Playsound.space: Inclusive Free Music Improvisations Using Audio Commons

Ariane de Souza Stolfi * [1]
arianestolfi@gmail.com

Miguel Ceriani [2]
m.ceriani@qmul.ac.uk

Luca Turchet [2]
luca.turchet@qmul.ac.uk

Mathieu Barthet [2]
m.barthet@qmul.ac.uk

[1]University of São Paulo
School of Communication and Arts
Av. Prof. Lúcio M. Rodrigues, 443 -
CEP: 05508-900 São Paulo, SP, Brasil

[2]Centre for Digital Music
Queen Mary University of London
Mile End Road, London
United Kingdom

ABSTRACT

Playsound.space is a web-based tool to search for and play Creative Commons licensed-sounds which can be applied to free improvisation, experimental music production and soundscape composition. It provides a fast access to about 400k non-musical and musical sounds provided by Freesound, and allows users to play/loop single or multiple sounds retrieved through text based search. Sound discovery is facilitated by use of semantic searches and sound visual representations (spectrograms). Guided by the motivation to create an intuitive tool to support music practice that could suit both novice and trained musicians, we developed and improved the system in a continuous process, gathering frequent feedback from a range of users with various skills. We assessed the prototype with 18 non musician and musician participants during free music improvisation sessions. Results indicate that the system was found easy to use and supports creative collaboration and expressiveness irrespective of musical ability. We identified further design challenges linked to creative identification, control and content quality.

Author Keywords

Web Audio, Inclusive Design, Music Improvisation, Creative Commons

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Information systems** → *Music retrieval;*

1. INTRODUCTION

Until recently, music production depended on the technical ability to play musical instruments [18]. This represents a barrier to music making since musical instruments can be expensive if not cumbersome, are not widely accessible, and/or require very specific knowledge to be controlled. The spread of personal computers and smartphones has improved access to music making technologies, however computer-based music making software are generally complex with steep learning curves and mostly target musical experts and professionals. On the other end of the spectrum, several tools appear to be too simple, lacking expressivity, or acting as toys [24].

This work is part of a larger project aiming at developing easy to use web-based tools for music making for ubiquitous modern devices without requiring extra software installation [29]. The interface presented in this paper, Playsound, seeks to support musical creativity and be engaging in an inclusive way to address "the needs of the widest possible audience, irrespective of age or ability" [10].

Our major domain of application is free music improvisation which is defined as an autonomous musical activity [9] that usually leads to pluralist situations, with the emphasis on the playing process, and the interaction between musicians in the moment [4]. In opposition to idiomatic improvisation, such as those practiced in some forms of jazz or hip hop, free improvisation can lead to non-metric forms without predefined key or structure but where variations of timbre [3] prevail. The idea of playing with "an expanded sound palette" has been explored in music since Luigi Russolo [25], but the advances of web technologies and access to online audio content now allow composers to access a more diverse array of sounds then ever. Such musical form lends itself well to the type of sonic material used in soundscape composition [27] such as field recordings or synthetic textures. With regards to experimental music, Cage welcomed "dissonances and noises" as any other musical sounds [8]. These are likely to occur in free improvisations due to the layering of sounds moving away from tonal compositions.

Amongst online audio content resources, a wide range of non musical and musical sounds are made publicly available through the Audio Commons Ecosystem [14][1]. The idea of Playsound started from the the first author's will to make use of such broad online Creative Commons sound material in practical musical contexts, without having to rely on personal local audio collections.

*corresponding author

[1]The Audio Commons initiative aims to bring Creative Commons audio content to artists and the creative industries. Creative Commons copyright licenses provide a standardized way to give the public permission to share and use creative work on conditions defined by the content creators.

NIME'18, June 3-6, 2018, Blacksburg, Virginia, USA.

2. RELATED WORKS

We considered related works in the three following research areas related to NIME.

(i) Technology-mediated group music improvisation. Within the NIME context, a lot of different approaches have been developed to use the computer as instrument in free improvisation. Examples include collaborative live coding [15] and laptop orchestras [2]. Collaborative live coding often includes development of technology for synchronization between devices [30], which is here not necessary since the aesthetic choice is to leave the rhythmic structure unconstrained.

(ii) Web-based music making tools. Over the past few years, especially with the development of the Web Audio API, a lot of research has been conducted to build platforms to make music online. Some of them are developed based on previous types of digital music instruments (DMIs) such as digital audio workstation emulators [19] or sequencers [12], while others leverage web connectivity for participatory experiences [21, 31, 29]. Such a diversity of works shows the potential of web technologies to support new interfaces for musical expression, but most of the currently developed instruments either require expert music knowledge or are simple to use but restricted in terms of musical expressiveness [11].

(iii) Re-purposing of sounds. Recorded sound samples are widely employed in several aesthetic music traditions such as *Hip Hop, Plunderphonics, Electronic Music, Musique Concrète, Soundscape Composition.* Online audio content collection such as Freesound.org, Redpanal.org, Sampleswap.org and others, are used by composers and producers for various types of multimedia applications, such as motion picture, advertisement, video games and music compositions [28]. The APICultor [26] uses machine learning techniques to provide an environment for re-purposing sound samples from online databases. Lee et al. proposed a live coding tool with the YouTube API for free improvisation [20]. By providing database access trough a REST API [1], Freesound.org enables musicians and designers to create applications exploiting its audio content in live applications. Freesound Explorer [13] organizes sounds in a spatial configuration related to sound similarity and uses colors to represent timbral aspects. However, this tool primarily targets navigation and exploration rather than music making and it does not allow users to select sounds from multiple semantic queries, as in Playsound (see Section 3.1). BeatPush [12] is a simple sound sequencer with special audio effects which can be used to produce metric music.

3. DESIGN

Following a practice-based research approach, the first author initially developed Playsound for her own use, as a tool to support her practice in free music improvisation as a solo performer and in ensembles. This objective was then expanded by opening the tool to other users and collecting feedback in a series of formal evaluations.

3.1 Motivations and requirements

As a musician non familiar with melodic/harmonic instrument practice and traditional music notation, but familiar with music technology and web development, the first author wanted to build a platform where she could select sounds from the Freesound database visually to play a large number of sounds during live performances. In this sense, the tool was primarily aimed at providing a rich sound palette without the necessity of instrumental and technical virtuosity.

Some difficulties were identified in current practice when using sound samples during live performances: musicians need to know how given sonic materials sound before playback; when browsing sound databases, users generally need to listen to a large amount of sounds to choose some that can satisfy their needs; also, complex sounds are difficult to represent through conventional music notation (e.g., the same note or chord played from different sources can sound very different), and traditional music notation is not capable of representing a whole range of non-musical sounds (e.g., nature-related sound, speech) typically available in databases such as Freesound [28]. We chose to use spectrograms[2] that can be directly sourced from the Freesound API as visual representation for the sounds, as they let users get some cues about the sound properties before playback.

3.2 Design choices and methodology

For computer users, typing text is arguably more accessible than controlling a musical instrument [22]. Our mechanism of sound selection exploits the idea of semantic queries which are opened to any users without requiring music knowledge. We followed a minimalist design approach to develop a simple and intuitive interface providing fast responses and a large number of search results, and we emphasized the display of sound spectrograms as, after training, they could become a quick way to characterise the sonic aspects of the sounds returned by the system.

During the first phase of development, *Playsound.space* was developed following a *LeanUx* [16] design methodology by starting with a very basic working model of the system and sequentially adding features. During this stage, that lasted over four months, user interface testing was conducted by the main designer, playing in solo sessions, and was also informed from feedback collected with other users. These were non musicians and musicians from different fields such as cinema, performance, music technology and media and arts technology, and were consulted in face-to-face interactions or by chat.

The development started by building a search engine which was gradually improved through the following steps: development of a URL-based system to store and recall selected sounds; adaptation of the user interface for smartphone; integration of a WAV sound recorder directly from the web interface; integration of the loop function for expressiveness; enhancement of the audio player by adding individual volume controls for each sound and a button to delete unwanted sounds from the list of selected sounds.

Since the start of the project, functional versions of the software were maintained online and released as open source software on Github[3]. After the system reached a certain level of maturity, a formal evaluation process was undertaken in the context of live performances (see Section 4).

3.3 Implementation

Playsound was coded in JavaScript with the Angular.js framework, as a single page application and a node.js server handling the authentication process with the Freesound REST API. The website is accessible at `http://playsound.space` and works with any browser compatible with HTML5 and the Web Audio API. Figure 1 shows Playsound's client/server architecture, and Figure 2 displays a screenshot of the UI. By using mostly client-side processing, the tool provides fast query responses and audio playback and does not require too much processing power from the server.

[2]Spectrograms are visual representations of the distribution of energy of sound frequencies over time.

[3]The source code of *Playsound.Space* is available at: `https:`

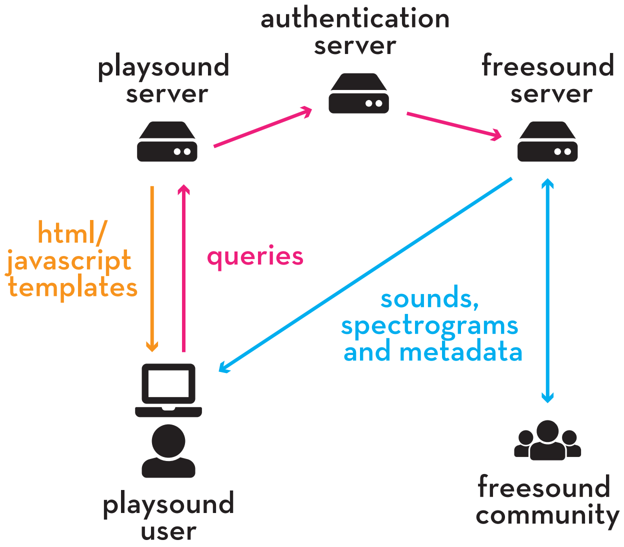

Figure 1: Playsound client/server architecture

3.4 User interaction

Users can search for sounds by entering textual descriptions (keywords) in a text input field. While the user is typing, a range of corresponding sounds appears on the right side of the UI[4], as shown on Figure 2. The nature of the retrieved sounds depend on the metadata provided during uploads from Freesound community users, such as tags, descriptions or file names. Users can then select retrieved sounds by clicking on their spectrogram image. This triggers sound playback and generates a player object which is displayed on the left side of the UI. While sounds are being played, it is still possible to search for other sounds or to select more sounds from the same search query. Users can play simultaneously any number of sounds returned from multiple searches (given computing limitations). When sounds are selected, their identifiers (ID) are appended to the URL of the website. This allows users to retrieve their selections by loading the same URL again. A video demonstrating an example of creative practice with Playsound is available at: `https://youtu.be/yv8T70rawzs`.

Sound controls include play, pause, loop and volume. The UI also allows the user to remove sounds from the selections. The audio player relies on a standard HTML audio object, so depending on the browser, the controls can be slightly different. Users can also save individual sounds locally through the player. A plus sign allows users to open an additional tab in the browser displaying an empty form that can be populated with concurrent queries and resulting playing sounds, and a record button allows users to record the audio streaming into a WAV sound file.

4. EVALUATION

We used Playsound as a technology probe in order to *"collect information about the use and the users of the technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers to think of new kinds of technology to support their needs and desires"* [17]. We assessed our system in two different music making contexts with a total of 18 participants having various musical skills: three participants belonged to an ensemble mixing participants using Playsound and other musicians; 15 participants used Playsound in trios. Our evaluation was centered on HCI frameworks related to usability [6], engagement [7] and creativity support. As in [31], we used a mixed methods approach combining quantitative and qualitative self-reports as well as behavioral data measured from log activity.

All the evaluation sessions were conducted in a performance room of about 80 m^2 with dedicated acoustic treatments and PA system. We documented the sessions using audio and video recordings. In both ensembles, participants were first introduced to the concept of free music improvisation based on mutual listening and the freedom to play spontaneously without pre-conceived arrangement, musical structure, key or meter.

`//github.com/arianestolfi/audioquery-server`

[4]The Sound samples that are ready to be played upon connection are the ones returned by searching "undefined" on Freesound.

Table 1: Performers in music improvisation mixed ensemble sessions: (M): musician; (N): non-musician.

Session	Performers
1	P1 (M), P2 (M), P3 (N), P4 (M)
2	P1 (M), P4 (M), P5 (M)
3	P1 (M), P3 (N), P4 (M), P5 (M), P6 (M)

4.1 Music improvisation mixed ensemble

We established a small free music improvisation ensemble including Playsound users and other performers to test the tool in a real use case situation, as it was designed for the free improvisation practice.

4.1.1 Participants and procedure

To date three rehearsal sessions each lasting one hour were held involving a total of six musician participants:
P1 (Playsound and vocal techniques), P2 (SuperCollider and Playsound), P3 (Playsound), P4 (guitar with effects), P5 (Playsound), P6 (smartphone and percussion); 3 females, 3 males (mean age = 33); see arrangement in Table 1. One participant did not have prior experience as a performer. In each session participants were invited to play three pieces of about 10 minutes and to discuss their experience after each piece. Audio recordings of seven 10 min improvisation pieces are available at the link below[5].

4.1.2 Results

With this process, we tested how the tool could be used as an "instrument" to improvise, how expressive it was, and how other musicians responded to the music produced with it. Discussions held with the musicians after the sessions revealed that both the Playsound users and co-performers were satisfied with the musical improvisations. The outcomes were well received given that none of the players had previously played together and that the form was left free. The tool was enjoyed for the richness of the sounds it provided ("I like the fact that every idea of sound I have is in my hands"). Feedback from participants also helped to improve functional aspects such as volume control. The fact that a non musician who used Playsound was able to play several live improvisations with trained musicians can be seen as a positive sign of inclusive design, and we tested this further by gathering musicians and non musicians in trio ensembles.

4.2 Playsound trio ensembles

[5]`http://finetanks.com/records/puppets/`

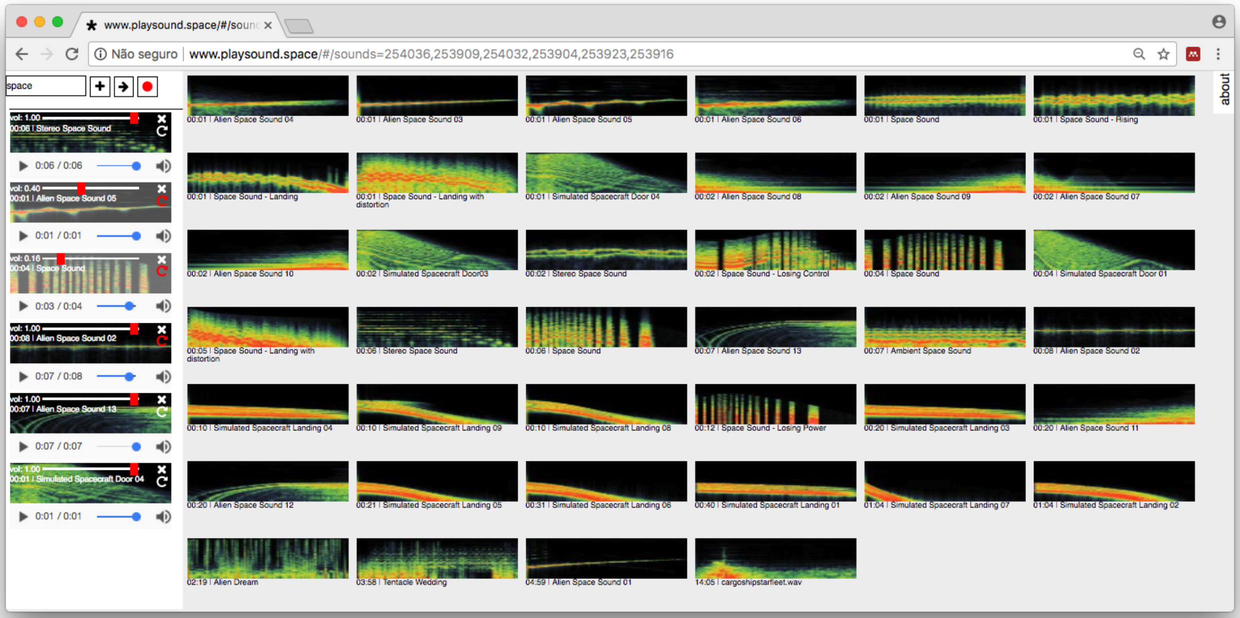

Figure 2: Screenshot of the *Playsound* web interface in Google's Chrome browser.

The second use case consisted in five trios playing music improvisations using Playsound as sole instrument. We wanted to investigate if users new to the system could use it to play collaboratively, how they engaged with it and how it supported their creativity.

4.2.1 *Participants*

15 participants were recruited (5 females, 10 males, age = 32.7±5.4 years). 8 of them considered themselves as musicians (4 intermediate and 4 experienced), while 7 did not. Figure 3 shows three of the groups in a playing situation.

Figure 3: Trios playing for Playsound user tests.

4.2.2 *Procedure*

Participants were instructed to use Playsound on their own laptops. They were first invited to explore the interface during 5 minutes for familiarization, phase during which they could ask questions to the experimenters. After this, they were asked to play three free musical improvisations each lasting about 5 minutes. They were encouraged to listen to each other to establish a musical dialogue and to develop sound ideas using the web platform, searching keywords that were representative of the sound ideas they had. Participants were free to propose any sound idea they wanted with the audio content available through the platform. After each session, participants were invited to discuss together their experience in using the interface and improvising music with others. After the music sessions, they had to complete an online survey. All sessions were filmed and recorded.

4.2.3 *Survey and analysis methods*

The survey included questions related to demographics (age, gender, musical experience), usability (SUS usability scale [6]) and overall feedback on engagement and creative learning. The SUS questionnaire investigates dimensions related to interest, complexity, ease of use, simplicity, integration, consistency, difficulty through 5-point Likert items. We also included 10-point Likert items to assess levels of engagement, learning, novelty, relevance and quality of retrieval, spectrogram familiarity and usefulness. Answers to Likert items were subjected to statistical analyses using the Mann-Whitney-Wilcoxon (MWW) test to compare non musicians and musicians. Browser console logs were analysed to characterise the creative musical interactions from participants. We also analysed group discussions held after each piece using an inductive thematic analysis [5].

4.3 Playsound trio results

4.3.1 *Usability and Engagement*

No significant differences were found between non musicians and musicians for all the questionnaire items (MWW test). Figure 4 illustrates the results of the SUS questions. Participants strongly agreed that the interface was easy to use and to learn, was not complex, and reported being confident in using the system. Participants were more neutral about whether they would use the system frequently, perhaps due to the novel exposure to the free musical improvisation style. Figure 5 indicates that on average participants felt highly engaged while playing with others. Some participants found the system to provide an innovative way to compose music and also found the spectrograms to be useful to find sounds. Participants felt more neutral about whether they learned something about sound and music making while using the system, which can be expected given the short exposure time (about 15 mins).

4.3.2 *Log data*

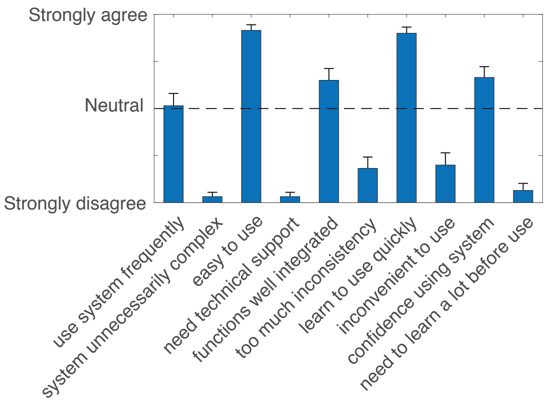

Figure 4: Mean and standard error of the results of the SUS questionnaire items.

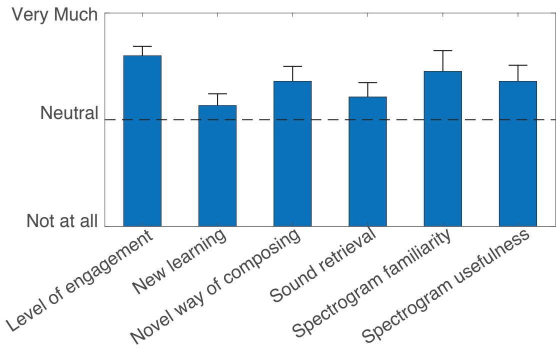

Figure 5: Mean and standard error of the results of the questionnaire items.

Out of 45 trio pieces, we were able to collect 27 logs from 10 participants due to technical issues. Three-way analyses of variance (type II) were conducted to test the main and interaction effects of musical experience (non musician, musician), participant, and piece on the number of queries and number of sounds played during a piece. No main nor interaction effects were found which indicates that the number of queries and sound played were unaffected by experience, participants and pieces. There were on average 8 queries (SD=2) and 24 sounds played (MIN=9, MAX=101, SD=18) per piece showing creative engagement with the system by all participants. The higher variance on the number of sounds played may be related to different playing strategies tested at various times. Sounds were either played once or multiple times and the number of repetitions varied also a lot from 1 to 66 (mean = 2.3, SD = 3.8) showing cases were the content is judged relevant, being repeated.

4.3.3 Thematic analyses

We conducted an inductive thematic analysis by generating codes from the group discussion transcripts. The codes were further organised into themes that reflected patterns, as described below.

Expressiveness. Three participants expressed strong satisfaction to be able to retrieve any type of sounds (e.g., *"I like the fact of being able to get immediately whatever type of sound comes to my mind and use it for composing in real time!"*).

Monitoring. Recurring comments by nine participants reflected that selected samples could not be auditioned prior to being played and that samples had to be initially played at maximum volume. However, participants reported to have found a workaround for these issues by using gradual fade ins.

Relevance and surprise. Five participants reported that the retrieved sounds did not fully correspond to the keyword they had typed in and highlighted the importance to have better tags in Freesound (e.g., *"Some sounds were different from what I expected. I had to try different sounds before finding the sound that I wanted"*). Interestingly, three participants valued the surprise element that could be the source of new ideas (e.g., *"It is a very interesting method to compose because there is a surprise factor"*, *"The surprise of having sounds that I did not expect gave me new ideas, and I used them"*).

Expressive control. Six musician participants felt the need of having more expressive controls as the interface allowed only volume modulations of the triggered sounds. They suggested to add controls for a master volume and the possibilities of synchronizing the beat of samples triggered by different users, to associate computer keyboard keys to samples, to be able to rate the sounds that they liked the most to identify them faster, and to decide which portions of the samples to loop. Two participants reported that the impossibility of being synchronized with the beat of other participants led them to adopt other compositional choices (e.g., *"I avoided sounds with rhythm and selected non-musical sounds"*).

Identification. Five participants reported difficulties in recognising which sounds they played and which were played by the others. This led one participant to suggest to *"build a collaborative interface which also displays what the other musicians searched and are playing."*.

Creativity support and narrative. Four participants reported that they tried to create a narrative in relation to what other musicians were playing (e.g., *"I searched the keywords to adapt to the context. An idea from the other musicians triggered another idea from me, so we can create a narrative all together"*, *"I tried to respond to what the others did, for instance I heard him playing the birds so I tried to find sounds of the cats."*).

Spectrogram usefulness. Five participants, who had a music technology background, reported to have found the spectrograms useful (e.g., *"The spectrogram really helped me to read the sounds and I based my decisions on that."*). One participant commented *"It is a different way of playing: I am using my eyes to play music."*. However, five other participants, who were not able to decode spectrograms, reported to have relied on the displayed name and duration.

4.4 Critical analysis

Results from the ensemble and trio performances indicate that it was easy for first time users to play live with others using the tool. The semantic sound search functionality facilitated interaction between musicians and led to interesting musical situations through the use of similar or contrasting materials at different moments, and rich variation of timbres and rhythms. It also allowed users to express sound ideas and emotions even without technical expertise and musical technique. As stated by Magnusson [23], "the design of a musical instrument or a composition is a design decision conditioned by the properties found in the source material". In the case of Playsound, constraints are linked to the type of audio material available in the Freesound database and its crowd-sourced descriptive metadata which are typically noisy. Other constraints result from the design choices, such as adoption of a minimalist approach, and limitations of the technologies adopted. Users could respond creatively to this constraint. For example, the impossibility to synchronize loops of different durations and with others, and the uncertainty of how samples will sound, generated polyrhythmic and layered timbre patterns that are desirable in free improvisation contexts and in experimental music practices.

5. CONCLUSIONS AND FUTURE WORK

In this paper we presented the design and evaluation of *Playsound*, a web interface for sample-based music making. The system proved successful in supporting the initial design goal from the first author to be able to re-purpose Creative Commons samples in free music improvisation practice. Results also showed that the query mechanism and user interface make the tool inclusive and accessible even to non musicians.

Throughout the evaluation, we observed different expectations from users, some who liked the simplicity and limited controls, others who desired more expressive controls. We have since then improved the player to include some of the features mentioned by them. These include the possibilities to control the sample playback rate, to select the sample starting point from the spectrogram, to select sounds without triggering playback, and to access the original content on Freesound. We will continue to include new features in the next releases aiming at improving the loop control (start and end points) and at providing filters to enable more complex sound transformations. Pursuing the Creative Commons philosophy, we wish to contribute uploading to Freesound new content, which may in turn be accessed through the tool. We also envision to create a collaborative platform that will let users share the the same environment for musical practice and participatory performances.

6. ACKNOWLEDGMENTS

We acknowledge support from University of São Paulo's NuSom Research group and the CAPES PDSE grant awarded to Ariane Stolfi. This work is also supported by the EU H2020 grants Audio Commons (No. 688382) and Internet of Musical Things (No. 749561). We would like to thank Adan Benito, Thomas Vassalo and Alessia Milo for their help in the development and we also thank all the participants in the evaluations.

7. REFERENCES

[1] V. Akkermans, F. Font, J. Funollet, B. de Jong, G. Roma, S. Togias, and X. Serra. Freesound 2: An improved platform for sharing audio clips. *Proc. ISMIR*, 2011.

[2] J. Albert. Improvisation as Tool and Intention. *Critical Studies in Improvisation*, 8(1), may 2012.

[3] M. Barthet, P. Depalle, R. Kronland-Martinet, and S. Ystad. Analysis-by-synthesis of timbre, timing, and dynamics in expressive clarinet performance. *Music Perception*, 28(3):265–278, 2011.

[4] C. Bergstroem-Nielsen. Keywords in Musical Free Improvisation. *Music and Arts in Action*, 5(1), 2016.

[5] V. Braun and V. Clarke. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2):77–101, 2006.

[6] J. Brooke. Sus: A quick and dirty usability scale, 1996.

[7] N. Bryan-Kinns, P. G. T. Healey, and J. Leach. Exploring mutual engagement in creative collaborations. In *Proc. C&C '07*, pages 223–232, New York, NY, USA, 2007. ACM.

[8] J. Cage. *Silence : lectures and writings*. Calder and Boyars, 1968.

[9] C. Canonne. Du concept d'improvisation à la pratique de l'improvisation libre, 2016.

[10] J. Clarkson. *Inclusive design: design for the whole population*. Springer, 2003.

[11] C. Dobrian and D. Koppelman. The 'E' in NIME: musical expression with new computer interfaces. *Proc. NIME*, pages 277–282, 2006.

[12] E. Feenstra. BeatPush. *Proc. WAC*, 2016.

[13] F. Font and G. Bandiera. Freesound Explorer: Make Music While Discovering Freesound! *Proc. WAC*, 2016.

[14] F. Font and X. Serra. The Audio Commons Initiative. *Proc. ISMIR*, pages 3–4, 2015.

[15] J. Freeman and A. Van Troyer. Collaborative textual improvisation in a laptop ensemble. *Computer Music Journal*, 35(2):8–21, 2011.

[16] J. Gothelf. *Lean UX: Applying lean principles to improve user experience*. O'Reilly Media, Inc., 2013.

[17] H. Hutchinson, W. Mackay, B. Westerlund, B. B. Bederson, A. Druin, C. Plaisant, M. Beaudouin-Lafon, S. Conversy, H. Evans, H. Hansen, N. Roussel, B. Eiderbäck, S. Lindquist, and Y. Sundblad. Technology probes: Inspiring design for and with families. In *Proc. CHI '03*, New York, NY, USA, 2003. ACM.

[18] F. Iazzetta. A Música, o Corpo e as Máquinas. *Revista Opus*, 4:1–20, 1997.

[19] N. Jillings and R. Stables. An Intelligent audio workstation in the browser. In *WAC 2017*, aug 2017.

[20] S. W. Lee, J. Bang, and G. Essl. Live Coding YouTube: Organizing Streaming Media for an Audiovisual Performance. *Proc. NIME*, pages 261–266, 2017.

[21] S. W. Lee, A. D. J. de Carvalho, and G. Essl. Crowd in C[loud]. In *Proc. WAC*, 2016.

[22] P. Levinson. *Digital McLuhan : a guide to the information millennium*. Routledge, 2001.

[23] T. Magnusson. Designing Constraints: Composing and Performing with Digital Musical Systems. *Computer Music Journal*, 34(4):62–73, dec 2010.

[24] J. McDermott, T. Gifford, A. Bouwer, and M. Wagy. Should Music Interaction Be Easy? 2013.

[25] E. X. Merz. Composing with All Sound Using the FreeSound and Wordnik APIs. *Musical Metacreation: AIIDE Workshop*, pages 83–90, 2013.

[26] H. Ordiales and M. L. Bruno. Sound recycling from public databases. In *Proc. Audio Mostly*, 2017.

[27] J. Pigrem and M. Barthet. Datascaping: Data Sonification as a Narrative Device in Soundscape Composition. In *Proc. Audio Mostly*, 2017.

[28] G. Roma and P. Herrera. Representing Music as Work in Progress. In *Structuring Music through Markup Language*, pages 119–134. IGI Global, Hershey, PA, 2013.

[29] A. Stolfi, M. Barthet, F. Gorodscy, and A. D. Carvalho Jr. Open band: A platform for collective sound dialogues. In *Proc. Audio Mostly*, 2017.

[30] S. Wilson, N. Lorway, R. Coull, K. Vasilakos, and T. Moyers. Free as in BEER: Some Explorations into Structured Improvisation Using Networked Live-Coding Systems. *Computer Music Journal*, 38(1):54–64, mar 2014.

[31] Y. Wu, L. Zhang, N. Bryan-Kinns, and M. Barthet. Open symphony: Creative participation for audiences of live music performances. *IEEE MultiMedia*, 24(1):48–62, 2017.