "... das Rauschen."
I: "... hat etwas brachiales, ist sicher keine Pflanze für den Feingeist."

> *Participant: "And then it obviously likes when I bring it closer, and think about this, so it starts to make a warmer sound (...)"* (>58:3)

Here, the sound is modulated with a filter and pitch shift in such a way that it transforms from a rather harsh to a rather dull, soft sound. The transformation accentuates the warm quality of the final state.

These examples suggest, that the sonic quality becomes meaningful not only as static property, but also in its *transition* - in fact the transition might play an important role in directing attention to the sonic quality (for further examples of transitions and transformations see Section 23.1.3)[8].

In the discussion about the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97) we see another case where various versions of the same event or process can be differentiated by varying the sonic quality. This leads to the correct interpretation of varying qualities or levels of matching between the dancers:

> *Participant: "I thought you were listening the same music, because of the synchronicity of the dancing, so the process is you find a much in interest, music, perhaps, and the device is playing the same thing. So you can start 'oh', I think , and there is different levels of match as well."*
>
> *I: "Even different qualities, I had the impression."*
>
> *Participant: "Yeah, different qualities."*
>
> *I: "Because you had a match also in the second."*
>
> *Participant 2: "Yeah but it was increasing."*
>
> *I: "It was breathing as well, a lot, but it was different."* (>86:4)

In this case, while the sequence and structure of the two examples are identical, the sonic quality differentiates them. And even the indexical sound of breathing left room for attending to the sonic quality. This relates to the discussion of the relevance of structure and composition covered in Chapter 23 and Section 27.6.3.

Last, but not least, sound quality may serve as representation of rather abstract dimensions, such as "positive" or "negative", but also can work as interaction invitations, or affordance, as the following quote from Explorations UDKL 2011 (PD 82, on page 95) shows:

> *Participant: "This last sound was very different from the others, why did you choose this? The positive sounds was clearly synthetic, while the other ones were, if not organic, at least mechanic."*
>
> *Presenters: "The positive sounds are more magical, more spherical, maybe more enticing to check it out. Whereas the other sounds were clearly like audible warnings, like flees or bees or tiger..."*
>
> *Participant: "I kind of liked this (...), you have a more visceral reaction to it because you know them. And the last one you are like: what the hell is this? What makes this sound."* (>82:26)

As we can see from this example, apart from what a sound may represent, it is about some kind of "effect" it has. This effect also here is a result of affective dimensions of aesthetic experience and

[8] The phenomenon that a sonic transformation, or the particular sonic quality can be meaningful is also described by Clarke in the context of "ecological music analysis" (Clarke, 2005). In an analysis of Jimmy Hendrix' rendition of "The Star Spangled Banner" at the Woodstock music festival in 1969, Clarke shows that the transformation of the sound quality - apart from the deconstruction of the melodic line - is transforming the conventional meaning in a substantial way, mixing the mere distorting power and roughness with indexical notes (such as sonic imitations of explosions and sirens). Another similar example would be the intonation of voice when speaking, which can substantially alter the meaning of a statement and always happens in mutual interaction with the words and their "conventional" meaning.

representative sonic codes such as "flies or tiger". But even the latter sounds do carry affective qualities: the nastiness of the flies dissonant hum, and the gut-wrenching power of a tiger roar.

In the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97) the representation of "better match" was achieved by changed qualities and attributes of the music. Here the idea of ecstasy and flow shines through, the better the players match, and the more they interact, the more the music gains momentum, which again affords more energetic dancing.

In general, analogies between the perceptual quality of a sound and a quality of a process or event was a common approach. For instance, "softer" sounds, that is, sounds that tend to be judged as warm, not harsh, or that have smooth attacks, are associated e.g. with a "softer" attitude.

In this way, sound design can link an abstract concept with sonic properties. This can be relying on analogies to real world sound events or processes, such as those described in Section 18.1 but also to perceptual sonic properties.

19.2. Combining Abstract with Indexical Sound Qualities

It turned out that abstract sonic elements or sonic qualities were usually not used in isolation, but often combined with other interpretational references, for instance indexical aspects[9]. As the following examples show, the interplay between these two seemingly differing references can be set up within one sound (or more sounds, if they are perceptually "fused") or in the combination of two distinct sounds.

A first example demonstrating the potential of the approach of combining abstract with indexical qualities comes from the presentation of the Sonic Car Boarding Project 2 from DD ZHdK 2009 (PD 35, on page 75). A participant stated:

> *Participant: "The other sound, in the first example, where you sit down, (...) and this bass sound comes, this is well done. You are not yet sure, you are simply there. But the security with the click should be there in any case. If you could combine the two, that would be great."* `(>35:18)`

In Section 16.1 we have discussed the use of water sounds as identifiable sound indices. In some cases, the water samples used were not indexical, but rather conveying the association with (or experience of) moisture. One example is the design of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *I: "They lose their watery quality, or the water-indexical quality, it might retain something like moisture, but it isn't clearly audible as water like in a river."* `(>25:29)`

This case shows, that there is a thin line between combining various interpretational hints, in particular when combining the indexical dimension of a sound with its affective quality or its ability to evoke cross-modal associations.

The sounds of electricity and tension in the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76) with the application of an "alarm" sound when the door is not closed entirely, are also an example of combining two interpretational hints. When I ask for a description of a sound, a participant states:

> *Participant: "Electric, a bit like a tesla coil, no, something like a gap."*
>
> *I: "Like a tension."* `(>37:4)`

This seems also to indicate, that those indexical sounds, who's identification lies on a rather vague memory (for instance, the sound of a tesla coil discharging) can contribute positively to the acceptance of multiple types of interpretational hints in one integrated design.

[9] The related code "combining abstract sonic elements with iconic or indexical components" contains 10 quotations from 9 cases.

Finally, in the Bag to the Future TAIK 2010 (PD 47, on page 81) we encounter another good example of how sonic quality often was one of several elements that was intended to contribute to the interpretation. When designing the sound for the bag being dropped, one intention of the designers was to convey something breaking apart, but not in the hard and definitive way, as it would be case with a sudden impact. It was important for them to acknowledge the softness and elasticity of the object, in their words *"trying to make it suitable for a bag"*. At the same time, the resulting sound was aesthetically different from other bag sounds. The sound was clearly categorized as a "purr"[10], but managed to convey a general animal quality, rather than the specific index to "cat". The design and its interpretation was led by both the diffuse notion of an animated presence and the notion of energy dissipation after an impact:

> *I: "(...) It sounds very different (...) a missing edge, the metal note was gone, it was definitely more on the organic side. (...)"* `(>47:3)`
>
> (...)
>
> *I: "And the purr. Maybe we can say something about the purr. When you drop it."*
>
> *Presenter: "The breaking thing... we wanted to have an element of something breaking or like it's not whole it's not like a clear sound of something and not like too much.. like (...), one impact. Trying to make it suitable for a bag." (...)*
>
> *Presenter 3: "... there's a (...) decay ..."*
>
> *(...)*
>
> *I: "Was our interpretation correct that the intelligence of the bag is a little bit complaining about how it's being treated?"*
>
> *Presenter: "Yes." (...)*
>
> (...)
>
> *I: "It's just also funny, because you could also imagine that your bag is made out of fur, or animal leather, and the animal is still there somehow, the spirit of the poor vermin, or the fox or a crocodile... with a lot of reverb [laugher and imitation of animal sounds in audience]."* `(>47:10)`

The association with a purr, the sonic gentleness and moderate, organic quality all are integrated into a single, multifaceted narrative, a sonic "character design" of the bag, which helps to form the relationship with the user. Thus, this is a good example of a relatively complex interplay between indexical (yet still somewhat general) and abstract sound qualities.

On closer inspection of some designs, it turned out that intended representations were not necessarily established by referencing a (naturalistic) source. The examples show, that also "abstract" sound quality, as intrinsic experience of sound, may contribute to a "representational" meaning of a sound[11]. Designers may have had representational functions in mind, or listeners may interpret sound quality in terms of what it represented, in addition to its affective quality.

An example of a referential function of sound quality can be drawn from a statement of the designer of the Assembly Line DD ZHdK 2008 (PD 5, on page 64), who wanted to *"reflect the quality expectations of the customers"* `(>5:29)` in the sound. In this case, the sound encodes quality through properties such as decreasing dissonance, which, however, also implies an affective component.

Sonic Properties were also sometimes representationally related to values, and emotional or moral qualities. An example is the use of a sound to convey "purity", not as an abstract sign, but as part of the sonic quality merged with the indexical component of the sound, in the Explorations UDKL 2011 (PD 82, on page 95):

[10] This example also was discussed in relation to zoomorphism, see 16.5.

[11] The related code, "indirect, 2nd order representational meaning of sound quality", contains 7 quotes from 6 cases.

> *I: "And then there were the glass sound which maybe were more signifying something like purity."* `(>82:12)`

Here we have a sound which is both an index to glass (and hence purity) but also through it's sinusoidal and high-pitched nature is perceived as "pure". Hence, we see that affective qualities may always play a role and color interpretation, or even provide decision making impulses.

The borders between abstract sonic quality and referential qualities often blur. For instance, a common way of speaking about sound is by associations with materials, which in turn are associated with certain sensorial experience. A point in case are metallic sounds, which are often associated with coolness, as here in the discussion of the Interactive Frying Pan TAIK 2010 (PD 45, on page 81):

> *Presenters: "Like this [sound] we thought it a bit cooling, for some reason, because it has this kind of ice or metal (...)."* `(>45:16)`

In relation to the action of taking something out of the bag in the Bag to the Future TAIK 2010 (PD 47, on page 81) demo, a participant states that:

> *Participant: "I would guess that the sound with the afterthingy is something more precious. And the simpler sound is something not so important."* `(>47:20)`

The sound referred to as "more precious" was a resonating, metallic impact with a clearly perceivable decay. The specific combination of a metallic notion with the fadeout, was the relevant design property motivating the interpretation and was supported by the perceptual contrast to the dry, simple sound, yet still it is also part of a potential index to metallic objects in the bag.

19.3. Figurative Synthetic Sounds

A special case of designs between abstract on concrete are those sounds, which imitate some real world sound using synthesis. This can be interpreted as means to establish indexical associations while avoiding a naturalistic presence of the represented sound event. When looking at the design cases related to an interplay between abstract and concrete elements in interpretation, it turns out, that the actual sounds used for providing indexical interpretational references were not necessarily based on recordings of the actual sources, but often sounds were designed (or chosen) for their ability to figuratively "sound like" something[12].

In the analysis, several codes related to figurativity were grouped. The code group was attributed to seven cases altogether[13]. In the following, we will have a closer look at the related outcome.

19.3.1. Imitations of Sounds of Water and Wind

An example of a synthetic sound imitating a natural pattern appeared in the first draft of the Intelligent Shower TAIK 2010 (PD 46, on page 82). Here, the showering was accompanied by a impulsive, repetitive tone, which would raise in pitch. The sound reminded me first of a hopping ball, then of water bubbling or dropping into a bucket:

> *I: "[The sound] had also another property, something like a hopping ball."*
>
> *Presenter: "Yeah."*

[12] Chion differentiates between actual cause and the figurative cause / figurative hearing, which is about "qu'est-ce que cela représente" (Chion, 1998, p. 121). I understand "figurative sound" as representative sounds, which do not provide an accurate imitation of a specific sound, but rather share certain essential properties, that allow the listener to identify the referred (sound)source.

[13] This was also associated with code "combining abstract with iconic / indexical sounds", containing 10 quotes from 9 cases, and "trying to link abstract concept to sonic properties", containing 12 quotes from 9 cases.

I: "For me it related well to the idea of water 'bomm bada bomm bomm', this kind of fluid, not too regular movement."

Pesenter: "True, and also because it didn't have that quality it probably would be rather irritating. [plays sound]"

I: "Drops in a bucket, you know. 'Blib blib blub blu'." (>46:9)

The designers worked with the irregularity associated with water sounds, which fits well to the showering scenario but also prevents annoyance. They aimed for the *"idea of water"*, rather than the identification of water as a concrete reference in the sound.

Another example is the use of a figurative, synthetic "wind" noise in the design of a warning sound for one of the smart car prototype from the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76). The sound appeared when the car's door wasn't properly closed.

I: "And did you hear the sound when the door was not properly closed?"

Participant 1: "Yes, (...) I think it is cool. That signs are not always an annoying beep, but (...) close to the other sounds. (...) Electric, a little bit like an electric arc, no, something like a gap, where something is not completely closed."

I: "Some kind of tension, some kind of 'schschschschwwww'. It's not necessarily wind, which was, I believe, the first idea."

Presenter: "Yes, that was the first idea."

Participant 2: "But it still reminds a bit of that, how it really sounds when the door is not properly shut."[14] (>37:2 & 37:9)

The first design draft of the warning sound for "door almost closed" was very explicitly relating to wind as physical phenomenon. In the second version of the prototype, which is discussed here, it was transformed into a sound which, according to participants, had an "energetic" dimension. However, wind noises were still present in a combination of gentle whistling with broadband noise, and a shifting bandpass filter. The design is appreciated as an alternative to a trivial beeping sound, at least partially because of its sonic analogy to the "natural" wind sound that could be plausible expected when driving a car with an open door. Elements of figurative wind sound in the mix were sufficient to support this attribution.

19.3.2. Imitations of Engines

Another example of figurative sound based on synthesis is the prototypes of the Assembly Line DD ZHdK 2008 (PD 5, on page 64), where the sound design of the virtual engine sound was an imitation of a sound from an engine with a simple sine wave as starting point. The resulting sound can be compared to synthesized engine sounds of vintage computer games. The following statement from this case sheds some additional light on the question of figurativity. The discussion emerged at the end of the presentation, where the design of the sound already had been discussed:

Participant: "The engine was authentic. It sounded like an engine."

[14] *I: "Und hast du das Geräusch gehört als die Türe nicht ganz geschlossen war?"*
Participant 1: "Ja, das (...) finde ich cool. Dass Zeichen nicht immer ein nerviger pieps sondern (...) nahe an dem dran am anderen Geräusch halt. (...) Elektrisch also ein wenig ein Lichtbogen, nein, so etwas eine Lücke, wo etwas nicht ganz geschlossen ist."
I: "So eine Spannung so ein schschschshwwww. Es ist nicht unbedingt Wind, was glaube ich die erste Idee war."
Presenter: "Ja, das war die allererste Idee."
Participant 2: "Aber daran erinnert es immer noch ein wenig, wie es wirklich tönt wenn die Türe nicht ganz zu ist."

> *I: "It sounded like an engine, but not like an engine (laughing)."*
>
> *Presenters "It's the assembly of an engine."*
>
> *I: "It is actually already a translation by you that it sounds like an engine, because if I listen to a car engine or a recording of a car engine it sounds quite different. (...) This is some kind of Gestalt perception as we know from the graphical domain, or the symbolic, or the icon."* `(>5:45)`

In this case it was clear that there were few, but important, similarities between the figurative engine sound and the actual recording of an engine sound. Still it is interesting, that for this participant, the sound was authentic or rather: the sound was unambiguously identifiable as the sound of an engine. There is an interesting interplay between naturalism and figurativity, which does not rely in objective similarity or sonic simulation. In this particular case this might result from the fact, that a "natural" engine sound exhibits the same dominant qualities: tonality, a relatively rough timbre with plenty of overtones, and pitch modulation (as audible manifestation of the engines RPM) . Thus, the sound image is actually both culturally coded and relying on actual imitation (rather than reproduction) of the natural sound.

19.3.3. Imitations of Frying, Boiling or Fluids

Another example of the sound design strategy to use synthesized, figurative sounds appears in the discussion of the Interactive Kitchen VID 2011 (PD 74, on page 90). In this design, a synthetic interpretation of bubbling water was used to inform about the state of the sauce cooking:

> *Presenter: "When the frying is up then he should know it's about frying and when the sauce is up, then he's supposed to put the focus on this one."* `(>74:2)`

The bubbling sound used was associated with the sauce bubbling in the frying pan after it was poured there. The figurative, synthetic design of the sauce sound would not only support the differentiation of the interface sounds from the actual sounds occurring when cooking, but also the differentiation of various cooking processes, e.g. boiling and frying.

Another related example, the sound of the Thermos Flask TAIK 2009 (PD 18, on page 68) contained synthetic bubbling sounds which reminded some participants of *"boiling water"* `(>18:2)`. Also in the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77), we encounter a similar phenomenon:

> *Presenter: "This means 'tank is full' and 'tank is empty'. And it has something of petrol sloshing about in the tank."* `(>38:20)`

Here, some temporal sonic morphology is figuratively imitated to create a sound design that plays with the notion of "authenticity", without being too naturalistic. Again, the function of figurativity as "in-between" indexicality / iconicity and abstract sonic qualities is emerging.

20. Other Types of References

20.1. Musical Codes and Conventions

Several design instances and interpretational phenomena can be categorized as based on musical codes and conventions[1]. "Musical" here is defined as based on tonality, (western) harmony and melodic elements. As such, musical sounds are abstract, in the sense of not referring to a acoustic sound source (except for the instrument as such).

20.1.1. Tonality, Harmony and Rhythm

The designers of the Intelligent Shower TAIK 2010 (PD 48, on page 82) advocated a highly reduced approach to musical design strategies:

> *Presenters: "As far as tonality [goes], we tried to avoid chords almost entirely, there is (sic!) two tonal sounds actually, the suggestion of the shampoo and the acknowledgment from the shower when you give the command. And then the background (...), it plays random depending on the [situation]."* `(>48:30)`

Here, isolated tones were used similar to conventional notification "beeps", but with a comparatively rich timbral design. The sonic foreground was based on glass impact sounds and birds with delay loops. As sonic background, the system generated a ambient-style soundscape, with some tonal but dissonant elements in the background, which remind of the sounds of "singing" glass. The "relaxing" version of the prototype showed a stronger harmonic component and more conventional music composition, using synth chords with overtones and single bleeps, with a clearly perceivable harmonic keynote. When the water emerged from the shower, a reverberant sound of a river was added. The project thus combined musical elements and "musicalized" sounds of nature.

Another example is the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76), which worked with very simple musical elements, similar to "beeps", but combined a few tones to a short Earcon which is integrated as closing element of the overall process. In addition, various melodic elements were used.

Also the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77) used a musical approach, which the designer described as follows:

> *Presenter: "Here I just played a basic sound, which you notice, then you enter the car and this should be the battery level [plays second sound component with higher pitch], I was looking for something energetic, a positive signal, then everything is ok."* `(>38:17)`

This strategy builds up tones to form a meaningful whole which itself has a kind of experiential quality[2]. Not only the tone relevant, but also its *"energetic"* quality.

The project Explorations UDKL 2011 (PD 82, on page 95) used melody and harmonicity to indicate different states of the system:

> *I: "I noticed, you went around a bit, you were looking and then finally, I think the melody became clear somehow, when the match was made."*

[1] The related code "sound design strat: musical design patterns" contains 9 quotes from 6 cases.

[2] The resulting chord is a subdominant quart-sixth chord which is rather unstable and slightly dissonant.

> *Presenters: "We had different ways of telling how far [away] he is, for example play the poor sounds, but play them inharmonic, so he would know the general direction was there, and would get more harmonic and start to develop a melody the closer you got."*
>
> *Participant: "I was hearing some major tones when he was approaching and when he was a little bit far from me it turned into minor."* `(>82:21)`

Here the designers work with musical harmony: both the transitions from inharmonic to harmonic and from minor and major are intuitively meaningful. The harmony provides the necessary "background" for the emerging melody. In my perception these elements were combined to the notion that *"the melody became clear"*. This is an example of working with a specific musical strategy, in this case harmonicity, which then can be varied and adpted to different situations. Musical elements are particularly well suited for this approach, because they are part of a culturally established and shared system of tonal composition, such as theme and variation. This is also a central argument for using Earcons.

A more complex design, which actually builds on the idea of a musical game, is the Sonic Puzzle IAD ZHdK 2010 (PD 70, on page 89). Here we have an assuring, but gentle, sonic impulse confirming the user interaction, but the expression of the state of the building game is a generative tonal pattern, emerging from a steady synthetic tone. The designers state that:

> *Presenter 1: "We chose a calming noise, because the rest is rather chaotic sometimes. The result is that you create your own beat somehow."*
>
> *Presenter 2: "It is defined rather by rhythmicity, the rest by tones."* `(>70:5)`

What is called "rhythmicity" in this case was the emergence of a beat, which reflects the steadiness of the player's actions. The tonal and harmonic aspects however were more prominent in the design. The composition of the tonal components turned out to be "chaotic" at times by necessity, as it was meant to represent the degree of chaos (or order) in the user's construction. We can see that the design generally worked well. However, the mapping strategy caused some confusion:

> *Participant: "But height is associated with pitch isn't it?"*
>
> *Presenters: "No, weight. The more stones you pile up the heavier it gets."* `(>70:11)`

This example shows that the meaning of pitch was misunderstood[3]. From studies in multimodal perception (Spence, 2011) we know that the association of pitch with elevation, and thus with the metaphorical "height" of an attributed value (see also 18.2.1), is common. This leads to the phenomenon, that other attributions and mappings are problematic, at least when they are not sufficiently explained beforehand, or when the intended association does not result from the (sonic) context. This seems to be particularly true when pitch changes are as prominent and perceptually foregrounded as they were in the case described here. Still, attributing pitch and weight is per se perceptually valid, but the mapping polarity in this case was not chosen appropriately: Larger objects are commonly associated with lower pitch (another common crossmodal congruency) and usually are also expected to be heavier than small objects, which would support an (indirect) inverse mapping logic of pitch and weight (high pitch = small size = low weight).

Besides melody and harmony, rhythm is another main element of musical expression. The Dancing Matchmaker from TAIK 2012 (PD 86, on page 97) worked with rhythm as variable to indicate a good match. Rhythm would emerge from the (simulated) generative composition and could be more or less prominent.

> *Presenters: "And the music that was chosen there is now three different tracks the more rhythmic tracks are likely to occur when there are very good matches."* `(>86:14)`

[3]The related code, "sound-specific ambivalence: pitch without reference tone", has 4 quotes from 3 cases.

Although the approach is built on the idea of music being generated in real time based on the player's movements and matching parameters, the designers' statement shows, that they followed a "track" paradigm, where individual "pieces" would be clearly distinguishable, instead of a single musical system with seamless modulation of the degree of rhythmicity.

In the case of the PARTY MATCHMAKER TAIK 2012 (PD 84, Section 15.1), pitch was used as a very "technical" indicator of distance. The Participant trying out the application notices a pitch modulation but is unable to say much about it as it is too generic and there is no reference tone.

> *Participant: "It's a match, and the match is indicated by the rhythmical increase, or is it the pitch?"*
>
> *Presenter 1: "It's the same. Both."*
>
> *Presenter 2: "Actually, technically speaking, I would say the match isn't indicated by the sound at all. The change of the sound indicates distance."* `(>84:13)`

It is striking that the designers used a combination of increasing tempo and pitch as a double coding. As they are just coding a relatively trivial parameter, distance, this seems to be almost too much sonic complexity. But rhythm might add a certain sense of urgency, which the design scenario certainly would motivate.

20.1.2. Cultural Musical Stereotypes

Another musical design approach is the use of stereotypical musical elements or instrumentation in order to establish a cultural or ethnological reference. An example of this approach is the use of a didgeridoo sample in the CROCODILE TAMER TAIK 2009 (PD 19, on page 70) as a background sound for the interaction.

> *Presenter: "And then, since it was Australia, we needed a drone, we didn't have a concept, but Australia, drone, and human, like a human (...) versus animal, we thought like, hey didgeridoo, because it has the drone element, but it has human elements as well, a rhythmic struggle so we rely on that."* `(>19:20)`

The designers' intention was that the sound were the actual sound of the artifact being active and working, and at the same time should provide a cultural context ("Australia", in this case). But the latter aspect was so prominent in the perception of the sound, that it was not able to merge with the overall experience of the artifact, and stood out from the other aspects. The sonic object "didgeridoo" was, as it were, attached to the design as some kind of "informative label". In the discussion, I am using the metaphor of a "tainted sound":

> I*: "So this really all fits into this didgeridoo sound, but the problem is, the sound itself is so much loaded with this kind of cliché Australia, whenever you switch on the TV and there is an advertisement about Australia you will hear a didgeridoo on the background. So this is kind of a tainted sound."* `(>19:39)`

Thus, this case of an ethnomusically coded sound shows how the sonic signature of such a stereotype is so strong and in itself salient, that it manages to "take over" much of the attention, even if it is presented as a mere sonic texture or background drone. The question is, if such sounds still an be useful for the design. The designers also offered an argumentation which showed they were not only referring to the symbolic content of the sound, but also to a sonic quality: the didgeridoo combines a drone with the "human element" of the user trying to get control over the crocodile robot. And this process was meant to be shaped in a rhythmic way, in an attempt to create an abstract, musical quality for the interaction. However, the symbolic power and stereotypical nature of the sound was dominating the interpretation[4]:

[4]This is comparable to the dominance of the indexical I will discuss in Section 24.1 of Part IV.

> *Participant: "(...) but when he was kind of adjusting this stuff when he was doing it the right way it snapped to sound, this 'whowhowho', didgeridoo stuff, I don't know was it, it was more like some kind of gesture, like (...) 'shshshshsh' , I don't know."* (>19:4)

The didgeridoo in the end was perceived as some *"didgeridoo stuff"*, and the interpretation was unable to reach beyond this superficial categorization. and I suggest to *"take the morphology of the didgeridoo sound to some other level"* (>19:40) as a solution to get away from the cliché of Australian aborigines or world music. This "other level" could mean, for instance, that the timbral characteristics are replicated in another "sonic material".

We can find a comparable case in THE FRIDGE, UDKL 2010 (PD 50, on page 86). The project featured a "smart" fridge which made a yodeling sound when the door was not properly closed. According to the designers the yodeling was meant to symbolize Austria. Thus, as opposed to the didgeridoo sound, which was meant to be a rather loose cultural or geographical reference, here the reference was meant to be more explicit. It is remarkable that the for most participants, the comical effect of the yodeling dominated their experience and seemed to strongly limit the referential function to a cultural context of the sound.

> *Participant: "But why does a door yodel?" [general laughing]*
>
> *Presenter: "Because we're in Austria." [general laughing]*
>
> *Participant: "Ah, you're right, its the alps."*
>
> *Participant 2: "An Austrian fridge."*
>
> *Participant 3: "Did you [ever] see any Austrian yodel?" [general laughing]* (>50:6)

Participant 3 from this dialogue was Austrian, and in her case the design did not work, because the yodeling for her was not even a proper Australian yodel. And the question *"why does a door yodel"*, and the subsequent collective laughter, indicates that the sound was understood as an absurd, comical reference to something out of context of the object and its function (see also Section 27.7.3 for further discussion of this issue). Similar to the didgeridoo sound, this example points to potential issues associated with using sonic stereotypes, which originates simultaneously in their strong connotation with a particular meaning, and the fact that they easily fall "out of context". For further details see Section 24.3.

20.2. Spatiality

After discussing aspects of design and interpretation which can be related to the actual sound material, we now turn our attention to those aspects which result from some kind of interaction of the sound with the environment[5]. It is important to keep in mind, that this distinction is not absolute, but made based on the analysis of the discussions from the cases studied here and relates to conceptual categorizations rather than the actual physical "nature" of sound.

20.2.1. Spatial Extension and Distance

Phenomenologically, we can encounter sounds which seem to origin from a point in space, but also sounds that seem to come from nowhere, or surround us like a sonic envelope. Flückiger uses the term "extension" for the perceived spread of sound in space (Flückiger, 2001). Augoyard (2005) describes a range of sonic experiences that have to do with the spatial location and extension of a sound. One related phenomenon that was discussed could be called "spatial mixing", as appeared in THE ELEVATOR TAIK 2009 (PD 15, on page 67).

[5] A comprehensive overview over sonic phenomena that emerge from spatial, environmental interactions is given in Augoyard and Torgue, 2005.

> *Participant: "I guess I liked most the fact that you could actually hear also when you were leaving the floor, that there were some remains of those sounds. I liked that. Because there's a good transition towards the next one. That was a good feature."* (>15:23)

This is also a good example of how a sonic phenomenon, in this case the natural transition between sounds due to spacial movement of the sources, can become semantically charged.

Volume (in the sense of perceived loudness) is another factor associated with spatial movement and can lead to several interpretive strategies as can be seen in the following quote from the prototype of EXPLORATIONS UDKL 2011 (PD 82, on page 95):

> *I: "And the moment when the sounds disappear could just be that you went inside somewhere. You shut the door and went to a different situation."*
>
> *Participant: "Or just that everything else disappeared from the mind."*
>
> *I: "Yeah but then it would be again symbolic or evocative, more like filmic."* (>82:19)

The perception of sounds becoming more silent, *"disappearing"* (to use another visual metaphor), is here not only associated with semantic mixing (in the sense of fore- or backgrounding), but also the actual (or metaphoric) movement into another room, and even *"everything disappearing from the mind"*, which is a relatively common sonic film narrative enunciation (e.g. when a protagonist is in a highly focused state). But, it could also just mean that the sounds just finished, or their playback stopped. Thus, volume as only parameter usually leads to rather ambiguous results[6].

At the same time, there is the need to take into account the importance of the listener's perspective in the case of spatial paradigms, an aspect discussed in the following statement of THE ELEVATOR TAIK 2009 (PD 15, on page 67) discussion:

> *I: "...as somebody already mentioned, when you are in the elevator, you are relatively not moving, actually the world moves around you. (...) What moves, me or the world? So maybe this relates a bit to the question of who is in action, is active (...). So there's some general energy feeling that some energy flows around me (...) but not necessarily directly movement in space, but still after the energy has stopped flowing I'm somewhere else."* (>15:25)

20.2.2. Transition from General to Specific Audience

The perceived spatial extension of a sound also plays a role in establishing the relationship between listeners and sound, in terms of who the sound is addressing, an individual, a few, or many people. For instance, in the initial phase of the interaction with the prototype of the MOODY HAT DD ZHdK 2008 (PD 6, on page 65) the designers worked with a sonic transition from wide to narrow. More specifically, they worked with sounds that were perceived as more spatially extended and sounds that were perceived more like coming from a point source. In both cases the playback system was the same, the loudspeaker was in the same location. It was rather the sounds themselves, that provided the feeling of a larger or smaller spatial extension.

> *Participant: "First the sound came from outside of the object, I think?. (...) First there was this surround and then the rest developed inside the hat."* (>6:5)

This transition from an environmental sound, addressing potential bystanders, to a more private sound, was related to the interaction process from a social point of view. The aim of the "public sound" was to raise interest and attract potential wearers, also expressing a certain living quality that should stimulate curiosity and interaction. This interpretation is confirmed by the designers. At the same time, the sound was perceived as communicative act of a sentient object:

[6]This will be further discussed in Chapter 25.

> *I: "Exactly this sound, how do we interpret it?... For me, the meaning of the sound is, the hat senses its environment."*
>
> *Presenter: "Well it notices that something is close."*
>
> *Presenter 2: "And at the same time it is attracting you, and then when you get closer an touch him, then energy flows."*
>
> *I: "And with the sound you can express that the object has a sensory system. Without display."*
>
> *Presenter: "Exactly."*[7] `(>6:24)`

Thus, in this case, I correctly interpret that the hat senses its environment, and the sound expresses the object's sensitivity. This interpretation origins in a change of the spatial extension of the sound in relation to the user's approximation and subsequent manipulation of the hat, as it was noticed already earlier by a participant:

> *Participant: "The hat presented itself on a pedestal, very inviting, but also alive, with its own dynamics. (...) As soon as you own it you hear the person that wears it."* `(>6:6)`

This is also a good case for shift of location of agency which was well understood (this aspect will be discussed in Chapter 21). The case is also comparable to the Matchmaker UDKL 2010 (PD 58, on page 85), where the initial phase of approaching and grabbing the snow globe corresponds to a sound transition from wide to narrow, as means for the object to attract attention[8] and at the same time transitioning from public communication to private individual interaction.

20.2.3. Timbral Shifts and Spatial Movement

An anecdotical, yet interesting, phenomenon emerged from mapping of sound qualities to directional change[9]. We commonly think about this aspect in terms of mapping pitch to height, with high pitches representing higher points in space, as discussed above. The following quote from the The Elevator TAIK 2009 (PD 15, on page 67) however shows an interpretation of horizontal movement instead, which is not based on a panning effect in a stereo setup:

> *Participant: "... and actually it gave me the feeling that you are turning right, instead of (...) turning down... It was on the same level, you know it just changed maybe a third of the first sound or a fifth one, like, it just tried to give the tonal aspect but not the feeling of you are really accelerating to up. It just switched to another direction (...)."* `(>15.7)`

This perception of moving horizontally was motivated by a timbral shift, in terms of perceived tonal intervals (from third or fifth interval). The sound was perceived as steady, not accelerating,

[7] *I: "Eben dieser Klang. wie interpretieren wir den?... Für mich ist die Bedeutung diese Klanges, der Hut spürt seine Umgebung."*
Presenter: "Also er merkt dass etwas in der Nähe ist."
Presenter 2: "Also gleichzeitig lockt er einen an, und danach wenn man näher kommt und ihn berührt dann fliesst die Energie."
I: "Und mit dem Sound kann man ausdrücken, dass das Objekt ein Sensorium hat. Ohne Display."
Presenter: "Genau."

[8] Again, as mentioned above, we need to take into account the possible ambiguity of attributing spatial distribution and extension or reverberation to either "naturalistic" or "semantic" dimension. Also, the design's meaning rests also to a significant extend on filmic use of sound: The sound space (spread) is not only used here for the transition between environmental sounds to localized sounds. But also used a filmic narrative strategy: First, energy and power is emanating from the hat into the surrounding space, and then, once worn by someone, the sound becomes an intimate voice in one's head.

[9] This relates to the code "interpretation of spatial cues / soundfield changes" (6 quotes, 3 cases).

and shifting horizontally. This might also be based on the expectation, that vertical movement would result in some kind of acceleration (downwards) or deceleration (upwards) “naturally”. Instead, the timbral shift encountered in this case relates to the phenomenon of phasing effects, which are the result of changing sound interferences caused by (horizontal) movement in space[10].

20.2.4. Reverberation Between Sign and Manifestation of Space

A good example of the complex interplay in the emergence of meaning related to “natural” sonic phenomena is reverberation. Reverberation is intrinsically linked to sounds propagation and reflection in space. Given the multitude of potential applications, it is not surprising, that reverberation was used in the design of a few prototypes[11], be it as imitation of the natural phenomenon, or for its aesthetic and symbolic powers. The examples show, that it was not always easy to distinguish between “naturalistic” and “representational” uses of reverb. Already natural reverb in real spaces can be a complex, multilayered phenomenon, as the discussion of the TOILET SOUNDSCAPE TAIK 2009 (PD 22, on page 70) shows:

> *I: “It’s funny about the space and the acoustic experience of being in a public toilet at least is that usually they are open up and down. So auditorily you have two spaces that are kind of layering, not really mixing, one is the direct reverb you get from the wall around you, which makes you feel enclosed, but there’s also perception that every sound you make can be heard in the bigger space around you.”* `(>22:8)`

Also consider the following statement from the same case, which shows how several interpretational approaches (spatial and metaphorical) are blended:

> *I: “I again noticed a lot of reverb. Kind of a big space, a big mental space.”* `(>22:1)`

Here, the occurrence of “a lot of reverb” is associated with a “big mental space”. It should be added that in this interpretation I rely on my knowledge about the filmic use of reverb, e.g. for subjectivization, and it is possible that the general audience did not even take notice. On the other hand, it was used by the designers on purpose, and the interpretation of “mental space” was consistent with their design goal:

> *Presenters: “Also, you mentioned about the reverb and we were thinking because toilets are very small and sort of (. . . ?...) you could exactly as you were saying with the elevator use the sound sort to open up and make it more airy to the feeling, not so (...) claustrophobic. . . ”* `(>22.7)`

Thus, in this case, reverb was not primarily used a sign of some sort, but rather as an augmentation or modification of spatial perception. This example also suggests, that the “schizophonic” reverb, the reverb detached from its natural conditions of production, is neither purely symbolic, nor naturalistic. A third quality may emerge, which seems to have to do with the subjective experience of being in a large, reverberant space. So while the reverb is still rooted in its spatial origin it simultaneously adds an affective sonic quality.

Whenever reverb was a plausible acoustic sonic effect of a proposed (spatial) setting, artificial reverb could be interpreted in this direction, as for instance in the case of THE ELEVATOR TAIK 2009 (PD 15, on page 67). But even here, there was some confusion about the implications of the reverberation:

[10] A similar example of timbral shift in the non-tonal domain is the effect of (generic) pitch shift versus the result of a formant shift: While the pitch shift simply shifts the entire frequency pattern up or down, the formant shift emphasizes or attenuates a spectral pattern that leads to perceived higher pitch.

[11] There were not many cases that made use of reverberation but when it was used it was relatively prominent. The related codes are “non naturalistic use of reverb“ and “ambiguity of reverb: spatial & symbolic“, which together contain 4 quotes.

> *I: "Since your interaction starts with pressing a button, but we didn't enter the elevator, we didn't open doors, and then when it began to operate we heard in cases lots of reverberation. So I didn't understand really am i inside the elevator and I'm operating and hearing the sounds or am I outside the elevator and now watching somebody operating that."* `(>15:16)`

In this case, the reverberation caused some confusion, not only because the demonstration of the scenario was slightly confusing, but also because the reverb was not an accurate rendering of the natural space, overemphasizing spatiality. Still, it did not sound artificial, but as plausibly originating from an actual spatial situation. In other words: the reverb was within a plausible framework of naturally occurring reverbs, and this was also consistent with the interaction scenario, which was about rooms (the elevator inside, and the various floors it would pass or stop at). But there was a slight exaggeration and, most relevantly, the position of the "virtual listener" was not clear: Was the reverb associated with the space inside the elevator or was it surrounding it? As a consequence, participants started to speculate, even considering rather absurd conclusions:

> *Participant 1: "It was like being on top of the elevator in the shaft."*
>
> *Participant 2: "Yeah, this makes most sense from the reverberation."* `(>15:17)`

From this quote it becomes evident, that there is a conflict between seeing the people standing in front or inside the elevator, but hearing a reverb of a different room. Also the symbolic dimension of interpretation of the reverb was present in this design case, as shown in the following statement:

> *I: "What confused me was the strong reverb, where sometimes I couldn't say, that the movement [of the elevator] has come to an end, it was more like (...) you start to move and then you dissolve into nothing."* `(>15:26)`

Here, the reverb blurs beginning and end of sounds and works on the temporal domain rather than the spatial, contributing to the perception of transition between sequenced events. This perspective does not consider the reverb as naturalisitc property of sound being reflected in a given space, but rather a property of the sound event dissipating over time. And it was this property of the sound event *"dissolving into nothing"* which gives rise to a metaphorical interpretation. Furthermore, in terms of perceiving and interpreting formal aspects of the interaction, the reverb prevents the perception of a clear "terminal state" in the interaction.

20.3. Technical Effects and Sound Processing

20.3.1. Comb Filtering or Phasing

As we have already noticed before, in the context of reverberation, some sonic attributes may have their origin in actual acoustic conditions, but very often they are familiar to us through their artificial generation using sound processing technology. Apart from reverb, this can also be said for the spectral movements in sounds caused by phase shifts. Acoustically, this is caused for instance by the movement of a sound source in spaces with a reflective surface, which results in the source sound wave being combined with the temporally delayed reflection, leading to wave interference, which emphasizes or dampens specific frequencies in the resulting sound. This naturally occurring acoustic phenomenon is the basis of electroacoustic effects such as phasers or flangers.

Phasing was used during the movement in the AcuPot DD ZHdK 2009 (PD 39, on page 79), where it was audible when the pot was lifted up in the air. The effect was clearly perceivable, but led to some confusion:

> *I: "What's nice, if you lift it up, the sound changes, the phase is shifted [moves the acupot]. But are you doing this now? Ok you got me, this is what really would happen psychoacoustically."* `(>39:11)`

In my statement I am referring to the fact, that it was not clear, whether the phase shift was caused by the wizard's actions or the actual movement of the object. It is striking, that the effect sounded indeed very artificial, but, if associated with actual spatial movement, still seemed to be plausibly caused by acoustic processes rather than electroacoustic design.

20.3.2. Distortion

As opposed to phasing, distortion is an effect which does not exist as such in the acoustic domain, but requires a medium of electroacoustic storage and reproduction of sound. From a strictly audio signal processing viewpoint, distortion is the result of a technical "error" of overloading the medium's dynamic range, and is to be avoided. However, just as reverb or phase effects, distortion has acquired a range of cultural connotations and semantic functions, for instance through its use in popular music. As result, distortion may lead to a wide range of possible meanings and interpretational approaches.

Distortion was used in at least two cases as design element. The two cases show very well how the experience and interpretation of distortion – just as with reverb – can be related both to an aesthetic affective quality of an interaction or as an informational device. The first case is a transformation of a blinker and distance warning sound employed in the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77):

> *I: "It's quite clear, because there is a basic sound which is soft, and then turns hard and sharp. There is something alerting in this distortion. We know it also a bit, when something starts to distort, we have to go back with the slider. (...) Distortion as an effect that helps you find the sweet spot."* `(>38:13)`

The notification design for leaving the track is inspired by the sound of the grooved indicators that already are in use on many streets. It is considered to be made *"more aggressive, as there are many distortions"* `(>38:23)`. During an audience tryout session, the modified blinker sound was discussed:

> *Participant [in car, the gentle blinking sound starts]: "This is great!"*
>
> *[blinking sound becomes slightly louder and starts to distort]*
>
> *Participant: "Why does this have to be so loud and so..."*
>
> *Participant 2: "Because you drive on the left, somehow."*
>
> *I: "What would it mean for you if the blinker would start to sound like this in a curve?"*
>
> *Participant: "I would drive immediately straight ahead again, because something can't be right."*
>
> *Participant 2: "Or maybe slower."* `(>38:24)`

This shows how effective the design of distorting an existing sound was. It also shows, that while distortion is a widely known and appreciated sonic property, it still works as sign of deterioration, and also seems to have an affective power, if it is added to a previously "clean" sound. In this way, the interpretation that something may be going wrong, and that whatever one just did should be revoked, is quite obvious.

A bit different is the outcome of the AcuPot DD ZHdK 2009 (PD 39, on page 79). Here an actual distortion of the signal was caused by overdriving the small loudspeakers. But also some of the sounds had a distortion-like quality, such as the noise of an analog FM radio. The following statement informs about the implications of this – more or less unintended – design:

> *I: "It has something brute, it is certainly not a plant for a sophisticate. Maybe if you play guitar hero in the evening and the plant reminds you to water her, like 'uarrrrr'! (...) the character of the object feels aggressive, yet playful."* `(>39:33)`

Here we can see how distortion affected the aesthetics of the artifact and the interaction. It is not only coloring the sound, but coloring the movement and contributing to the "feel" of the artifact. In particular this seemed to be related to the fact that the vase was touched and moved around and that there seemed to be a crossmodal correspondency (see Section 18.2) between the haptic experience of touching the rough surface of the vase, the sound of the vase moving over a surface, the scratchy FM signal and the distorted electroacoustic sound:

> *I: "The [sound associated with] dislocation [of the vase] has more to do with the object, it extends the object, it is also scratchy, almost like the vase."* `(>39:33)`

20.3.3. Audio Tape or Vinyl Record Manipulation

The choice or design of a particular sound may also be inspired by another sonic stereotype of a technical sound phenomenon, the fast-fowarding or slowing down of a vinyl record or audio tape. This was the case in the SONIC PAPER DD ZHdK 2009 (PD 40, on page 79) mockup. Referring to this kind of effect, I stated:

> *I: "... the browsing, like in Minority Report, (...) in analogy to the tape, which is fast forwarded. Or a record or something."*[12] `(>40:1)`

One the one hand the sound itself reminds me of the tape effect, and at the same time a scene from the movie "Minority Report" comes to mind, which was part of the movies from which clips were used as design examples. In this scene the main protagonist of the film is interacting with a large interactive display, the "holoscreen", browsing through recordings of another person's memory. The manipulation of the memory, represented as short video clips, is accompanied by a sound similar to the sound of an audio tape or vinyl record playback slowing down. This sound thus gets its meaning potential from both the actual technical process and its use in narrative contexts. We can speak of a metaphorical sound effect which makes speed perceivable, when browsing a silent digital medium.

20.3.4. The Impact of Knowledge About Sound Origin and Production

The discussion of the meaning of the tape speed sound modulation points us to a central question: what is the impact of a listener's knowledge about the causal reasons for a particular sonic phenomenon? The question applies both to the origin of "natural", acoustic phenomena as well as artificially created electroacoustic effects. For instance, consider the following statement from the presentation of the ASSEMBLY LINE DD ZHdK 2008 (PD 5, on page 64):

> *Participant: "The noise of the engine has to do with the exhaust tube, if it is rattling like that (...) thus I (...) thought which one is which noise. the majority of noises don't come from where they are produced, that's the problem, you think he's not working on the engine (...) because in the end the sound of the engine is generated by the exhaust tube."* `(>5:19)`

The interpretation of the sounds in this prototype was not straightforward, due to the ambiguity of the demonstration setting which resembled a musical live performance. As consequence, the interpretation takes into account the actual sound generating sources of a car, which, in the participant's understanding, mostly stem from the exhaust. The sound, which is meant to

[12] *I: "... also das Durchblättern wie bei Minority Report, so ein schnelles, eigentlich in Analogie zum Tape, welches schnell vorgespult wird. Oder Platte oder so."*

be associated with the construction process of the engine, is now attributed to the exhaust, which results in an insecurity of source attribution. This shows a potential issue related to “interpretational framing” of a sound as being more or less naturalistic and physically accurate, which seems only possible if the listener has sufficient knowledge about actual acoustic processes. While the participant’s explanations about the actual sound source of an “engine” sound is not entirely correct, it is indicative of how knowledge about sound production can influence the attribution with a source. It is important however, to put this phenomenon in perspective, as it did not occur very often. Also, the participant’s interpretational strategy was an exception, as others in the group readily interpreted the sound as an indicator of the engine, or at least related to the engine. But in general, the phenomenon relates to the larger discourse around source identification, which was relevant in several cases.

Also related to this aspect are similar cases where the knowledge of a person about acoustics prevented him or her from adopting the intended symbolic function of a sound related effect. In this following example from The Elevator TAIK 2009 (PD 15, on page 67), where the causes of reverberation and spatial position and movement were discussed (see also 20.2.4):

> *Presenter: “If you would be outside you would have a doppler, like ’oooooo’.”*
>
> *Participant (visiting expert): “Yeah, but I mean if you enter an elevator you are shutting down the outside reverberation, don’t you.”*
>
> *Presenter: “Yeah, sure.”* `(>15:18)`

Also in this case, the use and interpretation of artificial sound and sound effects is not obeying a single framework of references. One person assumes the moving elevator could produce some kind of doppler effect and the other person focuses on the plausibility of the reverb as originating from a diegetic space. in this case it leads to two plausible listening positions, inside or outside of the elevator. Thus we can observe, that interpretation is indeed influenced by the existing knowledge, but not necessarily in a deterministic way.

21. Establishing Source, Cause and Agency

A recurring topic[1] was the attribution of a sound to a source. However, the notion of "source", or "cause" in this case turned out to be different than it is in Auditory Display related literature, where it usually is discussed in terms of the recording source of a given sound file. This source could be a specific object, a location in space, or a certain action, e.g. by the user, but also a system with no particular spatial location. And, most importantly, a "source" has to be established, it is not an apriori attribution "attached" to a sound[2]. This multitude of potential source attributions also shows that there is space for ambiguities and ambivalences which would not be the result of an identification "error", but rather a consequence of a multitude of possible interpretational perspectives. In the following, I will discuss phenomena related to attribution of source, cause or agency.

21.1. Establishing Presence

In some cases, sound was used to establish a presence of an entity of the interaction system, which could be a human agent as well as a functional entity, or "the system". This means, that the sound would convey that something, be it a human or technical agent, an artifact, or a function, is present or active, waiting for input. This way of using sound is comparable to the use use of notifications which indicate the "attentiveness" of a system, but achieves it not through discrete, attention-grabbing sonic signals, but rather through continuous, rather subtle, sounds. Consider the following example from the DOC-O-MAT UDKL 2010 (PD 60, on page 86) final mockup:

> *Participant: "It was more like the private thing was more interactive, someone was like there."*
>
> *I: "Yeah, some other presence."* `(>60:4)`

Then, later, the presenters explain:

> *Presenters: "The doctor comes in with this sound and waits a bit."* `(>60:11)`

I this design case it was important, that the doctor's presence was not disruptive to the patient, but rather would be perceived as a change of state in the background and a more dialogical relation of sounds.

As example of expressing a technical, or functional presence of an artifact, consider THE FRIDGE, UDKL 2010 (PD 56, on page 86):

> *I: "This is the fridge's basic energy? The fridge as a presence?"*
>
> *Presenters: "Yeah!"* `(>56:10)`

In this case, a continuous sound was used that could potentially be backgrounded. A similar case can be identified in the use of sound in the MATCHMAKER UDKL 2010 (PD 58, on page 85), where I also explain a possible design rationale:

[1] The related code "ambivalence of attribution of sound to agent / location / source" contains 25 quotations from 17 cases.

[2] I will return to this aspect later in Part IV.

> *I: "For me, its a sound that tells that this is a dormant object, it's in a standby situation. I think attraction comes not through the sound itself so much (...) the attraction could come because I know this object can do something and its active and not switched off. In that case you wouldn't even need a sound that attracts attention out of itself, but you know this kind of artifact exists around you (...)."*
>
> *Presenter: "Like a whispering."* `(>58:12)`

This statement illustrates the importance of conveying presence, as sign of being available for interaction.

21.2. Attribution of Sounds to System or Setting

In some cases, the question emerged, wether sounds would be attributed to either the actual interactive system or the general setting of the interaction. A specific sound might be used to illustrate a (spatial) setting rather than being an actual designed sound of the functional artifact[3].

For instance, in the discussion of the prototype of Explorations UDKL 2011 (PD 82, on page 95), I was confused whether some sounds would origin from *"sonification or just the environment"* `(>82:2)`. The setting was known (city) but it was not clear whether some sounds, such as flies, or water, were "added" to the sonic scenery, or part of an informative auditory display. This problem can be mitigated by avoiding naturalistic sounds in the design as shows another quote from the same discussion, which refers to non-naturalistic sounds in the same interaction process:

> *I: "Here it was easier to assign sounds... (...) Some sounds were assignable to the setting and other sounds were diegetic of the interaction so to say, part of the interaction, that was quite clear. (...) I think it was not a problem for the interpretation."* (>82:8)

The discussion in this case also evolved around the specific loudspeaker configuration. It turned out, that loudspeaker placement may be an issue for source attribution to system or setting, but is not a primary concern, as long as there is a sufficient aesthetic, semantic and temporal coherence in the design of the sounds which belong together. For instance, to achieve an attribution to the environmental setting, sounds should exhibit a relationship to something obviously belonging to the setting, e.g. cars in a city. Conversely, a sonic relationship to the setting should be avoided when the aim is to establish the attribution to the interactive system, which can be further supported by providing an aesthetic relation between various system sounds.

Also the prototype Das System IAD ZHdK 2010 (PD 68, on page 89) raised the issue of how to make clear, that different sounds would originate from the same system, which in this case was also ubiquitous, literally "embedded" in the environment:

> *I: "And here we have now three entirely different sounds, and I had difficulties to put them into a continuum. I can force them, I can force them into the continuum, because you played this, because the action somehow forces the meaning of the sounds, but just in itself, they were very different. Except for the last sound, (...) there is again this nastiness of the system, that I also heard in the alarm clock, some kind of scratching with many overtones, which came in the very end, there I thought this belongs together somehow."*[4] `(>68:8)`

[3]This is comparable to the issues associated with reverb, which is used to simulate an actual spatial setting (see 20.2.4).

[4]*I: "Und hier sind es nun drei völlig andere Klänge, und ich hatte Schwierigkeiten sie in ein Kontinuum zu bringen. Ich kann sie zwingen, ich kann sie in das Kontinuum zwingen, weil ihr das gespielt habt, weil die*

The metioned *"last sound"* is thus an example of a successful combination of sounds, which fit and belong to each other through shared sonic properties and thus can be differentiated from sounds of the environment.

21.3. Attribution of Sound based on Object Size

In the attribution of sound to the artifact, one side aspect was the relation between the artifacts size and the size suggested by the sound.

The attribution of sound and object size is quite well studied in multimodal research (see also Section 18.2). Usually larger objects are associated with lower frequencies. One example where the object's size influenced sound source attribution – in addition to a certain temporal relationship to the actions – is the following example from the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76):

> *I: "This high sound, that is then more a consequence of me closing the door, isn't it? Because the rumble, is clearly coming from the car."*
>
> *Presenter: "Yes."* (>37:11)

But considering the design cases, the "natural" attribution seems to be somewhat more flexible: There were cases, where a sound clearly would not correspond to the visible size of an object, but could still be attributed correctly. The following example is from the presentation of the prototype from the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *I: " (...) we have a problem with the size of the sounds and the size of the objects. (...) It's not the loudspeakers, it's the sound design, you could suggest a smaller object as well."*
>
> *Participant (expert visitor): "You mean there is a lot of bass?"*
>
> *I: "Yeah, maybe for the basic energy that's not a bad thing, maybe there's a room tone or something. But for the chair, if the sound came from the chair really, from a small loudspeaker."* (>25:33)

On first sight, this example shows that the sound was too "large" for the object at hand. But after a closer look we can see that the issue emerges rather from a technical concern, related to the use of small loudspeakers, which prevent the transmission of low frequencies. In terms of sound semantics – in this case expressing a powerful embedded energy source – the design worked. In general, "large" sounds work for less localized sounds, backgrounds, room tones etc. but also for a certain sonic semantics (e.g. the large powerful energy source). Indeed, there were several cases, where the plausibility of a relationship between object size and sounds produced by it was not relevant[5].

In some cases it was unclear where a sound originated from, even if the size and object form correspond to the sound's properties. For instance, in the mockup of the AcuPot DD ZHdK 2009 (PD 39, on page 79), it was not clear initially if the plant or the pot was making the sound. This confusion took place in the very early stage of interpretation, without much reflection (>39:1). It was easy then to attribute the sound to the pot, as there were several crossmodal analogies[6] to build on. Furthermore, only the pot could plausibly host a technical system and also the pot was what the user actually was interacting with.

Handlung forciert ein Stück weit die Bedeutung der Klänge, aber rein für sich genommen waren sie sehr unterschiedlich. Ausser der letzte Klang, (...) das ist wieder so das Fiese des Systems, was ich auch im Wecker gehört hatte, eine Art obertonreiches Kratzen auch, welches ganz am Schluss kam, da fand ich das gehört irgendwie zusammen."

[5] I discuss this also in the Chapter 27.4 where I also indicate, that a "misfit" between object size and sound actually can be productive for the interpretive process.

[6] See Section 18.2.

In general, it seems, that the re-configuration and re-attribution of object sounds in relation to object size is possible, if the motivation for the sound does not relate to a physical dimension or process, but to a “expressive quality“ of the (inter)action, a semantic correspondence, or aesthetic coherence. It seems to work particularly well, if the sound does not relate directly to an actual action or manipulation of the object, but rather to an asynchronous response, or “passive” presence, of the system.

21.4. Attibuting Sound to Agency of User or Artifact

The attribution of a sound to agency of either user or artifact was a relatively common topic[7]. While many works in sonic interaction design are concerned with the combination of sounds and human gestures, a majority of the cases investigated here used sound in relation to agency of the artifact. Also, several design strategies for differentiating user interface sounds from sounds attributed to system processes and actions could be identified[8].

In Part I of this thesis, I have defined interactive commodities as artifacts, which can change their functional and “behavioral” patterns and even their multisensory appearance based on the dialogical process of interaction. Thus, interactive artifacts potentially can exhibit “genuine” agency. By consequence, their sounds may not result only from passive “mechanical“ processes of the artifact, but can be understood as the result of the processing of some kind of input, or some algorithmic “decision making”. In an anthropomorphic understanding, this can be even conceived of as enunciations, or utterances, of an artifact. On the other hand, we have the “user”, who is acting, be it intentionally or not.

Due to the dialogical nature of interaction, the border between the potential agents is often ambiguous. The following quotes from the discussion of the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97) points this out nicely:

> *Participant (visitor): “What remains unclear for me is the generative aspect of the music for the matchmaking, if it was purely based on some kind of profiles that react to each other or if it was coming out of the dancing part.”*
>
> *Participant 2 (visitor): “I also thought there is some connection to the (movement) like the gyroscope, something that would change the music or something.”* `(>86:8)`

Here, we encounter both overt, observable human agency and the notion of a smart interacting system. In this case, the attribution of agency is ambiguous by design, as there is a feedback loop between individual interactions or movement (dancing), its impact on the sonic material (the resulting music) which again is based on the system’s analysis of the human participant’s personal profile data.

> *I: “You have here the decision whether a system makes the sounds, or the user makes the sound. With the dance, you are making the sounds, you need sounds that relate to physical expression like this. And then you have the system level, you have to convey the feeling that the system acts now.”* `(>86:22)`

Despite the ambiguity, in the process of interaction, the attribution of the sounds of the two participants was rather clear, in terms of gradually shifting back and forth between agents (rather than discrete switching):

> *Participant: “And I even got that this is you and this is her. (...) I don’t know why I got it but somehow it was very clear in that sense. Maybe also because you made*

[7] The related code covers 10 quotes from seven cases and is semantically linked to further codes related to the same question, which together contain 15 more quotes from 11 cases, which will be discussed below. Also the code “Attributing Sound to ’System’, ’User Controlled Tools’ or ’Symbolic Level’ (8 quotations) is related.

[8] The related code contains 8 quotations from 6 cases.

> *the movements according to the sounds, or the other way around, the sounds were according to the movements and you had these clear gestures."* (>86:30)

The sounds could be clearly attributed to the human agents, due to the synchronization with their movements as dancers, but also because the sonic quality would correspond to the gestural quality. Also there were "clear gestures" mentioned, which were gestural emphases and key movements, reflected in simultaneous sonic emphases, that provided cues for the association. It is interesting to note, that this attribution to the human agents is not necessarily the attribution of who actually generates and controls the sounds, in a technical sense, rather who is "responsible" for them occurring and changing. In this case it is irrelevant, whether the sound is controlled by the system or the human agents

Attributing sound to the interactive system itself is sometimes related to the attribution of agency to an artifact, in particular if the system is present as an physical object[9]. As mentioned, the attribution does not have to be static but may shift from system to user, and back, in the process of interaction. A good example is the Moody Hat DD ZHdK 2008 (PD 6, on page 65). Agency was attributed first to the hat, which was interpreted as "radiating" his presence through spatialized sound into the environment, calling for attention, then focusing the attention to itself, by focusing the sound both spatially and by making it sound "thinner", and then finally expressing through sound its "inner workings".

> *I: "You mean, that Simon*[10] *was humming?"*
>
> *Participant: "Not necessarily..."*
>
> *I: "But that would fit, the hat has taken control of Simon, you can't say anymore who is speaking, Simon or the hat."* (>6:11)

Again, agency is shared between system and user, comparable to the Dancing Matchmaker prototype, and thus the sound design actually is meant to be ambiguous, in its oscillation between the two sources.

Similarly, in the case of the Matchmaker UDKL 2010 (PD 58, on page 85) we see an example of combining the notion of an "interactive setting" with a specific, focused agency upon the artifact as a process of transition, similar to the phenomenon we identified in the Moody Hat demonstration:

> *I: "For me in the interaction process there was a process from attention to the general situation, to "what does this object do", (towards) more into the project."*
>
> *Presenter: "Yes."*
>
> *I: "How does it react, how can I move it, and so on."* (>58:13)

One important aspect in meaning making is thus a correspondence in the temporal development[11] of the interaction and the sound. But temporal synchronicity alone is not sufficient. Consider the following statement from the demonstration of a prototype from the Sonic Car Boarding Project 2 ZHdK DD 2009 (PD 36, on page 76):

> *Participant: "I had the feeling I triggered this [sound for unlocking the door] with the keys. But maybe it only occurred because I came closer."* (>36:2)

In this case, the participant moves towards the car while unlocking its door with the button on the keys, and it is unclear, whether the sound (or the unlocking) was caused by the movement or the button press. In everyday life it is very common that we perform actions in parallel, and

[9] The related code "agency in artifact" contains 10 quotes from 7 cases.
[10] The demonstrator of the mockup.
[11] This topic relates to the code "temporal sequence guides interpretation" which is discussed in more depth in Chapter 23.

as a consequence we cannot rely on temporal sequencing alone to create causal connections. The statement indicates, that in this case, a synchronous action usually may dominate the association, but we might need additional hints, or a repetition of the process, to confirm the link.

Also the following quote from the same case shows, that synchronicity does not work necessarily as only indicator for interpretation. The statement occurs after the protagonist opened the car's door, which resulted in a growling sound:

> *I: "It strikes me, that the growling is like an after effect of opening the door. It has to do something with synchronization. (...) It comes, like, afterwards. It's like an answer of the car."*[12] `(>36:21)`

From the context we can conclude that, while the temporal arrangement clearly structures and guides interpretation, the semantic link between growl and the powerful car might be important in order to associate the sound with the car's "reaction". Again, the temporal sequence is not the only factor that guided my interpretation. Also the exact process of the manipulative action plays an important role: I might still hold the door handle after pulling the door open, or I might give the door an initial impulse, making it continue the movement, so in any case the sound is still related to the same process and works as an element of it[13].

Also the designer of the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76) discussed some considerations about the attribution of agency:

> *Presenter: "Then I made a difference (...) between the interaction that you can make, that is the moving of the door. Did you notice, the sound comes only when you move the door. You control the sound. And there are things that you can't influence: You close the door and the car gives his feedback."* `(>37:18)`

Another aspect that came from the cases was that the system might make a sound in order to motivate a user action, as opposed to the user's action causing the sound. Consider the following example from the Sonic Puzzle IAD ZHdK 2010 (PD 70, on page 89):

> *Participant: "It was relatively clear, that the sound is generated by what he is building and not the other way around. Before we heard exactly the opposite. There were indications, and then actions had to be carried out. Now we had first actions and then the related sound. This worked well."*[14] `(>70:4)`

Thus, in one instance of the interaction process, sound was the confirmation of an action, or the response of a sentient system, and in the other instance, sound was a call to action. At the same time, there is the temporal process of the interaction, in terms of the experience of the general transformation of both the Lego-puzzle and the sound composition, that contributed to the interpretation and the attribution of sound to the various agents.

Other statements related to this topic come from the Foley mockup of Matchmaker UDKL 2010 (PD 52, on page 85), and the AcuPot DD ZHdK 2009 (PD 39, on page 79):

> *Participant: "The thing was calling him."* `(>52:2)`

> *I: "There is something happening with the pot itself, you can't do anything anymore."* `(>39:19)`

[12] *I: "Mir fällt auf, dass das eine Knurren wie eine Nachwirkung des Türöffnens ist. Das hat mit der Synchronisierung zu tun. (...) Es kommt wie nachher. Es ist wie eine Antwort des Autos."*

[13] We see here a working case of an indirect action-sound relationship, where the action can be understood as putting energy into a system, which then responds. Another model of understanding, which would result from attributing actual agency to the system, would be that of a dialogical sequence. In any case, this relationship between sounds and interactions are ideally explorable, affording actual learning by doing.

[14] *Participant: "Es wurde relativ klar, dass der Sound generiert wird von dem, was er baut, und nicht umgekehrt. Vorher haben wir genau das Umgekehrte gehört. Es wurde vorgegeben und dann mussten Aktionen ausgeführt werden. Jetzt hatten wir zuerst Aktionen und dann den Sound dazu. Das hat gut geklappt."*

The pattern seems to be that we attribute sonically manifested agency to an artifact if the human agency involved obviously does not affect the artifact's sound, or if there is some kind of dialogical behavior, where human action results not only in a feedback sound, but in a sonically expressed action by the artifact.

There were a few cases, where agency was attributed to the human agent[15]. In the case of the Crocodile Tamer TAIK 2009 (PD 19, on page 70), when the robotic crocodile toy is grabbed by the tail, the didgeridoo sound starts to "move" in relation to this movement. The circular movement is linked to filter cutoff, or the similar effect of formant shifting, which also occurs when playing the didgeridoo. Control is clearly exerted by the user, and because the didgeridoo is not perceived as the "voice" of the artifact, agency is attributed to the human agent. This means that two aspects come into play: first a clearly perceivable relationship between movement of the agent and movement of the sound, and second, a sound which is not associated with the artifact.

However, this also means that the sound source and the relation of sound to agency are not the same thing, as in this case the sound also is clearly not coming from the user. Rather the sound is coming from the system itself, the user's agency is manifested in sonic modulations. Thus the sonic quality itself can also help to attribute a sound to an object, e.g. if there is an aesthetic or perceptual relationship, as in the following quote, again from the AcuPot DD ZHdK 2009 (PD 39, on page 79), where the scratching sound of the movement is clearly associated with the pot:

> *I: "Well, for me, this sound goes into another direction than the moving. The moving has more to do with the object, it extends the object. It is scratching a bit just like the pot. And the tipping is a movement that does not produce a sound itself, but the system utters a message. For me this is a different level of meaning."*[16] `(>39:9)`

Agency here originates from the human, but the sound expresses the pot's state, and is not related expressively to the human gesture itself[17]. This is a fine, but relevant distinction. Of interest here is also the strategy to relate a sound to a gesture like gentle tipping which in itself is subtle and soundless, which detaches the sound from the gesture and re-associates it with a response of the system. This of course requires the sound to be more than just a "click", as it is used for touchscreen keys. A similar example can be found in the Moody Hat DD ZHdK 2008 (PD6, on page 65), which produces a noise of breaking glass when touched on the rim. Here the sound was also understood as a response of the sentient hat to the touching. `(>6:19)`.

In the case of closing the car door of the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76) a higher pitched sound element (imitated as *"ding"* by a participant) is attributed to the user action and the lower booming hum (*"wummern"*) with the car's agency. The latter certainly is based also on an attribution with object size (see above). But the former emerges from both temporal coincidence of user action and the sound, as well as the more subtle sonic quality, which seems to fit to a more subtle, manual interaction.

In general, it seems that sounds that have a abstract, musical aesthetics, tend to be attributed to the system's rather than user's agency. Consider the following example from the Interactive Kitchen VID 2011 (PD 74, on page 90):

> *I: "Could you make a difference between sounds which come from the system and sounds that come from objects or devices which which you interacted? Was there a difference?"*

[15] The related code contains 5 quotes from 4 cases.

[16] *I: "Also für mich geht dieser Ton in eine andere Richtung als das Verschieben. Das Verschieben hat mehr mit dem Objekt zu tun, es erweitert das Objekt. Es kratzt ja auch etwas fast so wie der Topf. Und das Antippen ist eine Bewegung, die für sich keinen Ton macht, sondern das System gibt eine Meldung von sich. Für mich ist das eine andere Bedeutungsebe."*

[17] For a discussion of the relation between sound and gesture, see Chapter 22. Also, this relation of the sound to the pot is supported by a crossmodal analogy between sound and material surface of the pot, see Section 18.2.

> *Participant "I think so, the system was clearly audible when the screen was changed."*
>
> *I: "This was a totally different sonic world, yes. For me it was immediately clear, there are sounds that have to do with the interaction, in the sense of manipulation, now this, then the next, and the others were rather notifications that were detached."* `(>74:7)`

The case of the ASSEMBLY LINE DD ZHdK 2008 (PD 5, on page 64) reveals this phenomenon in a nutshell. From the same demonstration, the following interpretations emerged:

> *Participant 1: "Three sound designers working on the sound and then sending the sound to the next one."* `(>5:1)`
>
> *Participant 2: "This is the ornamentation of a car. Recording various noises."* `(>5:2)`
>
> *Participant 3: "It's about a dissection, you make the noise of the tires, then the engine sound, then the gearbox sound, and when you combine it you have a model car."* `(>5:3)`
>
> *Participant 4: "You can see who is active."* `(>5:9)`
>
> *Participant 5: "...that they are dissecting, preparing the car."* `(>5:13)`

In this case it seems clear at first that the presenters are designing something in relation to the car, and that they are the agents. The manipulative nature of the gestures lead to that interpretation. It is less clear what they are actually designing, and this problem has to do at least partially with the nature of the sounds, which are very musical and abstract. At some point of the presentation somebody states:

> *Participant: "They seem to be somehow electronic artists, music artists, you don't know who makes what, just moving around sounds."* `(>5:8)`

A similar interpretation is triggered by the Foley mockup of DOC-O-MAT UDKL 2010 (PD 54, on page 86), which was staged very expressively. The presenters behaved like actors, acting out the scenario very expressively, and the sounds seemed to have their own "life":

> *I: "There was actually a lot of action going on. It was hard to tell, for me it was generally art, a dramaturgic movement, (...) it was not so much on specific actions."* `(>54:4)`

So here, the quality of the theatrical performance and the independence of the sounds lead to a framing of the interaction as "artistic" performance[18]. Once this understanding was adopted, it biased the whole interpretation and even prevented a reconsideration of the initial framing.

The SONIC PUZZLE IAD ZHdK 2010 (PD 70, on page 89) offers another example of various associations of agency expressed through sound. When a brick is placed by a user on the puzzle board a "clack" sound can be heard. Also here we find a clear distinction between system and user interaction sounds, with the system using rather musical sounds, but the user interface sound being close to the actual clicking sound of a brick, thus being not a response of the system (only), but much rather a sound motivated and caused by user actions. The repeated click was also perceived as manifestation of the rhythmicity of the user's interaction.

Other projects worked with "sonic hierarchies". In the prototype of the INTERACTIVE KITCHEN VID 2011 (PD 72; 74; 76, on page 90) the designers worked with the metaphor of sonic "clouds", which were meant to be an informative background representing the overall process. Sonic events with increasing salience, considered by the designers as *"more annoying and penetrating"*, were then layered on top. The "soundclouds" were designed to *"hardly noticed, fitting to what you are*

[18] This relates to the code "abstract sounds / ambiguous actions lead to interpretation as 'art"', with 2 quotes.

actually doing" `(>74:6)`. As result, the sounds are attributed to the system, but with a more or less strong implication to act. Also, this case used a clear differentiation between system notification sounds, which were rather tonal, refined noises, which served to direct attention to the next instructions being displayed, and the "calls for action" and process state representations, which are closer to, or inspired by, actual cooking sounds.

Also the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97) showed the clear need for a differentiation, with some sound elements clearly synchronous to visible user action (action-sound relationship) and others not. The interesting aspect of this case is, that the informational aspect (the degree of matching) is present in the continuous action sounds during the dancing, through change of the dance "music", as well as in designated confirmation sounds.

The specific relationship between observable gestures and bodily movement, and its relevance for the interpretation of sounds, is the topic of the next chapter.

22. Relationship of Sound with (Gestural) Action and Function

As described above, sound was sometimes attributed to an agent based on a general gestural relation. In this chapter I will discuss phenomena associated with more specific ways sound and bodily action and gestures may be related, from formal or structural-temporal relationships to crossmodal analogies and associations.

In this context, it is important to differentiate between action as visible, bodily movement, and the notion of agency which was discussed in the previous chapter: Agency involves intentionality, motivation and the notion of a goal and is an important dimension in the interpretational process. In some cases gestural relations play a role in the attribution of agency. In this chapter, I will first focus on the "physically manifested action", in the form of observable bodily movement and gestures[1], and their relationship to other experiential dimensions of sonic interactions, and conclude with a consideration of the presence of gesturality in movement in sound.

The action-sound relationship was not a very prominent aspect in the discussions, but still was implicitly present in many cases[2]. This is not surprising, as in many cases we were dealing with artifacts which require manipulation, but where the manipulation itself was not at the center of attention.Also, an explicit discussion of the relationship between bodily movement to other elements of design did not often occur.

22.1. Sound Directly Relating to Continuous Actions

In some cases, sound was used to support continuous action-sound processes[3]. The following statement from the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73) shows, how the same functionality and action process (charging energy by repeatedly moving up and down on a chair) can lead to two different design ideas:

> *Participant (visiting expert): "If you wanna make people doing it as like bumping you want to do it more times, so something that pushes you back, and doesn't make 'uaaa'."*
>
> *I: "Think of something that will raise a level by repeatedly doing it, and when you reach a level there is something like harmony, or the sound gets cleaner, with a filter, and then it's like "ah well, I've pumped enough."* `(>25:24-25)`

In this case we have first the notion, that a sound design, where individual sounds make sense if activated repeatedly, could motivate sustained activity. This could be seen also as a "musical" notion, where a rhythm, or "groove" emerges from repetition. Secondly, we have the notion, that the overall design could be done in a way that represents the continuous change rather than each individual pump, and the development over time, and a final harmonic "resolution" (again, a musical idea) motivate continuous action.

[1] Gestures can be seen as specific form of bodily movement, which often contribute a specific semantic element to the interpretational process. While some gestures have a clear, culturally coded meaning, other gestures are more ambiguous, for instance conveying an emotional expression without a clear message, or requiring a complementing utterance to be understood.

[2] The related code "relating action and sound qualities in interpretative process" has 6 quotes, but there is a large amount of additional codes which are related to bodily movement and gestures.

[3] The related code contains 7 quotes from 4 cases.

On the other hand, in the case of the CROCODILE TAMER TAIK 2009 (PD 19, on page 70), the sound of grabbing and then continuous movement is a clearly associated with a continuous sound (didgeridoo):

> *Presenter: "And we first timed for action, looking at it a little bit, finding the right way, and then grabbing, whenever we are grabbing, the... [plays sound of didgeridoo] ...for us that's the human-animal thing."* (>19:21)

There are actually two stages of continuos action in this case: The designer differentiate between the continuous action of exploring the way to handle the pet and then the process after firmly grabbing the artifact, with the continuous sound becoming an expression of an established "union" between artifact and user. This relationship motivated a tight relation of the sound's modulation to the circular motion of the interaction. The former type of action is one of two separate entities, and the latter one of intimate bodily contact.

A similar relation to bodily contact and proximity between artifact and user can be found in the mockup of the MATCHMAKER UDKL 2010 (PD 58, on page 85), where a participant states about the artifact: *"When you pull it closer it focuses."* (>58:24). However, in this case, the gesture is not sonified in relation to the spatiotemporal bodily movement, but relates more to the expressive quality, or "meaning" of that movement, which refers to increasing intimacy, focus, closeness, and in turn is strongly related to the overall narrative of the interaction scenario. According to the discussions after the presentation, the designers of this case tried to correlate sounds to each single step of the gestural or manual interaction with the artifact, but connected everything into a integrated sonic "story", which shows the benefit of considering the series of interactions as a whole, instead of just looking at individual action segments or gestures:

> *Presenter: "When you get close to it and start almost touching it it goes [plays sound and modulation] and when you finally pick it up it gets your attention [plays sound]... to something very grained. I have your attention. (...) It's a more clear sound, and it's continuous, but it's not metric, its living, it's chaotic, so it's a thing that's sort of spinning, and thinking and waiting for you to make the next move. So when you first concentrate on it, if it was picked up by a person you didn't like, you would get such a reaction [plays sound] and then it would revert again."* (>58:25)

Also this design is an example of the intention to offer something similar to a "gestural sonic affordance" (Altavilla, Caramiaux and Tanaka, 2013), using sounds that motivate taking the object and trying out how it reacts to movement. Will will return to this aspect in Section 22.5.

22.2. Sound Indirectly Relating to Actions

Indirect relationships between bodily movement, or gestures, and (continuos) sound, were also discussed, and it turned out, that the relationship of an action with sound is not necessarily based on synchronicity[4]. In fact, this kind of relation seemed more common than a direct, analog link.

A relatively common pattern was that sound would "reply" to an action or that it felt like a consequence of the action or movement, not necessarily only in the sense of an informational "feedback". This was also discussion in the previous chapter, in relation to the attribution of agency. An interesting example comes from the discussion around the interpretation of the somewhat ambiguous final gesture executed in the demonstration of the CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *Presenters: "The final is the operating [of the artifact] and it's a sonic gesture that you first think you're doing the magic and then let it procreate."* (>19:28)

[4] The related quote contains 4 quotes from 4 cases, but this design configuration was implicitly followed in more cases.

In this case we encounter a "sonic gesture" which is a blend of a sound associated with the end of a gestural (arm) movement. The sound is more a response to the movement than actually controlled by it. The authors state that they *"ended up with magic sound"* (>19:26), which emphasizes this emerging, indirect relation to the gesture. Thus, this points out the notion of some kind of triggering gesture, where the sound seems to be an indirect - and somewhat independent - result, emanating or radiating into the environment or onto the target.

Consider the following statement from the SONIC CAR BOARDING PROJECT 2 ZHdK DD 2009 (PD 36, on page 76):

> *I: "It strikes me, that the growling is like an after effect of opening the door. It has to do something with synchronization. (...) It comes, like, afterwards. It's like an answer of the car."*[5] (>36:21)

Here, we can observe how a seeming disconnection between action and sound – an indirect action-sound relation in Chion's (1998) terms – motivates and guides the interpretational effort. The fact that the manipulative action is not in sync with the sound affords the interpretation of the sound coming from the car, or the car's system, but still relating to properties of the action execution, such as fast or slow opening.

Another similar example of an interpretation based on a disconnection between action and sound, comes from the presentation of the ENERGY HARVESTING OFFICE CHAIR IAD ZHdK 2009 (PD 25, on page 73). A participant remarks, regarding the pitch of a sound:

> *Participant: "It's always increasing, no matter if he goes up or down."*[6] (>25:7)

Here, the visible action is the bouncing on a chair which indirectly leads to a steady rising of a tonal sound. This indirect relationship is sonically differentiated from the pumping itself, which has its own sound. We could argue that the sound here is simply indicating the energy level, which is raising, but there is also the experience of actually "pumping up" the energy level, putting force into a system through an iterative movement which gets transformed in a linear process. In this case, the dissociation of bodily movement and sound change becomes meaningful in that it represents an indirect (charging) effect of a repetitive motion. What matters here is not the motion itself, but the continuous effect it has on the sound and the system.

In the BAG TO THE FUTURE TAIK 2010 (PD 47, on page 81) there was the sound associated with the bag being dropped on the floor. Dropping something is a very strong case of an inherently indirect relation between action and sound. The sound resulting from the effect of this action, in this case the bag hitting the ground, is even more detached from the user's action, and shifted to the object itself, without losing the link to the original action:

> *I: "It felt like indirectly related to the action. Not the dropping sound, but the impact and the impact is (...) not the impact itself, and the dropping for me was more like, it came out of the impact as a consequence, as a reaction."* (>47:4)

The impact (which is both a physical and sonic notion) is perceived as a twofold entity, first the actual event of the impact, then the after effect, resulting similar to the dissipation of energy, or anthropomorphized as some kind of answer from the object. This kind of integration of a fictional, narrative component (animating the artifact, artifact "utterance") with a natural physical phenomenon (impact sound and its dissipation) is resolved in an integration of both design aspects which, again, shows the "interpretational tolerance" and the interplay of various points of reference.

[5] *I: "Mir fällt auf, dass das eine Knurren wie eine Nachwirkung des Türöffnens ist. Das hat mit der Synchronisierung zu tun. (...) Es kommt wie nachher. Es ist wie eine Antwort des Autos."*

[6] *Participant: "Das steigert sich immer, egal ob er hoch oder runter geht."*

22.3. Reciprocal Impact of Action and Sound on Experience and Interpretation

The notion that actions, movements and gestures, or more precisely: the qualities of their execution, has an influence on how a related sound is perceived and interpreted, has been discussed in several contexts (for an overview, see Franinovic and Serafin, 2013). And in a workshop with theatre actors, it was observed, how actions could shape the way a sound is interpreted, both in terms of categorization and qualification (Pauletto et al., 2009). In the following I will discuss the various phenomena associated with the impact of action, bodily movement and gesture on the interpretation and aesthetics of sounds, and vice versa.

In some presentation situations[7], a particular focus on the aesthetic quality of the relationship between gestural movement and sound could be observed. This was very prominent in the discussion of the Assembly Line DD ZHdK 2008 (PD 5, on page 64):

> *Participant: "You have these fine movements on the touchscreen, together with the concentration, it has something meditative, it fits the sounds."*[8] (>5:6)

The participant here refers to the fine finger movements on the touch surface, which complemented larger movements of hand and arm (for instance swiping visual elements over to another section of the surface). In this case, a continuous sound was subtly modulated, resulting in a crossmodal aesthetic correspondence, that was well understood by the participants. However, this tight integration or aesthetic congruency, and the fact that the sounds would react to subtle control movements, also lead to the perception of the assembly line as a musical instrument, or artistic performance: A participant, asked why he thought that it was a musical performance, stated: *"because you could adapt it so subtly"* (>5:4).

Another example of meaning emerging from the relationship of action or gestural quality to sound can be observed in the Barking Wallet TAIK 2009 (PD 17, on page 67). The audience notices that the protagonist is pulling out the credit card very slowly, and some interpret it as having a resistance:

> *Participant: "When you actually physically try to pull your credit card out, you're acting like it was physically difficult to do it, so that implies some sort of other, non sounding (. . . ?...) I don't know, maybe it was just mentally (...)."* (>17:3)

The sound was the gnarling sound (created with recordings of zippers) which was meant to be the voice of the "barking wallet", but in combination with the slow movement it conveyed the feeling of resistance, that something is being pulled with force..

A similar phenomenon could be observed in the case of the Thermos Flask TAIK 2009 (PD 18, on page 68). Here, the perception of a "magic quality" was influenced by the gestural quality of interaction, in some way comparable to the assembly line:

> *I: "There was this gesture from bottom to up, very slowly, carefully, it was a careful gesture . . . somehow for me it was a magic gesture, because magic gestures use sometimes fingertips. You know like touching something slightly and doing something quite complex from that. It's a property of magic for me."* (>18:7)

This shows, that the experience and interpretation of a gesture-sound relationship does not only emerge from the technical mapping. The gestural quality itself, as a "sounding gesture" (sound being implicit in above statement), being subtle and executed with low effort using the fingertips evoked a the association to magic, or special powers. Thus, the quality of action and

[7] These cases are related to the code "associations to action qualities", which contains 6 quotes from 6 cases.

[8] *"Man hat diese feine Bewegungen auf dem Touchscreen, zusammen mit der Konzentration, es hat so etwas meditatives, passt zu den Klängen."*

function, how the hand is moving, what it produces, and the object, influences the experience and interpretation of the resulting sound.

In several cases, observable action and the related functionality guided interpretation, or even was the fundament on which interpretation was constructed[9], even though this was often rather implicitly reflected in the participant's statements. In some cases, the influence of action and performance quality on the interpretation could actually be stronger than the interpretational impact of the sounds[10]. An example of a direct influence of observed bodily action on the interpretation can be found in the discussion of the mockup of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73). I was asking if the sounds could be attributed to a source, e.g. the chair or the table, and a participant stated:

> *Participant: "I think it came from how he acted, I don't think it was the sound, it was more what he was doing."* `(>25:14)`

Also in the Foley demonstration of the Matchmaker UDKL 2010 (PD 52, on page 85), a sound, with the morphology of something snapping, is interpreted as related to physical effort, which was also motivated by the visible movement.

However, taking on a broader perspective on the cases, it turns out that there is no simple unidirectional effect of gestures and actions as "explaining" or justifying sounds[11]. For instance, while the Moody Hat DD ZHdK 2008 (PD6, on page 65) shows the relevance of observable agency and bodily movement on interpretation nicely, as without the gestures the interpretation of the various glass sounds would probably have been impossible, it also shows the mutual interaction between action related qualities and sonic qualities. The gesture of the protagonist, trying to pull the hat off his head, was actually clarified by the sound:

> *I: "It then started to clatter and hum when you wanted to take it off, I believe."*
>
> *Participant: "It fixed itself."*[12] `(>6.9)`

The sounds supported the interpretation that the origin of the resistance is some kind of reaction of the hat itself (as agent, fixing itself to the head actively) and not an illustration of the user's gesture. And thanks to the gesture, which was not hitting, but pulling, the identifiability of the sounds as glass shards or similar, did not lead to the interpretation that something was broken.

As another example of mutual influence between action and sound qualities, the interpretation of the Crocodile Tamer TAIK 2009 (PD 19, on page 70) as *"some kind of maybe very cool game toy"* `(>19:1)` is facilitated by the "craziness" of both the interaction (with some heavy shaking and swirling around of the artifact) and the didgeridoo sounds, which were judged to be *"a bit weird"* and *"magic" "alien", "crazy"*. I stated that the gesture reminded me of swinging a lasso, which emerges from the gesture itself, combined with the struggling action of capturing the crocodile and swirling it around, and the sonic context of the didgeridoo providing a sonic circular motion.

At the end of the interaction process a final gesture was performed, which led to some discussions. The participants soon agreed that it was some kind of distant control activity, as the gesture involved pointing and hand movement. The discussion revolved around what the gesture could mean exactly:

[9] The related code contains 13 quotes from 9 cases.

[10] The related code: "action / performance dominates interpretation" features 15 quotes from 10 cases.

[11] In fact, the association of a particular sound of the Energy Harvesting Office Chair with the elevator door sound from "Star Trek" (see Chapter 17) is an example of how easily the interpretation continuous action-sounds can be dominated by the sound itself, if the sound's identity (and, as consequence, identifiability) is strong enough, even if the sound's relationship to action (continuous, in this case) or the overall design context is very different.

[12] *I: "Er hat dann begonnen zu Scherbeln und Summen wenn man ihn abziehen wollte, glaube ich."*
Participant: "Er hat sich festgesetzt."

> *Participant: "I think it like the end of the game 'cuz he won and it's like 'I win'."* `(>19:10)`

This statement points out the interpretational impact of the gesture's quality. The final gesture of the interaction process is rather abrupt, pointing towards the artifact, and accompanied by a stereotypical "magic energy impact" sound. The discussion shows that the interpretation was not straightforward, but there was agreement that it was conclusive, decisive, and this aspect emerged mainly from the gesture itself, which was dominating, directional, determined. But only together with the sound, the gesture's effect - and thus meaning - could be more clearly narrowed down[13]. For some participants, the sound suggested some force emanating from the protagonist and being effective on the targeted object. Other participants related the sounding gesture to the interaction with the "robot pet", interpreting it as a gesture to dominate, to show *"who's the master"*, which was also inspired by the pet acting rather aggressively, and the sound being impulsive, energy burst-like. In both cases, the gesture was not understandable without the sound, and vice versa. The various strands of interpretation were finally integrated:

> *Participant: "But in a way it can be both because like if it some kind of like magic game artifact, (...) magic artifacts, they contain some kind of powers. And these power is some kind of spirit so it's kind of living forces. So you must beat these force as a like living creature to get some energy from it."* `(>19:10)`

Also the Bag to the Future TAIK 2010 (PD 44, on page 81) employed gesture-sound relations. In this case, several sonic confirmations were used, for instance for taking something out of the bag, or for dropping it on the floor. In addition there was a continuous sound associated with shaking. . The interplay of sonic and gestural or action related interpretational cues is illustrated by the following discussion:

> *Participant: "It's the bag that tells you if you don't have all you need with you and (...)"*
>
> *I: "How did you get to this idea that it tells you that."*
>
> *Participant: "Because she forgot her phone in the bag and it gave this warning sound. And then when she heard it she was like 'ah oh yeah' and she started looking."* `(>44:2)`

What the statement does not mention, is that the "warning sound" is actually audible in relation to walking around with the bag. Also, the warning was immediately evident to the audience, but not thanks to a typical "warning sound pattern" (e.g. siren or beep sequence) but rather because of "being out of place" in relation to the observed action (walking around with the bag over the shoulder) and the resulting experience of something not working or progressing as expected (in the logic of the tonal sequence). We can see here the interplay between interpretational cues from observed action, sound characteristics, and general, contextualizing behavior. Sounds and actions are both related in the interpretation. But in this ongoing dialogue between interpretational indicators in actions and sounds, we can observe that, even though the quality of the performance may contribute to the interpretation, the interpretation is ultimately initiated and motivated by the sonic event. Thus we could say that the performance was underlining the sounds in a way that provided their interpretation a more clear direction - or even a confirmation - rather than "explaining" them.

As this project involved a series of gestural interactions, there are further quotes that help to illuminate the interrelation between movement, or gesture, and sound in interpretation, such as the following:

[13] This also relates to quote "association with action qualities".

> *Participant 1: "...and then you were shaking it and you could hear some kind of..."*
>
> *Participant 2: "...confirmation..."*
>
> *Participant 1: "...sound (...)."* `(>44:6)`

The sounds being discussed here were sonically underlying the movement with a metallic tonality. Metallic sounds were also associated with the object being moved out of the bag. But interestingly, they were classified as "confirmation sounds", not just "things shaking" around, or the bag itself being moved. The sounds were not part of the sonic system associated with the actual bag and its contents, but by marking a sonic territory of their own (metallic, resonant qualities) they in fact express the functional extension of the artifact, where informative system sounds mark the semantic difference from the actual product's sonic nature, thus making it clear that it is the "system's voice" being heard, albeit stimulated by a gestural action.

22.4. Sound Qualities Motivated by Gestural Action

As opposed to the mutual integration of sound and gestural action in meaning making, sometimes sounds could be classified as motivated by gesture and action[14]. But interestingly, this is usually not a direct mapping of the objective gestural movement to sound, but rather a narrative exploration of the meaning of the gesture.

For instance, there is the gestural quality which leads to a sound design consideration from the CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *Presenters: "We're far away (...), we find a solution that we operate it without touching. So we made sonic gestures a bit and finally we ended up with magic sound."* `(>19:26)`

Here the notion of "touchless remote interaction" motivated the sonic design to move towards the sonic stereotypes of magic (which was also discussed in Chapter 17).

As mentioned earlier, an exact temporal analogy between the a sound and a simultaneous action was not often relevant in the designs studied here. Also, crossmodal analogies were not very relevant for establishing a relationship between a sound and gesture. Often, the connections would rather emerge based on what I would call "narrative", or "semantic relationships". For instance, in the Foley mockup of the MATCHMAKER UDKL 2010 (PD 52, on page 85) the designers explain the design strategy as follows:

> *Presenters: "The next would be pulling it closer and this would be a transition, transformation, calibration, increasing or deepening, which we used the straw because it made this like 'dgdgdgdgdgd' sound, and this you can't hear very well."* `(>52:13)`

The movement of *"pulling it closer"* was an important design orientation. The gesture was mainly understood from its narrative potential. So again, the gesture is not sonically "duplicated" or imitated, but the sound adds another layer of meaning and narrative dimension to it.

The association action-sound can work also when only a "part of the sound" relates morphologically to an action. E.g. a sound may have a steady component and a component with a change in spectrum, which is synchronous to a movement. Also the inverse counts: if a sound is not changed during an action, the listener looks for another possible relationship. The DANCING MATCHMAKER from TAIK 2012 (PD 86, on page 97) used modulations of musical sounds in realtime to make it clear that the dance influenced the music (and not vice versa). The prototype displays no sounds that accompany gestures, but musical modulations that are motivated by gestural qualities:

[14] The related code is "sounds motivated by gesture", altogether we find there 14 quotes from 7 cases.

> *I: "Where the modulations in real time?"*
>
> *Presenters: "Yeah."*
>
> *I: "Because that's what worked for me. I mean I think I had more the feeling that your dance actually was influencing the music."* `(>86:23)`

This shows the importance of clarifying, through the appropriate relation between sound an bodily executed agency, whether the sound motivates the gesture or the gesture motivates the sound, as expressed through gesturally motivated changes in sound qualities.

22.5. Gestural Sonic Affordances and Gestural Qualities in Sound

Affordances are an important topic in design theory. Altavilla et al. have proposed, that sound can afford, or motivate certain gestures, and thus act as "gestural sonic affordances"(Altavilla, Caramiaux and Tanaka, 2013). Gestural sonic affordances were not very often discussed explicitly during the workshops[15], three out of five related quotes in the analysis come from the same person, a design expert, and were uttered during the discussion of the same prototype. But as I will later show, related topics, such as "Ergo Audition" (Chion, 1998), the joy of self-hearing, could be associated with this theme.

Let us first have a look at the following statement from the discussion of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *Participant (visiting expert): "The sound you use now it makes you want to sit down. It goes like 'uaa...' You don't want to keep doing this. If you want to make people doing it like bumping, you want to do it more times. so something that pushes you back and doesn't make 'uaaa'."* `(>25:23)`

The visiting expert suggests that the sound resulting from the movement of sitting down should encourage repetition instead of being conclusive. This is a good example to illustrate what could be termed "gestural sonic affordance" in the temporal domain: Sounds can evolve over time, exposing a certain structure, which affords temporal continuation or repetition, emerging in dialogue with movement. Or, in the visiting expert's words:

> *Participant (visiting expert): "But you also have to think about what the sound does to your actions, what you want people to do."* `(>25:35)`

The office chair case can also be seen as an example of motivating the sound design by a certain gesture. The gesturality here seems to be the basis of some kind of affordance, at least this seemed to be the designer's intention: Through a crossmodal analogy, a sound, sounding like *"uaaa"*, would express a process from tension to relaxation, hence the affordance would be to sit down and remain in a relaxing position. This, however was not the aim of the design, which requires a repetitive movement to charge the device's battery.

A powerful design to motivate repeated use can result from the combination of the affordance of an object and the effect of "Ergo Audition", the joyful hearing of one's own actions, which would motivate the listening agent to repeat the sound-producing action. If sitting down produces a sound that affords repetition and is at the same time an enjoyable manifestation of the movement, the interaction is likely to succeed.

But considering repetition in relation to the temporal structure of sound and the potential results in terms of interaction affordance, also the expected (or desired) temporal intervals should be taken into account:

[15] The related code "discussing sonic affordances" appears in 5 codes from 3 cases.

I: "In this scenario you'd also have to think about how often you want to make people do it. (...) It's an action that you don't have to do every five minutes. (...) Maybe it's something you do in the morning, to charge the system up, and then you have peace for a few hours, and maybe after lunch the system invites you to do it again. That would require a slightly different design, the sounds would have to be a bit more solemn." (>25:37)

In addition to the consideration of the expected frequency of a specific sonic interaction I also suggest here to envisage "ritualized" interaction, which may stand out from everyday live as "special moments". So here two types of sonic affordances are used: the immediate motivation to repeat a movement (a combination of sonic affordance and Ergo Audition) and the recurring invitation after some time.

Another good example of Ergo Audition comes from the MATCHMAKER UDKL 2010 (PD 58, on page 85):

I: "At the moment when everything is 'shshshshsh', swallowed, (...) there is something, some narrative or dramaturgy, (...) but then you have an influence by saying, ok, I've got enough of this, and you put it down and this movement is where the sound doesn't just stop, but is kind of swallowed into this little thing." (>58:27)

The sonic interaction here is meaningful because the sound enriches the experience, not because it has a specific meaning. Also, it continues the "story" beyond the action itself, and expresses a dramatic transition (which again is an action, and action related) in the relationship between user and artifact.

A rather special example which also could somehow be attributed to the topic of sonic affordance is from the MACHINA OBTURANTIS, UDKL 2011 (PD 78, on page 93), where boredom and annoyance, resulting from a dull, repetitive sound, is used to motivate an action. The project provoked a a discussion about how people can be invited to interact with an artifact in another way than a more or less explicit "positive" affordance, as this project proposed to create annoyance through a continuous boring sound, which ultimately would motivate you to interact with the artifact by switching it off. Some design alternatives were discussed with the participants:

Participant: "Like as an interaction mode it could be that if you get closer the rhythm will change (...)."

I: "I know what you mean, it would be a kind of affordance to people. (...)" (>78:11)

A participant suggesed then to make it so that the artifact seems suffering. In this case, interaction would be motivated or afforded by a sound pattern which starts to go wrong, dissolve, or fall apart, while suggesting that it could be corrected or fixed by interacting with the artifact.

Finally, we should not forget the possibility of sounds actually discouraging interaction, as the following example from the discussion of the mockup of the MATCHMAKER UDKL 2010 (PD 58, on page 85) shows:

Participant 1: "...when (...) you want to take it then the sound is not really encouraging you to take it. (...) because it's like 'shshshshshsh'."

Participant 2: "It is aggressive." (>58:28)

A related sonic affordance comes from warning sounds, which require the listener to react. A particularity of alarm sounds is that they are often designed to have an immediate effect, exploiting properties of the hearing sense, such as sensitivity to certain frequencies. But as the following example from the INTERACTIVE CAR DD ZHdK DD 2009 (PD 38, on page 77) shows, more subtle (negative) sonic affordances can be powerful in order to motivate the correction of a movement:

I: (...) "What would it mean for you if the blinker would start to sound like this in a curve to the left?"

Participant: "Well, I would start to drive straight ahead immediately, because something..."

I: "So, correcting."[16] `(>38:7)`

In this case the warning is not just an abstract tone signal, but a transformation (distortion) of a existing sound (a tonal blinker sound, specifically designed to be "distortable"). It is actually not a warning sound, because it is not an added sonic event, but rather a modification of an existing interaction sound. This design approach adopts the way mechanical sounds usually inform us about changes in a process of interaction.

As a final aspect related to the topic of gesture and sound, the topic of sonic affordance is also related to gestural qualities evoked by sounds[17], a notion which has been discussed in literature related to electroacoustic music and new interfaces for musical expression. For instance, Pierre Schaeffer's concept of objet sonore (Schaeffer, 1966) features several dimensions which relate to gestural qualities, which have been further elaborated by Godoy (Godoy, 2006). Several versions of this association emerged from the discussion of the The Elevator TAIK 2009 (PD 15, on page 67), where no actual gesture or bodily movement was executed:

I: "There was something in the sound, something gestural of course, I think that was quite dominant." `(>15:4)`

This first quote refers to the phenomenon, that sonic movement is experienced as having a gestural quality, which is also present in the next quote, albeit more related to kinetic properties of physical bodies:

I: "In some examples you kind of had this inertia thing in the sound. You press the button and then it goes like 'shhhhhhshshhh' and some inertia has to be overcome first, and the thing starts to move." `(>15:24)`

The notion of inertia is another crossmodal quality of sound, being tightly related to physical phenomena. This perception of inertia can be associated with the overall process (e.g. being more laborious) but through its connection to heavy bodies, it applies well to the product in this case (elevators). We sonically experience the perception of force being applied, but also a smooth, steady progression, once the process in on the way. The sound also conveys a sense of acceleration, as response to pressing the button.

I: "You move more frequency wise than pitch wise, I think we also have this pitch shift to kind of enhance the... You get the feel of movement and acceleration and little bit of that." `(>15:31)`

This statement relates speed of physical movement to perceived pitch, which is based on the experience of change in revolutions per minute of engines related to acceleration of a car.

Another reflection on the gestural evocation of a sound itself comes from the Doc-O-Mat UDKL 2010 (PD 60, on page 86):

I: "(...) this login sound is (...) not just a gesture of sliding in and intruding, but also it's a noisy sound, it's not a tonal sound at all, but It'a also not a rhythmical sound, it's kinda going in." `(>60:25)`

[16] *I: (...) "Was würde das für dich bedeuten, wenn der Blinker in einer Linkskuve so zu klingen beginnen würde?"*
Participant: "Also ich würde sofort wieder geradeaus fahren, weil irgendetwas..."
I: "Also korrigieren."

[17] The related code, "sound design evokes physical processes / gesturality", contains 4 quotes from 2 cases.

The description refers to the sliding sound, which is related to an "intrusive" gesture. The sliding movement is in the sound, as it were, and disrupts the remaining sound aesthetics, thus giving it an alerting quality. This is a nice example of how the experience of certain sound qualities may in some caes intuitively lead to the perception of movement qualities. At the same time it shows, the often we find it easier to describe the experience in terms of movement qualities rather than the actual sonic properties.

23. The Impact of Structure and Composition

Some of the previous examples already have indicated, that not only the individual sound event, understood as isolated, informative or expressive entity, but also the temporal structure and composition of sound (as designed or emerging co-occurence and synchronization between various sound elements and progressions) played an important role in the interpretational processes[1]. The coding and semantic accumulation of statements related to this compositional dimension of sound design for interactive commodities led to several related categories which are discussed in the following sections.

23.1. Temporal Development and Relationships

First of all, sound is a temporal phenomenon. Thus we can use sound to structure time. This possibility emerged in several design cases[2].

23.1.1. Sequentiality

First of all, the specific sequence of sounds contributed to meaning making. The sounds in these cases were not heard (only) individually, but (also) in relation to their predecessors. Participants did take explicit note of sonic processes in several cases[3]. For instance, in the discussion of the Assembly Line DD ZHdK 2008 (PD 5, on page 64), a participant refers to the sequence of sonic changes in relation to manipulation of the interface:

> *Participant: "The manipulation, there is a moment, when you turn around on the touchscreen, and then at some point it is correct."*[4] `(>5:24)`

This final "point", which in fact is marked by a sonic resolution, makes only sense as conclusion of a preceding (sonic) sequence. The concluding sound of the sequence contributes to the interpretation of previous actions and sounds.

The following statement comes from the discussion of the The Elevator TAIK 2009 (PD 15, on page 67):

> *I: "It was actually an observation that you dissolve time. Your elevator ride, (...) you don't have the feeling of a precise time fragment, fragmentation. It's more like a flow (...) and you don't know exactly when it ends."* `(>15:38)`

In this case the temporal sequentiality is interpreted as a flow rather than a succession of discrete phases or events.

A somewhat special case of meaning emerging from sequentiality, is the use of an intensified version of the same sound when the same event occurs several times (repeating). An example for this is the statement from the prototype presentation of Das System IAD ZHdK 2010 (PD 68, on page 89):

[1] The related code, "analyzing design along structural, temporal, dramaturgic, compositional dimensions", is related to 12 quotes from 8 cases.

[2] The related code "sound design strategies: working with time and rhythm" contains 9 quotes from 9 cases.

[3] The related code "temporal sequence guiding interpretation" contains 11 quotations from 9 cases.

[4] *Participant: "Die Manipulation, es gibt so einen Moment, man dreht auf dem Touchscren herum, und dann inrgendwann gibt es einen Punkt an dem es stimmt."*

> *Presenter: "It is just always getting worse. It's not a sequence."* (>68:2)

As clarification it should be added that the presenters emphasized the change and evolution of the sound in each repetition and that they chose not to employ a sequence of the same sound being looped. This can be seen as a combination of two design strategies, one relying on each individual sound event, the other on the fact that each new sound expresses the same event in a more negative quality and thus relies on a specific sequential order for interpretation.

A similar situation was manifest in the various cooking scenario prototypes. Cooking usually involves a more or less strict temporal sequence. The related design challenge becomes apparent for instance in the demonstration of the Interactive Kitchen VID 2011 (PD 74, on page 90):

> *I: "The problem in this whole situation is at the moment that the system is not made for entering the process in the middle, but on the overall process from the beginning. At the beginning this basic sound starts and is emphasized und you know then, if it is played I have to take care of this part of the menu. And if you enter in the middle of the process, the sounds just happen and you think, ah, cool, the kitchen just sounds somehow..."* (>74:3)

Another interesting example of a rather unintentional effect of working with time and sequentiality emerged from the audience tryout of the same mockup. Here, a "ducking"[5] effect was employed in order to foreground an error sound. The fact that the ducking was proceeding relatively slowly, could be interpreted by some as indication that the overall process could have been affected by some kind of error from which it then would recover, as the ducking effect fades[6] (as discussed in (>76:7)). While volume as sonic dimension usually is not very helpful, it is effective in this case, because the volume modulation of one sound can be put in relation to another, ongoing or newly arriving, sonic object.

A sound in a sequence of events and sounds may retrospectively influence the interpretation of the previous sound. This can be the case in relation to an indexical sound, or a figurative sound with a "indexical trace", such as the synthetic boiling sound used in the Thermos Flask TAIK 2009 (PD 18, on page 68):

> *Participant: "And if he was waiting for the temperature, he would not have the boiling afterwards."* (>18:11)

Here it is important that the "sound afterwards" is identified as "boiling". In this case, the indexicality of the sound allows to deduce a related order of events (water first needs to heat up before it boils).

The Fridge, UDKL 2010 (PD 56, on page 86) is a very basic example of a causality-based sound - event - sequence, where the interpretation of a sound emerges from a logic of sequentiality:

> *I: "Why do you think that the door was left open?"*
>
> *Participant: "Because I heard the sound still. Because when you first used the fridge you shut the door and the sound was off, and the second time it goes on."* (>56:7)

Also in relation to the Sonic Car Boarding Project 2 ZHdK DD 2009 (PD 36, on page 76) the sequential order of events is discussed. Here, a sound is intended to be a *"reply of the car"* to the opening of the door. The presenter confirms, that this was her design intention:

> *Presenter: "My intention was that it is a reaction to being used, to me, but it being almost synchronously."* (>36:23)

[5] "Ducking" denotes a reduction of a sound's volume based on the event of a second, more important sound. The most common application is the reduction of music volume when a moderator speaks in a radio emission.

[6] This would be analogous to the phenomenon when the lid of a heated pan or grill is opened: some heat gets lost and one has to wait a bit for the heat to reach the previous level.

The following quote from the Intelligent Shower TAIK 2010 (PD48, on page 82) shows a conflict in interpretation between looking for hints in the sound itself ("cold" sound) and revising or questioning this interpretation because of the sequence of events:

> *Participant (visiting expert): "(..) Somehow it detects that (...) this guy is sleepy and needs to be woken up and the sounds are kind of designed for that purpose, but I was thinking perhaps it was related to the temperature, which is not, at least to my ear, audible."*
>
> *I: "So you mean it could be the sound that you hear already before you turn the shower on (that) could have warned you that it's going to be rather cold. (...) Because it was first the sound and then only he said 'shower' and the water came."* (>48:7)

Similarly, in the Matchmaker UDKL 2010 (PD 52, on page 85) temporal sequences were discussed:

> *I: "There were three stages happening in three events."*
>
> *Presenter: "Well, kind of."* (>52:1)

Here, we were discussing a Foley mockup, where the sound was not refined yet. But the distinction of phases in the interaction process was a central functional element in this design. In this case the discussion starts from this general structural distinction and then starts looking at the individual sounds.

An interplay between linear progression and events of change can be observed in the demo of the Foley mockup of Doc-O-Mat UDKL 2010 (PD 54, on page 86). Participants noticed the sequentiality of the narration, supported by sounds:

> *Participant: "After there was an obvious peak, and then the things go back, or they don't go back (...) as they were. There is no more breathing, there is no heartbeat, there is just (...) the crumbling of paper, everything is like very dry, very crisp."* (>54:8)

In this case, the appearing and disappearing of sonic components, or the absence of elements in otherwise similar sonic states, is noticed and also identified as potentially meaningful. Also there is an explicit reference to sonically expressed states, to which the process is "going back", but at the same time acknowledging, that it is not simply a reversal, but rather a "re-visiting" of a formerly previous state, which has been changed as well:

> *I: "Obviously there seem to be two phases. The one with the heartbeat and the breathing is kind of the initial phase, which somehow builds up to... and then a transition happens."*
>
> *Participant: "There is some discharge - or charge."*
>
> *I: "This transition moment is somehow initiated with the water sounds."* (>54:9)

It is striking that the transition is both a certain point of change in a otherwise linear and foreseeable process and also stands out sonically (water sounds). The water sounds used here are abstract enough to avoid being overly indexical. The participant hears a *"discharge - or charge"*, thus perceiving specific states and temporal development. This can also be related to the following quote from the discussion of the Sonic Car Boarding Project 2 from DD ZHdK 2009 (PD 35, on page 75), which shows how a participant perceives elements of the process, their connections and the related processes:

> *Participant: "I heard relationships, (...) individual processes I heard indeed."*[7] (>35:1)

[7] *Participant: "Zusammenhänge habe ich gehört, (...) einzelne Abläufe habe ich schon gehört."*

23.1.2. Impact of Sequentiality on Interpretation of Sound Qualities

In the following, I will discuss cases which show, how the purposeful design of temporal or compositional relationships between individual sound events could foster attention to sonic qualities, emerging from spectro-temporal configurations of sound.

For instance, consider the following observation from the same Foley mockup of the Doc-O-Mat UDKL 2010 (PD 54, on page 86):

> *I: "I get something much less temporally structured (...) than in the beginning, which was much more structured through the heartbeat and the breathing. The first part was more rhythmic, the second more fluid. (...)"* (>54:10)

Note that I take note of the change in the temporal structure in an early, even foundational, stage of interpretation, and it seems that sonic qualities like *"rhythmic"* or *"fluid"* help me in making my interpretation. In the statement, I continue:

> *I: "Probably what we all would agree is that something has been built up, becoming more intense, eventually breaking out or over and then ... this relaxing in some way. It's kind of the metalevel."* (>54:10)

This shows that by listening to the sonic qualities, in relation to their compositional arrangement, I was able to identify various semantic levels and a general development of the process.

Another interesting case comes from The Elevator TAIK 2009 (PD 15, on page 67). The design does not rely (only) on notification about discrete events, but aimed to convey an overall process with various states (riding the elevator) in various aesthetic interpretations. A motivation behind the flowing sonic structure was to support "peripheral attention" in that the listening could happen on a general level rather than being caught by individual sound events. But the compositional quality also motivated a detailed interpretational analysis of the sounds, as it allowed to identify sonic properties exhibiting something like a "counterpoint" function, as discussed in the following quote:

> *I: "Actually it gave me the feeling that you are turning right, instead of (...) down. It was on the same level (...) it just changed maybe a third of the first sound or maybe a fifth (referring to tonal intervals here). It just tried to give the tonal aspect but not the feeling of you really accelerating upwards."* (>15:8)

First, a design pattern for up and down is established. Then, somewhat surprisingly, another design pattern is introduced, which can lead to an interpretational effort, because it works on other parameters than the established pattern. The effect of this systematic relation, and the necessary structural, analytic listening, was supported by the overall "musical", melodic, design approach. Also this particular example shows that complex timbral or harmonic changes can be understood and learned, and are in fact a good alternative to one-dimensional pitch change:

> *I: "I've heard at least three different total setups of sounds (...) in the beginning it was this rather low frequency and harmonically dense drone. (...) At some point we had this high pitched whistle sound, where I almost thought something was broken in the elevator. And there was some wind sound of movement. And on the top there was a very thin, string like high pitched sound."* (>15:12)

And, just following this statement:

> *I: "So it's not like a pitch change but more like different areas and within these areas you then modulated the sound more subtly between state one and two."* (>15:14)

By avoiding the obvious change of pitch, or "embedding" it in a more sonic composition, the interpretation can be detached from the stereotypical crossmodal association of pitch with "up" and "down", and represent a more abstract, general "state change".

A interesting case in this context is The Sonic Puzzle IAD ZHdK 2010 (PD 70, on page 89), also because it can be analyzed in relation to the pitch discourse from the Elevator case:

> *I: "Yes, it was very obvious, (...) in particular in the last stone where the tones approach in pitch and finally merge to one unison sound."* `(>70:3)`

Here as well it is not pitch per se to denote "higher" or "lower", but the merging of two different tones to a single one to inform about a process change and its quality. The relationship between two (abstract) sonic entities becomes the basis for interpretation. The following quote from the same prototype actually confirms the interpretation:

> *Participant: "It was quite clear to me, in the beginning one builds a chaos with the white bricks, the music*[8] *there sounded very chaotic, when they built this beautiful white pyramid, it sounded very beautiful and clean."* `(>70:2)`

This participant, while not explicitly mentioning the convergence of the pitches, perceives a transition from chaotic to "clean" sounds. This change is caused by both timbral change and the changing dissonance in the interval.

Another possible design dimension was the perceived, or actual, complexity of a sonic composition, here with an example from the same project:

> *I: "Somebody said 'more complex', I think this was clear. Also more moving. I also had the impression, when he took something away (...) that it would make a step back, (...) that it disappears. (...) I certainly perceived more movement and more beeping when it is constructed in an irregular fashion, and when it was constructed in a more regular way it becomes rather static."* `(>70:12)`

In this example, complexity and simplicity, as two different states of the interaction, are expressed sonically. This "information" is not conveyed in an individual triggered signal, but as a continuous change which moves between known and identifiable sonic states.

In this context, a sound which kind of stands out sonically, and is staged as a clear response to he process, can be meaningful even if it is rather abstract. This was evident, for instance, in the case of The Dancing Matchmaker from TAIK 2012 (PD 86, on page 97):

> *I: "I remember there was a very bassy full thump. I interpreted that as the system kind of says 'no it's enough, enough events happened. I can judge, or help you judge each other' (...). Also it relates with the starting sound."*
>
> *Presenters: "Yes, there is actually some bass used in the samples at the very ending of the perfect match and then at the beginning."* `(>86:26)`

The low *"thump"* stands in contrast to the other process sounds, is voice on a second layer, originating from the system. And in addition it is designed to correspond with other system sounds.

23.1.3. The Sequential "In-Between": Transitions

A particular aspect related to sequencing and composition is the moment, or process, of transition[9]. While it was explicitly discussed only in four design cases, it certainly was implicit in several designs, in particular those who try to convey a (gradual) change through sound. It also

[8] *The participant uses the word "music" also when she speaks about other sounds.*

[9] The related code, "design focusing on transitions", contains 5 quotes from 4 cases.

turned out that, although "transition" as a (sonically expressed) phenomenon is very common in everyday and filmic sound experience, it seems difficult, at least for novice sound designers, to grasp conceptually and use intentionally in design decisions.

The designers of The Elevator TAIK 2009 (PD 15, on page 67) focused on representing the continuous transition through several states (floors):

> *Presenters: "It's kind of a transition with phases within them, so we were focusing on these transitions."* `(>15:29)`

These transitions play a crucial role in the experience of this type of artifact, as the elevator crosses the various floors of a building, but cannot be sensorially experienced, except for the floor number changing on some kind of display. In order to ensure the listeners focus on transition as central design aspect, the creators explicitly avoided any rhythmic elements in the design, avoiding an association with the stereotypical "elevator music" scenario, where the purpose of sound is to distract from the elevator as moving, claustrophobic space.

Another example of a design emphasizing transitions comes from the Crocodile Tamer TAIK 2009 (PD 19, on page 70). The designers discuss a sonic transformation they employed:

> *Presenter: "I am not sure if you heard this sound... So it's nature, changed a bit, more playful, like sizzling, and then gradually to the end pacing down and finally, a house cat."* `(>19:23)`

An interesting aspect of this design is the transition from abstract qualities of the sound to a sonically identifiable object (the house cat), which, however is still used as a sonic metaphor, as the artifact is not meant to actually transform into a cat.

Also, consider the following statement from The Toaster UDKL 2011 (PD 80, on page 93):

> *I: "There was always something happening (...) so for me that were lots [of sounds] that express transformation, something changes inside, but the change is not clearly structured, it's not cumulative."*
>
> *Presenters: "Yes."*
>
> *I: "...it doesn't go to a specific point and then it's over. You don't really understand, you just understand that something is changing, something material is changing, and in the end, quite to a surprise, this change stops."* `(>80:14)`

This quote reflects the aesthetic and informational benefit and added value of representing systematic or structural relations sonically. In this case, a transformation which seems open ended, comes to an abrupt stop. This project case also shows, that transitions can come across also independent from a detailed understanding of a design, which is emphasized in the following quote:

> *I: "And I also couldn't make much sense out of it, but what I really got was the three versions of the transformation. The first one (...) was really gentle (...)."* `(>80:15)`

The failure to "make sense" does not hamper the overall interpretation and experience, as there is a lot of additional information conveyed. It is thus worthwhile to take care that perception of transformation is ensured, both in terms of systematic relationships and in terms of qualities of the various states.

An example pointing to a potential issue comes from the Assembly Line DD ZHdK 2008 (PD 5, on page 64). The designers built on the idea of having three sounds merge into one sound in the process of transformation:

> *Participant: "I did not hear three sounds, I heard only one. Simply a beautiful sound. (...). More that now it's over, finished."* `(>5:22)`

The "finishing" moment does come across. the rest seemed blurred into one single, yet *"beautiful"*, sound. Actually the indication of conclusion of a process was actually the main purpose of the sound, and the fusion of the three sounds was part of the design strategy to achieve it. But in this case of combining or merging individual sounds, care has to be taken that elements of a design are audible as such, also to a relatively untrained listener or in suboptimal listening conditions.

For a similar example, consider the SONIC CAR BOARDING PROJECT 2 from DD ZHdK 2009 (PD 35, on page 75), where I stated:

> *I: "A problem is maybe: the moment of the impulse and the resonance form a single event and can't be distinguished well."*[10] `(>35:12)`

The desingers' intention was in fact to work explicitly with an impulse sound and its resonance, which is also noticed by the listener. However, in this case, the mixing and arrangement of the elements would need elaboration. Investigating this design case further, we find, that the designers aimed at conveying a flow of phases into each other:

> *Presenters: "Everything should be in a flow, should have a melody. The [elements of the] whole process of entering (...) flows into each other."*
>
> *I: "Musical, isn't it. But obviously it is not quite clear that it is a coherent flow, maybe because the presentation was a bit confused for technical reasons."* `(>35:5)`

Note how the designers refer to "melody" as aesthetic orientation for the flowing experience of a series of transitions. According to my answer, this progression did not come across, assuming that it might be due to technical issues. A bit later I state that:

> *I: "This was also a bit the problem, you wanted to represent a process with an end. What is missing is an overall dramaturgy, in the melodic parts. Here you could have worked with simple concepts of musical processes."* `(>35:9)`

It turns out, that while there might have been some technical issues, they were not the main obstacle to the establishing of a flow of events. Rather, a kind of "musical" dramaturgy, joining the elements in a common arch, was missing, and the experience resulted in a series of rather dissociated elements. This is a good example why musical design strategies do not necessarily make the conveying of coherence and transitions easier, but rather require a significant amount of compositional competence. This indicates the relevance of how the temporal progression is designed, if there are clear segmentations (such as bars in a metric composition) or if there is a rather continuous flow of changes. But the understanding of structured transformation as such, based on a sonic modulation, seems to be quite reliable[11], and independent of an understanding of other informational aspects.

23.1.4. Tempo, Beat, Rhythm and Event Density

Another design strategy was to work with change in tempo. In discussion of THE TOASTER UDKL 2011 (PD 80, on page 93), the interpretation focused on the temporal experience of the toasting process:

> *I: "The toasting process is always a bit of a surprise when it ends. (...) For instance, when I boil coffee (...) I don't have this surprise, because of the 'chchchchch' increasing (...). Also the tea kettle starts to whistle slowly, it doesn't whistle apruptly. (...) Maybe (...) some more musical acceleration towards the end could make the experience more smooth."* `(>80:27)`

---

[10] *I: "Ein Problem ist vielleicht: der Moment des Impulses und der Nachklang formt sich zu einem Event und lassen sich nicht gut auseinanderhalten."*

[11] Transformation in fact is one of the main narrative functions of sound in film, as emerged from the analysis of "Narrative Metatopics" (Hug, 2010a).

Here, I am referring to several everyday live sonic processes and their temporal structure, which relies on the perception of increasing dynamics in the process, and I suggest that acceleration can be used to achieve a similar effect[12].

Also the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73) contributes to an insight related to working with time. I have discussed this earlier, in the context of gestural affordances in Section 22.5, that the "call to action" may also be differently articulated depending of its temporal structure. I am suggesting that sounds that occur more rarely should or could be more elaborated than sounds that correlate with intermittent interactions such as pumping or jumping. Here the timing and speed is actually a correlate of the user's action.

In some cases, beats and change of tempo in a metric design was used as means of conveying information. For instance, in the discussion of the Thermos Flask TAIK 2009 (PD 18, on page 68), the presenter argues:

> *Presenter: "I also thought of a sound that when it's getting near the temperature I had chosen, there would be some kind of sound that is accelerating (...)."* `(>18:19)`

Also the statement in relation to the possibility of creating your own rhythm in the Sonic Puzzle IAD ZHdK 2010 (PD 70, on page 89) relates to this aspect:

> *Presenters: "There we have a rather calm noise, because the other one is quite chaotic, which becomes something like your own beat. (...) You have this in order to prevent the whole thing from becoming too stressful, you provide your own beat, by this noise."* `(>70:5)`

This design understands sonic interaction pacing as potentially self-regulating process where a beat and rhythm pattern emerges in the process of interaction.

23.2. Establishing Foreground and Background

When discussing aspects of structural composition, strategies of foregrounding and backgrounding sonic elements are of central importance.

The Sonic Puzzle IAD ZHdK 2010 (PD 70, on page 89) used sound which disappear in a overall mix:

> *Presenters: "With the idea, that what you are building right now is loud, and the other (elements) are in the background, and when I continue building here, this comes to the foreground."* `(>70:6)`

This project used a simple "clack" as confirmation for setting a brick. Here the sound, albeit very neutral, stands out because the rest of the sounds are a tonal blend, in the words of the designers,

> *Presenter: "It defined itself rather through rhythm, the others were rather tonal."*[13] `(>70:5)`

Hence, the sound, albeit silent, always stood out very well, and at the same time fit to the physical interaction[14]. The repetitive "clack" of the interaction produces also, by means of the user's actions, a steady beat, which:

[12] This relates to the code "temporal sequence guides interpretation" which was discussed above.

[13] *Presenter: "Es hat sich eher durch die Rythmik definiert, die Anderen waren eher Töne."*

[14] Note how this design handles the balance between indexicality and abstract sonic quality: Despite being a "physical" clack sound, the sound is sufficiently generic or abstract in terms of source attribution. We hear a generic, functional clack, or impact, but it is clear that whatever may have caused it originally is irrelevant for the interpretation.

> *Presenter: "...prevent the whole thing from being too stressful."* (>70:5)

Foregrounding of notifications was often achieved by using tonal or timbral contrast. For instance, in the Interactive Kitchen VID 2011 (PD 72; PD 74, on page 90) we find the use of tonal and musical design strategies in notifications. A spherical chord was used for a general "process finished" event. This worked well, as it is an ambiguous musical sound which conveyed a musical closure, while also standing out from the other sounds. Thus here we have a notification with a more general meaning, which is less frustrating if you don't understand it precisely, which in this case was even not required. In addition, tonal sounds can profit from their temporal sequencing.

Also the Bag to the Future TAIK 2010 (PD 47, on page 81) is a good example of a "neutral" design being a useful for a sound being understood as "confirmation" or "feedback" – even without resorting to cliché beeps. The purring sound occurring when the bag was dropped is a case in point:

> *Participant: "(it) wasn't aggressive for me, it just tells 'now you dropped me, it's OK'."* (>47.17)

Other sounds used had a metallic resonance, which clearly differentiated them from the organic impression of the bag's own sounds. As consequence they were interpreted as notifications related to the objects in the bag. The sound of taking out something of the bag is related in timbre (metallic), with an added resonance. Still basically a quite neutral, metallic notification sound, this resonance was sufficient to foreground the sound and the related gesture of taking something out of the bag and holding it up.

23.3. Establishing Semantic Links and Groups

As the examples have shown, building perceivable sonic relations can play an important role for establishing meaningful semantic relations, even with abstract sounds, that do not by themselves convey a specific information. In the discussion of the Dancing Matchmaker from TAIK 2012 (PD 86, on page 97), I put it this way:

> *Presenters: [play sound] "...and this one is different. Here it's three, actually."*
>
> *I: "Yeah it's three, but it could be two. That's the semantics I mean. You know, you can actually have a lot of change in the sound to express different qualities, and still communicate that they belong to a family, that they are kind of part of the same group. And that's how you can build, that you can create usability, but at the same time go quite far with the sound design itself, go further. And this 'dongng-dogngng' could be the recognizable element, that's kind of persistent, and then you can modulate a lot of other stuff around it to create different qualities."* (>86:20)

I am referring here to the strategy to combine sonic elements in a suitable way, and providing "persistent sounds", in order to convey belongingness and thus structure the temporal process (which in this case relates to the negotiation of linking between two participants, or a recognition progress related to the matching of their profiles). In this way, "sound families" are established that help expressing the overall process and it's varying qualities in relation to each other.

One means to establish a semantic link is to use a sound of an expected event to anticipate it. An example of this is a sound from the Intelligent Shower TAIK 2010 (PD48, on page 82) which accompanies the showering process, but starts slightly before the water comes out of the shower. It is designed as an abstract sound using "dropping" elements, which establish an association with water.

Another approach from the same design case is a repeating notification sound which is slightly changed, on each repetition, on a linear progression of increasing "emphasis". The other sounds are always happening in relation to specific events (such as voice commands). If all these sounds are designed to be perceived as belonging together, yet associated with different types of events, they contribute to a structure which is understandable, or learnable. Of course, the design has to make sure, that these relations can be perceived, at least after they have been learned, and well memorized for future reference.

Related to semantic links is the notion of semantic grouping, which signals belongingness of several sounds to each other. A related example comes from the EXPLORATIONS UDKL 2011 (PD 82, on page 95). The creators used distinct sonic groups, which were also perceived as such. This aesthetic differentiation (I use the word "gap" in the quote) itself worked well, in particular between "sounds from real life" and "created sounds" (which here refers to musical or tonal elements of the design):

> *I: "You are right, there is quite a gap, but the gap is there for a reason... Maybe the gap should be designed in a slightly different way, but it should still be perceivable as different. Because they have the same mapping principle, or the same procedure, but with a different quality."* `(>82:6)`

Grouping also contributes to the establishment of hierarchies, as means of foregrounding and backgrounding sounds or activities, as discussed in the previous section (23.2). Such sonic hierarchies can also be established "vertically", as "layers". The prototype of the INTERACTIVE KITCHEN VID 2011 (PD 72; PD 74, on page 90) used this strategy:

> *Presenter: "Well, we have something like a sonic hierarchy. And those clouds are actually way down in the hierarchy. This means, you can also ignore them, (...) that's why you hardly recognize them, they should be like blinkers, so you know in which pan you are right now, so to say. But higher up in this hierarchy are the info sounds, and on top, there is the error, which we did not show, so when you make something wrong regarding the process. And when you leave the room and the oven is still on, then there is also... this one's then also higher in the hierarchy, is more annoying and obtrusive. And those soundclouds we designed on purpose that you hardly notice them, that they fit to whatever you are doing."*[15] `(>74:6)`

Another insight from the analysis is that a perceivable structure is particularly important, when some sounds suggest elements of transitions or change, as it is evident in the the following sequence from the discussion of THE TOASTER UDKL 2011 (PD 80, on page 93):

> *I: "For me, there were lots [of sounds] that express transformation, something changes inside, but the change is not clearly structured, (...) it's not cumulative."*
>
> *Presenters: "Yes."*
>
> *I: "It doesn't go to a specific point, and then it's over. And the change just happens, you don't really understand you just understand that something is changing, something material ist changing, and in the end quite to a surprise this change stops, with no further notice before."* `(>80:14)`

Hearing that a particular sound is changing to another sound, is thus indicative that there must be some kind of systematic relationship involved.

Let us return to the DANCING MATCHMAKER from TAIK 2012 (PD 86, on page 97) for a closer look, as it is a good example for the need of clear sonic grouping. It works with temporal

[15] *Presenter: "Also wir haben so wie eine Klanghierarchie. Und diese clouds sind eigentlich in der Hierarchie ganz unten. Das heisst man kann diese auch negieren, darum sind sie, darum erkennt man sie fast nicht, sie sollen eigentlich wie Scheuklappen, damit man weiss in welcher Pfanne man sich jetzt befindet, sozusagen. Aber in der Hierarchie höher sind die Infotöne, und ganz oben ist dann der Fehler, den haben wir gar nicht gezeigt, also wenn man irgend etwas falsch macht im Ablauf. Und wenn man rausgeht und der Backofen brennt noch, dann gibts auch noch... der ist dann auch höher in der Hierarchie, der nerviger ist oder penetranter. Und diese Soundclouds haben wir extra so gestaltet, dass man sie fast nicht bemerkt, dass sie passen zu dem was man gerade tut."*

structure, but in this case it is always the same structure, or process, which gets repeated, and it is the differentiation of sonic developments which convey the changed quality of the same process. A particular challenge of this design was the sonic dialogue between the two systems involved, one being the handheld device and the other being some kind of invisible ubiquitous tracking system. Upon activation of the system, there was a sonic dialogue going back and forth between the two elements, and finally the system was audibly activated `(>86:6)`[16]. Referring to this audible agency[17] of the system, the various levels of agency involved in the user interactions, and the need to clearly structure the related sounds, I stated:

> *I: "You have here the decision whether a system makes the sounds, or the user makes the sound. With the dance, you are making the sounds, you need sounds that relate to physical expression like this. And then you have the system level, you have to convey the feeling that the system acts now. In the startup, in these confirmations in the end, also in the qualification of these confirmations which is three different ways of qualifying the outcome in a way, so that's the assistant system telling you something, and the other sounds have to do with you doing something. The performance is there different. I think the approach is quite well done, and the startup sound should sort of correspond to these ending sounds, and kind of create a bracket. Also when you hear the ending sounds you immediately get the feeling 'aha, I heard this sound already, ah yes, it was in the beginning', kind of creating a logic between the two. Kind of make the whole experience a whole and not fall apart too much."* `(>86:22)`

This shows also the relevance of appropriate semantic grouping of sounds in supporting the attribution of agency.

In this mockup, we can also identify a special case of semantic grouping, which is the use of notification sounds[18] as a "container" for information:

> *Presenters: "(...) the computer knows when the girl arrives, gives the popup message, 'wowoh, this is a highly like match for you' (...)."*
>
> *I: "I clearly heard that when somebody entered, she would kind of emit something, some 'bing', and then on his side, 'bung' (...)."* `(>86:12 & 13)`

An interesting duality of the "popup sound" manifests itself in this statement: The sound, first and foremost, is a "popup message", and does not really have an information content, it is not the more specific "*wowoh*", as uttered by the presenters, which would be a sound of joy and satisfaction, but a neutral "bing" in response to an observable event. This "bing" is then followed by a "bung", which is only informative in terms of relating to the "bing" through being a sonic variation of the former. So on the one hand, we can clearly differentiate between structural/semantic information given by the sound and informative content. This also indicates, that even on this simple, even trivial level of sonic communication, careful design can contribute to semantic clarity[19].

An even clearer example for the semantic relevance of the popup sound category, and the understanding of a notification sound as providing a "sonic container" for some kind of information, comes from notification design of the mockup of Das System IAD ZHdK 2010 (PD 68, on page 89):

> *Participant 1: "(It is) something like 'now the Message comes', Some kind of popup, like an error message."*

[16] This observation is linked to code "differentiationg user interface sounds from system processes" and the question of attributing the sound to an agent in the interaction, as discussed in Section 21.

[17] For an in-depth discussion of agency, see Chapter 21.

[18] The related code "interpretation of sounds as 'notifications' contains 11 quotes from 8 cases.

[19] A good example (and success case) for a current software which offers a comparably complex semantics of short notification sounds is Skype.

> *Participant 2: " (...) for me this would be rather neutral, nor warning nor success, but rather an indicator."*
>
> *Participant 3: "(....) maybe (it is) like a speech balloon."*[20] (>68:1)

This conversation suggests, that there is a notion of a "neutral popup sound" which serves to attract attention, but also can be seen as the sonic manifestation of the very event of something occurring. The notion of sound establishing some kind of temporal "container", background, for an actual message is striking. The sound is, as it were, marking a segment of time, during which another piece of information can be transported. Also, the "sonic notification container" could be theorized as a means to foreground something in the same way as a verbal or non-verbal expression may be used to underline and emphasize a hand signal (or vice versa). In conclusion, these two last cases are examples of neutral popup-as-container (or background) on the one hand, and a semantically constructed system of notifications, which become informative by their sequential relationship and semantic and sonic grouping.

[20] *Participant 1: "(Das ist) so wie eine Art 'jetzt kommt dann die Message', so eine Art aufpoppen, wie ein Popup, eine Fehlermeldung."*

Participant 2: "...So wär es für mich eher neutral, weder Warnung noch Erfolg oder so, sondern eher als Hinweis."

Participant 3: "(Das ist) vielleicht so wie eine Sprechblase, das Fenster wo die Message darin erzählt wird."

Part IV.

Designing Interpretational Force Fields for Interactive Sonic Identities

Introduction to Part IV

After scrutinizing the details of the discourse around design and interpretation in Part III, I will assume a somewhat superordinate analytic stance in this final part of the thesis, while still maintaining the link to the discussions from the workshops.

The following chapters set out to discuss some of the fundamental issues and paradigms as they emerged from the discourse in the workshops. These paradigms are partially also present in Auditory Display discourse as described in Part I. The analysis will show, that rather than focusing on naturalism and indexicality of sound in design, we should consider the persistent phenomenon of ambiguity. As it turns out, ambiguity does not necessarily have to be an issue in the interpretational process. More often than not, it is simply unavoidable, and in many cases it may even contribute to the experience and the interpretational process in a positive way. Also it is linked to a general notion of instability of meaning making in interaction processes with artifacts and humans.

Building on this insight, I will propose an alternative conceptual model to approach the design of interactive sonic commodities. Instead of suggesting that there is a more or less reliable ground for establishing, or even pre-determining, interpretations, this model posits the metaphor of interpretational force-fields, where more or less converging points of attraction can be established, which are subject to processes of negotiation and transformation. This model is particularly helpful, when dealing with the design of "possible futures". Based on the insights from the workshops, I will then outline some possible approaches for design, and show, why an emphasis on design, understood as careful crafting of elaborate *sonic identities*, is important, if sound is meant to succeed in being considered a major asset in the creation of new everyday experiences.

Also throughout this part of the thesis, quotations from the workshop discussions are set in *italics* and their index number in the Atlas.ti database is indicated in brackets.

24. Issues with Naturalism, Indexicality and Stereotypes

> "The second doctrine is this. All bad art comes from returning to Life and Nature, and elevating them into ideals. (...) The moment Art surrenders its imaginative medium it surrenders everything. As a method Realism is a complete failure (...)."
>
> *Oscar Wilde, The Decay of Lying, 1891*

I have discussed earlier (see 2.4) how the scientific paradigm of much research related to Auditory Display relies on identifiability of sound, the use of already existing and established sounds and sonic stereotypes, and a general tendency towards sonic naturalism. I also have described the problems arising from this approach. Thus, it was of particular interest to investigate how issues around naturalism and identifiability manifested in the cases discussed here.

Despite the heterogeneity and diversity of interpretational approaches reported in Part III of this study, the function and relevance of indexicality of a given sound for the interpretational process turned out to be a major topic. Sounds were often motivated or discussed in terms of their (original) sources, and the indexical function of sounds was quite prominent. However, not only "purely" naturalistic indexical sounds, which directly represent a specific source, were used. On the one hand, naturalistic indexicality was often combined with symbolic or emotional dimensions or as indicators for metaphoric narratives with an affective dimension. And also in many cases I encountered figurative rather than naturalistic sounds, i.e. sounds which were mimicking a certain source but were not based on a recording of the source.

But even in this "weak" form, indexicality was often a core motivation of sound design, and also related to issues[1]. In the following I will summarize and discuss the phenomena collected in relation to this underlying paradigm.

24.1. Naturalism and Indexicality Conflicting with Other Meaning Potentials

One common motivation to use naturalistic sound in the projects from the workshops was to build on its symbolic or metaphorical potential. This lead to the identification of a negative impact of using "natural" sound references, which was that their indexical power may conflict with other meaning potentials[2]. This is also true for natural sounds which are used in narrative or coded contexts, such as animal growls, which have been discussed earlier (see section 16.5). The following examples will illustrate this point.

[1]The related code, "researcher explains issues with indexical sounds", contains 13 quotes from 9 cases.

[2] This is reflected in the code "naturalistic sounds prevent symbolical meaning", which contains 2 quotes from 2 cases as well as the code "perception of source index conflicts with metaphorical or symbolic function" (5 quotes from 5 cases) . In general, the potential conflict between indexical and other means of meaning making is associated with the question about first and second order semantics, as defined by Flückiger (2001).

Concerning the issue with animal growls, we have the case of the SONIC CAR BOARDING PROJECT 2 from DD ZHdK 2009 (PD 35, on page 75). During the demonstration, the presenter suggested, that she wanted to convey an attitude, or emotive expression of the car, but in the discussion it turned out that the sound was not heard for its affective quality, but as simple index to "predator", as specific (growling) animal category, and could not be interpreted as symbol for its affective, emotional expression.

The conflict between identified natural source and other meaning potentials can also be illustrated with the use of sounds of water. In many cases, a recording of water was used to evoke metaphorical and associative dimensions[3] related to water. In these cases, the index to a natural sound producing object may conflict with other (intended) meaning potentials. For instance, let us consider the discussion of the ENERGY HARVESTING OFFICE CHAIR IAD ZHdK 2009 (PD 25, on page 73). In this case, the goal of the design was not to focus the attention on water as physical entity, but instead to express purity:

> *I: "You have to find something in the sound itself that is pure, which does not need this index to water."* `(>25:29)`

And I am continuing to create an ad-hoc theory:

> *I: "The indexical thing (...) may work but often it doesn't, especially when the mapping is abstract and symbolic."* `(>25:29)`

In order to understand the point here, it is important to acknowledge that I am using the term "mapping" in a somewhat confusing way here, as I am not referring to the causal relationship between sound parameters and data parameters, but instead to a more general relation in the meaning making process, which is not purely representative of a sound source, but rather stands for a concept which is attributed to the source by convention.

In the Foley mockup of the DOC-O-MAT UDKL 2010 (PD 54, on page 86) water was used to display relaxation. Here the occurrence of a clearly identifiable sound led to confusion:

> *Participant: "From the sound I wasn't sure about the water, what was going on, except from the last part when Anne was relaxed, that was like a wave thing, but why we had the curly water I didn't get really."* `(>54:6)`

In this case there were two instances of water: one instance were wave-like sounds which can be seen as an instance of "water" with a stronger emphasis on the temporal structure of the change of loudness rather than on the identification of the material object[4]. The other instance was clearly identifiable as water splashing. This sudden presentation of a clearly identifiable sound confused the listeners, as it suggested a more explicit index to water itself instead of an affective expression of relaxation through slow, wave-like sounds.

Another example of a naturalistic reference to a sound producing source were sounds of metal, which were in some cases used to evoke the association with coldness, similar to the sound of water in the case discussed before. Underlying is the idea that a certain sound (water or recordings of resonant metal being hit) signifies cooling both because of a bright spectrum and an association with a cool object. This would result in a combination of both indexical and metaphorical qualities in the same object. But also in this case, the indexicality could turn out to dominate the interpretation. The following quote from the discussion of the Foley mockup of the INTERACTIVE FRYING PAN TAIK 2010 (PD 45, on page 81) is a good example:

> *Participant: "...like this one we thought it a bit cooling, for some reason, because it has this kind of ice or metal (...)."*

[3] I have discussed various examples using water sounds previously, see Section 16.1.

[4] The sound used in this case was in fact a continuous crumpling sound.

I: "For me (...) the sounds remained (...) as too bell like sounds with a rather hard attack that reminded too much of metal being hit. So the physical quality was very present and that's the thing with the metaphorical use of sound (...), for the symbolic content. (...) Also if we understand them symbolically, (...) especially if they are so material like this one, they just are archetypes of some objects, of materials, of material qualities. So coldness is a very indirect association with metal." `(>45:16)`

Similar to some of the uses of water sounds mentioned before, the intended use of the sound was to convey "cooling" and some participants were able to interpret the sonic transformation in the intended way, but only if the abstract metallic notion was defining the sonic impression. The designers in fact used generic metal sounds, but due to the hard attack and timbral characteristic an indexicality of metal being hit emerged, and the resulting material "image" (*"bell-like"*), dominated the interpretation[5]. I also state then, that some sounds like this can be so strongly coded by film that we would understand the "meaning" of the sound, but this would not mean that they would necessarily be useful in a given design context, because everyday interaction does not usually take place in a controlled "narrative context" as film does.

The use of an accelerating heartbeat[6] in the design of the Doc-O-Mat UDKL 2010 (PD 54, on page 86) exhibited the same problem. During the discussion, I made the proposal that not the (cliché) heartbeat should be used, but some kind of acceleration as pattern, and keeping the organic notion. The reason was, that the codes associated with the sonic artifact of "heartbeat" are distracting from what it was meant to convey (in this case: increasing excitement, acceleration, pressure) `(>54:14)`.

In the prototype of the The Toaster UDKL 2011 (PD 80, on page 93) clinging glassy sounds were used both symbolically and as abstract expression of the process. But they were associated by some with the sounds of rattling dishes on a train `(>80:1)`. Another example of "indexical mishearing" comes from the Matchmaker UDKL 2010 (PD 58, on page 85). Here we can hear a sound which was intended to be an abstract expression of a process quality, conveying release of energy. However, the sound was heard as "purr of a cat" by participants `(>52:8)`[7].

A possible generalizing explanation of these examples could be, that they all seem associated with a type of familiar sounds, which do refer to a sonic quality usually encountered in nature or in mediated representation of nature. These sounds and their occurrences are characterized by being generally in the background of attention yet usually they are also appreciated as listening experience, at least in western cultures. Very few people would argue that the sound of a river is in itself an annoying or boring sound. Also it is imaginable that a naturalistic rendering of a river sound in a film, or even in an audioplay, might be something we would rather enjoy listening for quite some time. The problem lies in the fact, that in the case of this interactive application, the sound of water, or of a river, is only there because it is meant to convey a certain information. The water sound has no "raison d'être" in itself, neither for its aesthetic quality, nor for its narrative potential. It is merely a carrier of an intended referential function. The listener is not supposed to listen to the water sound, he or she is supposed to listen for what is *supposed to mean*. And this creates a discrepancy between the familiarity of the sound itself, its potential aesthetic quality which still might be noticed, and, on the other hand, the potential obscurity of its meaning, because sounds like these in the first place are references to themselves: The meaning of the sound of water is to indicate that there is water (hence, *indexical* sounds).

How could this issue be approached in design? Obviously, there are good reasons to work with clearly indexical sounds in some cases. The following examples may provide an indication: In the discussion of The Toaster UDKL 2011 (PD 80, on page 93) I point out:

I: "...'cause ambiguous scratching sounds could really happen inside a metal thing,

[5] This can be compared with sounds which retain their symbolic meaning from film codes (see also Chapter 17).

[6] A discussion of the heartbeat sound stereotype can be found in 17.4.2.

[7] In this case, however, this interpretation was not in direct conflict with the design, as it aimed at conveying a "living" quality in the object.

> *they are not a cliche, they are not a symbol of something, they are just sound in the first instance. (...)"* (>80.8)

In this case, we are dealing with a identifiable sound (scratching inside a metal object) which still avoids the identification of one specific type of object, thus remaining quite general, and therefore not establishing an indexical point of reference. Also the "scratchiness" is an affective, almost corporeal sonic quality which helps to bridge the gap between the general and the specific. As opposed to naturalistic reproductions of sound producing sources, such as water, more abstract notions of "wateryness"[8] did not dominate or bias interpretation. This can be illustrated by returning to the discussion of the DOC-O-MAT UDKL 2010 (PD 54, on page 86):

> *I: "What I liked is also that you worked with water sounds, and this relaxation was perfectly understood, I think."*
>
> *P: "Cooling down".*
>
> *I: "But maybe not the watery notion, but this structure that water has."* (>54:26)

While spectro-temporal structure was reminiscent of water, the sound used was not too naturalistic reproduction of a specific water-object (such as a river, creek, fountain etc.). In the discussion following this statement, I suggested some strategies to create a "watery" sound without using water, in order to focus on the quality of coolness, rather than the physical object "water" (or an object producing it). In this way, the interpretation would still rely on the identification of water, as it works based on our bodily experience of cool water, but it would direct attention towards the sensory perception associated with touching it.

24.2. Undesired Foregrounding of Indexical and Stereotypical Sounds

Another recurring observation, also in relation to the aforementioned interference of indexical sounds with other meaning potentials was, that naturalistic, indexical sounds tended to "absorb" the listener's attention. Either they would *foreground*[9] the sonically indicated object, or the sound itself would perceptually stand out among other sounds. This was accentuated by stereotyping, which was often required to reinforce an indexical function. A good example of this unintended foregrounding is the case of the SONIC CAR BOARDING PROJECT 3 DD ZHdK 2009 (PD 37, on page 76), where the design used a sound of a tiger roar. This sound immediately attracted the listener's attention (>37:20), as it was heard indexically, giving virtual presence to an actual tiger. This prevented its intended symbolic meaning potential (e.g. "power", "aggressiveness") to become effective.

Another example of a misunderstanding, which emerged from foregrounding, origins from the project EXPLORATIONS UDKL 2011 (PD 82, on page 95). This is a case of an interpretational code associated with a sound "overwriting" its naturalisitc interpretation. The discussion around the sound of water in the prototype showed, how a sound of water, which was meant to be a fountain in a virtual city soundscape, was interpreted as potentially symbolic sound, because it was *"way too present"* (>82:20). Curiously, there was a glass of water placed on a table near

[8] In the sense of "Index Sonore Materialisant", i.e. notions of materiality in an otherwise non-indexical sound.

[9] I use this term in two ways. On the one hand, there are processes of identification and indexicality described in this chapter, which make a sound "stand out" and may even lead to it dominating our interpretational attention. On the other hand, a similar effect occurs in relation to performative action: Performance studies posits, that self-referentiality may emerge through the performative quality of interaction. An example would be a person performing a gesture very slowly or stretching syllables when speaking. This performative phenomenon leads to what Elam calles "foregrounding" (Elam, 1980), and has been observed in several cases described here. I have described the impact of performativity on meaning making in sonic interactions in more detail in previous work (Hug, 2010b).

the location where the water sound was audible, which led at least one participant to speculate that the water could have to do with this object (>82:13).

> *Presenter 1: "Well, we had three levels of sounds, positive sounds, negative sounds and ambient. The ambient was the city, that does conclude the water, it was maybe..."*
>
> *Presenter 2: "...it was a fountain, actually."*
>
> *Presenter 1: "It was probably too prominent to still be the ambient sound. And..."*
>
> *I: "Ah so the water we heard there was an ambient sound."*
>
> *Presenters: "Yeah it was a coincidence."*
>
> *I: "It flipped into the other level, so to say."*
>
> *Presenters: "It was way too present."*
>
> *Participant: "It happened at the time... I saw a glass of water and... [all laughing]"*
>
> *I: "Yeah, it happened,... [laughing] It was like the funny (...) in a movie, because its like this sound there that there two ladies sitting and all of a sudden... 'shshshhshsh' [all laughing]."*
>
> *Participant: "We will always see a pattern when there is none, this is crazy."* (>82.20)

In this case, the motivation to use a water sound was to evoke the notion of a diegetic fountain in a sonically represented city. But the sound's prominent quality led to listening to it as a potential sonic code, and the potential archetypal or symbolic meaning potentials of water, and much more interpretational attention was devoted to it than the design would have required.

I allude to another aspect of the design in relation to the sounds of flies and geiger counter, in the following quote from the same presentation:

> *I: "In particular in this very clearly foregrounded way it doesn't even sound like this, I think from the device, it sounds probably more thin, more 'chchc', thin and small."* (>82:10)

While both sounds (flies and geiger counter) are already problematic because of their filmic stereotyping, foregrounding of such sounds adds to the issue that they do not "merge" with the environment or are not perceived as part of the artifact.

Another example of undesired foregrounding of stereotypical sounds is the following statement from the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *I: "The water as a sample (...) isn't clearly water like in a river, and it shouldn't be, because it would be boring after a while and why should I hear a river."* (>25:29)

Here, foregrounding is additionally driven by repetition of a sound which in itself is distracting from the actual artifact and situation to some kind of absolute sonic object. Also in the discussion of the AcuPot DD ZHdK 2009 (PD 39, on page 79) there were issues with using naturalistic water sounds:

> *Presenters: "With the watering sound it backfired. It's too indexical."*
>
> *I: "Yes, its very comic-style."* (>39:24)

Here the actual watering was complemented with a watering sound, not just as "Foley" effect to simulate the actual watering, but as the system's confirmation. Apart from being redundant in that it does not bring any benefit to the understanding of the situation, the clarity of the sound gave it a somewhat cartoon-movie effect. In the case of the project Explorations UDKL 2011 (PD 82, on page 95), I expressed my increasing annoyance with the recurring use of naturalistic water:

> *I: "The index is so strong. Water water water, what the heck! If it's coded, culturally, to have this meaning, then of course you can understand it, but it doesn't necessarily fit an aesthetic."* (>82:13)

The sound thus is not only an index, but it is also overwhelmingly strong, dominant. Also in the presentation of the Foley mockup from the Doc-O-Mat UDKL 2010 (PD 54, on page 86) I react to the disruptive character of indexical sounds, when a participant proposes to use the sound of a door opening and closing for logon and logoff (>54:23). First, the door sound could be too realistic and thus either misinterpreted or ignored. Second, through its foregrounding, it faces the problem of distracting interpretational focus away from the actual scenario at hand.

Sounds that can be identified as human or animal vocal utterances play a particular role among the indexical sounds in terms of foregrounding and disruptive quality. The animated, vocal quality seems very persistent in sounds that are developed from recordings of such sources. In an experience prototype, the often dominating vocal notion may accentuate the foregrounding issues associated with indexical and stereotypical sounds.

To conclude this section, let us also consider the – rare – cases, where familiarity of an indexical sound did lead to the opposite effect of foregrounding, resulting in them being simply ignored, or backgrounded, as it were. This is a likely outcome particularly in sounds, which we usually encounter as simple perceptual background of a soundscape, or as subconscious listening experience, as in the following example from Machina Obturantis, UDKL 2011 (PD 78, on page 93):

> *I: "The ticking clock has the disadvantage that it is quite a familiar sound and it could just happen that people simply don't notice it. (...) So its about the semiotic of the sound as well, that the same idea could profit from more unique sounds, that have to do with the character design of this thing."* (>78:9)

Also it should be noted that foregrounding is not problematic per se, but needs to be employed carefully and as a means for communication and expression. In particular it can be an important means to stimulate and sustain attention, to which we will return in Section 27.4.

24.3. Sonic Stereotypes: Between Simplicity and Caricature

In many project cases, including the ones described above, the indexical, naturalistic sounds were actually sonic stereotypes, either in that they were designed after established sound stereotypes, or created as simplified versions of some natural example (what could be called "stereotyped sounds"). As mentioned earlier, stereotyping is a consequence of the aim to achieve identifiability of a sound.

In fact, stereotypes can be quite reliable (and convenient[10]) tools for establishing interpretations, and there are many good reasons to rely on them for communication purposes, provided the interpretational context is narrow enough. In film or games, this context is provided by the setting and narrative. Indeed, stereotypical and cliché sounds may clarify and inform the interpretational process, as is evident from the related cases[11]. In particular, stereotypes were useful in earlier drafting stages of sound designs to get an idea across. For instance, in the discussion of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73), which was designed to help the user to distinguish between more or less environment-friendly energy sources, I asked the designers why we were supposed to think one energy was "good" and one "bad":

[10]On a side note, some cases suggest, that lack of inspiration of creativity may have lead to the use of stereotypes, and they were seen as some kind of "efficient" (or even "cheap") design solution. This lack in turn might in some cases result from a lack of experience with sound, or a lack of motivation to innovate and be original. On the other hand, sonic stereotypes were also used by more experienced sound designers.

[11]The related code "cliché sounds clarify" collects 14 quotes from 11 cases.

> *Presenter: "The bad sound should be very deep, industrial, powerful, you should hear the atomic energy generator in this sound. In the good sound there is a natural thing, I had the sound of water in the sample, it should be light energy, happy."* `(>25:18)`

And in fact, the intended meaning came across quite well in this case.

But several observations also clearly point out issues associated with sonic stereotypes, where the very stereotypical nature of the sound could be misleading the interpretational process, making them, as it were, "false friends"[12]. A first issue is, that sonic stereotyping may cause or contribute to an undesired foregrounding effect, as discussed above. Moreover stereotypes often oppose the goal to create a specific, unique character or identity through sound, an aspect to which we will return later in Chapter 27. For example, many conceptual categories do not have a unique sonic stereotype as counterpart.

An example comes from the Interactive Kitchen VID 2011 (PD 74, on page 90). A continuous background sound was used to monitor the general heating process of the oven, using a synthetic, resonant, bubbling sound:

> *Participant: "The only thing which was not so clear was the thing in the background, that the individual ingredients were still boiling... [sound is played] This is has been generated, but... [it is unclear] if this is now coming from the onions or from whatever..."*
>
> *I: "(...) This reminded me of cooking with water, (...) If I see here a pan and a pot I would rather associate it with the pot than with frying, wouldn't I."* `(>72:4)`

This example shows the use of a sonic stereotype in the form of an abstracted "generic" Auditory Icon which ultimately is based on "boiling", as "pars pro toto" for "cooking". This is problematic, because the represented conceptual domain (cooking) can be sonically manifested in many more forms, which all are linked to rather specific events and processes (noise of frying, steam, etc.). But these processes are not suitable to create a sonic stereotype, as they are variations of white noise, and this resulted in the use of the more characteristic sound of boiling, with the described interpretational problem as result: The sonic stereotype of boiling was indeed a "false friend" in this case.

But not only sonic stereotypes and stereotyped sounds, but also the use of stereotypical symbolic associations with sounds was quite common[13]. By symbolic, here I mean sounds, that have a specific meaning by narrative convention (as described by Flückiger (2001)), such as the scream of a red-tailed hawk, which in many films is used to symbolize "wilderness", and a "lonely place"[14]. In this kind of stereotype not only the sounds themselves are stereotypical (both in terms of stereotypical sound type, and stereotypical sound property) but the actual way how they are used in a functional or narrative way is a stereotype.

It is not surprising, that the most reliable sonic stereotypes were those which are also established in media, in particular in mainstream film. It is plausible to assume, that the narrative mainstream media of a specific culture deliver a good basis for building on reliable and established conventions. At the same time, this strong binding to specific semantic and narrative contexts is another issue associated with sonic stereotypes. On the one hand, several of the examples mentioned above indicate that sonic stereotypes, both from film and based on everyday sound experience, can be transferred to other contexts in some cases[15]. For instance, the startup sound stereotype seems to work well in the general context of starting interaction processes, at least in a draft design version. As it turned out in the comparison of the various "startup sounds" of the Sonic Car Boarding (DD ZHdK 2009), this seemed to work under the condition, that

[12] A related code, "cliché sounds misleading", contains 6 quotes from 3 cases.

[13] The related code, "relying on cliché symbolic associations", contains 25 quotes from 13 cases.

[14] See http://www.filmsound.org/cliche/.

[15] In fact, the related code "sonic stereotypes can be transferred to other contexts in some cases" only contains three quotes from two cases.

it is understood as absolute sonic signal from the car's "system", framing the actual interaction process (e.g. the beginning and end). But if a "startup sound" stereotype was integrated into the sounds occurring when operating the car as driving machine, it would lead to a break in the sonic narrative, and perceived as a functinoal unit of its own. In this case, a it would become a caricature, and potential disturbance. The same was the case if the startup sound was too similar or even identical to a known startup sound.

More often than not, the transfer from (filmic) stereotypes is not working out. Consider the Sonic Car Boarding Project 3 DD ZHdK 2009 (PD 37, on page 76), where the designer tried to transfer an design quality expressing an aspect of a product identity from advertisement to the sound design. In this case, some transformation of the sound was necessary: the brand identity was not conveyed using an metaphor like "strong as a tiger", and then using a recording of an animal growl in the mix (as it was done in the Sonic Car Boarding Project 2 (PD 36, on page 76) but as a more abstract sound quality of "strength and power", which was conveyed by an abstract, deep, vibrating sound. We see from this, that sonic stereotypes cannot be well transferred, if they are strongly association with a specific application domain (such as advertisement). Also many examples given earlier (geiger counter, heartbeat sounds, etc.) illustrate the problematic use of sonic (filmic) stereotypes[16].

A particularly strong version of sonic stereotypes is the use of "cartoonified" sounds. "Cartoonification" refers to a sonic quality of some indexical sound designs, which sound like "generalized" and simplified sonic versions of a "natural" sound. A related sound design strategy has been proposed in Sonic Interaction Design literature (e.g. Monache et al., 2009; Brazil and Fernström, 2011; probably first proposed by Gaver, 1988, p. 88). The rationale behind this approach is, that "Auditory Icons" can be understood as simplified versions of the sounds they are based on, but that the simplification occurs specifically by reducing detail and focusing on particular "outlines" of a sound, the perceptual qualities that would generally make the sound identifiable, while getting rid of all "unnecessary" details. Often these qualities are so called perceptual invariants, for instance related to perception of material, size and movement.

But while this approach can be very effective, there are some issues associated with cartoonification. The very reduction of the sonic complexity – be it by design, be it a side-effect of the synthesis method used – may lead to an effect which I would call "caricature", where selected properties of a sound are over-exaggerated to an extend where the sounds character may easily flip over into the comical[17]. The modification of the sound in respect to it's reference source can also lead to the perception of "reduced quality", or even the notion of a malfunctioning sound reproduction. Furthermore, the process of making certain sonic elements, e.g. changes in resonance, more prominent often results in sounds which are not subtle and stand out in the sonic environment, resulting in an undesirable foregrounding. Here, the strive for clarity and understandability often stands against the need for subtlety and "good mix", and the achievement of the essential quality criteria for a soundscape, according to Truax (2001): diversity, variety, balance. Ultimately, this relates to the issue of the balance between subtle design and clarity of the "message", which appeared occasionally in the discussions[18]. From the discussion of the Interactive Kitchen VID 2011 (PD 74, on page 90) we have the following quote from the designers in favor of subtlety in sound design, at least in the case where a learning process is acceptable:

> *Presenter 1: "Well, the system is designed in such a way, that you first have to become acquainted with it."*
>
> *Presenter 2: "If it is so penetrant right from the beginning, you will switch it off after*

[16] See also the discussion of design approaches building on "filmic listening" in Chapter 17.

[17] This phenomenon occurred relatively often in the cases studied here. The related code "design motivated by fun / irony / exaggeration" is related to 12 quotes from 7 cases.

[18] The related code "conflict between need for subtlety and need for clarity" covers 3 quotations from 2 cases.

two times preparing a meal."[19] (>76:4).

We will return to this issue also further below in Section 27.3.

24.4. The Power of Filmic, Mediated References

24.4.1. Dialectics and Ambivalence of "Everyday" and "Filmic" Interpretation

The concept of "listening modes" describes ways, how we perceive, experience and judge the same sound differently based on how we listen to it. The modes most commonly referred to are "causal", "semantic" and "reduced" listening (Chion, 1994). Other modes, such as "critical", "empathic" or "functional" listening have been proposed by (Tuuri, Mustonen and Pirhonen, 2007). From the cases described above it becomes evident, that the use of sounds in mass media plays an important role in their interpretation, and a new category of listening emerges, which is not covered yet by current theories of "listening modes". It could be called *"audiovisual media based listening"*, or more specifically, *"filmic listening"*. This denotes a mode of listening to sonic events, which frames the sound in a specific interpretational context of film sound. This mode can be seen as complementing the other listening modes, because its contribution to the interpretational process lies in specific narrative contextualizations and normative functions of (mainstream) film.

An important insight from this study is, that this filmic listening mode may both inform and bias the interpretation of sounds. Thus, in this understanding, a "realistic" sound's properties do not have to be rooted in reality. In at least eight cases participants applied what I would like to call "filmic listening mode". This means, that the (situated) sounds were interpreted in the context of learned filmic schemata. Other codes relate to filmic clichés and sound ideas originating in filmic sound experience[20].

This popularity of filmic sounds in design, and the filmic listening interpretation, raises the question if filmic sound design strategies and sonic schemes can be applied in non-filmic contexts. There is good reason to assume, that sounds that are well understood in a filmic context are not necessarily useful "everyday" settings. The transfer of symbolic functions from image to sound, or film to "real world", may not be working at all, because of the contradicting context, or it may be working as such, but lead to undesirable results.

In fact, the relation is dialectical: Many everyday sounds have their stereotypical counterpart in their use in audiovisual mass-media, particularly in film, because many sounds of movement and physical interaction on the film set very often cannot be used in the film, and thus are added in the post-production process through Foley techniques. Often the sounds are also overemphasized in order to improve perceivability in a mix, or because of technical limitations of the recording chain (mixing possibilities, weak signal-to-noise ratio). Overemphasis may also result from a narrative function of a sound: While the lock of a door may be rather subtle in the context of a "natural" soundscape, it can become a device of suspense if standing out in the soundtrack of a thriller. It was a common phenomenon, that people would use, and recognize, sounds, which they never could have heard, or noticed, in "real life", as the following statement by a presenter illustrates:

> *Presenters: "It's like firing up a power plant or something."*
>
> *I: "Which I don't know how it sounds like, I have never fired up a power plant [all laugh]. But that's what I mean , we have these codes in our head an think that's how it should sound."* (>86:28)

[19] *Presenter 1: "Also, das System ist so gemacht, dass man sich zuerst etwas einarbeiten muss."*
Presenter 2: "Wenn es von Anfang an schon zu penetrant ist, dann stellt man es nach zwei mal Kochen ab."

[20] Moreover, there are 16 quotes associated with the code "association with filmic sound cliché".

Thus, filmic sounds may be taken for actual "natural" everyday sounds, and the borders between mediated and actual experience blurs.

But filmic sound does not only provide us with stereotypes of everyday sounds. Film has also the power to establish new stereotypical "sonic realities". For instance, the sound of the lightsaber from the Star Wars movies is a complex artificial creation without a real world equivalent, but has become part of a "naturalized" sonic vocabulary. The same goes for countless sounds associated with all kinds of artifacts and interactions from fantasy and science fiction films. We could speak of a "naturalizing power of filmic sound (stereotypes)", that leads to a particular version of a sound of X being accepted as "the only sound of X"[21].

A closer analysis of the related cases in the following sections shows, that there is good reason for being sceptic towards the use of filmic sound, and in particular filmic sound stereotypes, as inspiration.

24.4.2. Issues of Changing Listening Modes

I have described that interpretation of a sound based on filmic associations constitutes a change to the "filmic listening mode". In this section I will have a closer look at this phenomenon. The issue also relates to the question of a sound being a *presentation* or *representation*. For instance, we encounter the filmic strategy of enunciation of magic in CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *I: "I think I understand, because this clingeling sound is an enunciation of magic power in a movie, directed towards an audience."*
>
> *Participant: "It's a kind of fantasy sound."*
>
> *I: "It's not a sound that Harry Potter hears."* `(>19:33)`

Here, the occurrence of the magic sound is foregrounded through the memory of the filmic cliché which then alters the listening attitude. This creates a problem on two levels: Firstly, it is not anymore a diegetic sound of the artifact, it becomes an extradiegetic sound. And secondly, and as consequence of the first, it changes the whole attitude towards the artifact and the interpretive setup towards a *representation* rather than first-hand experience.

In a related statement, I refer to using sound to mark something as magic, and that although the stereotype may work, it may bias the whole approach as a "cinematic" story.:

> *I: "I think it was successfully applied, because we understood it as magic. So in that sense the communication worked. But if, maybe if you would design really such an artifact... Well you still could use it if it is part of the game of playing the magic wizard you wanna maybe be part of a cinematic story as well in some way..."* `(>19:34)`

The destabilization of the listening mode and interpretation is here also caused by an incoherence in design resulting from using a single filmic stereotype in isolation, as the following statement shows:

> *Participant: "One of the reasons why it might have seemed different, is because the other sounds were like tangible sounds. They were sounds that actually come from something you can identify. The magic sound was, like, what makes a magic sound! You know, like, it doesn't exist really in real life."* `(>19:35)`

Thus we can conclude, that one of the main problems of using filmic sound stereotypes is, that the interpretational attention is moved away from the actual artifact and the interaction with it to another (narrative) context.

[21] This effect has thus a different cause than the normative effect of the scientific method on design of sounds (see Section on page 22), but the effect on design is the same.

The association of a sound with a filmic narrative is not always as evident and reliable as in the case of the "magic" sound cliché. Depending on the specific design, and the ability of listeners to remember and associate a potential filmic origin, there is a potential ambivalence of attributing a sound to a "filmic" or "real" origin. For instance, during the interaction process of the EXPLORATIONS UDKL 2011 (PD 82, on page 95) the sounds suddenly disappear and it was unclear if we were dealing with a sonic representation of someone leaving the room (in this case, the sound would represent what the protagonist would hear) or if it was intended to work like an filmic enunciation sound (where disappearing sounds can be used as "subjectivization markers", as described above). This interleaving of "naturalistic" and "filmic" sounds (and clichés) is a possible reason for perceived inconsistency (see `>82:19`)[22].

In THE TOASTER UDKL 2011 (PD 80, on page 93) we encounter two other sound examples: heartbeat and whispering. The sound for the heartbeat was the stereotypical heartbeat familiar from audiovisual media, increasing the probability that it will be associated with the filmic heartbeat cliché. Referring to the whispering, a visiting guest states, after seeing the final presentation:

> *Participant: "And this sound makes me think that the sounds are about your memory."*
>
> *Presenters: "Yeah. Like imagination."*
>
> *Participant: "Yeah, (...) because before I had the same picture as the others had, and it was directly connected to the machine. But when the heartbeat started I connected the sounds with you."* `(>80:10)`

Thus, the whispering and the heartbeat as a symbolic stereotype from film transports the (staged) everyday experience into a filmic narrative context, where sound become enunciations or "comments". The listening mode is changed, which may, or may not, fit the overall interaction situation or the designer's intentions. Observing my own interpretational process, I stated:

> *I: "I think it's very true in a way, because the heartbeat as a symbolic sound from the movie language, so to say, is lifting it out from a kind of fake everyday experience to something more filmic or narrative. So we have a little break of coherence there."* `(>80:12)`

Despite this "break of coherence" of the design, it seems that it could, in principle, be accommodated in the interpretational process. And following the statement from above, it was actually the heartbeat who helped to connect the whispering with the protagonist, as it was interpreted as enunciation of the subjective state of the protagonist, and thus led to a reframing of the other sounds as belonging to the same context, which in principle, was the designers intention. Still, the whispering voices, originating from the toaster, were also associated with the filmic narrative of "inhabited (or magic) artifact", which stereotypically relies on enunciation sounds, such as diffuse, whispering, voices, to be established. This interpretation could also flip over to the imagination of something actually living inside the toaster, which is another adoption of a filmic fantasy narrative:

> *Participant: "I didn't quite know what to do with this, but its kind of weird that the toast inside of the toaster was some kind of living [being] (...)."* `(>80:7)`

From this emerged the idea of an alternative space inside the toaster, where some "little gnomes" would get angry because of too much work, now clearly entering a purely "narrative" mode of understanding. From a purely functional point of view, even in this case we could have an working interpretation, as it would lead to the correct conclusion, in this case the toaster being activated, the toasting process ongoing and potentially the toaster being an smart artifact, extended with

[22] Coded as "possible reason for inconsistency: using both 'naturalistic' and 'filmic' sounds (and clichés)".

additional functionality. The problem is, that the designers intended the voices to represent non-diegetic voices in the protagonists (user of the toaster) head, which again, is an entirely different form of filmic sound narrative:

> *Presenters: "The voices that you imagined to be the toaster were more like a thinking person."* `(>80:18)`
>
> *Participant: "The sound comes from the toaster but was reflecting you somehow?"*
>
> *Presenters "Yeah..."* `(>80:20)`

The whispering sound is partially diegetic (as actual sound of the artifact), and at the same time can work as a (filmic) sign of subjectivization, or a narrative explanation, or, as "inner voice of protagonist", thus leading to an insecurity in terms of how to listen and interpret it. And also it turns the artifact into part of a staged narrative instead of standing for itself.

Such designs, as I put it in a discussion, is *"going out of the artifact"* `(>80:23)`, leaving its "diegetic space", the sound leading the interpretation away from a current situation and the artifact at hand, which opens the door to conceptual inconsistencies and interference with unrelated narratives and aesthetics. This leads us to the fundamental problem of diegesis in schizophonic interactive commodities, which directly relates to the question of attributing agency (see Chapter 21). The problem of diegesis is also related to the question of how sound is attributed to a source or a location.

24.4.3. Foregrounding, Filmic Indexicality and Caricature

The Explorations UDKL 2011 (PD 82, on page 95) case reveals another issue associated with using filmic stereotypes and clichés: In their original, filmic context, the sounds are carefully embedded in a mixture of sounds, including often background music. Furthermore the audience's attention is guided by the narrative and action on screen. In the case described here, the sounds instead were standing out, even played singularly, as signals, which alters their relevance. This was a particular problem when the sounds were also trivial and uninspiring.

A particular foregrounding issue arises from certain sounds being strongly associated with a particular filmic genre, such as horror, fantasy, or science fiction, as discussed in Section 17.3, or if they even evoke specific TV series or movies. Such sounds often are quite widely known and have become part of a cultural sonic vocabulary. As described, this was the case in the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *Participant: "I associate it rather with Spaceship Enterprise, the door of the elevator."*[23] `(>25:9)`

Here, the sonic memory of film sounds leads to a distraction from the intention of the design, by evoking the fictional object of the elevator in the spaceship enterprise (or a sonic stereotype of science-fiction elevators), which is misleading in two regards: The conceptual object "elevator" is misleading in terms of the presented artifact (which is an office chair) and the association with Star Trek interferes with the construction of the artifacts very own narrative. When the sound was detached from this connotation in the discussion, it remained nothing more than a trivial and superficial notion of a generic "hydraulic system", as a participant stated, which did not further support the interpretation.

A similar case was the Gremlin association of the Sonic Paper DD ZHdK 2009 (PD 40, on page 79), in quote `(40:13)`, as well as the association with the Chewbacca character (`(19:8)`, for both cases, see Section Section 17.1). This case works a bit differently than the office chair, as it shows that a sound may well trigger interest, even through a filmic association, but also here we can see that it rather seems to impede the necessary further interpretational process.

[23] *Participant: "Ich verbinde es eher mit dem Raumschiff Enterprise, die Türe des Lifts."*

A further issue of use of filmic stereotypes arises because they may be just too common and "worn out". In this case we deal with a negative effect of recognizability, leading again to caricature. For instance the usual sonic stereotypes to denote "magic" in film are not only strongly biased by a filmic context, but also banal to such an extend that it becomes an annoyance, as we can see from the reaction of a participant to the presentation of a "magical gesture" at the end of the presentation of the CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *Participant: "Yeah, magic again!"* `(>19:9)`

A related general observation of using familiar filmic stereotypes is, that the filmic narrativity of the sound (or its cliché function) not only may destabilize the listening mode and interpretation, but actually may dominate the interpretational process, and once adopted, makes it hard to open up for other possible approaches to interpretation. We will return to this issue in Section 24.1.

24.5. Overcoming Sonic Servitude

In this chapter I have addressed some conceptual principles underlying not only the design and interpretation of Auditory Displays and Sonic Interactions, as demonstrated in Section 2.5, but also was manifest in several case related discussions of this study. These principles are: naturalism, identifiability and familiarity. "Naturalism" describes the aim to adhere to a sonic phenomenon as it can be found in "nature", to reproduce it as accurately as possible. Identifiability requires sounds to be identifiable in terms of the source they represent, which commonly refers to a "naturalistic" source (e.g. a physical object emitting the sound). Familiarity posits, that sounds should not be new, but familiar, to the listeners. Thus, we can differentiate between identification of a sound, recognition of the sound's source, and, apart from that, the question about its actual "cause" or "represented / imitated cause". While the motivations for each of these specific principles might differ, they usually serve to establish "indexicality" of a sound, in the sense, that it points to an object of reference, and is itself supposed to "disappear" in the interpretational process. These sounds do not have any other relation to the artifact or interaction than being a support for an interpretation, which does not really consider them, for their own sake. They are, as it were, *sonic servants*, shortly appearing to fulfill their duty, just to vanish again into the shadows.

Often, this approach limits the possibility to take into account the specific qualities (such as form, affective and sensorial aspects, temporal development, etc.) not only of the sounds themselves, but also of an artifact and the interaction process involved in its use. It was striking that often, when the participants were asked about what they heard, their answer would be something like "water", "heartbeat", "flies", and not, for instance, "a fragile device for social interaction which was telling you that you are in the wrong place". Indexical sounds (including those pointing the attention towards "the filmic"), sounds that refer to an event or process "outside" of the experiential frame of a given interaction, put themselves into the foreground and force the listener to construct an interpretation that accommodates the sound's indexicality. This leads to an experience of the sonic dimension as a "soundalike" and the sounds are there as add on, as some kind of interpretational crutch[24]. And the experience from the cases reported here shows, that even if a sound is understood and properly decoded, it does not necessarily work well.

With slight overemphasis, we can speak of a conflict in relation to a designer's goals: On the one hand, relying on established sign structures and codes, which inform the interpretation from an outside position, as it where, or, on the other hand, on forming an aesthetic integration, where the sound is experienced as an inherent and unique part of the artifact's design and identity. And, maybe more importantly, the indexicality leads the listeners attention away

[24]There is good reason to believe that this is part of the reason why functional sounds are often met with skepticism, but this claim would need further study.

from the artifact at hand, to an entirely different sonic experience and context. In any case, the effort of using naturalistic, identifiable sounds may result in an unnecessary complication of the interpretational process. If the designers are lucky, the listener might go through an interpretational process leading from identification of a source to a reflection about its possible sensorial qualities or associated codes, but the cases indicate that this process is rarely occurring, and even if it does, it is rather cumbersome and unreliable, as each additional interpretational step introduces possible variations and deviations.Which leads us to the topic of the next chapter, ambiguity and the “instability” of interpretation.

25. Embracing Ambiguity and the "Instability" of Interpretation

> "...if you stick a Babel fish in your ear you can instantly understand anything said to you in any form of language... the poor Babel fish (...) has caused more and bloodier wars than anything else in the history of creation."
>
> *Douglas Adams, Hitchhiker's Guide to the Galaxy, 1979*

As many examples reported in Part III of this thesis involving "abstract" sounds and sonic qualities indicated, there is another recurring topic of prominent relevance when it comes to interpretational phenomena: the topic of *ambivalence* and *ambiguity*[1]. What at first might sound like an indication of a lack of clarity or precision, turns out to be complex and multifaceted, and constitutes a central resource for designers to work with. Most prominently, ambiguity was neither associated with abstract sounds exclusively, nor was it only a negative phenomenon. The following chapter will thus elaborate the related phenomena and discourse, addressing the issues and benefits of ambiguity and ambivalence, the effects they produce, and the role they can play in the interpretational process.

25.1. Uncertainty and Instability in Perception and Recognition

In Auditory Display and Sonic Interaction Design literature, ambiguity is often discussed in the form of "causal uncertainty" in experimental recognition task assignements. Already Mynatt (1994) discussed the recognition problem when choosing sounds for the interface and considered the evaluation whether the user can identify the auditory cues a central step. At first glance this issue seems to be rather trivial, as recognition of sound is something that we rely on on a daily basis. But as Barras and Vickers (2011) concede, that establishing successful identification and recognition is "an art with many hidden dangers and dependent upon the skills of the designer" (p. 333). Özcan and van Egmond (2007) showed that listeners fail in correctly identifying a product sound in a free identification task and naming or identification errors occur during labeling because of high perceptual similarities or increased causal uncertainty. Vicario has pointed out how complex the preconditions for the possibility of identification may be, even in simple, seemingly familiar sounds (Vicario, 2003). Also Chion has reported several fundamental issues related to identifying or recognizing sounds and their cause: A sound of a piano can be the tone emitted when pressing a key on a piano or it can be the sound resulting from hitting the piano with a hammer. Or the sound of a piano can actually result from a synthesizer. And although we might identify a certain sound as coming from a wooden box we can not say that one particular sound of a wooden box exists. Depending on where and how we exert physical force on the box it will sound differently. In summary, it is usually not possible to claim that

[1] The analysis of the codes reveals 22 codes relating to the topic of ambivalence or ambiguity. The codes are relatively well-grounded with about 5 to 25 quotations per code. Also, regarding the semantic networks, the quotations of these codes are also highly interlinked.

a sound is the sound of something specific, or, vice versa, that every thing has its *one* sound (Chion, 1998).

Figure 25.1.: *Example of multistable perception: "My Wife and My Mother in Law", by W.E. Hill, 1915.*

From the study of perception we also know about the so-called multistability of perception, demonstrated by Figure 25.1. Similar phenomena of ambiguous stimuli also exist in the auditory modality (Bregman, 1990)[2]. In general, all phenomena of auditory stream analysis (sequential, spectral and schema based integration) are subject to this perceptive ambiguity: the transition point (or field) partially depends on voluntary attention and past learning (interaction of "primitive" and schema-based organization). And even if we assume that a sound is unambiguously identified, this does not predict its successful interpretation. The sound does not speaks "for itself", as it where, certain interpretational "rules" must first be agreed upon.

A suitable example from Sonic Interaction Design, which shows the dynamic relationship between "identifiability", "ambiguity", "imagined cause" and "actual interaction situation" is the case of the "Spinotron", an interactive pumping device that served to investigate the relationships between sound, action, perception and interpretation (Lemaitre et al., 2009b). One proposed sound generating model was based on a synthesized sound of a rolling ball which was successfully used before in a balancing device, the "Ballancer" (Rath and Rocchesso, 2005). The perceived speed of the rolling ball was mapped to the pumping motion. During pretesting with the Spinotron, however, users had problems to understand how to control the sounds, and/or the sounds were too ambiguous. It turned out that to some extend it was the same parameters which contribute to the identification of a rolling ball, essentially modulations of resonances dependent on rolling speed, which could easily lead to "misinterpretation" in a dynamic context. Finally, the much more simple sound model of a ratchet was used, whose identification relies only on a specific temporal pattern of impacts and uses a relatively simple and static timbral configuration.

But there might also be another aspect involved. If identification of the source, in this case a rolling ball in a larger bowl, can not plausibly be connected to the experience of the actual interaction of pumping a rather slim cylinder, then there may not be sufficient motivation to *force* an interpretation and to match the related "mental models" (cf. Norman, 1988). This may be interpreted as an argument in favor of establishing "causal" relationships based on other approaches than identification of imagined physical processes and mapping of related mental models, which, of course, implies another understanding of causality, which does not resort to something like "naturalism" or "everyday sound source".

25.2. Impact of Electroacoustics on Indexicality and Source Attribution

In terms of relationship between sound and source as basis of indexicality, the issue of recognition is accentuated in the electroacoustic condition, in which the sound we hear is disconnected from

[2]These principles are also used artistically. Minimal music for instance works with polirhythmic pattern shifts through shifting perception of the underlying metre.

its source *a priori and by definition,* and the "reconnection" to a source is always more or less construed. This is also supported by the findings of this research. In addition to the problem of identification described above, we thus are also confronted with the phenomenon, that sound is already transformed upon recording and electroacoustic reproduction. More precisely, when a sound is recorded and played back electroacoustically, it has been transformed already at least three times. First, by the microphone, its distance from the source, and internal amplification. Second, by the storage process, be it analog or digital. And third, by the characteristics of the loudspeakers and amplifiers in the playback. We could also add the room in which was recorded and played back, listener position, etc., as fourth aspect. Altman states:

> "(...) recorded sound (...) always carries some record of the recording process, superimposed on the sound event itself (...) including information on the location, type, orientation, and movement of the sound collection devices (...)" (Altman, 1992, p. 26)

Of course, this transformation may not stop the sound from being identifiable as "sound of X". In fact, in the approximation of an ideal hi-fi recording and playback system, with binaural method or ambisonics, we may not be able to distinguish between real and reproduction. But this is not the way sounds of interactive commodities are reproduced usually. Quite frequent, the sonic reproduction may lose it's indexicality, because the electroacoustic transformation results in a denaturalization, and this in turn may lead to foregrounding of the sound, with all the effects described above. Historically the basic function of electroacoustic sound storage and reproduction, the "sillon fermé", the closed groove, and the resulting constant repetition, was one of the first and most important means to transform such sounds into new percepts[3], not to mention the possibility of cutting and reversing the tape at a certain point or repetition, which was some of the main means for creating the "objet sonore" in Musique Concrète (Schaeffer, 1966).

Looking at the cases of the present study, several quotes give evidence of this phenomenon. For instance, during the presentation of the of the ENERGY HARVESTING OFFICE CHAIR IAD ZHdK 2009 (PD 25, on page 73) I noticed that:

> *I: "The water as a sample very much loses the watery quality, or the water-indexical quality."* `(>25:29)`

As described above, the insecurity of identifiability of electroacoustic sounds in terms of their "original source" motivates the use of sonic stereotypes and clichés, which leads to the problems described above.

An exemplary approach that would encompass the impact of the electroacoustic transformation, was the exploration of the sounds of the actual object class the new sounds are meant to be designed for, as done by the creators of the BAG TO THE FUTURE TAIK 2010 (PD 47, on page 81). The presenters stated that they "recorded the sound of the bag as well, leather..." `(>47:11)`. Their aim was to get organic, leathery sounds as basis to work with. Also the group reported that they experimented with these object sounds both by playing with the microphone during recording and during sound editing:

> *Presenter: "...we managed to get some funny sounds out of it. Really wet sounds could come out and you (didn't know that it's) leather."* `(>47:11)`

A this statement shows, the designers did not fall victim to the assumption that a recording of a sound is identical to the actual sound event and instead made this phenomenon part of their creative process.

[3] In fact, we might be familiar with this phenomenon also from spoken language, where constant repetition of a word tends to transform its meaning, lead to estrangement, and foreground its abstract sonic qualities.

25.3. Ambiguity as a “Problem”

It turned out, that a certain degree of ambiguity was part of almost all interpretational processes. Also, there was the general notion, even acceptance, of subjectivity of the interpretations, as expressed in the following statement from the the presentation of the AcuPot DD ZHdK 2009 (PD 39, on page 79):

> *Participant: “(...) We made this association, somebody else understands it differently.”* (>39.28)

In some cases ambiguity would indeed cause problems for interpretation and a positive experience of the design[4]. For instance, if an abstract, ambiguous sound stands indexically and unambiguously for another, very abstract concept such as “time”, and the design would not offer any “hints” for the interpretation, the interpretation would get stuck in the abstract domain. Furthermore, issues with unknown or ambiguous sounds were accentuated when interpretation and interaction takes place under time pressure.

In the following I will have a closer look at some types of problems associated with ambiguity in the workshops.

25.3.1. Ambivalent Attribution of Sound to Source and Performative Agency

Insecurities in interpretation often occurred in relation to attribution of a sound to a specific source[5], which could be an agent, object or location. One example case which relates to ambiguity of attributing sound to both spatial origin and to a specific object can be identified in sounds expressing movement. Consider the following quote from The Elevator TAIK 2009 (PD 15, on page 67):

> *I: “And actually in a way it makes a lot of sense to me not to have something like a continuous pitch change from bottom to top, because as somebody already mentioned, when you are in the elevator, you are relatively not moving, actually the world moves around you. So this... you could use the same sound design for a train, you know. What moves, me, or the world? So maybe this relates a bit to the question of who is in action, is active, maybe the world moves around me, I don’t know. So there is some general energy feeling, that some energy flows around me, (...) but not necessarily directly movement in space, but still after the energy has stopped flowing I am somewhere else.”* (>15:25)

Thus the movement can be perceived in terms of an object moving in relation to the environment, or can stand for the environment moving in relation to an object. I suggest in the quote that as a consequence of this ambiguity related to the experience of riding an elevator, it could be advisable to use a sound which would not be attributed to a bottom-up polarity (as it would be the case in a pitch mapping).

In terms of attribution of sound to source and spatial location, there is another example from the project TakeMeAway, DD ZHdK 2008 (PD 2, on page 63), where a sound would be filtered and enhanced with a reverb in order to place it inside a virtual space:

> *I: “One interpretation could be that this is a technical feature to generate sounds. And the other is, this technical feature does not exist, it’s really the soundscape that you hear.”* (>2:4)

[4]The code “general ambiguity of sound: interpretation fails mostly” contains 9 quotes from 8 cases.

[5]The related code, “ambivalence of attribution of sound to agent / location / source”, contains 25 related quotations from 17 cases. For interpretational phenomena related to the attribution of source, cause and agency can be found in 21.

This shows the inherent ambiguity associated with electroacoustic sound in terms of spatiality and sonic environment (see also Section 20.2 on interpretational phenomena and design strategies related to spatiality).

Finally, let us have a look at the following quote from the Foley mockup of the Matchmaker UDKL 2010 (PD 52, on page 85):

> *I: "I also had the association that something was snapping, (...) snapped over. Because associated with your thinking thing, my very first interpretation was actually, if you put a lot of mental effort into something until (...) something pops."*
>
> *Presenters: "Yes, the information is getting out, so..."*
>
> *I: "Ok, but I had a negative [feeling] with this popping."* `(>52:12)`

This example shows the source attribution conflict: My first association was a physical event, which in the given scenario could only be a sonic metaphor, representing an effort of thinking, and increasingly tense mental state, and the pop was an almost physical bursting in the "brain muscle". But for the designers it was something "popping out of the artifact", which constitutes a shift of the assumed source from user to artifact.

25.3.2. Ambivalence of Attribution to Mapped Parameter

While all sounds which relate to some kind of process are mapped in one or another way, what is interesting in the context of sonic interactions are those situations, where a specific value or parameter is functionally related to a specific sound related parameter (e.g. pitch of sound mapped to amount of money). The mapping problem is well documented in Auditory Display literature (see, e.g., Walker and Nees, 2011 for an introduction and overview). However, it was not a very common occurrence in the cases documented here[6], presumably because the systematic representation of (numerical) values was hardly used in the proposed designs. An example of a case, where the problem of mapping was discussed, was the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73):

> *Participant: "We have a sit down and stand up situation, when you sit down it's decreasing, when you stand up it's increasing."*
>
> *I: "The question is: what is decreasing and what is increasing! It's a quesiton of the mapping. (...) You chose the analyogy of sitting down and up. What happens is an increase of energy so something goes up! Also, the good energy was on a higher level than the bad energy. Maybe the association would have been easier if the sound would have raised to a level similar to the good energy and emerged from this increasing sound, maybe then you could have made a connection between the two events more easily."* `(>25:19)`

In the case of the Intelligent Shower TAIK 2010 (PD48, on page 82) a longer discussion between several participants unfolded about the meaning of different pitches heard in sounds, which were identified as water. While the mapping in general seemed to be clear (higher pitch = more of something) the interpretations varied between "more", "hotter", "more forceful" water, or even the *"remaining amount of hot water, the time you have left"* `(>46:2)`. But if the aim of the design was to convey increasing "stressfulness", as common denominator of hotter / stronger water, or impeding lack thereof, the various interpretations are all valid. This indicates a certain tolerance to mapping ambiguities in the interpretational process if the design affords it.

The following quotes are interpretational speculations after observing the demonstration of the Thermos Flask TAIK 2009 (PD 18, on page 68), and illustrate the potential ambivalence of

[6] The code "ambivalence of attribution of sound to mapped 'parameter"' contains 6 quotes from 4 cases, and the code "conflicting parameter-sound mapping polarity: parameter-action-soundproperty" only contains 1 quote.

parameter mappings. In this interaction, the user slides the index finger along the metal bottle which results in a modification of the sound. First, a participant stated:

> *Participant: "I guess you were like somehow measuring with the help of sound and maybe feeling how much coffee you want."* `(>18:3)`

Later, I added:

> *I: "I don't know, the raising of something, first I thought he is setting the temperature level, but it could also be that he is raising an energy potential somewhere, to a certain point."* `(>18:8)`

And, a bit later:

> *I: "But maybe it was just a, how do you say that, a power potential, you raise the potential, tension, in a kind of system and when you release it the system enacts it."* `(>18:13)`

In this case, it was clear that the sound somehow sonically related to a boiling fluid, and it was also clear that the sound changed in relation to the movement of the finger, resulting in the idea of manually controlled transformation, But it was unclear, how it would contribute information about the functionality of the artifact. From the nature of the sonic transformation it was understood that the change referred to the process of "rising" or "lowering": There were two sonic elements: a granular, high pitched metallic chirping and synthetic bubbles, and the metallic chirping changed pitch slightly, in relation to the movement of the finger. In this respect, the interpretation was reliable, but the conclusions in terms of *what* actually was controlled by the gesture differed: it was unclear if the movement is about measuring some kind of state, or if it is a form of input.

Thus we deal here with an ambivalence in relation to parameter mapping, where the mapping is structurally clear in terms of change and polarity, but it is not exactly clear what it refers to. The interpretation relates to abstract qualities of function, e.g. raising of some parameter in general. Sound thus can become meaningful also independent of a specific identifiable cause. The meaning here results from a more generic experience of transformation or closure. What also can be seen in this example, is that the use of rich, evocative sounds is superior to the use of simple, generic sounds, even in simple bipolar parameter representations, as the sound itself, and the properties of its transformation, provides already some interpretational "hints".

Another example of ambivalence of the sound in terms of informing about the mapped parameter comes from the Sonic Puzzle IAD ZHdK 2010 (PD70, on page 89), where a participant associated the height of the lego-puzzle construction with tonal pitch. The designers, however, mapped the sound's pitch to volume and weight of the construction:

> *Presenters: "The more stones you pile up, the heavier it gets."* `(>70:11)`

In this case, the interpretation followed the common (and, despite the perceptual basis, somewhat stereotypical) association of higher pitches with higher values. This interpretation was the logical consequence of using pitch as sonically dominant indicator: why would a listener "risk" to build an alternative understanding of a rather trivial and established mapping paradigm? But on the other hand, even with the inaccurate interpretation, the functional consequence was the same. Furthermore, despite the trivial mapping approach, the sounds themselves were interesting and stimulated ongoing attention, which again underlines the relevance of using rich, complex sonic material[7].

[7] I will get back to this aspect, the contribution of sound design to the stimulation of attention and sustained interpretational effort, in Chapter 27.4.

25.4. Benefits of Ambiguity

25.4.1. Ambiguity Is Not an Interpretational Dead End

Certainly ambiguity could be a problem in design and lead to confusion and, in extreme cases, to loss of interpretational commitment. In general, as discussed earlier in the section about naturalism, identifiability and familiarity, the denotative aspect, or a source attribution, was often unreliable and prone to errors and a certain degree of frustration. A sound which could not be identified, could indeed lead to a a breakdown of the interpretational process. But the following discussion from the mockup of the INTERACTIVE FRYING PAN TAIK 2010 (PD 45, on page 81) shows that this dropping out of the interpretive context may only temporarily cause a problem:

> *I: "And what's the 'tskskskssss' sound?"*
>
> *Presenter 2: "That's when it's really hot."*
>
> *Presenter 1: "That's when it's ready to start cooking."*
>
> *I. "Ah yeah, ok... I don't get it you mean you're frying something, or you're cooking something. Like boiling water?"*
>
> *Presenter 3: "No, frying, maybe I'm preparing onions and I was going to fry the onions."*
>
> *I: "Ah now I understand the oil has to be hot enough yeah now i get it. Yes. Very good idea."*
>
> *Presenter 1: "Yes."* `(>45:9)`

The sound's properties afforded the identification of boiling water, which would indicate an ambivalent state in the context of cooking: it can either be a moment where a cook's action is required or one where the cook only has to wait a defined amount of time. But, from the designer's point of view, the sound was supposed to represent a particularly high level of heat, required when frying something, which is a much more discreet event which requires a relatively quick reaction of the user. Thus, the resulting mismatch of the sound's index and the intended function led to the breakdown of interpretation. But at the same time the sound's abstract, ambiguous nature actually triggered the listener's curiosity, and a basic function of the sound, triggering attention and signaling an important change in the process was fulfilled.

This example shows that, despite ambiguities, often the interpretational process was sustained and a basic interpretation usually still could be established[8]. There were indeed several cases where people were not able to fully understand what a sound meant, but only in very few cases there was no understanding at all, or a breakdown of the interpretational process would occur[9]. It turned out that conveying information on "what is going on" is not the only relevant "function" of sound, and often it was more appropriate to convey information about the quality of a process or important (qualitative) changes in it. Even a certain level of insecurity was not entirely counterproductive, and interpretations could still be correct in many cases, and satisfy the designer's expectations, as it happened in the case of the CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *Presenter: "First of all I am very surprised that despite of (...) [masking] and unbalanced [mix] that you still heard so many things we wanted to communicate."* `(>19:6)`

[8] A related code, "despite design flaws / ambiguities, basic interpretation correct", contains 10 quotes from 9 cases.

[9] The related code, "general ambiguity of sound(s): interpretation fails (mostly)", contains 9 quotes from only 5 cases. Only four quotes from three cases are associated with the code "interpretation fails because action, gesture and sound ambiguous".

The *"things we wanted to communicate"* suggests that there was a list of information that the designers wanted to get across with the sounds. But also it refers to an understanding of the overall interaction process, its structure and dynamics as well as narrative or dramaturgic aspects. The quote suggests that the designers successfully devised specific design solutions to convey those aspects. And while we encounter several statements expressing individual failure to interpret in this case, on closer inspection they were not actual "failures", but rather expressing a certain feeling of insecurity resulting from ambiguity:

> *Participant: "I didn't understand a lot, I didn't understand any of it."*
>
> *I: "But there were a lot of interpretations that actually seemed to be right?"*
>
> *Presenters: "Yeah, there were."* `(>19:32)`

This example indicates that the experience of *"not understanding"* a sound might have to do with a subjective conception of what is "correct" understanding. It could be speculated that this might relate to a general lack of "judgmental certitude" or lack of trust in the individual faculty of judgement in relation to sounds. Also it might be that with sound we are not used to the fact, that understanding is built in an abductive process, and/or learned: It seems that in common understanding, either sound is meant to be understood "musically", as absolute experience, or as "everyday sound" or "signal", which is supposed to be unambiguously rooted in a "source" or a conventional sign.

25.4.2. Ambiguity as Positive Experience

Apart from the strictly interpretational aspects related to ambiguity, a range of phenomena suggest, that it was relatively common to experience ambiguous sounds as pleasurable and interesting[10]. For instance, in the mockup of the Toilet Soundscape TAIK 2009 (PD 22, on page 70), we encounter an example of a participant who reacts positively to a defamiliarization of a sound, as *"something we know but also something we don't know"* `(>22:4)`, as something interesting, which triggered also interpretational curiosity. Unfamiliar sounds can also challenge people to solve the riddle, as it where. An example could be the vivid discussion of the Foley Mockup of the Interactive Frying Pan TAIK 2010 (PD 45, on page 81): here, the fun experience of identifying a sound together in a group would most likely lead to a increased memorability of the sound and its meaning[11].

The Foley mockup of the Doc-O-Mat UDKL 2010 (PD 54, on page 86) also shows the potential of ambiguity as making a sound interesting, while maintaining a general understandability, but also reminds of the potential confusion arising from it:

> *P: "For me it was getting closer, the sounds getting more intense, going to peak, then relaxing, going down. From the faces you understood that one was happy and the other [not]. (...) From the sound I wasn't sure about the water and what was going on (...) why he had the water, I didn't get really."* `(>54:5)`

This example is another indication that sonic indexicality may conflict with abstract, expressive sounds: The design is clear in terms of dramaturgy and expressivity, but the interpretation stumbles as soon as there is a (seemingly) indexical sound. A resulting design strategy might be to design sounds, that are interesting, because they are unfamiliar, but somehow still are related to a familiar sonic pattern. This is suggested by my statement during the discussion of the AcuPot DD ZHdK 2009 (PD 39, on page 79):

[10] The related code, "ambiguous sounds may be pleasurable, interesting", contains 12 quotations from 9 cases.

[11] This assumption could not be tested in the framework of this research, but is very plausible, given the knowledge about the impact of both negative and positive emotions on memory processes (cf. Erk et al., 2003, MacKay et al., 2004, Schupp et al., 2007).

> *I: "What I find interesting are sounds that originate from pepper mills but sound like a boiling kettle. Then we don't have this indexical quality, which sounds too clearly like something recorded."* `(>39:15)`

An interesting detail in this statement is the reference to the audible "recordedness" of a sound, which means that a sound is clearly understood as having a "real" counterpart, but not meant to be heard as such.

Finally, the following statement from the same discussion underlines the positive experience and potential affordance of well designed, ambiguous sounds:

> *I: "The funny thing is, you don't want to stop watering the plant. When this thing sounds like this, you actually want to hear it scream, in order to experience the watering."* `(>39:17)`

25.4.3. Ambiguity as Productive Element of Interpretational Processes

I will now have a closer look at the complex interactions of elements contributing to an interpretation in situations involving ambiguity. For instance, we can observe the emergence of a general understanding of functional aspects in relation to and structural dimensions of an interaction process as apparent in the following quote from the Party Matchmaker TAIK 2012 (PD 84, Section 15.1) demonstration:

> *Participant: "(...) It was obvious that certain sounds were kind of signaling some kind of attraction to some kind of relationship, but it wasn't always clear to me whether it was attraction or..."* `(>84:5)`

In this case, the sounds establish an abstract semantic relation which allows to accomodate the interpretation of attraction, which was a central aspect of the design, at least to some extent. Another good example is the following quote from a participant who just tried out the Bag to the Future TAIK 2010 (PD 47, on page 81):

> *Participant: "(...) the other ones are like clinging sounds, like, clearly like objects, adding more objects, but when I dropped it, there was something like an animal, something more alive. So it was, like, the bag was telling you 'don't drop me'. But the object when they get out it's sort of like the objects telling (something)."* `(>47:1)`

This quote shows a range of things related to ambiguity as productive element in interpretation. Firstly, it is an example of how attribution of agency and sound source (in this case between objects, the bag and the user) emerges in a multidimensional semantic space of relationships: the sound of the objects appeared only when they were already out of the bag and there was no direct interaction with the bag anymore (indicating a certain degree of causality), and they also had a sonic signature (metallic) which could be associated with hard metal or glass objects that are often in a bag. And the purring sound, although quite ambiguous, was clearly associated with the bag as it extended the natural impact sound with a "sonic decay". The origin of the sound may have been an actual animal purr, but it was defamiliarized, and this ambiguity helped that it could be associated to the bag, and attribute it a quality of *"something like an animal"*, which was in line with the designers' intention.

The pleasure of listening to a sound which triggers curiosity through it's ambiguity, can result in a motivation for sustained or repeated interaction, an aspect which was also discussed in the context of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73). In the Foley mockup of the Interactive Frying Pan TAIK 2010 (PD 45, on page 81), we have another example of sounds, that are hard to "decode", but are appreciated and stimulate interpretation through their ambiguity:

> *I: "What I liked about it, there were so many unexpected sounds (...) I mean you could hear the table somehow and it was really funny. (...) Sure that it's not meant to be the table."* `(>45:3)`

As the quote shows, the sounds, which seemed to originate from the table, caught my attention, I liked them and found them *"funny"*, but not in a negative, or inappropriate, way. And even though the sounds were ambiguous, it was clear what caused them in general, mainly because I was aware that the design scenario is about cooking with pan or oven.

Another interesting example comes from the Foley mockup of the Matchmaker UDKL 2010 (PD 52, on page 85) which used the subtle and interesting sounds of a drinking straw being bent and some toothpicks in a box:

> *Presenters: "But still I think the straw is not enough. Because it is actually trying to go deeper into the information more specific about the person, which would be age, and sex, and for this we were using the box with toothpicks. And the younger the person is, the faster they would rattle."* `(52:17)`

This design is interesting because on the one hand the sound, which is meant to "enhance" the sound of the straw (which is considered to subtle) has its own generic, abstract texture (rattling, overemphasized and defamiliarized by close-up recording) which does not relate to the mapped parameter directly[12], but in itself sounded interesting and subtle, stimulating curiosity. The information is conveyed by representation of movement qualities, or rhythmicity. The latter also has a metaphorical dimension, by associating "young" with "quicker movement" or "agility". The association is not based on indexical sound, but an expressive sonic gesture or movement pattern.

An example of the benefit of carefully designed ambiguous sounds, in particular when the overall interaction is relatively difficult to understand, comes from the experience of Explorations UDKL 2011 (PD 82, on page 95):

> *Participant: "I mean the noises were really interesting, but it took me a while to realize 'ah ok that's what it was'."* `(>82:14)`

Or, as expressed in the following statement from the Matchmaker UDKL 2010 (PD 52, on page 85):

> *I: "But I like the ambiguity of the sounds, I have to say."*
>
> *Presenters: "It makes sense when you know what it is."* `(>52:9)`

Maybe it can be argued that in these cases the respondent would not have committed to making sense to the extend they did, if the sounds would not have been interesting. Thus, while "making sense" may be the goal of the design, it is not restricted to "informational sense", but can as well be linked to "sensorial sense". And, if there is the prospect of learning the "full" meaning eventually, well designed, ambiguous sounds can be perfectly acceptable, and indeed stimulate, support and sustain the interpretational effort.

Another potential benefit of ambiguity, as productive element of interpretation, relates to the management of attention. This emerged in the demonstration of the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77). Here, the participants could identify the basic concept and meaning of the overall sonic functionality, which was a noise that warns you when you are driving to fast in a curve. The design worked through the sonic properties of the noise, which was abrupt, and very rough, granulated, but also through its general ambiguity and unfamiliarity, which contributed to a higher level of attention.

Conversely, ambiguity can also help to keep a sound in the background of attention, as the example from Matchmaker UDKL 2010 (PD 58, on page 85) shows: a metallic, continuos

[12] This example relates also to the question of ambiguity of mapping discussed above.

sound, originating from the interactive object, has been playing for a long time in the background, but did not seem to disturb anyone. In the discussion, the participants even speak of silence, and *"absence of information"* (>58:19). This is a good example of a working "sound of presence", where a sound is just meant to express that something is present in the background. Here, ambiguity is used in a way that does not trigger attention and interpretational effort, but rather allows to put the sound in the background, simply because it is *not* explicitly informative.

25.4.4. Ambiguity Supporting Multiple Interpretational Perspectives

Being confronted with ambiguous meanings and varying interpretations, an interesting phenomenon started to emerge, which shows another potential benefit of ambiguity in relation to the often discussed issue of individually varying associations. It could be argued, that a purposeful ambiguity in design in fact allows people with individual experiential backgrounds to approach the design from their respective perspective[13]. For instance, let us look again at the example of the "popping" sound from the MATCHMAKER UDKL 2010 (PD 52, on page 85):

> *I: "Well, I also had an association that something (...) snapped over. Because associated with your thinking thing, my very first interpretation was actually, if you put a lot of mental effort into something until..."*
>
> *Presenters: "And it just pops."*
>
> *I: "... 'ummmmm-tack!' - until something pops."*
>
> *Presenters: "This is good!"* (>52:12)

"Something popping" was interpreted metaphorically as brain "popping" after a great mental effort, or information getting out of the artifact. Agency is attributed differently in both cases, once it is agency of the user "on" himself, in the other case agency is attributed to the artifact. But at the same time the two interpretations converge with the designers intention, to convey the abrupt end of a charging process.

An example from the TOILET SOUNDSCAPE TAIK 2009 (PD 22, on page 70) supports the finding, that multiple and diverse associations can work and may even be necessary:

> *Participant: "...some sort of double meaning ... or the double function of the sound, like you'll be doing the masking and then you'll be doing the ... (...)"*
>
> *Presenter: "Motivation!"*
>
> *Presenter 2: "Definitely, that's exactly the point. Multiple sort of functionality."* (>22.5)

In this case we are dealing with a design which conveys "multiple functionalities" of the sound, in this case the sound design in fact needs to convey a *"double meaning"*.

Of course, for multiple meanings to provide consistent access to a design's interpretation, they should exhibit a (semantic) relation of some sort. For instance in the following quote from THE FRIDGE, UDKL 2010 (PD 56, on page 86), we see a case, where two interpretations seem to diverge:

> *I: "...you sometimes leaned into the fridge and it looked like you would feed the organism or so."*
>
> *Participant (visitor): "No, this was bad food, no? Rotten food?"* (>56:4)

[13] The related code "multiple meaning and ambiguity can lead to multiple uses / afford multiple 'perspectives"' contains 4 quotes from 4 cases, and the code "working with ambiguity of sound source to switch between associations" contains 1 quote.

Of the two interpretations, *"feeding the organism"* and *"rotten food*", the latter corresponds to the designers' intention. But in both cases, the food theme as common denominator was clear. We could also say, that a high-level semantics, relating to food and eating was clear and although the specific meaning of the sound was unclear, a suitable interpretational framework was established[14].

25.5. Ambiguity as Resource Rather Than Threat

From the examples discussed above we can conclude, that ambiguity indeed may be a problem for interpretation. I have discussed the combination of abstract concepts with abstract sounds, time pressure, defamiliarization of sounds through electroacoustics, the ambivalence of attributing sound to source or agency and ambivalence in mapping between sound and information as factors that can even lead to a breakdown of the interpretational process. Ambiguity could emerge in relation to the sounds themselves, or in relation to their function in a semantic system. For instance, when confronted with an indexical sound, we might hear the represented source, but we still might be unsure which of the agents in an interactive system caused the sound to happen: Was it a user action, the system's reply to such action or a state change in the system? On the other hand, a system of cause-effect relations and general functionality may be clear, but the source, or object of interaction, can not be inferred.

One factor which would support the breakdown of interpretation seemed to be the combination of indexical and abstract sounds in the same design. When an interpretation looks for explanations or denotations in terms of identifiable *sources*, abstract, ambiguous sounds may disturb. Also the reverse is true: A sound which is meant to be heard as abstract, affective timbre should not be combined with naturalistic, indexical sounds.

But even if a breakdown of the interpretation occurred, it was not necessarily terminal[15]. First, ambiguity often was related only to one aspect of the design and it was possible to compensate for it by diverting interpretational attention to other dimensions of the design, provided such dimensions were available.

In relation to a sound's identifiability and codedness, we can also look at the matter of ambiguity in the context of the "false security" provided by presumably "fixed" or "obvious" meanings. From the discussions during the workshops, we can conclude that it is relatively probable, that even a sound with a seemingly obvious meaning can be "misinterpreted". Thus it makes sense, to simply take the possibility of ambiguity into account in the design.

As a matter of fact, ambiguity can bring several benefits to the design. It may stimulate interpretation, attention, and appropriation. Also it affords that sounds can be learned and associated with a new product as well as accommodated with varying interpretational approaches. It offers the advantage of the possibility to switch between associations, for instance in relation to a sound's source, and thus afford multiple approaches to, and perspectives on, the same interaction.

This also correspondents with views in interaction design which propose to see ambiguity as a resource rather than a threat (Gaver, Beaver and Benford, 2003). In this view, ambiguity may stimulate dialogical negotiation of meaning in action and can also be seen as creative force, questioning the taken-for-granted and provoking discourse through estrangement and defamiliarization (Bell, Blythe and Sengers, 2005).

The Russian director Andrei Tarkovsky in particular explored ambiguity as a catalyst for engaging experience and depth. His use of ambiguity in films like Solaris (1972), Stalker (1979) or Sacrifice (1986) creates a sonic environment in which the audience struggles to make sense of a sound heard, creating meaning through establishing coherence between the heterogeneous

[14] The related code, "sound meaning clear on abstract level, but specific meaning ambiguous", contains 8 quotations from 5 cases.

[15] The related code "general ambiguity of sound(s): interpretation fails (mostly)" refers to 9 quotes from 8 cases.

elements of the audio-visual narrative. Truppin (1992) describes specific design strategies used by Tarkovsky: The revelation or negation of a (unexpected) source of a sound, the subversion of the coherence between sonic and visual space, or the use of sounds on parallel levels in order to enunciate qualities of both the material and the psychological or spiritual. On the other hand, Truppin notes that Tarkovsky's use of clearly identifiable, specific and naturalistic sounds in a surreal setting might unhinge established conceptions of the real or provide signs of safety in an otherwise confusing narrative world[16]. Buidling on such examples we can see, that in the end, ambiguity may lead to a thorough appropriation and an intimate knowledge of the design by means of a sustained interpretational and sensorial engagement.

[16]This embracing of ambiguity is not confined to "artistic" films (or design, for that matter). Indeed, it turned out to be an important driving factor in New Hollywood sound design (Flückiger, 2001). The science fiction and fantasy genres provide the narrative space for novel, unknown, ambiguous sounds. But at the same time, these sounds were designed in such a way that they provided the necessary "interpretational hints" to be easily integrated into the overall narrative. Provided the listeners were motivated to invest "interpretational energy" in the movie. We will get back to this essential aspect in Section 27.4.

26. Approaches to Understanding Interpretation of Interactive Sonic Identities

Note: This chapter somehow takes a somewhat special position in this thesis both formally and functionally. Although it is not at the center of the thesis, it somehow represents a pivot point of my analysis, around which everything seems to turn in retrospect. And, being a pivot point, it is quite small...

I would like to start with a longer quote:

> "Suddenly you were in a dark environment, where you couldn't distinguish any more visually what was around you. The most bewildering experience was the sound. It was a sound I have never heard before.
>
> How can I describe this sound? It consisted of a countless multitude of micro intervallic layers of sharp frequencies. The colours and timbres of these sounds were far from seeming natural. It sounded very synthetic, very technical and I got immediately the impression of being immersed in an electronic studio with a lot of different sound generators. I had never heard something like this before. The sounds were strange and abstract. They didn't resemble anything I knew. They didn't reveal anything to me which seemed to be related to the world. That much strange was it. It was not easy to overcome the awe and fear and to become finally receptive to these sounds, like you can become receptive to a piece of music. Finally I became aware that I was listening to sounds, which seemed organized. The sounds developed. The sounds followed a certain dramaturgical itinerary. And the reason for this itinerary was my presence in the jungle.
>
> The deeper I came into the forest, the closer I came to the gorillas' lair, the more dense and vibrant became the sound. Any sound I made by walking or by acting somehow returned to me by a multitude of sounds created by the jungle. It was a composition which had eyes and ears and something maybe you would call today an interactive sonic environment which responded to me. I influenced the compositional development with my presence and activity although the effect of my influence was unpredictable. You could not say for *[sic!]*, what would be happening when I did this and that or just went around a certain corner and so on. It was just surprising what happened. The sounds as I said already, seemed synthetic, no natural or concrete association was revealed by these sounds." *(Breitsameter, 2005)*

26.1. Interpretation as Negotiation

During my research and work as designer and consultant, I am repeatedly confronted with the wish for some kind of guidelines or even recipes for how to using sound to its best effect. Bonebright and Flowers summarize this desire concisely, when they call for a

> "comprehensive compilation with the necessary norms for the populations of interest. Such a guide of auditory perceptual parameters for auditory display researchers would allow the development of sound applications for specific groups in addition to

> the construction of sound applications that could provide a range of sounds that would work for the majority of individuals within a heterogeneous population." (Bonebright and Flowers, 2011b, p. 115.)

While this desire is understandable – and the striving for some kind of decision making support is indeed justified and necessary – I would like to offer an alternative approach, illustrated by Sabine Breitsameter's anecdote from her journey through the jungle.

In some ways we are on a journey into an interpretational jungle of sound possibilities. And it will be necessary to get rid of some preconceptions about what works and what does not. As we have seen from the discussion above, interpretation of sounds in the context of interaction is a complex process with many influencing factors. Just as in an underdetermined system (to borrow an analogy from mathematics[1]), there are always more unknowns than equations. Also, the interpretational process usually does not result in a single outcome, which is "right" or "wrong". The (often implicit) notion of designing for a specific meaning is problematic for several reasons. I have described in the previous chapters serveral issues associated with naturalism and indexicality as means to "enforce" a specific interpretation. Already recognition of a sound or sound source is an issue. Also, the border between "natural" and "artificial" is blurred or even inexistent, and interpretations are often influenced by "naturalized" experience from audiovisual media. A designer may rely on highly conventionalized sign systems and sonic stereotypes, to be on the "safe" side. But apart from all the problems this generates, a sonic phenomenon is never "hardwired" to one single meaning. And even if a sound is identified, and "correctly interpreted", this does not mean it will fit into the overall constellation of interpretationally relevant elements in a meaningful way. As I have shown in Chapter 25 a certain degree of ambiguity is the rule rather than the exception. To say it in the words of David Sless:

> "It is not generally realised how fragile and vulnerable is the infrastructure of understanding." (Sless, 1986, p. 19)

The concept of "infrastructure of understanding" is of particular interest here. The metaphor includes two important aspects of interpretation: On the one hand, there is the insight that for interpretation we rely on a complex collective of interacting and inter-linking elements, some of them more fixed, others more dynamic and flexible. And, on the other hand, a infrastructure is potentially unstable or can be destabilized. Meaning is not like a particular object of experience which could be "integrated" or "imposed" on an artifact or communication (Bridgett, 2010). Depending on the degree of conventionalization and previously established agreement on a certain interpretation, there is always a certain degree of negotiation of meaning in the process of interaction. This understanding is also adopted by Petra Maria Meyer (Meyer, 2001), who proposes a "semiotics of surprise" in the context of the performative arts, suggesting to adopt "anti-dogmatic, semiotic approaches" (p. 146). She finds those in Peirce's pragmatic take on semiosis as a potentially infinite sequence, where meaning evolves around signs constantly influencing each other in an ongoing dialogical process. These signs, and their meaning, can be seen as a cultural reservoir of potential meanings, from which new meanings are individually and collectively emerging.

The conceptual understanding of interpretation of sonic interactions is thus one of negotiation, rather than straightforward "decoding". Also the definition of product sound quality acknowledges the complexity of and emergent nature of product sound quality:

> "Product-sound quality is a descriptor of the adequacy of the sound attached to a product. It results from judgements upon the totality of auditory characteristics of the said sound – the judgements being performed with reference to the set of

[1] However, as opposed to mathematical underdetermined systems, which have no or an infinite number of solutions, interpretational processes indeed may come to a conclusion, as they can involve dialogical processes of negotiation.

> those desired features of the product which are apparent to the users in their actual cognitive, actional and emotional situation." (Blauert and Jekosch, 1997, p. 748)

What the design thus has to offer is a dialogical structure, which affords this negotiation. This is of particular relevance in interactive technologies, where in fact output can be modulated and changed based on varying input.

26.2. An Alternative Conceptual Model: Interpretational "Force Fields" and "Hermeneutic Affordances"

Let us look at a particular example of a shared interpretational discourse, as it emerged during the discussion of the Foley mockup MATCHMAKER UDKL 2010 (PD 52, on page 85), showing the many interpretational directions emerging throughout a sustained discussion, and somehow summarizing many of the points discussed in the previous chapters:

> *Presenters: [make sound]*
>
> *I: "Ah that was nice! Then it disappears into something smaller. I think this is now in the can."*
>
> *Participant: "Yeah. It's kind there is something [incomprehensible]."*
>
> *Participant 2: "Yeah."*
>
> *Participant 3: "No, it's the contact between them."*
>
> *I: "Yeah, yeah..."*
>
> *Presenters: "No, I try to..."*
>
> *I: "And this was with thinking, some brain... and then something snaps..."*
>
> *Presenters: "Yeah, good!"*
>
> *Participant: "Here it's really like you are opening..."*
>
> *I: "... entering it! It's like snapped in."*
>
> *[Presenters continue to play sounds]*
>
> *Participant: "Now he's taking it out of it. Whatever was inside."*
>
> *Presenters: "Ah, yeah. that really needs to be... [makes sound again, slightly changed]"*
>
> *I: "Yeah we hear it, I hear it, the 'crrrrrrr'..."*
>
> *Participant: "You are squashing it."*
>
> *Presenters: "This one needs to fade more, to dissolve more."*
>
> *I: "I could imagine it's more like a purr of a cat, like 'trrrrrr, trrrrrrr'."*
>
> *Presenters: "Yeah, well, no! [all laughing]. And the last one: [makes sound] ... yeah this is very ambiguous also."*
>
> *I: "But I like the ambiguity of the sounds, I have to say."*
>
> *Presenters: "It makes sense when you know what it is."* `(>52:7)`

We can see from this example very nicely how the interpretational dialogue evolves, and we also see, how it involves a bilateral influence between designers and participants, sounds being performed and modified, interpretations being made and revised, in an ongoing abductive process. If we look at the "wrong" interpretations (*"it's the contact between them"* or *"you are squashing it"*) it turns out that they are not opposing the design, but still remain within a coherent semantic space. The sonic transformation to which the statement refers was not caused by physical contact, but the increasing intimacy of the interaction, which in turn was expressed by physical proximity.

And the squashing was in fact holding it tightly, which potentially could well turn into squashing. Also the ambiguity between something opening for entering or leaving can be accommodated, as it was indeed meant to be a bilateral, inter-active process. Furthermore, the interpretations were at least partially referring to the ambiguity of the gestures, not the sounds. The discussion shows that a fundamental understanding is conveyed across subjects. It is striking that all sounds in this case were abstract. It seems, that as soon as the sound is sufficiently abstract, i.e. not clearly attributed to an object but more a general process, this facilitates the development of a common understanding on a general level.

Also in the demonstration of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73) we see how various interpretional dimensions actually blend in the process of experiencing and interpreting a sound:

> *Participant: "There was a steady noise like a generator and when Jan moved, there was this sound of a scotch tape (...)."* `(>25:3)`

We find references to abstract sound qualities (*"steady noise"*), possible sources belonging to the interaction context (*"generator"*) other indexes to sound sources not belonging to the interaction (*"scotch tape"*), and observations about related possible causes (*"Jan moved"*). The "scotch tape" in this case was a typical example of a sound which is abstracted by the recording and did not lead to the conclusion that actual scotch tape would be part of the design, but rather that the sound was meant ot be understood for its own quality, which could be well integrated with the overall framing of the sounds as rather abstract.

Referring to Sless (1986), I have mentioned above the metaphor of "infrastructure", to describe this quality of multidimensional interpretational setups. Another, maybe more suitable metaphor that emerges from this study and the quotes above is the one of *"interpretational force fields"*. Throughout the cases, I observed how people would refer to interpretational "points of attraction" that could provide their considerations certain directions. We could call those attractors *"interpretational,* or *hermeneutic affordances"*, as they are more or less conductive to certain associations, afford certain interpretational processes.

Such hermeneutic affordances can emerge on several different levels of aesthetic experience and cognition. This is also acknowledged by authors taking on a semiotic stance. Jekosch, for instance, describes several intertwined dimensions of semiosis: Involved in meaning making are the auditive properties of the sound itself, the form of the auditory event, the resulting mental representation in the listener, and and the mental image of a product (Jekosch, 2005). In interpretation, everything comes together at once: interpretations that rely on some form of crossmodal associations as link between abstract and concrete, and sometimes concrete, iconic connections (Haverkamp, 2013), where a property of a form is recognized in the form of the sonic modality (see Chapter 18). Such (crossmodal) analogies are not necessarily built on apriori codes, but may emerge from experience qualities in context. Also, there is the informational and expressive dimension of material sound, informing us about *how* something was done with *what*, a kind of "first order semantics" (Flückiger, 2001). In addition, even simultaneously, we have the influence of cultural codes and interpretational conventions, even based on mediated forms of sound and meaning, termed "second order semantics" by Flückiger (2001)[2]. However, there is no clear distinction between "first" and "second order" semantics, and, as we have described earlier, in the schizophonic condition, there is also no clear distinction between acoustic or mechanically produced sounds of the artifacts and their electroacoustic companions. Perception studies confirm the multiple layers of meaning making: The way, the actual quality in which a sensory percept is perceived and processed in the brain, the related action-perception loop, and all further systems of meaning making, language and so forth, play a role in the emergence of meaning, and they do it in a non-deterministic way (Roth, 1992).

[2]We have encountered some of these in the Chapter 17.

In conclusion, the often abstract and ambiguous nature of electroacoustically transformed sounds, and the schizophonic situation established by electroacoustically enhanced interactive commodities, always will result in a multitude of interpretationally effective forces, be it from the sound itself, the inter-action, movement, or the artifact. And thinking the metaphor to the end, interpretational force fields are likely to also contain divergent forces, or ambiguous points between equally strong attractors. These may be caused by (naturalistic, indexical) sounds which conflict with other interpretationally effective dimensions (see section 24.1), or by sounds which cause undesired foregrounding or result in the domination of perception and interpretation (see section 24.2), or the use of inflexible stereotypes (section 24.3). Last but not least, the force field also can contain "black holes", which absorb the interpretational potential. Often naturalistic, indexical and seemingly familiar sounds result in being such black holes by effectively stopping the interpretational process by means of their "obviousness".

The goal of the design is thus to ensure that there are enough converging vectors in the interpretational force field, not too many divergent or neutralizing forces and, if possible, no "black holes".

27. Approaches to Designing "New Everyday" Interactive Sonic Identities

> "If you want something new, you have to stop doing something old"
>
> *Peter F. Drucker, date unknown*

I have described above why sound design for interactive commodities needs to consider alternatives to a design that relies too much on seemingly clear "signs" based on a sound's indexicality. But apart from these theoretical considerations, there is another motivation for leaving seemingly safe and familiar paths and to openly explore possibilities of design and interpretation of sounds for interactive commodities: The challenge is, to design *new* sounds for *new* everyday experiences. As mentioned in Section 3.4 we are designing inherently schizophonic artifacts, and this schizophonia results in yet unknown reconfigurations of meaning making between artifact, sound, and inter-action.

The following statement from the presentation of the Bag to the Future TAIK 2010 (PD 44, on page 81) summarizes some of the issues associated with using indexical (or "iconic"[1]), naturalistic sounds and concludes by a recommendation to design sounds which have their own identity:

> *I: "That would be a strategy that you could call iconic. That you say, the coins are missing, so I get a sound that are coins. This can work well with very specific objects but maybe not so well with others. (...) This is the most obvious, the sound of keys*[2]*, then again, the danger there is that if it's too naturalistic, there is a chance of confusing it with the actual keys. (...) So you have to design it in a way, not that it stands out, but that it has an identity of its own."* `(>44:23)`

In the context of the discussion of The Fridge, UDKL 2010 (PD 50, on page 86) I underline the importance for the artifact getting an identity of its own:

> *I: "...these sounds are funny but they are also dangerous. (...) I think the level works very well for stating the purpose, but it can't stay (...). I would appreciate if you tried to (...) give this fridge an identity. Not such a cartoony identity, but one which maintains this humorous aspect of friendly fridge."* `(>50:19)`

This "own identity" is also important, because naturalistic sounds may contradict a new design language. The question is, how plausible and aesthetically convincing it is to hear a indexical sonic representation in the interaction at hand. Also, the inflexible nature of naturalistic, indexical, familiar, even stereotypical sounds makes it difficult to accommodated them in new "fresh" aesthetic systems.

We also have to keep in mind that if a sound is based on a sonic pattern familiar from "natural" sounds, or from sonic stereotypes, it also inherits the problems associated with it. In particular, the sound will have to exhibit the same perceptual qualities of the natural or

[1] In the context of sound it is hard to differentiate between "iconic" and "indexical", as the "iconic" sound is not comparable to a simplified image. in terms of sensory qualities, as it ideally should sound almost exactly like the original sound event, which in turn is an index to its cause.

[2] *The designers used keys to create the sound of coins, it refers to a Foley mockup.*

otherwise stereotypical pattern, which might be unsuitable for the context at hand or downright unpleasant.

Furthermore, a sound which is already "occupied" by a specific semantic function, "importing" it into the scenario at hand, as it where, often binds the listener's attention, distracts from the actual situation and artifact at hand, preventing the experience of aesthetic unity, and potentially a flow of interaction, where the artifact recedes into the background of perception, and allows us to be fully immersed in the activity.

In Section 24.3, we have furthermore described issues and misconceptions associated with using sounds for their presumed "clearness" and intuitiveness, on the one hand, because the presumed intuitiveness is often an illusion, on the other hand because a too obvious sound can impede interpretational and emotional investment in an experience. There can be design situations where you need to rely on the attention-grabbing effect of "strange" or unfamiliar sounds (see the discussion on attention management and about learnability below in Chapter 27.3) or where a more open and playful setting is the goal. But it applies also to many situations where the goal supposedly is to convey some kind of "clear" message. More generally, my critique is directed at the underlying assumption we should strive for interpretational "safety" in design. In response to a presenter, who argued that their design aimed at being "really clear", I stated:

> *I: "Yeah, but be careful, because the most interesting interactions are those that are not just self evident from the beginning, but can be easily learned, but then, because they have a very outstanding aesthetic quality, they last longer I think. Because sounds that are very familiar, they wear out a lot, they wear out very soon. And it's unheard sounds that become interesting, and you can create new sonic vocabularies. In the [world of] film it happened in the seventies and we take it for granted nowadays. I think it's dangerous from a design perspective to stick too much to what we think is a safe ground of interpretation. Because from my experience it isn't a safe ground."* `(>82:27)`

Several arguments in favor of designing novel and original sounds are presented here. Sounds should be learnable, attractive, initially rather unfamiliar, interesting, and part of a systematic vocabulary. And also that this design challenge is not new but has been addressed in film sound decades ago.

Will novel sounds lead to confusion of the listener? Maybe initially. But one major insight I gained through the experiences and discussions of this research is, that it is indeed possible for novel, rather abstract sounds, to become "second nature" for a novel device, in the sense that after a relatively short period of getting accustomed and learning, they become like a natural element of the device and interaction[3]. What I mean by this more specifically comes out in the following statements from the Foley mockup of MATCHMAKER UDKL 2010 (PD 52, on page 85):

> *I: "What works well, is these kind of abstract sounds, if they stand for the nature of the artifact."* `(>52:19)`

By this I argue for trying to achieve a kind of "genuineness" of the novel sound in the context of the novel artifact at hand, which is not based on physical parameters, but on a narrative related to the "nature" of the artifact itself. I further state:

> *I: "What I like about this draft is that it's going towards a sound design that could become a natural component of this artifact. It becomes second nature, its not too much put on top, it's not too much 'clingeling' signal here, signal there (...)."* `(>52:19)`

This supports the general design approach, which does not see the sounds as added information, signals (both in terms of sound quality and type of use), but rather as integrated design element.

[3]The related code, "researcher: novel rather abstract sounds can become second nature", is related to 3 quotations from 2 cases, both being from later editions of the workshop.

With the hope and expectation, that if they are well designed, will be learned and adopted by the users. Which again is at least partially an aesthetic problem, as we will discuss later, in Section 27.8. Abstract sound qualities can even support this strategy by allowing to adapt a sound to the existing sounds of an artifact, as the example of THE TOASTER UDKL 2011 (PD 80, on page 93) showed:

> *I: "It's a different thing using a heartbeat sound than using ambiguous scratching sounds, because ambiguous scratching could really happen inside a metal thing, they are not a cliché, they are not a symbol of something, they are just sound in the first instance."* (>80:9)

In the case of "ambiguous scratching", we have a correspondence with a material quality of the artifact, which allows even for a relatively prominent, attention grabbing sound, to be experienced as a "natural" addition to an objects sonic identity.

The anecdotical evidence spread throughout these and other cases leads to several informed hypotheses and rules of thumb for design in favor of designing novel sounds. Abstract, and novel, sounds that are not defined by an indexical function via iconicity, are not established and familiar already, and convey abstract, dynamic qualities, are beneficial for sound design, because:

- They can be better accommodated into an interpretive context
- They are more adaptable for achieving multisensory fit.
- Their behavior in interaction can be defined quite freely
- Through a certain (initial) ambiguity, they can stimulate a holistic interpretation, establishing a dialog between object, form, function and interaction.

These assumptions can not be proved, at least not on the basis of this thesis. But we should not forget that there is a long-established field of sound design practice which supports exactly this notion: (post)-"New Hollywood" film sound, and in particular fantasy and science fiction film sound design. Inspired by the musical avant-garde and technological possibilities the concern of these sound designers was – and is – to make fantastic objects, interactions, processes feel "real". In this process these designers did not replicate, or even evolve, existing sound design paradigms, rather they defined entirely new aesthetics. The resulting sounds fulfilled their role to convey interpretational hints of all sorts as part of the interpretational force field established in the movies. On the other hand, they rarely ever trigger our attention, but blend in with the filmic universe and support the suspension of disbelief. And surprisingly often, they carve themselves deep in our memory, as the many anecdotes in the context of "filmic listening" (Chapter 17) showed.

These novel, yet unheard, sounds (and sonic interactions) turned out to become the new standard, "naturalized", as it were, through mass-cultural consumption, from which sound design still nourishes today. This is what is so fascinating – and encouraging – about the art of mainstream film sound design: to come up with something new that feels familiar very soon (for an in-depth discussion, see (Hug, 2011)).

Motivated from this opportunity to design new sounds and establish new aesthetics, I will discuss several design approaches which emerged from the workshop analysis presented in this thesis, again building my argument around the many discussions of the design cases.

27.1. Defamiliarization and the Play with Source Attribution

As mentioned, one goal of design should be to avoid a potentially dominating connotation of a sound with a specific existing source or with a strongly pre-coded meaning. Also, it is often the case, that a given sound does not fit the aesthetic quality of the object or interaction it is meant to be used for. A proposed strategy, which also was evident in the design cases reported here, is to defamiliarize[4] the sound, which can help bridging the gap between the indexical and the abstract. The goal of defamiliarization is to change a sound in such a way, that the index to a specific source gets lost and the abstract affective and sensorial qualities of the sound, the slicing *sharpness*, warm *grumble*, happy *glucking*, airy *sizzling*, wet *purity,* are more prominent[5].

For instance, the goal could be to keep a phenomenological quality of wind sound, but remove the obvious indexicality, so that, if asked, people would not identify the sound as "wind". Such a case is documented in the SONIC CAR BOARDING PROJECT 3 DD ZHdK 2009 (PD 37, on page 76)*:*

> *I: "How would you describe the sound and what could it express?"*
>
> *Participant: "Electronic, a bit light a tesla coil, no, something like a gap which is not entirely closed."*
>
> *I: "Some kind of tension, a kind of 'schshshshw', it's not necessarily wind, which was the first idea I think."* `(>37:4)`

The listeners get the key properties right: a small gap, tension (danger) and wind-like, movement related qualities.

The question is, how to balance the "recognizability of a coded connotation" and the "novelty". A good strategy could be to orient the design along the morphology of a strongly connotated, familiar, even stereotypical sound[6]. An exemplary for this comes from the case of BARKING WALLET TAIK 2009 (PD 17, on page 67). The bark of a dog is a good example of a highly familiar, identifiable sound which – in its stereotypical form – would dominate the design. The related discussion reveals the designer's motivation to go beyond the obvious and allow for accidental discoveries. She started from the sounds that could be produced with a wallet or similar container objects, which lead to the discovery of the sonic analogy of a slightly modified zipper with a dog bark.

In the context of the TOILET SOUNDSCAPE TAIK 2009 (PD 22, on page 70) we have a special case of defamiliarization which could be described as *de-tabooization*, on which I commented as follows:

> *I: "Like taboo sounds that we know that also are actual strong social taboos which are associated with our inner organs working and excrement and so on processing, going to toilet, so they have kind of been covered in a sonic, how would you say, ... Stardust, or something like that (laughter). So they are glittering and all of sudden parallels appear between dripping of small streams of water with dripping in a beautiful cave."* `(>22:2)`

The defamiliarization of the original sound is done in such a way that the sounds potential source is disconnected from the undesired association with urine. The sound still has certain associative qualities that fit the sonic universe of the actual scenario (water, toilet noises, reverberant space).

Finally, a good example of a known design using defamiliarization in the way described here, is the Skype ringtone, which blends design elements reminiscent of traditional phone ringing with the sonic identity of the Skype brand, all in consistence with its visual appearance and corporate identity.

[4]This relates to the code "need to defamiliarize strongly connoted sounds", containing 6 quotes from 6 cases.

[5]We should remember the fact, that already the technical apparatus of recording and electroacoustic (schizophonic) reproduction defamiliarizes the sounds, as discussed in section 25.2.

[6]The related code, "sound des. strat.: re-creation of morphology of a 'cliché' sound (defamiliarization)", contains 4 quotes from 4 cases.

27.2. Embracing Abstraction and Affect

While defamiliarization still maintains some link to an original source, abstract sounds are purely reduced to their non-referential, sensory form. The importance of the affective, and the power of the abstract to support it, is well documented in the cases analyzed in this work, and is consistent with the position, that not only the "content", but also the "form", understood as the sensorial quality of the spectro-temporal sound phenomenon, holds a central position in the interpretative process, in particular in relation to affective[7], "pre-cognitive" meaning making[8]. Also in the context of auditory streaming we encounter not only schema-based (and hence, depending on previous listening experiences) processes to decompose auditory mixes, but also what Bregman calls "primitive auditory scene analysis" (Bregman, 1990, pp. p. 38). Conceptual models that divide sound as sensory phenomenon and sound as referential phenomenon rest on the idea that there is a domain of representations, for instance a painting showing a tree, and on the other hand the domain of the actual things, the actual tree. But this position ignores that every entity of perception always also exists and is experienced as form, with its primary qualities, like the density or lightness of color or the sharpness or thickness of its sound (Sauer, 2011). Also Chandler points out that it is misleading to associate signifier with form and signified with content, as it may lead to the equation of content with meaning, implying that meaning can be "extracted" without an active process of interpretation and that (affective) form would not in itself be meaningful (Chandler, 1995a). What is important in this context, is the relevance of aesthetic perception in this process:

> "Einerseits ist Wahrnehmung konstitutive Voraussetzung von Zeichen und Ziel der Zeichen-Setzung gleichermassen, andererseits ist jede Wahrnehmung bereits Interpretation von Zeichen. Insbesondere aber ist Wahrnehmung sinnliche, physische und subjektive Gewissheit (Kant)." (Meyer, p. 148)

Thus, the design for emotion and affect is inseparable from "conveying information". This dimension of meaning making does not rely on verisimilitude or iconicity in the Peircean sense. The preconditions recognizability, identifiability, familiarity, or even naturalness, which I have discussed earlier in the context of the predominant "referentialism", do not necessarily have to be met. The affective power of abstract sounds - and the relevance of the affective dimension in meaning making - is discussed, for instance, by Kai Tuuri, in the context of vocal communication:

> "Studies presented above make a convincing suggestion that couplings between forms of intonation and communicative functions do exist. These couplings pose themselves as a promising source of sound-meaning structures, as melodic characteristics of vocalisations can be easily implemented in virtually any kind of UI sounds." (Tuuri, 2011, p. 27)

Klaus Scherer (1994) proposed a conceptual tool for understanding various types of affective communication (which is also adopted by Tuuri (2011)), modeled as continuum between "affect bursts" and "affect emblems". Affect bursts here stand for a raw vocal display of affective or intentional states. Affect emblems, at the other extreme of the continuum, refer to conventionalized gestures. This model allows to place abstract, affective sounds on a continuum between the two poles.

[7] The term "affect" here is understood as an expressive, proto-emotional and sensorily conveyed intentional communicative act, a concept linked to Daniel Stern's concept of vitality affects *(Stern, 2001)*. This view on affective dimensions of sound is also linked to the aspect of intentionality and agency, which we will discuss further below, in Section 27.5.

[8] The relevance of pre-cognitive processes for the emergence of meaning, based on insights presented from neurobiology, is discussed, e.g. by (Roth, 1992) and Sauer (Sauer, 2011). Many of these insights support the Gestalt theorist's positions about "innate" laws of perceptual organization.

Abstraction lends itself particularly well to gestural interactions. A study of Caramiaux et al. points out a phenomenon, which supports the argument to use abstract sounds. They found out, that indexical (causal) sounds may be less reliable for intersubjective gestural associations than non-identified sounds: gestural associations with sound-causing actions would show a higher variability than gestures tracing abstract sound features (Caramiaux et al., 2014).

Of course, abstraction as design means comes with its own caveats. Care has also to be taken to prevent perceptual quality might "dominate" another one. More specifically, the following example from The Elevator TAIK 2009 (PD 15, on page 67) shows, how spatiality, or perceived spatial extension, dominates the interpretation of the sonic texture, which was intended to be earthy, more rough, indicating that the elevator arrived on the lowest floor[9].

> *I: "I'm not so sure about the lower one (...) [it] was still a quite unlocated broad enveloping sound (...) I don't think it feels very earthy, because our experience of physical world, except if we swim in water, is quite much about pointing, touching, feeling a presure, quite localized usually (...). You are more in this kind of immersive space maybe."* `(>15:32)`

Thus, the sound design that works with blurred, reverberating elements, and lower, not locatable frequencies, is experienced as a spatial, enveloping phenomenon. The low frequencies were motivated by the designers aim to convey "deepness", "earthliness". But the spatial imprinting did turn out to dominate the experience of the sound.

Also, several examples from the case analysis show, that abstract sounds may be prone to confusion and ambiguity[10]. It seems that a particular problem emerges, if a metaphoric sound, or a sound which is expressive based on its perceptual sonic quality (or gesturality), is too similar to an everyday sound phenomenon with indexical implications (that is, a sound which tends to be heard as index to a specific source). For instance, certain rhythmic patterns remind people of a train, as it was the case in The Toaster UDKL 2011 (PD 80, on page 93), where a rhythmical clinking noise of porcelain reminded of a train restaurant `(>80:1)`. The same is true for sonic transformations is too similar to a sonic phenomenon we are familiar with from everyday live (or the staging of everyday life in film). An example for this appeared in the Explorations UDKL 2011 (PD 82, on page 95) `(>82:19)`. The continuous fading or disappearing of sounds exhibited in this demonstration may be caused by somebody leaving the room. In addition, it may also be associated with a filmic subjectivization, which often makes use of fading out of specific sound elements. Likewise, a metallic, high pitched tonal sound may be used to signify *"cooling"*, emerging from an association of a sound with *"ice or metal"* `(>45:16)`, which in fact establishes a metaphor based on crossmodal analogies. But the same sound also could be identified as a *"small bell"*, which either would be an interpretational dead end, or - in this specific example - to the association with the sonic stereotype for "magic".

In terms of conceptual tools to work with abstract affective dimensions of sound, we can learn also from film sound, which has managed to create novel, abstract sounds that could become new, identifiable (and often familiar) sound identities. In order to leverage this implicit design knowledge, the related "Narrative Metatopics" were investigated[11]. They provide a means of navigating a complex semantic space, and can help to link qualities of interactive processes with qualities of sonic processes. Narrative metatopics include: Nature and judgment of artifact, Qualities of Use, Qualities of Control, Qualities of power and energy, life cycles and dramaturgy, structural states,

[9] This also relates to code "ambivalence of attribution of sound to location", which is discussed in 25.3.1.

[10] This leads us back to the discussion of the role of ambiguity and ambivalence, which I have discuss in Chapter 25.

[11] Narrative metatopics are abstracted themes and attributes associated with narratively significant artifacts and interactions in fictional media, like film or games. They were established during the first editions of the workshops executed in the context of this thesis, by means of structured sessions of group discussions, coding and clustering of extracts from over thirty films and games, in which sound played a significant interpretive role (Hug, 2010a).

manifestation of life, gesturality and motion, transformation processes, temporal structure, and, last but not least, atmosphere or mood (cf. Hug, 2010a).

27.3. Supporting Learnability

The discussion of defamiliarization and use of abstract, novel sound inevitably raises a major issue: It is a common expectation that a sound should be clear and understandable. This relates to the ideal that an interactive application is expected to be self-explanatory, and intuitive. This conception is linked particularly with so-called "functional" utility products and applications, just as the navigation tool from Explorations UDKL 2011 (PD 82, on page 95):

> *Presenters: "We designed it to be a navigational tool, so it should be really clear."* (82:27)

Several cases however suggest that we may revise this understanding. Also we may have to revise the definition or scope of "information" which could potentially be communicated through sound. Some cases even suggest, that "clarity" is neither desirable nor necessary prerequisite for a "working" design. From the experience of the workshops, and also based on the insights in relation to the complexity of interpretational processes described earlier, it soon becomes clear, that an "immediate, intuitive understanding" may be not the only, or even the most appropriate design goal. Serafin et al. state:

> "There may be sound categories with very salient sonic parameters which are perhaps very intuitive, yet the sound would be less pleasant for long-term use, or even irritating or provoking an unwanted emotional reaction." (Serafin et al., 2011a, p. 105)

More generally, intuitiveness relies either on established codes or on obvious affordances, which themselves are routed in established experiential schemata. As I discussed above, both are rather an exception than a rule in the context of sonic interaction design, where many interpretational codes still need to be established and schizophonia creates new kinds of potential affordances between the physical and the digital. Bovermann et al. state:

> "It is very common to assume that acoustic or visual displays provide us somehow with more immediate or intuitive access to the object of research. This is a common pitfall: every sonification (just like an image) may be read in very different ways, requires acquaintance with both the represented domain and its representation conventions, and implies theoretical assumptions in all fields involved (i.e., the research domain, acoustics, sonification, interaction design, and computer science). This pitfall can be avoided by not taking acoustic insight for granted." (Bovermann, Rohrhuber and de Campo, 2011, p. 239)

Thus a goal should be to design *learnable* sounds, first and foremost, and *learnability* becomes an important factor in terms of judging the quality and benefit of a sound design solution.

What could be approaches to ensure, or at least foster learnability? Returning to the metaphor of the interpretational force field and hermeneutic affordances, a fundamental precondition is that there are actual potential points of convergence in the design that support the interpretational process. An example comes from the following statement from the presentation of the prototype Das System IAD ZHdK 2010 (PD 68, on page 89), where the sonic elements first could not be easily related:

> *I: "And here there are three entirely different sounds, and I had difficulties bringing them into a continuum. I can force them, I can force them into the continuum (...),*

> *but taken for themselves, they were too different..."*[12]

However, one particular sound provides an interpretational anchor point, through its abstract, evocative qualities, to which I refer in my continuation:

> *"...except for the last sound, if found, this 'dadadada', that is again this nastiness of the system, which I heard earlier in the alarm clock, a kind of scratching with lots of overtones also, which came at the end, there I thought this belongs together somehow."*[13] `(>68:4)`

The *"nastiness"* establishes a semantic relation across episodes of the interaction, thus sound quality itself becomes a point of orientation in the learning process.

Also the Crocodile Tamer TAIK 2009 (PD 19, on page 70) is a good example of a prototype where the sounds themselves were somewhat confusing, but still many design intentions came across due to clear structural relationships and the perceptual qualities of the sounds. For instance, the "alien" quality of the crocodile helped understanding that it was not about an actual crocodile, but some kind of experimental toy, and the action sound relationship between the swinging gesture and the didgeridoo sound supported the learning of the gestural pattern required to win the game.

Based on the insights from the cases, another rule of thumb would be to provide the design with a simple "core", which brings a general meaning across rather clearly, can be easily memorized, and may become the basis for more complex interpretational dimensions. This could be, for instance, an obvious association between a gesture and a sonic development, or a clear qualitative property of a sound, which conveys e.g. a warning or confirming information immediately.

Another example comes from the case of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73). Here, two abstract, yet complex, energy sources were used, one "good" and one "bad".

> *Participant (visiting expert) "And the basic sound was that the energy you get from the house? So the new sound comes only when I act. And it has to stay, no?"*
>
> *Presenter: "We have these two basic energy sounds, the good and the bad." [plays the sounds]*
>
> *Participant (visiting expert) "Ahaa!"* `(>25:17)`

The participant here speaks about one "basic sound", thus it was not evident that there were two versions for the two categories. But once the "good and bad" sounds were demonstrated, both sounds were immediately identifiable in the following sequences. Also, it was not necessary to explain which version of the sound was associated with witch expressive quality. This means, that the sounds required only a very simple framework to become "self explanatory", in the sense that the sonic representation of the two poles was immediately obvious thus showing a way of providing learnability.

But it is also important that a sound can be memorized *after* its meaning has been learned. And this applies not only to individual sound events (as they are usually studied in literature) but also to variations of repeating sound events or continuous sound streams, where it is a modulation over time that conveys information. But there seems to be little research in this direction. Learnability as design feature in a broader sense is to some extend a blind spot of Auditory Display research. There is indeed quite a number of studies dealing with learnability,

[12] I: "Und hier sind es nun drei völlig andere Klänge, und ich hatte Schwierigkeiten sie in ein Kontinuum zu bringen. Ich kann sie zwingen, ich kann sie in das Kontinuum zwingen, (...), aber rein für sich genommen waren sie sehr unterschiedlich..."

[13] I: "...ausser der letzte Klang, fand ich, dieser 'dädädädä', das ist wieder so das fiese des Systems, was ich auch im Wecker gehört habe, eine Art obertonreiches Kratzen auch, welches auch ganz am Schluss kam, da fand ich das gehört irgendwie zusammen."

usually comparing Earcons against Auditory Icons. Often, the former are criticized because they require learning, and Auditory Icons are appraised for their familiarity[14]. The problem with many of those studies is, that they remain within the a priori design paradigms. They are testing specific design approaches rather than providing general guidelines for designers.

While it has not been studied systematically, it seems, that learnability is supported by the sound's uniqueness and originality. Considering a particular type of memory called "episodic memory", which relies on a certain complexity to work, a design approach which strives for sonic elaboration and development of original sounds seems promising in this regard. However these are mere hypotheses which would require further testing[15].

As we have discussed above in section 27.1, it often is necessary to work with defamiliarization of sounds, to avoid the association with an existing sound source or event. This seems to be in conflict with the call to design learnable sounds, at least if we assume that familiarity supports learnability. But as stated earlier, it can be assumed that defamiliarized sound, which have a root in familiar sounds actually raise the interest and interpretational awareness. We could hypothesize that the raised awareness, combined with the motivation to exchange about the experience of the sound with others, will contribute to learnability and memorability of a sound. This aspect will be discussed in the next section.

27.4. Stimulating and Sustaining Interpretation

Learnability can only come into effect if the listener's interpretational attention is first stimulated, then sustained. As interpretation is not a isolated event, but a process, often involving negotiation and integrating multiple sensorial and semantic aspects, it is important to sustain the interpretational process over a more or less extended period of time[16].

One important insight from the workshops is, that it is important to find ways to open the user's minds, to enable appropriate listening attitudes which facilitate interpretational processes. In some cases a vivid discussion emerged around a sound, with associations literally building up around it. The potential for establishing an interpretive dialogue through appropriately designed sounds is also remarked by a presenter during the presentation of the final Mockup of the Matchmaker UDKL 2010 (PD 58, on page 85):

> *Presenter: "I expect this to be like someone (...) who found (...) this object and then [wants to understand] how it worked. He or she would start making experiments with it (...)."* `(>58:15)`

A common observation from the case study is, that some designs generated more interpretational activity in the audience than others. In the following, I will try to elaborate some properties of such sounds based on the cases reported in this thesis.

One argument emerged from the same Matchmaker UDKL 2010 case. In the continuation of the discussion, I express my preference for sounds that stimulate exploration, and I argue for some design properties to achieve this:

> *"I think we have too many functional sounds that are very informative. I think it's interesting to explore sounds that have a strong profile, which can be identified once you know them."* `(>58:15)`

[14] Learnability is discussed for instance by Garzonis et al. (2009) or Dingler, Lindsay and Walker (2008). The result of the latter study is, that spearcons are as easy to learn as speech and seem to require "virtually no learning to comprehend" (leaving aside the effort to learn a language in the first place), of course and that Earcons would perform better if combined with Auditory Icons.

[15] Another aspect of the relation between learning and the auditory modality should not be forgotten: Sound, or music, is often used to support learning as mnemonic "tool", as the countless "learning songs" show.

[16] In the workshops this process was sometimes initiated or pushed by myself, sometimes self-driven, which indicates the possibility to motivate interpretational effort by design.

So this means, a first property contributing to stimulating and sustaining interpretational exploration would be sonic uniqueness.

Another beneficial element could even be a "break", or purposeful incoherence, in the design. This could change the interpretive "lens", stimulating curiosity and attention. In the following quote from the EXPLORATIONS UDKL 2011 (PD 82, on page 95) I identify a gap between different sound groups, which triggered attention and finally informed the interpretation:

> *I: "(...) the first prototype (...) also had distinct sonic groups. (...) I think you are right, there is quite a gap, but the gap is there for a reason."* (>82:6)

In a similar way, inconsistency between object size and sound, which for instance is the case when a sound with strong deep frequencies is emitted from a small object, or a boomy sound from a compact object, can raise curiosity and attention based on incoherence.

We see that generating and managing attention thus is an important aspect in this context. From this perspective, we can understand ambiguity, but also surprising inconsistencies or changes thus as potentially "productive" forces. While this can not be conclusively verified with the given material, there are some strong hints that support this direction. For instance, consider the following discussion, again from EXPLORATIONS UDKL 2011:

> *Participant: "Why this last sound was very different from the others, why did you choose this? The positive sounds was clearly synthetic, while the other ones were, if not organic, at least mechanic."*
>
> *Presenters: "The positive sounds are more magical, more spherical, maybe more enticing to check it out. Whereas the other sounds were clearly like audible warnings, like flees or bees or tiger..."*
>
> *Participant: "I kind of liked this (...), you have a more visceral reaction to it because you know them. And the last one you are like: what the hell is this? What makes this sound?"* (>82:26)
>
> *I: "(...) well I sometimes think that a rustling sound can raise a lot of curiosity... yeah you know this kind of 'chchch' from a corner or whispering, as a basic sonic quality (...)."* (>82:27)

It seems that some sonic qualities may grab enough attention in order to increase interpretational focus. In the case of notifications or even warnings, it may seem that the more immediate our attention is grabbed, the better. On the other hand, another form of attention is based on curiosity which stimulates exploration and a more sustained interpretational process. In this case, the design was geared towards combining both aspects. Also the following quote from the DOC-O-MAT UDKL 2010 (PD 54, on page 86) points into this direction:

> *I: "It's exactly this very fineness but still perceivability of the sound, and this pure quality, that distracts. You get the attention away from the physcial experience of love to this 'what's that clingning thing?"'* (>60:24)

These cases provide some indications regarding the question, which sounds are more successful in grabbing attention. This statement points to *"rustling"*, *"whispering"*, and in the case discussed before "*fineness*", and *"purity"* – in this case as a contrast to other sounds – are mentioned. Thus, we have the two approaches of subtlety and ambiguity on the one hand, or even strangeness, and contrast, counterpoint, on the other hand.

A tentative conclusion could be that abstract, atmospheric sounds are useful for opening up an interaction, a dialogue. Unfamiliar, even strange sounds can raise curiosity[17]. Curiosity leads to, and may also sustain, attention and interpretational effort. Indexical sounds, which refer

[17] The related code, "ambiguous sounds may stimulate curiosity, interest, attention", contains only two quotes from one case, but the phenomenon can also be attributed to other cases involving ambiguity.

to fundamental threats or pleasures (such as water, birds, predator growls) could then be more about "immediate reaction" through familiarity or strong coding, combined with affective power. However, in terms of the "visceral reaction" to sounds such as flies and tiger growls, there is reason to doubt that it is the indexicality of the sound alone, and its evolutionary meaning, that could trigger such a reaction. It could be suspected that the immediate alarming was at least partially due to the stark contrast to the other pure, magic sounds, thus, again pointing at the need for careful composition of sound elements, to which we will return in Section 27.6.3.

An interesting observation was, that also modulations of sounds could trigger the attention in such a way that an interpretation process would start. Sometimes, an effect may be used to modulate a sound to convey meaning, or to trigger attention. An example is the ducking effect that was used in the Interactive Kitchen VID 2011 (PD 74, on page 90) when an error sound was played, or the distortion of the blinking sound in the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77).

Another approach can be illustrated based on the presentation of the Interactive Frying Pan TAIK 2010 (PD 45, on page 81), where we were struggling with the interpretation of a rather prominent, repeating sound. But some statements indicate that the sound was perceived as funny and entertaining. This made it memorable and unique, helped it to grab our attention and raised our interest to invest "interpretational energy". But as I will discuss in Section 27.7.3, care has to be taken when working with such sounds, as they can easily disrupt the experience and aesthetic coherence of a design.

If a sound is done right, we may very well appreciate the little disruption of the steady flow of foreseeable events. In some cases described here, surprise moments were often appreciated. For instance, I stated after the presentation of the aforementioned Interactive Frying Pan TAIK 2010:

> *I: "What I liked about it, there were so many unexpected sounds."* `(>45:3)`

But in general, care should be taken to manage and balance the degree of attention needed or provoked by sound, as there is a thin line between attention grabbing and annoyance. Certainly, we need to pay attention to a specific sound in order to start interpreting it and, without going into the details of the various form of attention, it should be noted that attention can take place in various degrees of conscious awareness. Ultimately, the relationship between attention and annoyance is, by all means, a dialectic one. A widely held belief[18] related to film sound is that if the sound design is done well, it is not noticed. One might even argue, that attention is often linked to "bad design", as expressed in the following statement from the discussion of the mockup from Machina Obturantis, UDKL 2011 (PD 78, on page 93):

> *Participant: "If you design something well, then it's transparent and people won't see it. People will bring more attention to something which is badly designed."* `(>78:10)`

But, as we have demonstrated above, there are indeed other means to subtly grab one's attention and interest, some of them relying on discontinuities, some of them on surprise, without necessarily being experienced as "bad design". In any case, the balance between "pleasant surprise" and disruptive "startling" has to be controlled. This is even true for sounds which rely on grabbing the listener's attention as part of their function, as it is the case with notifications, reminders and warning sounds. An interesting viewpoint is expressed in the following statement during the presentation of the Intelligent Shower TAIK 2010 (PD48, on page 82):

> *Participant: "(...) do we want to be guided to do the right thing by annoying sounds. Like it should be maybe also already guided or taught to you to take a shower without wasting too much water, but I at least from personal point of view, I want to feel that I can make the choice and it's not like, ok, if I take a shower over five minutes, I will get such a hell of a noise that I just have to leave the bath."* `(>46:10)`

[18] At least, in my experience, this is often stated by students of mine sometime during courses.

This participant is arguing for a dialogical, or at least less predetermined kind of notification, and a friendly expression in the related sound, and the possibility to gradually raise the urgency of a notification.

We quickly notice that in fact we are facing a coin with two sides here, and managing attention in order to stimulate and sustain curiosity and interpretational effort is thus subject to tradeoffs. Considering this, we must not forget that attention can also be achieved by means of gradual modulation as it is nicely demonstrated in the case of the Matchmaker UDKL 2010 (PD 58, on page 85), where the sound is indeed present during the whole opening phase of the interaction, and still does not become annoying:

> *I: "For me its a sound that tells that this is a dormant object. I think attraction comes not through the sound itself (...). The attraction could come because I know this object can do something and it's active (...)."* (>58:12)

So here the sound generates a presence and does not actively call for action (in a notification sense), but its subtle strangeness, combined with the enigmatic object sitting there, waiting. The sound design stays in the background and tries to sneak into the attention of a passing by person, maybe on purpose more directed towards an attentive flaneur rather than a busy traveller. There is no moment of calling, no moment of disruption or surprise, which normally is used to call for attention. What seems relatively certain, is that salience alone, the (objectively measurable) degree to which a sound perceptually "stands out" from a background, is not necessarily useful design parameter for positively grabbing attention.

27.5. Design for Agency, Performativity and (Bodily) Action

Interactive sounds have something to do with action, agency and performance. I have discussed several cases where the attribution of source and agency, as well as the quality of the involved action, influenced interpretation in Section 21. Even the seemingly reliable indexicality and referentiality of a sound could be destabilized by agency and (perceived) intentionality. A sound might be attributed to the action of a user or an artifact, and the related question of attributing agency to a human person or the artifact itself, which is a consequential possibility in interactive commodities. Another aspect is the identification of a goal, or object, of an observed (or sonically implied) action. Thirdly, there is the related aspect of "intentionality", actual or supposed, by human or non-human agent.

Therefore, agency and performativity has to be considered in both design and evaluation of sound for interactive commodities. To understand this aspect, and to help dealing with them in design, performance and theatre studies provide some useful concepts to work with (Hug, 2010b), as they deal with performance, enaction of roles and intermedia situations, and integrate semiotic thinking with the understanding of the impact of action, expression of self and affective experience (Meyer, 2001). The related insights can be applied beyond the stage, to the performance of self in everyday life in Goffmann's (1990) sense. Of main interest to this study are the aspects of presence and representation and the dimensions of emergent meaning, such as self-referentiality, foregrounding, perceptive multistability and association, as described by Meyer (2001), Fischer-Lichte *(2004)* and Elam (1980)[19].

[19]In the context of her analysis of the aesthetics of the performative, Fischer-Lichte *(2004)* describes the phenomenon of "presence", discussed in relation to the Peircean conception of "firstness". For Peirce, "firstness", or, as he also calls it, the "qualisign" is the actual sensual experience of a given phenomenon and its qualities (e.g. "redness"). The "qualisign" cannot be separated from its realisation in a concrete aesthetic form, the "sinsign", or "secondness" (e.g. a red lightbulb). And on the level of conventionalized meaning, the thirndess, or legisign in Peirce's categories, (e.g. "Stop") is always experienced with and through its firstness and secondness (Meyer, 2001). Thus, in what regards presence and representation, there is always both, the phenomenon in its self-referentiality and the emergence of associations. Furthermore, there is the perception of phenomena as signs. And these modi do not occur exclusively but rather intertwined (Fischer-Lichte, 2012, p. 66). The

For a better understanding, it is important to distinguish between agency as intentional action, which is not necessarily manifest in bodily movement, and overt agency in the form of movement and gestures. In the following, I will elaborate on these two aspects of agency and performativity.

In an interaction with humans and computational systems, the relevance of material sound is limited. Usually, sounds occur because there is an intention for communication, and not because of physical necessity. This indicates, that the sonic reference to mechanical sound events might be less adequate, or beneficial, than, for instance, a reference to expressive vocal utterances. This is also confirmed by the case studies. In many interpretations, the attribution of a sound to a cause was important, but not necessarily in terms of "material" cause, e.g. the attribution to a specific object. This confirms my earlier suspicion, that it is not sufficient, or even misleading, to analyze interpretation of sounds in schizophonic interactive commodities only in terms of the material sources they represent. The "causal listening mode" is indeed of central importance to how we experience our auditive environment, but needs to include also the aspect of (actual or assumed) agency, intentionality, and "utterance" in the process of dialogical interaction.

Thus it often is necessary to define different sonic characteristics for sounds being produced by either the a particular artifact, the "user", the "system" or even the overall "process", and to establish the appropriate aesthetic or semantic links (see also the discussion of these associations in Chapter 21). Another approach could be based on the understanding of prosody in vocal communication and its application in sound design. Tuuri has studied the impact of intonation patterns of vocal "gestures" on the regulation of physical training activity, and found that function-specific intonation patterns indeed were able to convey intended meanings, even when "detached" from the context of vocal utterance to an user interface (Tuuri, 2011). He proposes a "prosody-based" sound design. This approach builds on the observation, that intentionality is expressed through embodied action, in the form of modulation of vocalizations. These are even universal in many cases, albeit intertwined with the observer's position (as argued by Searle (1983)) and the situational context (Tuuri, 2011, p. 19). Leman suggests that biologically relevant movement patterns, suggested by movement sounds, facilitate the attribution of intentionality (Leman, 2008). This attribution is not restricted to human or animal sound sources, but even artificially made sound, as long as it is able to evoke ecologically valid motor-mimetic experiences (Godoy, 2009). Building on this understanding, Tuuri proposes a range of "sensorimotor experience contours", associated with "kinesthetically characterized schematic gestalts" which are associated with four communicative functions: Slow down, Urge, "OK", and Reward. These in turn are related to gestural signatures of an interpersonal affect. This approach turned out to be highly successful for communicating the four intended functions, even when using very simple synthetic sounds modulated according to the prosodic qualities (Tuuri and Eerola, 2008).

In terms of observable bodily movement and gesture, I have discussed several related phenomena in Chapter 22. Research in Auditory Display, New Interfaces for Musical Expression and Sonic Interaction Design shows, that already on a basic level, sound has a significant impact on the perception and execution of movement and vice versa. For instance, balancing a virtual ball can be supported by an accompanying sound of a rolling ball, helping to understand and anticipate the processes of acceleration and deceleration of the inert object (Rath and Schleicher, 2008). Other examples include the use of sonification to guide bodily motion when reproduce jumping heights (Effenberg, 2005), for swimming (Seibert and Hug, 2015) or rowing, (Schaffert, Mattes and Effenberg, 2011) (for an overview see Höner et al., 2011). Also, bodily action has an impact on the judgement of sound, for instance when manipulating a user interface, as

chair on a stage stands for itself, and not for a car seat. But at the same time, through a performative act, it is transformed into a stage prop, a signifyer. Likewise, the actor-agents demonstrating gesture is perceived as standing for itself, as well fulfill a function as a (coded) sign. Both, objects and human agents, are potentially self-referential *and* representative (Fischer-Lichte, 2004; Meyer, 2001). This interpretational perspective can shift in the very act of perception, as in figure-ground illusions, a phenomenon known from Gestalt theory. For instance, the sensory quality of a sign itself can attract our attention, the red traffic light at night may osscilate between sign for stopping and the intensive sensation of red color.

Susini et al. (2012) show.

But the question of gesturality can also be approached from sound, rather than bodily motion, as I discussed also in Chapter 22. From the cases it could be observed, that a correspondence between a quality of an action (in the sense of bodily movement or gesture) and the related sounds would contribute to a positive judgement. However it needs to be emphasized, that this is not necessarily resulting from a correspondence of morphologies of gesture and sound. The emerging action-sound relationship is not restricted to exact and continuous temporal synchrony, but includes a more open aesthetic and structural relationship of the two modalities[20]. It also turns out, that the relationship between sound and gestures can be re-interpreted and re-designed in both directions, and the approach pioneered by Pierre Schaeffer, the "typomorphology" of the sound objects ("objets sonores") can indeed serve as a shortcut to action-sound rleationships, as origially proposed by Godoy (2006).

Further expanding on the analysis provided in Chapter 22, it is striking that a general identification of the action-sound relation could often be observed, but usually occurred on a relatively superficial level of establishing the general attribution. And once an association with the "object of reference" was made, the temporal structure and mapping properties were not further considered by the participants. For instance, a movement could easily be identified as "belonging" to a sound (and vice versa), but usually, the question how exactly this relationship would be established was not considered in the interpretation. This may also be because a more detailed analysis of such relationships would have required closer and more careful listening to details of the sounds development, which was not possible in the given circumstances. However, this does not mean, that designed relationships would not have an impact on interpretation, but presumably a more intuitive, affective one.

Another phenomenon was, that sounds changing over time were often interpreted as temporally developing objects, and the possible gestural relation - if existing - was often in the background of interpretational attention. It thus turns out, at least based on the case analysis given here, that continuous, isomorphous (Chion, 1998) action-sound coupling, where sound morphology corresponds closely with the development of a gesture, was not as relevant as expected. Indirect mappings where much more common. A possible explanation could be, that sound was usually not used as expressive channel for the user, but rather for the system. On the other hand the discussions of the cases shows, that if sounds indeed are to be associated to a gesture, they should exhibit a clear relation to the functional semantics of the gesture, thus, not (only) to the gestural dynamics, but the gesture's effect on the artifact and/or system, and its role in the overall interaction process. Also there needs to be a coherence in terms of sound "material" and its transformation, in order to establish belongingness and a mental model of cause and effect.

27.6. "Musical Design Thinking": Potentials and Limitations

The call for the abstract, and some of the considerations regarding gesturality of sound, are certainly bringing sound design closer to the musical realm. Several of the design cases studied here, and also my experience as sound designer, suggest, that musical approaches indeed can contribute to sound design in many ways. In the following I will look at the topics in this respect in relation to the insights from the workshop cases.

To begin with, the question is, whether musical approaches could contribute anything at all to better and more effective design in sonic interactions. Some musical principles have left a reasonable big mark, with the principle of Earcons explicitly building on musical paradigms, and also experimental musical approaches have been included in the discussion, in particular

[20]In relation to the question of "agency" discussed in Chapter 21, we could observe that when a clear relationship between a sound and and observable action was missing, the sound would be rather attributed to the "system's" agency. But this relationship does not emerge on a morphological level or some kind of analog gesture-sound mapping based on synchronicity.

in relation to the possible parallels between Sonification and algorithmic composition. Vickers proposed the "The Ars Informatica–Ars Musica Æsthetic Perspective Space", which associates sonifications with their closest analog in the musical world, and suggests that if a sonification is organized along the lines of a piece of tonal music then it could draw upon the aesthetics of tonal musical composition. Likewise, a sonification makes use of rather concrete sonic events, then it could draw upon the aesthetics of musique concrète (Vickers and Hogg, 2006).

It is striking, in this context, that the design approaches of many sound designers from New Hollywood were influenced by 20th century music. The aesthetic achievements of musique concrète inspired the use of what could be termed "musical" design strategies, and musicality emerged as a principle to create and arrange every noise of a sound track (Flückiger, 2001). Commenting on his sound work for THX 1138 (Lucas, 1971) Murch states that:

> "It is possible to just listen to the sound track of THX exclusive of the dialogue. The sound effects in the background have their own musical organization" (cited in Whittington, 2007, p. 57).

A further consequence of this resolution of the border between "music" and "noises" was the combination of synthesized sound with recorded sound that opened up new narrative and aesthetic spaces. For example, the screams of the birds in Hitchcock's eponymous movie (1963) were created by Bernard Herrmann, Remi Gassman, and Oskar Sala on an early electronic instrument called the Trautonium. Another striking example can be found in "Apocalypse Now" (Coppola, 1979) where the naturalistic recording of helicopter sounds are combined, juxtaposed, and fused with wobbling sounds from a synthesizer[21].

But the musical analogy has also been criticized, at least in relation to sonification. It is true that in music algorithms and data mapping has been a concern for creating sound (Barrass and Vickers, 2011). But in sonification, the goal of the outcome is to make structures and dynamics in given data perceivable, and not an outcome with a musical value in itself (which, in their view, accounts for the "precarious aesthetic state of sonification" (Barrass and Vickers, 2011, p. 215)). In musical context structure is usually hidden, or may emerge as a new quality from a piece. Also in musical experience there is no constant focus, which motivates repetition, variation, and the various forms that help the listener to orientate within the work. Such forms are not the subject of sonification and contradict its purpose diametrically (Harenberg and Weissberg, 2012).

27.6.1. Challenges of the "Musical"

Indeed, several examples from the workshops do indicate that there are specific challenges associated with musically inspired design, albeit usually not related to the specific issue of conveying information about specific data sonically[22].

Let us start with the most basic and common element, pitched tonal sound. Pitch may be a very simple parameter, but can be surprisingly challenging to handle, in particular if used arbitrarily to differentiate variations of an event, or to represent many different events. For instance, in the case of the Intelligent Shower TAIK 2010 (PD48, on page 82) for the user interface sounds to indicate the use of shampoo, the designers used a simple tonal interval in some variations: up and down, then two tones for first occurrence, and three in a repeating instance. The same timbre was used for a voice command confirmation, which they described as a variation of the tonal suggestion to use shampoo (`>48:18`), and a warning sound to indicate the imminent arrival of water. Thus, all sounds have a very similar sonic quality or timbre. This made it difficult to differentiate the sounds. Furthermore the up and down sequences afforded

[21] I have developed this thought further in the context of new directions for game sound design in (Hug, 2011).

[22] There are three codes which are explicitly related directly to this issue. The most prominent one is "musical design strategy difficult to decode" which is associated with 5 quotations from 3 cases. The code "issues asociated with musical design" has 2 quotations from 2 cases. The code "'wrong' interpretation due to (unintended) musical codes" has 1 quote.

interpretations such as "open/close". But the designer's intention was to use the downward interval sequence to indicate the use of shampoo.

Also, the use of pitch may result in musical intervals which are themselves coded in certain cultural contexts, as was the case in the EXPLORATIONS UDKL 2011 (PD 82, on page 95). Here, the tritone was used, which is associated with mystery or scariness in the western world. Another pre-existing musical stereotype is the dominant - tonic resolution, and some melodies have a specific (musical) meaning.

Furthermore, pitch (not of a single tone, but overall transposition of a musical pattern) which might be associated with height, might also be intended to express "weight" as in the SONIC PUZZLE IAD ZHdK 2010 (PD70, on page 89).

In general, design strategies relying on tonal sounds and pitch configurations face the same issues as Earcons: They might be difficult to understand, learn and memorize[23]. Apart from this, pitched sounds are generally associated with the issue of salience and dominance, to which we will return later. And last but not least, it should be taken into account, that in general, simple, tonal sounds tend to be attributed to the system rather than the user, as several cases indicate.

On the other hand, pitch can be a powerful means for communication, if the design follows patterns familiar from language intonation (Tuuri, 2011)[24]. Pitch-based features of sound are also expected to resist masking effects of noisy conditions more robustly when compared to features such as timbre or intensity.

A more general aspect is, that the perception of musical instruments and musical elements, such as tonality, harmony and rhythm, establishes an *musical interpretational mode*. The musical, once established, becomes the point of reference for all other sounds, as the following quote from the INTELLIGENT SHOWER TAIK 2010 (PD48, on page 82) points out:

> *I: "The musical approach is always tricky, because at one point its very useful, but on the other hand it's very difficult to integrate meaningfully into an everyday soundscape. Because very musical sounds tend to become a realm of their own. And then you hear a river in this music, of course here we have another connection because (...) it is more than just a natural sound in a musical context, (...) it's also associated with esoteric relaxing soundscape cliches (...)."* `(>48:25)`

In the case of this mockup, there was a general difficulty to tell whether a sonic change was meant to be meaningful or "just" part of musical motion:

> *I: "I heard water coming and going, that was the obvious part, so to say. then I noticed also a lot of movement in he soundtrack and I could imagine that it has meaning."* `(>48:5)`

The events in the musical background were grabbing my attention, and, in particular when contrasted with some indexical sonic elements in the design, seemed to have a meaning. But at the same time, they could as well just be motivated by musical considerations.

The following quote from the same prototype shows a case where two properties of a musical instrument, melodics and saliency, are combined mimicking birdsong. The presenters were discussing the challenge of designing a melody for their smart shower which would not get annoying on repeated use (in the morning) and was at the same time subtle and distinguishable. Their solution was to build the design on bird song. A member of the audience, who was visiting the presentation, stated:

[23]As musical designs similar to Earcons were only used in few cases, this was a rather rare phenomenon, with 5 quotations from 3 cases being associated with the code "musical design strategy difficult to decode".

[24]In the discussion of the INTELLIGENT SHOWER TAIK 2010 mentioned before, participants suggested that the two descending tones could be actually an imitation of the word "sham-poo", but this mimicking of language (or singing) was not intended. The application of language intonation could have worked here.

Participant (visitor): "That is interesting, because in the end this is made with some kind of synthesizers and that's an interesting question, (...) because if you wake up every morning in the countryside in summertime and (...) you wake up to bird song, you can't get bored, it's always nice. An this is a completely different thing (...)." `(>48:29)`

The design approach to use synthetic figurative sounds certainly makes sense, but the nature of bird song requires a high level of variability to avoid creating overly simplistic, and potentially annoying, series of tonal impulses. I further state:

I: "I think the subtle quality is easy to achieve if you don't go too much towards pure tonality and very full musical scores." `(>48:29)`

The issue of dominant tonality and emphasis on musicality - turning an auditory feedback into a musical score, as it were - came out also in the discussion of the EXPLORATIONS UDKL 2011 (PD 82, on page 95) which was just discussed as example of the advantages of musically inspired design by helping to build structure. Following this observation I add that:

I: "Musical elements are not very well suited for everyday situations, because they stand out too much in the environment." (>82:23)

The salience of musical sounds, which is criticized here, is both grounded on a perceptual level and – as in the case of instrumental sounds – through familiarity leading to the identification of the sound as coming from a musical instrument outside of the context of "music". Furthermore, as soon as a design is associated with "music" it becomes part of an already coded, complex sonic universe[25].

Another example comes from the SONIC CAR BOARDING PROJECT 2 from DD ZHdK 2009 (PD 35, on page 75) where at some point the "abstract musical" sounds became too prominent, making the listeners move their attention to chord progressions and various versions of thirds. I suggest that:

I: "...one could try, in stead of intervals of thirds, which are always a bit technical, (...) abstract (...) to come to a more musical interpretation, or something that becomes more narrowband (...) something that leads to the perception of 'narrowing'. Or a cadence." `(>35:13)`

This reflection shows the need to make a design decision in terms of choosing either a more elaborate (and less generic) musical approach, or by focusing on crossmodal analogies and perceptual qualities of sound transitions. A conclusion of this consideration could be, that, as soon as the sounds get too "musical", they are not working as interaction between the abstract and the concrete anymore, but tend to switch over to a purely "musical" interpretational system.

Managing subtlety and salience in musical design thus is a particular challenge of musical design approaches. According to the designers of the INTELLIGENT SHOWER TAIK 2010 (PD48, on page 82), a primary design goal was to have a "subtle" design where informational sounds would blend with the overall ambient soundtrack in a musical "symphony". However, the consequence of this aesthetic integration was, that the UI sounds emerged and disappeared into the musical ambient background, which made it difficult to understand them as specific signals. A visiting expert points this out:

Participant (visiting expert): "(...) in the first time of listening it was hard to concentrate on the kind of musical elements which are kind of a sonification and then the

[25] A special case of the association with music being an obstacle to a unbiased interpretation could be observed in the case of the ASSEMBLY LINE DD ZHdK 2008 (PD 5, on page 64). Here, the whole demonstration was perceived as musical performance by some, because the interface requires three people sitting next to each other, each one silently manipulating a touchscreen, which results in abstract, tonal sounds.

> *water sounds which is kind of the display of the actual action of taking the shower, so now when you play them again and you point the htings out (...) you notice them. (...). I would say perhaps that it's a too well done mixdown. Because it's too well balanced. it kind of feels like one entity, the water sounds and the signal sounds and the background music and stuff."* (>48:25)

In this case, the modulations of the interaction sounds are so much part of the overall musical structure, and the changes happen so smoothly, that they are "backgrounded" into the music. In comparison, the confirmation sound just before the water would start to flow, consisted of several gentle, short impulses, which were clearly different than the remaining sounds, while still fitting the overall style. This is thus an example of achieving sufficient salience with subtle, tonal sounds.

27.6.2. Considerations for Working With Pitch and Melody

Notwithstanding the potential problems and the limitations, there are some considerations, which show possible approaches to using tonal, musical sounds. On the level of basic auditory perception, it is important to know and use the procedures of *grouping and streaming* (Bregman, 1990), which require attention to how sequences of (pitched) sounds are composed spectro-temporally.

Another very basic feature of tonality which can become meaningful beyond abstract musical functions is, *dissonance and consonance*. These are not two discrete states, but rather dynamic entities on a multidimensional spectrum. On the one hand, dissonance is a measurable acoustic, and psychophysiological dimension which has its roots in the the fundamental frequencies as well as the overtone spectrum (coincidence of partials, after the definition by von Helmholtz (1895)) of two simultaneous tonal sounds, manifested for instance as "beating" and "roughness".

On the other hand, the judgement and experience of consonance and dissonance was always subjected to cultural and historical developments. A prominent example is the tritone and the "jazz interval" major seven who in general are judged to be strongly discordant and "unstable" (i.e.: harmonically ambiguous), but have become an important element of the music of the 20th century. The use of terms such as "stability" also shows, how consonance and dissonance may have a "dramaturgic", even narrative function, and are related to concepts such as (in)stability, (dis)continuity, arrival, tension, rest and resolution.

The phenomenon thus has to be understood first by its aesthetic and affective quality, creating certain sonic "feels" and perceptive qualities such as "hovering" or "shimmering" by layering to slightly dissonant tones. Bregman refers to this as "psychoacoustic" dissonance (Bregman, 1990, p.681). This dissonance can then have a semiotic function, e.g. to express the raising tension in a scene of a movie. Also it fulfills functions in temporal developments of music, where in most "western" music dissonances establish tensions to be resolved to a consonant, even "tonic" sound (referred to by Bregman as "musical" dissonance (Bregman, 1990, p. 681)[26].

And from this, we arrive at the more general harmonic and melodic phenomena of tension and relief, or resolution, and compositional strategies such as counterpoint, which can help to structure a sonic design. Another related technique would be the establishment of a melodic theme and then deriving variations. On the level of motifs and melodies, an example which attempts to develop a musical language for Auditory Displays based on "rhetorical design" is provided by Polotti and Lemaitre (2013). In the design of their Earcons they do not primarily aim to represent a specific event using simplified musical "rules", but rather focus on making each earcon a musically relevant motif[27].

[26] Bregman points out, that composers who worked in the polyphonic style are able to control dissonance by the use of methods that exploit auditory scene analysis (Albert S. Bregman, *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, Massachusetts: MIT Press, 1990, p. 681).

[27] It should be mentioned that those motifs are either longer (up to four bars) or contain more notes (at least

27.6.3. Sound Design as Composition

On a higher level of musical abstraction, we soon arrive at the topic of *composition*. Theo Van Leeuwen (1999) described, how meaning emerges from structural features of sounds, and in particular from relations between sounds and (musical) parameters such as volume, pitch and meter and their modulation. The concept of sonic composition was evident in several cases (see also Chapter 23). Several examples from the workshops have shown, that is not only the individual "sound-signs" that motivate interpretation, but also the way they are sequenced with other sounds and events. And in some cases we can even speak of a (multisensory) temporal "montage" of various sensory elements, contributing to an integrated experience. Thus it may be less the design of individual sonic events which profits from "musical thinking", but rather their composition into temporal and formal arrangements which do not only work on a semantic level, but also in relation to the sonic correspondence and the "mix", but also the careful management of time and pacing of sound in the interactional process.

In particular the insights from the discussion about the attribution of agency between user and system, and between various forms of agencies (including visible gesture, see Chapters 21 and 22) suggests that it is a useful strategy to look for a good sonic structure on the compositional musical level instead of focusing only on individual sounds, or building individual sounds in relationship to each other, so that sound elements are reoccurring and thus become noticed as potentially meaningful. Another interesting phenomenon was, that when a specific sequential arrangement was perceived, more listening attention would be given to sonic details and qualities, supporting their contribution to interpretations (see 23.1.2).

In some designs it became clear, that the compositional aspect matters, because despite their complexity, they were perceived as clearly structured and understandable[28]. The Sonic Car Boarding Project 2 from DD ZHdK 2009 (PD 35, on page 75) brought with it several examples of sequential design, where the multidimensionality of information results in a compositional challenge `(>35:22)`.

The sequence as such is not the only important factor. The relevance of how the elements of a sequence are related to each other, and how transitions between them take place, became apparent in the Sonic Puzzle IAD ZHdK 2010 (PD70, on page 89). Here, an interpretational problem arose due to the fact, that whenever some sonic (in this case musical) element was established, it would be concluded by letting it disappear completely and starting with a new element. This conflicted with the concept underlying the prototype's structure, which entailed that a newly emerging element would become part of a whole, instead of just disappearing `(>70:6)`.

As mentioned already in the discussion about the sound design strategy to work with time and rhythm, interaction processes with a prominent sequential order, such as cooking, may offer the possibility to (re)enter an ongoing process. From a compositional point of view, this means that the sonic "main theme" should also be understandable if it's "introduction" was missed by the interacting listener. This could be achieved for instance by conveying what kind of modulation would be used to create variations of a theme. In the discussion of the Interactive Kitchen VID 2011 (PD 74, on page 90), I compared this to the possibility to guess a musical theme by hearing later variations of it `(>74:3)`. This prototype was also a good example of the fact, that a multilayered composition requires both "musical" fit, but also clear and systematic relationships, hierarchies, and associations between the various elements of the system, its functions, and the user's actions.

Several exemplary design cases related to structure and composition were discussed in Chapter 23. The expectation would be to be able to construct a *"system of meaning that you can then*

8 16th notes) than common examples of earcons representing basic concepts such as copy or paste (see, e.g. (McGookin and Brewster, 2011)).

[28]The related code, "sound des. (temporal sequence and layering) as compositional task" contains 5 quotes from 4 cases.

adapt to several others" (>82:22). On a basic level, this is the approach of Earcons, and in general the use of tonal patterns and specific intervals, consonance and dissonance. An example of building on musical design strategies, even using simple tonal sounds, is the SONIC PUZZLE IAD ZHdK 2010 (PD70, on page 89). Here two pitches approach each other until they are in unison and thus reach a conclusive state (>70:3). This shows, that also simple tonal sounds can work, if they are integrated in a suitable, systematic structural relation.

Musically inspired design could also support the establishing of dramaturgy in order to support the structuring of the sound design as well as the interaction process[29]. For instance, in their prototype for the SONIC CAR BOARDING PROJECT 2 from DD ZHdK 2009 (PD 35, on page 75), the authors aimed at conveying an iterative process with a clear conclusion. In the discussion (>35:9) I suggested that a general "arc of suspense" and sense of development was missing in the melodic elements they were using. Also, I suggest that the design could have built on musical strategies, instead of *"using sometimes a low, sometimes a high sound"*. Other potential improvements included to avoid simple jumps of thirds , and becoming more "musical", referring here to more subtle harmonic progressions (>35:13)[30]. Further suggestions were to use a timbre that becomes more narrowband, reducing the overtones, which leads to a perceptual reduction of complexity in the tonal construct. Another suggestion was to use a musical cadence to provide a sense of direction and – eventually – closure.

But how to associate such sonic compositions to interaction elements and sequences? Linking to the notion of interpretational force fields, and building on the example of film sound, we can see the possibility to "force marry"[31] sound, their affective potentials and specific (inter)actions, through composition, thereby creating new associations and relationships. This concept involves a voluntary compositional activity by the designer.

The possibility to define these associations, at least in listening contexts that resemble the acousmatic condition (i.e. when there is no observable cause of a sound, as it is often the case in interactive systems) is also supported by Dennis Smalley, when he refers to a concept of "source-bonding", in his theory of spectromorphology. He defines it as "the natural tendency to relate sounds to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins" (Smalley, 1997, pp. p. 110). Smalley emphasizes both the a priori openness of this bonding, and its relevance for design:

> "The bondings involve all types of sounding matter and sound-making, whether in nature or in culture, whether they arise as a result of human agency or not. Source bondings may be actual or imagined – in other words they can be constructs created by the listener; different listeners may share bondings when they listen to the same music, but they may equally have different, individual, personalised bondings; the bondings may never have been envisaged by the composer and can occur in what might be considered the most abstract of works; wide-ranging bondings are inevitable in musics which are not primarily weighted towards fixed pitches and intervals. Bonding play is an inherent perceptual activity." (Smalley, 1997, pp. p. 110)

Smalley continues to emphasize, that these bondings are essentially multisensory phenomena:

> "Extrinsic–intrinsic threads of the 'as if' variety need not refer only to sounding experience. Non- sounding extrinsic links are also possible, whether based on human physical movement (see the section on gesture) or environmental experience. For

[29] A related code, "suggesting to work with simple musical rules for establishing sequential coherence" contains 3 quotes from 2 cases.

[30] A closer post-hoc analysis of the sound design shows, that the sound design actually employs a range of compositional strategies, but the amount of individual elements and their fast succession obscured this structure. This indicates the importance of managing arrangement and time appropriately, which is ultimately a compository task.

[31] Referring to Chion's (1994) famous exercise "forced marriage" for combining the same movie sequence with different soundtracks as inspiration.

> example, spectromorphology is concerned with motion and growth processes, which are not exclusively or even primarily sonic phenomena: sonic motion can suggest real or imagined motions of shapes in free space. Spatial experience itself can involve sounds or not. Energy, which is inherent in spectral motion, is part of both sounding and non-sounding experience, linked not only to motion in general but to human gesture as well – the energetic impact of an implement hitting a sounding body, for example, has spectromorphological consequences." (Smalley, 1997, pp. p. 110)

We can recognize in this description many phenomena and design features identified in the Chapter 18. Other, somewhat similar design approaches building on formal and abstract qualities have been proposed, e.g. "Temporal Semiotic Units", which are abstract sonic fragments that have a temporal signification due to their morphological organization (Favory, 2007), "Morphocons", which are short audio units that aim at constructing a sound grammar based on the temporal evolution of sound (Parseihian and Katz, 2012), or Kai Tuuri's "Vocal Affective Communication" (Tuuri, 2011). Also rhetorical approaches using short, abstract melodic fragments (Polotti and Lemaitre, 2013) have been proposed.

Another way to enable bonding between sounds and interaction processes could be to consider them from a narrative point of view. These narratives do not only refer to larger forms, but can be seen as actual compositional elements. For instance, Curtis Roads refers to storytelling when talking about his microsound composition:

> "For me, composing is about telling a story. The sounds are born, they live, they change, they meet other sounds, they collide, one sound destroys another, they merge together, they get married, they get divorced, they get unstable, they change identity, they mutate and then they die. So it's all about a narrative. Its a narrative about sound."[32]

Also Maribeth Back has discussed the notion of "Micro-Narratives" when discusssing the way how individual sound events are designed to convey a structured information and affect related to a function or interaction (Back, 1996).

In experimental music, the dimensions between individual sound and longer composition blur in a way that can also inspire Sonic Interaction Design. In an analysis of "Gesang der Jünglinge" Stockhausen (2009) speaks of a "micro- and macrocontinuum" and "processes of diminuition and augmentation". Diminuition, for instance, is his musical method, to achieve a statistical distribution of new sound phenomenas by means of concentration. This supports the creation of sound textures, which have an internal composition, making them unique and very flexible in their temporal extension (Stockhausen, 2009, p.18 -19).

27.6.4. Musical Composition for Sonic Interaction: Between Control and Adaptability

In conclusion, while they can be designed to be meaningful and learnable in some cases, musical design strategies certainly do have their limitations. One issue is related to the a priori abstract nature of musical expression which may make it difficult to decode, learn and remember the associated meaning. Another one is "wrong" interpretation due to unintended musical codes. Furthermore, an unintended framing of sounds as "musical" in general can be the result of identifying musical forms in a design. Also, musical elements tend to be quite prominent. The reason for this can be their tonality, and the fact that when hearing musical sounds our attention is activated, at least at the first (unexpected) occurrence of such a sound. It is important to explore alternatives to simple tonality and pitch: Working with spectral centroid and formant

[32] Curtis Roads, originally on VICE Motherboard TV (https://www.vice.com/alps/article/curtis-roads–2), video now available at https://youtu.be/M3viqsxQuIU?t=3m41s, retrieved 30.1.2017.

shift on complex timbres results in spectral changes which still "feel" like pitch changes, but are much more interesting and versatile.

But structure and composition as musical design thinking is highly valuable. First of all, the power of sequential order, the expressive and informative potential of temporal structure of sonic events can be exploited. The composing sound designer can guide the listener by designing carefully the temporal development of a sound providing it an element that shows how a process reaches a certain state, for instance signaling a conclusion, change of agency or calls for an action or user input. This "musical design" does not necessarily rely on harmonies and melodies, but adopts a "compositional stance" to sound. In this task, care has to be taken that the sonic elements can enter a balanced musical correspondence, where the listening is governed by compositional aspects rather than perceptual salience (emerging e.g. based on its spectral properties, general aesthetic inconsistence, or indexicality) of an individual sound event. At the same time, the design can take care of carefully shaping individual sound elements to be actual sonic "Micro-Narratives", that tell us something about the process associated with a button press, or the relation between a gesture and an accompanying sound and its effect on an interactive system.

This reminds us of the importance to consider musical design also as performative design, almost as if we were designing musical instruments. To given an example from everyday experience: Doorbells or bicycle alarm bells are very generic tonal sounds. But we can play them in different ways, depending on what we want to communicate, and how. We may agree on sonic patterns in order to know who it is at the door[33] or spontaneously express anger or impatience. We also may modulate our knocking or rining in the attempt to not disturb. This shows again the importance to consider affective, compositional-narrative *and* performative dimensions of interactive sound.

Last, but not least, we have to consider, that the sound composition in interactive contexts will be to some extend non-linear and emergent based on the interaction itself. Thus, balancing compositional and procedural design is one of the core challenges in interactive sound design practice. Ultimately we are designing improvisational frameworks, sets of rules that allow to generate and modulate sounds in a non-arbitrary, yet responsive way. In this context it is beneficial to consider the notion of the composition-instrument and Herber's discussion of various adaptive approaches to musical composition (Herber, 2006), or the concept of "musical metacreation" (Bown et al., 2016).

27.7. Achieving Acceptance and Making it "Appropriate"

A fundamental precondition for successful engagement with sounds in interaction and the related processes of meaning making and learning is, that a sound is accepted or even appreciated, which may be decided within fractions of seconds upon hearing it. How can this necessary appreciation be achieved?

It may be a letdown for ambitious sound designers, but at first sight it seems that aesthetically pleasing and elaborate sound design is not absolutely necessary for a design to succeed. For instance, Schaffert et al. used a simple synthetic tone whose pitch was mapped to rowing boat motion (Schaffert, Mattes and Effenberg, 2010). From a sound designer's perspective, the direct mapping to the pitch of a pure tone is about the most trivial and unrefined "sound design" imaginable. In the qualitative evaluation, however, despite some critique, the sound was quite well received and accepted. The sound, being mapped to a dynamic and highly nuanced process, and directly linked to the motions of the rowers, provided a simplified "surface" that provides an intuitive way of enhanced self-perception, supported the detection of nuances in movement patterns, and the ability to modulate the own action in new ways. Moreover, the sound actually merged strongly with the complex sounds of the environment: wind, water, boat noises and

[33] Consider the Tony Orlando song "Knock Three Times".

human voices. What seemed trivial and simple at first, is in fact part of a complex and rich system, emerging in the process of dynamic movement, which also creates the variations necessary to bring the sounds to life, and the feeling of ownership and control over the sound.

A comparable experiment, where sonification was used to transform parameters of human movement patterns into sound to enhance perception accuracy, showed, that a sonification could be quite successful without particular attention to sound quality or sound design. Effenberg states, that they "were surprised by the high efficiency in movement sonification, since some subjects had mentioned during the investigation that they didn't like the sound at all" (Effenberg, 2005), p. 58).

But the conclusion, that dealing with complex phenomena will always justify trivial sound design, would certainly be misleading, as indicated by many cases from the workshops which used simple tones or very salient indexical sounds. But it also shows, while "likeability" is highly desirable, in particular when long-term motivation and emotional investment is a goal, the question of acceptability of a sound is not exclusively associated with "beauty" or "pleasantness". Thus, the question is not (only), how sounds can be designed to be judged as "beautiful" or "pleasant", but how sounds can be designed to be appropriate and acceptable in the context of a specific artifact or situation.

Of course, the first criterion for acceptance is, that the sound is heard by those who are concerned in a situation which requires it. Often, this is hard or even impossible to achieve. But the hearing sense has amazing ability to focus on sounds which have been learned to be important. Thus a designer can try to exploit this in order to solve the issue of adressing the right "target group". As I put it during the discussion of the Doc-O-Mat UDKL 2010 (PD 54, on page 86):

> *I: "So, the difficult thing with this idea is to exactly figure out which sounds are heard by whom at which stage, and to find also good representations for that of course. But I would say. you can't entirely control who hears the sounds, at least not in public spaces. Thus the design has to work for all possible listeners, but in different ways. For those who are actual users there has to be a semantic and aesthetic integration. For the others, the isolated sound should sound 'irrelevant' or 'nice but uninteresting'."* (>54:15)

Beyond this initial considerations, I will now summarize the various phenomena from the cases associated with the judgement of appropriateness.

27.7.1. Relation to Form and Other Sensory Qualities of Objects

One aspect influencing appropriateness emerged from the relation of sound and object size. Motivated by the laws of acoustics, larger objects usually are able to emit lower frequencies. But, as I have demonstrated above, our experience and interpretation of sound is not based only on the laws of physics, but also from the experience of cultural artifacts such as films. For instance, cartoon movies often play with "natural laws", e.g. by letting a small mouse speak with a boomy voice.

In the context of the Crocodile Tamer TAIK 2009 (PD 19, on page 70), we discussed the appropriateness of the sound of a crocodile for a small object such as the handheld vacuum cleaner, which was used for the mockup. I explained, that the playful variation of the "natural" relation of size and sound has limits in the "physical" world:

> *I: "In cartoons of course you have small animals with huge sounds, but if you're in the physical world then maybe (...) you want to convey danger you have to maybe look into domains of sounds where danger comes from something small as well. Then you have a better unity and there are examples like, again, clichés like snakes and scorpions."* (>19:38)

Usually, the goal of sound design for interactive artifacts is not to evoke associations with cartoons or slapstick[34]. But the relation of object size and sound was discussed also beyond that aspect in several cases[35]. For instance, consider the following discussion from the ENERGY HARVESTING OFFICE CHAIR IAD ZHdK 2009 (PD 25, on page 73):

> *I: "We have a problem with the size of the sounds and the size of the objects. This is something we can explore later a bit more because this is a mockup. (...) It's not the loudspeakers, it's the sound design, you could suggest a smaller object as well."*
>
> *Participant (visitor): "You mean there is a lot of bass?"*
>
> *I: "Yeah, maybe for the basic energy that's not a bad thing, maybe there's something like a room tone or something. But for the chair, if the sound came from the chair really, from a small loudspeaker."* `(>25:33)`

This example shows the possibility of the dissociation of a sound from the desired source due to the incongruence of sound and object size. In the extreme case, the sound is foregrounded, standing out in the overall composition, falling out of a diegetic framework, and thus can be interpreted as enunciation or commentary of some sort[36].

It also has to be taken into account that the dissociation of object size and sound may result in an ambivalence of attribution of sound to filmic or naturalistic origin. For instance, the "mighty, powerful sound" used for the door in the third prototype of the SONIC CAR BOARDING PROJECT 2 (PD 36, on page 76) could be heard as *"too filmic"* `(>36:19)`. The "movie-like" quality to a large extend came out of a combination of the sound itself, with its references to tiger roars, as much as from the boomy and loud design and reproduction, in combination with the relatively small object of interaction, the car's door. From the third case from the SONIC CAR BOARDING series, we can see that the powerfulness of a deep thumping sound can well fit to the large SUV car used in the project.

The cases analyzed here also show, that rules based exclusively on "natural" phenomena are by far not the only possible point of orientation for sound design. I have also discussed that a playful incongruence between perceived object size and sound may indeed work as attention grabbing element. The careful design and modulation of this relationship can also help to shift the focus of interaction from environment to a point source, and also afford semantic "narrowing" and increasing intimacy. For instance, it was used in this way in the prototype of the MATCHMAKER UDKL 2010 (PD 58, on page 85) where the sound design remains ambiguous in terms of source - it can be heard both as originating from the snow globe or as coming from the environment, enveloping the user.

Another relevant factor influencing appropriateness emerges from the relationship between designed sounds and general *sensory* qualities of the artifact. In this case we are dealing with crossmodal relationships, which have already been identified as a central motivator for sound design decisions and meaning making (see Section 18.2). For instance the aim of the designers of the BAG TO THE FUTURE TAIK 2010 (PD 47, on page 81) was to create an impact sound for the bag being dropped, which was "suitable for a bag", investigating leather sounds and soft and more organic sounds `(>47:18)`. On the other hand, for establishing appropriateness for the sounds which were meant to represent the (subjective) value of an object in the bag, and to embellish the gesture of taking something out of it, they applied the opposing approach: In this case, a resonant, metallic sound was used, which is both consistent with the material quality of the bag's contents, affords the association with precious metals (e.g. coins, jewelry) and also stands in aesthetic contrast to the bag's own (organic) sounds. This case thus is an example of achieving

[34]On the other hand, some more humor may sometimes be desirable in the design discipline. For more about the issue of sonic comedy clichés, see Section 27.7.3.

[35]The related code, "good fit: relationship of sound to object size" contains 4 quotes from 4 cases.

[36]In fact this is a good example of sonic hermeneutic affordance, as the subversion of "natural" relations affords an interpretational reorientation.

coherence with the object's characteristics by developing the sound design in accordance with an existing sonic element of the artifact[37]. The approach is also based on the assumption (and best practice) that sonic similarities and relationships supports the grouping of related sounds to form more dense "interpretational force-fields". And this, in turn, may be assumed to contribute to a coherent design, which in turn would increase acceptability and appreciation.

But it is also possible to develop a sensorial relationship based on a common *symbolic* reference, for instance to magic, which is explicit in the mockup of the MATCHMAKER UDKL 2010 (PD 58, on page 85). Here, some sounds are interpreted as expressing a "magic quality", which is also conveyed by virtue of the object (a snow globe) itself `(>58:8)`. It seems plausible to assume that this kind of crossmodal fit and congruency between sonic aesthetics and object aesthetics also helps preventing annoyance and (undesired) attention. It is important to note that we do not need familiar or identifiable sounds for this purpose, but that we can work on the abstract level of cross-modal relationships.

In the following, further design approaches are described, which focus on establishing a correspondence between the electroacoustic sounds and the actual sounds of the (physical) object or an environment. In terms of relating the design to the sounds of an environment in which the interaction takes place, we can refer to the EXPLORATIONS UDKL 2011 (PD 82, on page 95), which tracks the position of a user with regards to "guys to be avoided" in an urban space:

> *I: "What would be interesting then would be to play more with merging the background of the city soundscape, and standing out from the city soundscape. (...) The guys you want to avoid are modulations of the city soundscape. You know, you have your headphones, there is the microphone, it records, like RJDJ*[38] *stuff, there is the signal and it modulates it, and the modulation expresses that."* `(>82:24)`

Another example of relating the design to environmental interaction sounds comes from the INTELLIGENT SHOWER TAIK 2010 (PD48, on page 82), where the appropriateness was established based on the typical rhythm and timbre of water sounds, which is in accordance with the showering scenario `(46:9)`.

The sonic correspondence with an existing sonic element was also used in relation to sounds which had a more symbolic function[39]. For instance, in the discussion of the SONIC CAR BOARDING PROJECT 2 (PD 36, on page 76), the participants referred to the sound of a Lamborghini resembling the growl of an animal:

> *Participant: "But now, a Lamborghini or a Porsche, no, not so much a Porsche, but a Lamborghini, when it drives off..."*
>
> *I: "There are obvious similarities in the sound."*
>
> *Participant: "...this is a very huge..."*
>
> *I: "This is used by many Sound Designer, actually, the Batmobile*[40] *is an example, and very clearly, what we just heard."*[41] `(>36:25)`

[37] The strategy of using and adapting some given sonic element is covered in the code "good fit: aesthetic fit of sound with object quality / type" (3 quotes from 3 cases) and the code "suggesting to work more with the given sound qualities to develop sound modulations" (9 quotes from 8 cases).

[38] RJDJ was a now discontinued App for smartphones which provided so-called "scenes" which were processing sound input to generate real-time soundscape music.

[39] The related (relatively insignificant) code: "symbolic transfer may work better when 'real' sound is similar to symbolic sound (e.g. engine - animal)" has two quotations from 2 cases, but has a relatively high linking density.

[40] I am referring here to a movie clip which was analyzed in this class, where the Batmobile "Tumbler" from the movie "Batman Begins" (Nolan, 2005) is presented and the engine sound contains a relatively clear trace of a predator cat growl.

[41] *Participant: "Aber jetzt so ein Lamborghini oder ein Porsche, nein, ein Porsche weniger, aber ein Lamborghini, wenn er losfährt..."*

The screaming wheels analogy discussed in relation to the squealing blinker design from the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77) can also be seen as an example (>38:8). Overall, these kinds of sonic similarities and correspondence seemed to support the acceptance and integration of the sound in a schizophonic artifact, while still allowing metaphoric or symbolic associations.

A similar but slightly different strategy was to relate a sound design to sound qualities of added artificial sounds, for instance by modulating the first sound or creating a variation of it. This means, that a relationship is established between various designed sonic elements. I speculated during the discussion of the design proposal for the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73), about the possible benefits of this approach:

> *I: "Maybe the association would have been easier, if the sound would have raised to a level similar to the good energy and emerged from this increasing sound."* (>25:22)

On another occasion, I made a concrete proposal, as to how such a design could be constructed:

> *I: "That's where we can make the semantic link. We have the door open and there is the presence of the machine there. And this presence is modulated depending on the stage of the fridge and its happiness or something, and also the same presence sound becomes an alarming sound... (...) if there was a modulation in the normal steady presence sound, that becomes unexpected, play with the surprise moment, maybe all of a sudden this 'shsshshhchchchchchchch-k-j-jj-jk-kkkk' starts to move very fast."* (>56:14)

Another argument for this approach is based on the notion that in product design it is important to convey "belongingness", e.g. of various artifacts to a product family or a brand. For instance, referring to the Dancing Matchmaker from TAIK 2012 (86, on page 97) I stated that:

> *I: "In terms of product design you would have to design modulation qualities, that are kind of part of the product. (...) I think the most interesting and powerful approach would be you can change styles maybe, but always there is the notion that this product has an identity of it's own. Its not totally exchangeable. Its like branding a bit, the experience, but still giving the user a certain degree of freedom (...)."*
>
> *Participant: "You can even argument from this matchmaker thing. Because the two are using the same product, there is already a certain agreement about the sounds."* (>86:24)

It could even be stressed, that in such a scenario, the aesthetic correspondence to a product or artifacts "identity" is mandatory, to establish the necessary sense of causality in relation to the system as mediator of the interaction between two people.

In general, we can see, that an approach who tries to develop informative alternatives based on a variation and modulation of an existing sound, seems to be quite promising, in particular compared to the approach to add a new, unique sound for every single level of information. Several approaches involved the transformation and variation of a single sound[42]. In the Crocodile Tamer TAIK 2009 (PD 19, on page 70) a visitor suggested an approach to the "magic" sound for the crocodile tamer which would avoid both a break of aesthetic coherence, and a sonic stereotype:

I: ..."Da gibt es offensichtlich Ähnlichkeiten vom Sound."
Participant: "...das ist ganz ein riesen..."
I: "Wird von vielen Sound Designern eigentlich gängig genutzt, das Batmobil ist so ein Beispiel, und sehr deutlich, was wir gerade gehört haben."

[42] The related code, "sound design strategy: transforming one single sound for various purposes", contains 7 quotes from 7 cases.

> *Participant (visiting expert): "Imagine if the magic sound would be also made out of the didgeridoo, (...) with an upward going pitch glissando and then fading away, like 'shshshsshh' and then you kind of recognize the didgeridoo, and it's kind of the same family and it relates to what was seen before, because this magic sound could be like any, like 'look how clean your dishes will look after using fairy, cling white'."* `(>19:42)`

In the case of the Energy Harvesting Office Chair IAD ZHdK 2009 (PD 25, on page 73), another visiting participant suggested:

> *Participant (visiting expert): "...working with the same sound and modulating different qualities of the sound, (...) working with granularity of the sound. So you don't need necessarily two sounds. Morph into the bad one."* `(>25:34)`

The blinking sound the of the Interactive Car DD ZHdK DD 2009 (PD 38, on page 77) worked with distortion as indicator of the level of danger associated with driving through a curve in high speed, which is a typical example of a simple transformation of one single sound:

> *I "It is clear, because there is a basic sound which is soft and turns hard and sharp. This distortion has something warning. We know this a bit, if something distorts, we are supposed to move back a bit."* `(>38:13)`

In the case of the mockup of Das System IAD ZHdK 2010 (PD 68, on page 89) the design presented an alarm in three levels of urgency. Here, variations were more like varying expressions of a similar sonic gesture. And the final prototype of the Matchmaker UDKL 2010 (PD 58, on page 85) uses two different modulations of a sound for younger and older subjects, with the younger being perceived as sonically *"more active"* `(>58:20)`.

Last, but not least, the question of the relationship and relevance of "form" vs. "function" emerged as a topic. *"Form follows function"* is an often cited guideline in design. This also applies to "sonic form" which is supposed to support a given functionality. Establishing a suitable correspondence between functional aspects of the sound and other levels of relation to artifacts (in the sense as described above) certainly complicates the design[43]. The question is, whether a design should actually strive for sonic differentiation between function and object character, or if the functional aesthetic and the object aesthetic should be integrated. In the AcuPot case the combination of functional and aesthetic aspects was called for[44]. On the one hand, we have a functional sound, which serves to inform the user about states, and transitions between them (i.e. various more or less ideal positions of the plant on a surface). On the other hand, the sound corresponds with the sonic identity of the pot scratching on a hard surface `(>39:26)`.

Also the Foley mockup of Matchmaker UDKL 2010 (PD 58, on page 85) shows the challenge of combining sounds (or sonic qualities) which correspond with sensory product properties and the "informational content":

> *I: "The challenge for you will be to find ways of balancing the..."*
>
> *Presenters: "Mood of the object and information?"*
>
> *I: "...meaningfulness, or the symbolic meaning of the sound, with something that is more like second nature of the artifact, how it works, the sound it makes, while it works."* `(>52:21)`

[43] The related code, "differentiating, yet, integrating function and character / quality of artifact", contains 4 quotes from 2 cases.

[44] This relates also to the code "researcher reflecting on the relevance of form, function and sound aesthetics", which contains 3 quotes from 2 cases.

27.7.2. Socio-Cultural and Psychological Appropriateness

Another dimension of appropriateness emerges from the judgement of sonic properties in the context of the socio-cultural context of an interaction, and the relevance of cultural conventions and psychological effects[45]. One aspect in this regard is related to the possibility of using unnaturally dominant, powerful sounds, which also relates to the question of the appropriateness of "filmic" sound design, in the sense of designing sounds that are "bigger than life", as discussed in Chapter 17 on page 115. If we consult the discussion from the SONIC CAR BOARDING PROJECT 3 DD ZHdK 2009 (PD 37, on page 76) such sounds may be acceptable if also the emitting object is "over the top":

> *Participant: "If it is such a fat car, then I find it OK, I would not feel ashamed."*
>
> *I: "You mean the closing? This deep bang, or the reverb?"*
>
> *Participant: "Yes, exactly. The booming when everything vibrates, (...) is so dominant and pretentious that it just fits then (...)."*[46] `(>37:1)`

This understanding of appropriateness can be explained as a form of crossmodal analogy, but seems to be relying more on the subjective value judgement than merely formal relations. A similar example is THE ELEVATOR TAIK 2009 (PD 15, on page 67). The argument for appropriateness here worked similarly as in the example of the car sound, as the sound could be heard as belonging to "an elevator for a huge enterprise in Dubai or something like that" `(>15:34)`.

Appropriateness in relation to socio-cultural connotations was also discussed in relation to the noise of squeaking tires, which was used in the INTERACTIVE CAR DD ZHdK DD 2009 (PD 38, on page 77):

> *I: "The squeaking tires is also cool, of course. The squeaking tires is also nasty, if you sample this and play it back in the studio, people will tell you that it is a sound which is painful or unpleasant, when they don't know the context."*
>
> *Participant: "The squeaking tires have also a coolness factor. (...)"*
>
> *I: "But that's maybe just something you learn. I don't know. The squeaking of tires is only cool in some cultures, as well."*[47] `(>38:10)`

In this case, it is assumed, that the acceptance of a sound which is as such not very complex, and "objectively" even annoying, could be based on cultural codes associated with very similar sounds (and the related actions).

The TOILET SOUNDSCAPE TAIK 2009 (PD 22, on page 70) dealt more explicitly with cultural and psychological implications of sound. This work also relates to the discourse of appropriateness of natural "taboo" sounds. Referring to the noises associated with going to toilet, a presenter states:

> *Presenter: "(...) you're thinking what other people are thinking , or hear, ...even though it really is a common experience (...)."* `(>22:12)`

[45] The related code, "reflecting on cultural aspects of design or sounds", contains 5 quotes from 5 cases. Another related code, "reflecting on psychological aspects of design", contains 3 quotes from 3 cases.

[46] *Participant: "Wenn es so ein fetter Wagen ist find ich es OK, würde ich mich auch nicht schämen."*
I: "Du meinst beim Schliessen? Dieser tiefe Knall oder das Nachhallen?"
Participant: Ja, genau. Das Wummern, wenn alles vibriert, (...) ist einfach so dominant und protzig, das passt dann schon (...)."

[47] *I: "Das Reifenquietschen ist natürlich auch cool. Das Reifenquietschen ist zwar auch eklig, wenn du das samplest und spielst im Studio werden dir die Leute sagen dass es ein Ton ist, der schmerzt oder unangenehm klingt, wenn sie den Kontext nicht kennen."*
Participant:"Das Reifenquiteschen hat auch einen Coolnessfaktor. (...)"
I: "Aber das ist vielleicht auch nur etwas, das man lernt. Ich weiss es nicht. Das Reifenquietschen ist nur in gewissen Kulturen cool, auch."

Staying in the bathroom-setting, in the INTELLIGENT SHOWER TAIK 2010 (PD48, on page 82) we discussed cross-cultural design aspects of the design:

> *Presenters: "There will never be any universal shower sound. If you live on the countryside you just don't buy this (...).“*
>
> *Participant (visitor): "I was immediately thinking, Japanese hotels would buy this immediately."* `(>48:30)`

Here, we have a discoursed associating certain aesthetics with cultural context, suggesting various degrees of acceptability.

Finally, the impact of cultural aspects appeared also in the context of the use of strongly referential sounds, such as bells. The final demonstration of the DOC-O-MAT UDKL 2010 (PD 54, on page 86) illustrates this:

> *I: "(...) some sounds have a strong referential quality to the object, and the culture behind the object, and bells are of course the classical example. And this small bell works (...) at least conceptually. I don't know if it would in a real life setting, but first there is the bell as the sign of something pure and sacred."* `(>60:22)`

Here we have a typical case of interference between understandability and suitability for daily use: Cultural codes are very powerful and quite reliable, but they are also inflexible and can not be easily re-contextualized, and are hard to integrate with other sounds or with a strong product identity.

From a broader perspective on psychological and socio-cultural appropriateness, we could also include the notion of situational configurations, which I have proposed based on an earlier analysis of some of the cases presented here (Hug, 2013). The respective categorial dimensions can be represented as semantic differentials representing the trajectories across situational categories that are related to the use of interactive commodities. The categories include social situation (which can be private or public, and individual or shared), the level of "intimacy" (from abstract-objective to intimate implant), in terms of the relationship between user and task (modeled along the line of "tool" and "assistant", as well as "casual" or "professional" use). These categories are meant to be elements of the multidimensional interpretive force field, as described above in Section *26.2*.

27.7.3. Heirs of the Slapstick: Can Fun Sounds Be Appropriate?

As mentioned earlier, in some cases sounds exhibited a comical effect[48]. For instance, there were some obviously humorous or even ironizing approaches to sound selection, as it was the case in the THE FRIDGE, UDKL 2010 (PD 50, on page 86), where a recording of yodeling was used as an alarm sound for the fridge's door. This suggests that there was a certain playful carelessness of the designers, but also it can be interpreted as the desire to design "fun" interactions, and in this specific case, fun (rather than annoying) notifications[49]. In any case, the design perfectly fulfills the purpose of a notification, but results in a disruption of the aesthetic coherence, as it is completely out of context regarding the fridge as potentially everyday functional object.

In the same case also the sounds of flies were used `(>50:1)`, which was considered *"funny"* by one participant and *"convincing and obvious"* by another `(>50:10)`. Here, the comical emerges not from the sound itself, but rather by its narrative meaning in the context of the fridge and food. The designers indicate, that humor was seen as means to "humanize" a design, and to make it more approachable.

[48]Under the code "design motivated by fun /irony / exaggeration" I collected 12 quotes from 7 cases which help to get a clearer understanding of this phenomenon.

[49]The design strategy of cartoonification is not motivated by making a design "fun" but by the aim to simplify communication. As discussed in section 24.3, this approach may still lead to unwanted comical effect and caricature.

Also the use of sounds which were meant to attribute something as "magic" were sometimes motivated by the desire to be funny, or at least self-ironic, as it was the case in the Mockup of the CROCODILE TAMER TAIK 2009 (PD 19, on page 70):

> *Presenter: "But we thought, like, let's have some magic! We can't do without!"* `(>19:24)`

Irony was also present in other cases, particularly those with a critical approach to their scenario. For instance in DAS SYSTEM IAD ZHdK 2010 (PD 68, on page 89) a sound reminded of the standard notification sound of the Microsoft Windows Operating System at that time:

> *I: "But this 'bimbim', the bell of Windows, I did not know what this means now, if it was some kind of joke, that the whole totalitarian system is based on Windows [audience laughing] or..."*[50] `(>68:5)`

Also in the SONIC CAR BOARDING PROJECT 3 DD ZHdK 2009 (PD 37, on page 76), the big SUV-type car that was used as prototyping environment, stimulated ironic or comical approaches to sound design which emphasized or played with aspects of bragging or showing off:

> *I: "This would be cool, when arriving at the red carpet, a line of limos and every one sounds different, has it's own show, like a boxing star, who comes into the arena and plays his song. You can get rich with such stuff, when you can sell such gadgets to Hollywood stars which have nothing better to do. 'Hey, Paris Hilton, have a look!"'*[51] `(>37:13)`

In the case of the DANCING MATCHMAKER from TAIK 2012 (86, on page 97) the designers expressed their joy in making use of a retro style Science-Fiction start sound which was perceived as somewhat over the top and tended to ironize the whole design.

Apart from the motivation to ironize design or make it feel more "human", it also seemed that sound as medium lends it self to the comical. A reason could be that sound has a long and prominent history as comical effect and it is from cartoons and clownery, where some of the most prominent sonic stereotypes originate, and these sounds are always prominent and designed to be noticed, obviously influencing the way we think about sounds. This started with the "slap stick", or batacchio in italian, a device used in Commedia dell'Arte, which produces a loud clapping noise when hitting an actor. Related to this is the snare drum hit known from the circus, when a clown stumbles or falls. The typical exaggerated hit sounds known from cartoon movies follow this tradition. Cartoon movies have also created numerous other examples of stereotypical "fun" sounds.

The question from a design perspective is: How comical and fun can a design be? Can such design approaches really be used in practice, for instance to humanize a design or will they always devaluate the design? In the end it seems that comical sounds per se are not a problem, but the problem lies in their tendency to lose their "comedy" aspect when used (repeatedly) in (non comical) everyday interaction contexts and end up being what they often actually are, deprived of their original humorous function: bland, oversimplified and predictable stereotypes.

---

[50] *I: "Aber dieses 'bimbim', die Glocke von Windows, da wusste ich nicht, ob das jetzt bedeutet dass das irgendwie ein joke ist, dass das ganze totalitäre System Windows basiert ist [allgemeines Lachen] oder...."*

[51] *I: "Das wäre ja noch cool, beim Anfahren am roten Teppich, eine Reihe von Karossen, und jede klingt anders, jeder hat so eine eigene Show, wie ein Boxstar, der reinkommt und sein Song spielt. Da wird man reich mit so Zeug, wenn du so Gadgets verkaufen kannst an Hollywood Stars die nichts besseres zu tun haben. 'Hey Paris Hilton, schau mal'..."*

27.8. Design Elaboration: Managing Sonic and Semantic Complexity

> "[S]ounds (...) can be made in any and every way."
>
> *Michel Chion, 1993, p. 53*

> "Listen to the city as though it was music and to music as though it was the city, or to speech as though it was music and to music as though it was speaking to you."
>
> *Theo van Leeuwen, 1999, p. 4*

When discussing acceptability, or even pleasurable experience, of sounds, and related interactions, we should not forget that ultimately we are discussing issues of *design*, and that it is the very activity and competence of the thoughtful design activity (Löwgren and Stolterman, 2005) which can contribute to creating new everyday sonic interactions which are accepted and even appreciated. This leads to the question regarding the relevance of (sound) design refinement and elaboration. Looking at the reports from sound design practitioners, and the numerous handbooks on sound design, there seems to be the agreement, that sounds need to be designed as complex mini-compositions, with careful attention to details. For instance, a common practice in sound design is the so-called "sweetening" and "layering", which servers to embellish or enrich a sound, to make it interesting, expressive, and unique (Beauchamp, 2005). The importance and relevance of careful sound design and attention to details and elaboration is also confirmed by a series of interviews I conducted with eight professional sound designers as complementing research for this study (Hug and Misdariis, 2011).

Also, while there are all the issues mentioned earlier associated with the use of naturalistic sounds, we can also learn from "natural" and "everyday" sound from physical interactions: Complex, varied sounds are more likely to be appreciated (cf. Truax, 2001), and the brain is literally designed to deal with complex and multidimensional sonic streams (Bregman, 1993).

In Auditory Display literature this aspect is often addressed under the term "aesthetics", following the understanding of the term as meaning "beautiful, pleasing, attractive". In many cases, this aspect may turn out to be one major obstacle to a greater appreciation and acceptance of Auditory Displays and sound in interaction. Barras & Vickers (2011, p. 159) report several sources complaining about "impoverished aesthetics" of sonifications and Auditory Displays in general, and they remind us that already early authors showed a sensitivity for the issue. They cite one of the founding members of ICAD, Gregory Kramer, who was particularly frank:

> "Gaver relates that SonicFinder was frequently disabled, Mynatt reports that poorly designed sounds degraded Mercator, and Kramer considers some of his sonification experiments downright ugly." (Kramer, 1994, p. 52)

There is anecdotical knowledge about people working in Auditory Display turning the sounds of their sonifications off, just "to take a break" (Kramer, 1994, p. 52). Occasionally, dissatisfaction with the sonic aesthetics of auditory displays is mentioned explicitly in publications (e.g., Dubus and Bresin, 2010). And a survey among 86 participants from the HCI and Auditory Display communities revealed, that audio is often associated with annoyance and is not considered as a serious alternative to the visual channel (Frauenberger, Stockman and Bourguet, 2007). In one of the few articles explicitly focusing on the questions of aesthetics in auditory display, Barras & Vickers ask:

> "(...) the question still arises as to what are sonification aesthetics? What do they sound like? Are there some specific guidelines that, if codified, will guarantee (or at least offer the chance of) successful aesthetic expression? After all, areas such as graph theory and web design have established aesthetic metrics, sets of rules which, if followed, promise an easy-to-read graph or a usable web site." (Barrass and Vickers, 2011, p. 161)

Serafin et al. points to the open question of

> "how to design the sound themselves, balancing between pleasantness versus annoyance, artistic expression or ability to understand the message conveyed by sounds as in the case of interactive sonification. The design challenges proposed by SID are no longer predominantly of a technical nature. The wide availability of sound design, synthesis and processing tools, together with physical computing resources, allows practitioners who are not technically trained to easily produce sonic interactive artifacts. Instead, the challenges are mostly focused on the ways in which designers may successfully create meaningful, engaging and aesthetically pleasing sonic interactions". (Serafin et al., 2011a, p. 107)

Barrass emphasizes the necessary shift "from 'interpretation' and 'communication' to 'usefulness' and 'enjoyment"' (Barrass, 2012, p. 181) and remind us of the impact of (popular) culture on the judgement of auditory display aesthetics.

A major motivation for considering aesthetics of Auditory Displays is to ensure acceptance and sustained interest, and thus success of an otherwise functionally "well designed" solution. But also the reverse is true: In 2004 Leplâtre and McGregor (Leplâtre and McGregor, 2004) conducted an experiment in which it was found that the functional and aesthetic properties of Auditory Displays are not independent and that one impacts on the user's experience of the other[52].

How did the question of benefit of elaboration and care for detail manifest in the design cases discussed here? Looking at the material from the workshop discussions, this question was usually not explicitly discussed[53], which may be due to the fact that many participants were not (yet) professional sound experts or designers. Still, in quite many cases, there were indications that the participants put considerable effort into elaborate and reflected design decisions[54]. This also seemed to be independent from their knowledge about sound design or sound production, as the example of the Moody Hat DD ZHdK 2008 (PD6, on page 65) demonstrates. The design of this group, which did not have previous experience with sound design, is remarkable, as indicated by the following statement:

> *I: "How did you get to the sound design?"*

[52]This is in line with research in the context of so-called user experience (UX) which demonstrates that hedonic aspects and even fun significantly influence a software's appeal and even it's (perceived) usability (Hassenzahl et al., 2000). This view has been accentuated in the somewhat oversimplified statement that "attractive things work better" (Norman, 2002). In turn, others, including Norman, point out that usefulness and usability contribute to the attractiveness of things, and that also other circumstances further influence the judgement of usefulness at a given situation (Norman revisits his famous teapot case study from "The Design of Everyday Things" (1988) to make this point). The beneficial impact of designing for pleasure and beauty is seen rather in "neutral" or "positive" use scenarios. That the judgement of quality is influenced by a variety of (complex) factors, such as functionality, usability, reliability, look and feel, etc., and highly dependent on the point of view, not only of the "consumers", but also of the "producers" (or, designers for that matter) has been recognized in product quality research and management science since long (see, e.g. a review of various approaches to the meaning of "product quality" by Garvin (1984)) and also product sound quality research has generally recognized the complexity of the issue (Blauert and Jekosch, 1997; Västfjäll, 2002; Fastl, 2005; Özcan, 2008).

[53]For instance, in relation to the practice of "sweetening" a sound, the related code "adding sound to 'sweeten' a design, without direct 'meaning"' contains only two quotes.

[54]The related code contains 18 quotes from 12 cases.

> *Presenter 1: "The energetic comes from a power hum, mixed with noises from the hat. We were in the sound studio and added some reverb to the whole thing to give a spatial impression. The starting... we took an engine as inspiration, 'it's running now"'.*
>
> *Presenter 2: "I did record something and played it back in order to accentuate the metallic quality."* `(>6:25)`

From the replies of the participants it seems that the design mostly worked well in terms of aesthetics and functional understanding.

Also the project SONIC PAPER DD ZHdK 2009 (PD 40, on page 79) reveals the great level of imagination and sonic sensitivity by participants without particular expertise or experience in sound design. The sounds of this team were highly original and triggered interest, and the designers put a lot of considerations into them:

> *Presenter: "The first page (...) and we thought that the individual pages are a bit excited together, full of expectations, and when we browse the pages then the individual pages are audible (plays sound) as living and happy, the happy of every single page can be heard, they are still blank. Then the tearing out is a short pain, a relief, and the joy of being used (plays sound)."*
>
> *I: "Why do you have this 'wuwuwuwu'?"*
>
> *Participant: "Happiness, isn't it?"*
>
> *Presenter: "Yes, a bit like 'yahoo, yahoo'."* `(>40:14)`
>
> *Presenter: "The folding is an influential intervention (...) it leaves a trace, a scar, and this kind of transports the quality and value of the paper (plays sounds). Then the crumbled page, it has a scar, is damaged, and the data on it is somewhat defragmented (...) [sound is played]. This is added to the sound of the page, a car that does not start. (...) Then the crumbling is the disintegration of the data, the content which is stored on it, and the overall quality is extremely severed, the page is really destroyed [sound is played]. The effect during the flying is then the dying, the energy evaporates and it is a painful process for the paper, then in the bin it whines, it is sad. And then we also differentiate if you throw it to the trash or to the recycling it would react differently, in the recycling it would not be so bad, the whining would be some kind of 'shshshsh'."*`(>40:18)`

The considerations for the design of the BAG TO THE FUTURE TAIK 2010 (PD 47, on page 81) were equally elaborate:

> *Presenter 1: "We wanted to have an element of something breaking or like it's not whole it's not like a clear sound of something and not like too much... like... an impact, one impact. Trying to make it suitable for a bag. (...)"*
>
> *I: "Ok. You heard both clings, these bellish clings, and there heard this purr then also."*
>
> *Presenter 1: "There's a decay... (...) it was supposed to be like something broken."*
>
> *(...)*
>
> *I: "Was our interpretation correct that the intelligence of the bag is a little bit complaining about how it's being treated."*
>
> *Presenter 2: "Yes. (...) Is this bag about the objects inside of it or is it the bag that's you know, the object. And you should be just responsible of the object that's inside, so the grabbing on the bag is more hurting the bag."*

> *Presenter 1: "Yeah, we didn't want it to be so like: 'how dare you drop me'. Because bags are dropped (...)."*
>
> *Presenter 2: "And not like alarm, (...) because we went in this direction also, if someone steals your bag, then..."* `(>47:10)`

And, a bit later:

> *Presenter: "We actually did some field recordings, we recorded the sound of the bag as well, leather. We also worked with reverse, too, of the sound, just to change it up a bit, to change the dynamics of it. It was interesting to play with the actual, placing a microphone next to the back and just record the sounds. Because we managed to get some funny sounds out of it. Really surprising wet sounds could come out and you [wouldn't know that it's] leather."* `(>47:11)`

The project TOILET SOUNDSCAPE TAIK 2009 (PD 22, on page 70) is an example of how the creators aimed at integrating multiple sonic requirements, in order to prevent the bathroom from being a scary, claustrophobic place:

> *Presenter 1: "We did try to sort of make it coming slowly so that it's not too loud a noise, that is just scary to go to the bathroom."* `(>22:14)`
>
> *Presenter 2: "Yeah, before we made it to this version it actually sounded quite intimidating, very dark."*
>
> *Presenter 1: "Yeah, lot's of echo, lots of space."*
>
> *Presenter 2: "So we needed to brighten it up."*
>
> *Presenter 1: "We didn't want it to be frightening."* `(>22:16)`

They integrated these considerations with the need to mask unwanted sounds and *"fill in the higher frequencies, because a lot of the sounds we used were very low and sort of deep and if, you know, actually, if you are peeing it's that very high, sort of tinkling sound."* `(>22:17)`. Thus, many aspects of aesthetics, emotional effects and psychoacoustic effects were tackled in this sound design.

In the final mockup of the MATCHMAKER UDKL 2010 (PD 58, on page 85) the designers describe their careful attention to sonic detail:

> *Presenters: "So this is like the idle state [plays sounds] like this whispering thing. And when you get close to it and start almost touching it, it goes [plays sound and modulation] and when you finally pick it up, it gets your attention, it has your attention... [plays sound] ...to something very grained. I have your attention. And it's a more clear sound, and it's continuous, but it's not metric, its living, it's chaotic, so it's a thing that's sort of spinning, and thinking and waiting for you to make the next move. So when you first concentrate on it, if it was picked up by a person you didn't like, you would get such a reaction (...) [plays sound with modulation]."*
>
> *Participant: "Hehe!"*[55] `(>58:17)`

Several cases indicate that these efforts and considerations did actually have an effect on appreciation and acceptance of the sounds[56], as the following extracts show:

> *Participant: "The sound of fastening the seatbelt was quite cool."* `(>35:21)`

> *Participant: "I liked that there was not just a beeping as we know it already, but something completely different."* `(>36:3)`

[55] Here we also see that a sound design which does not rely on humorous stereotypes can provoke laughter.
[56] The related code, "spontaneous appreciation of interesting sound" contains 7 quotes from 7 cases.

Participant: "The one from the beginning was beautiful." (>70:1)

I: "I liked actually this grittyness (...) , also because it always changed the color a bit it was not just getting higher, but also getting rougher, but not rougher in a pure synthesis way of distortion, but in this very complicated thing which involved resonance of wood and so on." (>45:10)

Participants: [laughter]

Participant: "It's nice work!" (>47:2)

An indicator that subtle and interesting sounds can actually contribute to more enjoyable designs and help avoid annoyance is also indicated in the discussion of the MATCHMAKER UDKL 2010 (PD 58, on page 85), where the continuous sound of the interactive object has been playing all the time and did not seem to disturb anyone (>58:19). One of the external visitors stated:

Participant (visitor): "I very much enjoyed this performance and liked the sounds, especially I think what you said they are (a)live, this is very well, it's not metric, it's mechanical, I liked this very much." (>58:22)

These observations show, that the quality of the sonic design implementation, and the strive to create unique designs with an own character indeed was relevant[57]. This is also reflected by my own inputs and contributions to the discussion, in terms of promoting the use of rich, complex sound modulations[58]. These statements reflect my growing conviction based on the experience of the various outcomes of the workshops, which supported also my general motivation to strive for a sonic elaboration comparable to the one found in film sound and the example of design attitude and practice given by New Hollywood sound creators, which *integrates* both rationality and artistic experimentation. Ben Burtt reported about his almost "scientific" approach to design:

> "Since I was trained scientifically, part of my attitude is first a literal one. I ask myself, 'If this sound-producing object really existed, what would it sound like?' (...) I do always consider the literal aspect of it, because ultimately you're trying to convince the audience of a certain truth." (LoBrutto, 1994, p. 142)

At the same time, a lot of imagination and ad-hoc inspiration went into his design work:

> "I could kind of hear the sound in my head of the lightsabers even though it was just a painting of a lightsaber. (...) At that time (...) we had a projection booth with some very, very old simplex projectors in them. They had an interlock motor which connected them to the system when they just sat there and idled and made a wonderful humming sound. It would slowly change in pitch, and it would beat against another motor, there were two motors, and they would harmonize with each other. It (...) was the inspiration for the lightsaber and I went and recorded that sound, but it wasn't quite enough. It was just a humming sound, what was missing was a buzzy sort of sparkling sound, the scintillating which I was looking for, and I found it one day by accident.
>
> I was carrying a microphone across the room (...). It picked up a transmission from the television set and a signal was induced into it's sound reproducing mechanism, and that was a great buzz, actually. So I took that buzz and recorded it and combined it with the projector motor sound and that fifty-fifty kind of combination of those two sounds became the basic lightsaber tone (...), and to achieve this additional sense of movement I played the sound over a speaker in a room.

[57]The related code, "creating character or identity through sound", contains 4 quotes from 4 cases.

[58]The related code, "benefit of rich, complex modulations of sounds", contains 15 quotes from 8 cases, and the code "asking for more variation and differentiation in sound design" contains 4 quotes from 3 cases.

> Just the humming sound, the humming and the buzzing combined as an endless sound, and then took another microphone and waved in the air next to that speaker so that it would come close to the speaker and go away and you could whip it by, and what happens when you do that by recording with a moving microphone is you get a Doppler's shift, you get a pitch shift in the sound and therefore you can produce a very authentic facsimile of a moving sound. And therefore give the lightsaber a sense of movement and it worked well on the screen at that point." (Ben Burtt, in Carlsson, Year Unknown)

These examples of elaboration and complexity does not mean that simplicity may not be a design goal. The marvellous thing about the light saber example is, that despite all its sonic complexity, it appears to be "simple", just "natural". But if simplicity is understood as *simple sound* design, it leads to monotony, repetitiveness, over-presence and - as consequence - to annoyance. From many cases it seems evident, that the sonic solutions often were too "simple", too one-dimensional to adequately relate to the complexity of the underlying information and the interaction process. An example case which makes this issue visible, was the Party Matchmaker TAIK 2012 (PD 84, Section 15.1). A simple tonal sound was used to indicated distance between partygoers, similar to the sound of a sonar. Also here there is no semantic complexity at all, just a linear progression, which was not able to reflect the semantic complexity which was inherent in the scenario (finding a "personality match" at a party). My position is, that this extremely technical and "passive" sound design is potentially too annoying, and not open for interaction variations.

In some cases the issue of simplicity can be related to the use of sonic clichés and stereotypes. Even when such sounds were quickly decoded and understood (which is one of the key rationale behind using stereotypes after all), these sounds often were not considered to be of further interest, which resulted in a kind of casual listening in a situation where actually an attentive listening mode, sensitive to details, would be called for. We also have discussed the general issue that sonic stereotypes prevent a sound design from becoming part of a novel everyday sonic interactive identity. But, as I have demonstrated, one design goal is to give a sound a character (or give an artifact a character through sound), to creating unique sounds, with the aim to support interest, readiness to explore and learnability or memorability.

The main question in terms of sound design strategy for interactive commodities thus is: what strategies can help to convey complex semantics? And what level of complexity is advisable? How can we achieve an adequate sonic expression of semantic and structural complexity and simplicity of the sonic implementation in terms of experienced "holistic" integration? The symphony can be seen as ideal here: many timbres and voices are integrated into an overall sonic gesture, which is expressive and meaningful to even "naive" listeners in terms of understanding musical context, e.g. when we are struck by the reprise of a theme. And also there are many encouraging examples of highly complex sonic processes, from both everyday life experience, e.g. in cities and other jungles, as well as from filmic sound design, which are both enjoyable and meaningful (even if not always entirely "understandable"). This leads to the conclusion, that apart from designing memorable and rich sounds, careful mixing, appropriate sequencing and overall composition, considering all levels of interpretational references reported here, can contribute to a complexity in sound design, which still remains "functional".

28. Conclusion

28.1. The End of One Journey...

We have now finally arrived at the end of our journey through the "unknown territory" of design and interpretation of schizophonic interactive commodities.

In Part I, I have discussed the potential of using sound in the design of such artifacts. Then I set out to discuss preliminary considerations concerning approaches to this design in the relevant disciplines in the area of Auditory Display and Sonic Interaction Design. I have also discussed some aspects which demonstrate, that the design of electroacoustically augmented artifacts poses a challenge beyond the mere question of how to convey information in an efficient (and even pleasant) way through sound.

Therefore, after providing an overview over all design cases created throughout this study in Part II of this thesis, I set out on an exploration of both interpretation and design in relation to the design of possible futures in Part III. I chose to investigate this through a series of workshops with students in interaction design and media, and by means of creating low-tech experience mockups that afford a dialogical and interactive exploration of design approaches and the related meaning making processes. The analysis revealed a broad range of topics, concepts, design approaches and reference points, emerging in the interpretational discourse. The result is not a coherent theoretical framework, and also does not provide a set of underlying rules or guidelines. Rather it forms a "systematized conglomeration", an attempt to make diversity and the creative interpretational chaos accessible.

Still, some underlying narratives, or meta-topics did emerge. One central insight relates to the diversity of the points of reference in the emergence of meaning. These could be as simple as trivial "everyday" sounds, but the naturalistic notion of the familiar everyday and the "indexicality" of sound, in the sense of sound referring to a natural source, needs to be questioned. The source a sound may refer to, represent or "make present", can be both from "natural" and "designed" sources and both of *mediated and non-mediated* nature. In particular *film sound* showed its power in forming our idea and memory about sound. At the same time, problems associated with stereotyping emerged.

In parallel to interpretations which ultimately were based on some kind of sonic reference, another, often simultaneously occurring motivation for interpretations emerged, which I refer to as "*analogy-driven*". These phenomena represent a broad field of meaning based on a more diffuse association between two or more entities, but are more "felt" than "understood", often affective, and clearly different from references to specific objects.

From there, the journey continued to even more abstract domains, affective and emotive qualities, and the relevance of the quality of sensory experience itself in meaning making, but at the same time – maybe surprisingly – revealed that indexicality can still be present in the abstract and affective. *Abstract and concrete – indexical – qualities* are not mutually exclusive. And they are supplemented by further types of references of all kinds, from musical codes and associations to spatiality and even specific sonic effects associated with their storage and reproduction on technical media.

After this, I discussed statements revealing the relevance of establishing and *attributing a source or cause* for a sound, independent of its possible reference to an original source (in terms of the source of a sound recording, for instance). The source could also be understood as *attribution of agency* in an interactive exchange between humans and computers.

It also turned out, that, in addition to the sounds themselves, the *structure and composition,* the way sounds were ordered, sequenced, combined, was another important factor in meaning making, in some cases even guiding the interpretations of individual sound elements. It is here were words become sentences, and utterances statements.

In the final Part IV, I aimed at distilling the central insights underlying all those various phenomena. On the one hand it was the identification of various issues associated with a design approach that attempts on relying on presumably "save" indicators of meaning, on naturalism, familiarity and identifiability. This led to the identification of various forces that can destabilize seemingly save interpretational grounds, including the very nature of the "schizophonic artifact", where the sounds of the physical-mechanical interaction with the artifact are co-occurring with electroacoustic sounds.

Along the way, we got to know our travel companion, which was always present throughout the whole journey: *Ambiguity.* There is no shortcut to a "correct" interpretation, and no method to predetermine the mental processes, associations and emotions arising from interactions and sounds. Meaning is not a fixed property of a sensory perception, but emerges in interaction, in a procedural way, often extending beyond the actual interaction moment with a specific artifact at hand.

At this point it became necessary to develop a framework of understanding that could match this polyphony of aspects and helps to cope with the fact, that the design task at hand deals with the creation of "*new everyday"* interactive sonic identities, and that it may be necessary to establish new aesthetics and meaningful sonic systems. I chose the metaphor of the *interpretational force-field*, where several interpretational "attraction points", or "hermeneutic affordances", are effective and result in a vectorization of the interpretational space to one or several points of convergence.

28.2. ...Marks the Beginning of Another

As designers, we are navigating this interpretational force field in a dialogical exchange between the involved actors, man or machine, and our discourse about meaning making becomes a force itself. But this conclusion also means that the exploration of design and interpretation of schizophonic interactive commodities, as presented in this thesis, is only a modest beginning, providing but a first glimpse into the domain, test-driving conceptual approaches and theories. The research workshop was an ideal breeding ground for getting a first overview over the diversity of species that is "out there". But the research workshop is not the "real world" (although it is part of it). What remains to be done, is to explore these aspects through actual design "for the real world", both in the sense of going out of the lab into the wild and in Papanek's (1985) sense of designing in response to actual human ecologies an social change.

What will this exploration entail? In order to provide some conceptual starting points I have provided some first considerations for designers in the final chapters of Part IV, again based on the analysis of the outcomes of the workshops. There, I have discussed the relevance of the *affective*, the benefit of *abstraction* and the playful exploration of "source" attribution. In this context I argued for the need to *motivate and sustain interpretational processes* as positive experiences, and supporting the *learning* of new sounds for new everyday interactions. Dealing with interactivity, the aspect of *performativity* and sound as expressive channel in interaction has to be taken into account. I also have discussed potential inspirations from "musical" approach to design, namely what could be called "*compositional elaboration*".

In the end, everything is in vain, if the sounds designed are not accepted and considered inappropriate in a given situation of interaction. Also here, some first approaches emerged from the workshop cases, which could support the design. This entails the careful *management of attention* and the various listening modes. And we can be encouraged by insight, that this is facilitated, most of all, by interesting, attractive and even surprising sounds. Rather than aiming to simply achieve "pleasantness of stimuli", as usually discussed in the literature, we could take into consideration humanistic concepts such as *Ergo-Audition*, the emergence of joyful self-hearing in action-sound. In this way, we might work towards the fulfillment of Don Norman's wish: "Let the future of everyday things be ones that do their job, that are easy to use, and that provide enjoyment and pleasure" (Norman, 2002, p. 41).

As starting point for future research, I might dare to postulate the following design assumption:

> *If the sound design of a novel interactive commodity is socio-culturally acceptable, stimulates interest or curiosity, offers sufficient complexity (in terms of sound richness and structure), evolves with an adequate dramaturgic structure, features a composition where the interplay of elements of design is counterbalancing ambiguity of single elements, resulting in an interpretational force field which affords converging interpretations in the course of an ongoing experience of the interaction, and if it manages to afford subjective appropriation of the artifact and its sounds, then it may succeed, beyond the fulfillment of an informational function, as a new socio-cultural artifact.*

Future work will have to show ways how to specify, operationalize, apply and test this in research and practice.

It is important to understand, that this investigation of new aesthetic directions also requires a contribution of the "listener-consumers". Bovermann et al. point to this caveat and argue in favor of an openness in terms of judgement criteria, and listening expectations:

> "It seems more advisable here to create opportunities for practicing more open-minded listening, which may be both epistemically and aesthetically rewarding once one begins to read the sonification's details fluently." (Bovermann, Rohrhuber and de Campo, pp. p. 240)

And last, but not least, the exploration also entails the consideration of adequate didactical approaches to sound design in interaction-related disciplines. The method applied in the workshops described in this thesis is one example of how to approach this. Another important task is the creation of appropriate tools, which combine the possibility of sound design elaboration as known from film with the creative exploration and controllability of the procedural, dynamic aspects, that interaction entails. Examples in this direction are not only the various audio middleware tools from game sound design, but also with new tools emerging from the collaboration between designers and scientists, such as the Sound Design Toolkit (Monache, Polotti and Rocchesso, 2010; Baldan, Monache and Rocchesso, in press, 2017).

This might all sound not just like a nice little journey, but rather like a huge expedition with inestimable costs and a lot of insecurity about both routes to take and destinations to reach. But we should keep in mind that in the design of interaction sounds for new commodities we are not the first ones to enter unknown territory. Our situation is comparable to the arrival of sound in film, and also be the reinvention of the sound's role in mainstream film during the New Hollywood era. In particular the latter may serve to encourage us: If some freshly graduated "movie brats" managed to break new aesthetic ground with their sounds for interactive artifacts, and could even sell it to the masses, so can we.

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