Design Resources in Movement-based Design Methods: a Practice-based Characterization

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ABSTRACT

Movement-based design methods are increasingly adopted to help design rich embodied experiences. While there are well-known methods in the field, there is no systematic overview to help designers choose among them, adapt them, or create their own. We collected 41 methods used by movement design researchers and employed a practice-based, bottom-up approach to analyze and characterize their properties. We found 17 categories and arranged them into five main groups: Design Resources, Activities, Delivery, Framing, and Context. In this paper, we describe these groups in general and then focus on Design Resources containing the categories of Movement, Space, and Objects. We ground the characterization with examples from empirical material provided by the design researchers and references to previous work. Additionally, we share recommendations and action points to bring these into practice. This work can help novice and seasoned design researchers who want to employ movement-based design methods in their practice.

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CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**; **Empirical studies in HCI**.

KEYWORDS

Embodied Design, Bodystorming, Design Methods, Embodied Ideation Methods, Movement-based Design Methods

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1 INTRODUCTION

Movement-based design methods have increasingly been adopted in several domains due to their capacity for providing early insights into the embodied experience of participating stakeholders [49, 70]. They can be used in multiple phases of a design project, ranging from sensitising exercises to evaluation [39]. However, while some methods are known and documented, these are not always well-suited for the specific characteristics of a design project. One has to consider the requirements, goals, limitations and possibilities, context, available resources, and emerging contingencies; as well as when in the design process the methods may be used. Hence, designers must often adapt or create them *ad hoc*.

To guide designers in selecting, adapting or creating their methods, we worked towards a comprehensive characterization of movement-based design methods. The goal was to identify salient characteristics of the methods that influence their applicability in different contexts. For this purpose, we were interested in collecting and analysing methods that design researchers use in a specific context. Some of these were adapted from previously-known methods and some others were created from scratch. Section 2 provides an overview of the movement-based design methods that are relevant to our practice.

Through a series of workshops, we analyzed a total of 41 key movement-based design methods used in 12 interaction design projects. All of these were facilitated by the authors, an international movement-based design consortium working together in the Method Cards for Movement-based Interaction Design (MeCaMInD) project supported by Erasmus+. We characterized and classified the methods using a comprehensive thematic analysis [7] with a bottom-up approach. This process is described in Section 3.

We obtained 17 categories that encompassed the significant characteristics of our corpus. We arranged them into five main groups: *Design Resources*, *Activities*, *Delivery*, *Framing*, and *Context*. In Section 4, we present the core considerations related to each category and then in Section 5, we focus on the discussion of the *Design Resources* group. Finally, in Section 6 we provide action points and recommendations that ground the Design Resources with the practice of actually using movement-based design methods.

This paper serves as an articulation of tacit knowledge from experts that use movement-based design methods in their practices. The characterisation and the corresponding examples can function as a detailed map of considerations and prompts for Interaction Design and HCI researchers and designers interested in integrating these kinds of methods into their practices.

2 BACKGROUND

Movement-based methods have been in the spotlight for some time now [8, 9, 38, 44, 49]. Many methods have been proposed and welcomed by the Interaction Design and HCI communities. In the following, we briefly present methods and strategies that are relevant to the trajectory of movement-based design research in HCI and that are important in the practice of partners in the consortium. Afterwards, we discuss previous works that classified or provided frameworks to analyze movement-based design methods.

2.1 Movement-based design methods

Bodystorming is a situated generative design method focused on generating multiple design ideas. In contrast to brainstorming, bodystorming uses full-body engagement with objects, the space and other people to come up with ideas. Several takes on bodystorming have been proposed, exemplifying how movement-based design methods are often appropriated, adapted and tweaked to fit a specific design agenda and design process. For example, Oulasvirta et al. [44] focused on carrying out ideation sessions in the very context in which designs will be used. Schleicher et al. [49] articulated bodystorming as three different approaches: prototyping using enactment; physically emulating the spatial environment in which technology will be used to generate/evaluate ideas in context; and employing actors and props to play out expected use case scenarios.

More recently, Márquez Segura et al. [38] advanced bodystorming for movement-based interaction as a generative strategy to develop ideas from scratch, emphasizing its playful and participative components. Turmo Vidal et al. [62] introduced *Sensory Bodystorming*, which bridges bodystorming and material ideation approaches. This method uses non-digital materials and objects with different sensory qualities to foster exploration and ideation of sensing/actuating possibilities. Finally, Weijdom [69] proposed *Performative Prototyping*, which combines bodystorming methods and Wizard of Oz techniques with a puppeteering approach in collaborative mixed-reality environments. They leverage both somaesthetic and dramaturgical perspectives, the former conceived as a point of view from the *inside out* and the latter from the *outside in*.

Schiphorst [48] contended the importance of somatic facilitation during a technological design process and named it the practice of *Somatic Connoisseurship*. The careful and trained focus on the lived experiences in the body can enrich the design space in Interaction Design and HCI [48].

Relatedly, *Soma Design* [20–22, 57] refers to a design process that is holistic and builds upon the ideas of *Somaesthetics* [50, 51]. It connects sensations, feelings, emotions, and subjectivity in participants' bodies and aims to examine and improve them. These frameworks emphasize introspection, slowness, increased awareness, and the use of sensitizing and body maps.

On a similar note, *Embodied Sketching* [39] encompasses movement-based ideation practices that harness a combination of physical engagement in the surrounding context with play and playfulness to elicit a creative mindset. This context includes the social and spatial settings along with digital and non-digital artefacts, which are catalyzers of engagement and idea generation.

Estrangement, which refers to the process of turning "the familiar" upside-down and making it unfamiliar, is also a common resource and an important component of *Soma Design* [20–22, 57]. Wilde et al. [70] analyzed the use of estrangement as a powerful approach in embodied design methods. Estrangement can be used to inspect and experiment with already-known practices, movements and actions, causing a *disruption* that makes the familiar tangible or visible. Estrangement can be used to arrive at new kinds of movements, objects or design concepts [70]. With *Moving and Making Strange*, Loke and Robertson [26] centred bodies and movement in the design process using a choreographic approach. The work foregrounded the use of choreographic strategies, e.g. explorations of variations of movement qualities—such as speed and direction—as possible ways to defamiliarize everyday movements and arrive at interesting interaction possibilities. The first-person perspective of the mover was the emphasis, alongside the third-person perspectives of the observer and machine. Relatedly, Bell et al. [5] also contended the use of estrangement to open design spaces, specifically in the context of the design of home appliances.

Role-playing as a method involves deliberately assuming a character role and playing out a more or less defined scene or script, with or without props [52]. It can be used throughout the whole design process: to discover and identify issues to solve; to observe and understand the design context and target users; to generate new ideas; to evaluate them; and to communicate them. *Informances* [9, 52] are an example of role-playing which combine performance, scenario-based design, and Wizard of Oz to simulate and improvise future generative-oriented situations with future technology. In Informances, simple props are often used to simulate and recreate the technology and key contextual elements of the scenario. A more elaborate form of role-play is *Larping*—Live Action Role Playing—, which involves complex and well-crafted simulations, character descriptions, narrations and strategies for representation [36]. It has the potential to cultivate deeper connections between participants and their characters and can be used as a sensitizing activity or as a stage for testing and evaluating design concepts and prototypes [36].

Other methods that are used as references and inspiration are Service Walkthrough [6] and Interaction Relabelling [13]. Even though these were not originally proposed as movement-based design methods *per se*, they similarly entail physical engagement with artefacts and the environment. Additionally, they are cited as relevant methods by others like Bell et al. [5], Loke and Robertson [26]. Service Walkthrough [6] is a design technique that facilitates and guides the physical representation and enactment of service moments or stages to prototype/evaluate them. While the entire service journey is walked through, feedback can be gathered as a whole process or in each journey moment/stage. Interaction Relabelling [13] supports the ideation process of novel forms of interaction with electronic devices by asking to use an existing product simulating to be the intended design. Interactions are mapped and evaluated. When the products are quite different to the intended designs, they may lead to creative ideas/concepts.

Finally, a common physical resource employed in movement-based design methods is paper cards. These are used to provide descriptions and instructions [33], to aid in ideation/reflection [56], as a documentation tool of design constructs in workshops [47, 63], or as rule facilitators of body play [30].

2.2 Previous work related to the typography of movement-based methods

Previous works have addressed the need for a comprehensive framework to understand, describe and appropriate movement-based design methods. Andersen et al. [1] analysed 23 methods in seven articles and constructed a typology for movement-based design methods. This typology consists of seven foci: (1) *Sensing*; (2) a *Playful* approach; (3) an *Experimental* approach; (4) *Props, Artifacts and Technology*; (5) *Enactment*; (6) *Social Interaction*; and (7) *Specific Context*. Simultaneously, they classified the methods regarding the design stage in which they were used: *Divergent*, *Explorative* or *Convergent* stage. We argue that a limitation of their approach is that methods are pigeonholed to a specific focus and thus it can be difficult to see how they benefit from the seven found dimensions. Additionally, it is not straightforward to use the classification to implement one's methods. In our paper, the categories are not exclusive and therefore reflect several methods at the same time. Further, we make the categories in Section 5 actionable by providing recommendations and considerations for the reader.

Two works focused on a single yet powerful dimension as their starting point for the analysis of embodied design methods. Wilde et al. [70] proposed and used a framework to analyze *embodied design ideation* methods with a focus on *estrangement*. They interrogated (1) What is being done to cause a *disruption*, (2) What is *destabilized* by this disruption, (3) What *emerges* from the process, and (4) What is *embodied*, e.g. made tangible or visible from doing it [70]. They used this framework to analyze eight embodied design methods. Alternatively, Loke and Robertson [26] focused on the first-person perspective of the person in movement and from there proposed a design methodology based on a whole set of choreographic tools and grounded in prior interactive design projects from the same authors. In contrast to these two works, we followed a bottom-up approach to map the characteristics of a larger corpus of movement-based design methods employed in several interaction design projects in an international design research consortium. We aimed to obtain a set of general categories that would allow describing elements in play before and during the implementation of these methods in practice.

3 METHODOLOGY

We worked with design researchers from six institutions participating in an international Erasmus+ project focused on movement-based design methods. They facilitated the interaction design projects that constitute our original data corpus by writing reports of the movement-based design methods used for the different stages of their design processes. For each technique, they reported its description, account of logistics and facilitation, benefits and outcomes, and reflections.

The process for the thematic analysis [7] that led to this paper consisted of the following steps: (1) Facilitators reported on movement-based methods used in practice in their projects. 12 projects were reported, each using between one and seven methods. This built a corpus of 41 descriptions of movement-based design methods. Table 1 summarizes this corpus of projects and movement-based design methods, along with the shortcodes used to refer to them throughout the discussion. (2) The first four authors labelled these methods according to salient features and characteristics; (3) The same four people, plus the last author, categorised the resulting characteristics using a bottom-up approach; (4) Two (first and second) authors refined the categorization and obtained meaningful subcategories; (5) Four (first, second, third, and last) authors grouped these categories and selected the group to elaborate on; (6) Facilitators were asked to comment on categories and results and provide more illustrative details to articulate them.

3.1 Characterization

The labelling and characterization process was performed by the first four authors. We printed the reports of methods on big sheets and arranged them on the floor of a closed space. To characterize them, we used sticky notes, where we wrote sentences or individual concepts that best described the methods. We tagged them with their corresponding project and method names. This approach aimed to gather insights bottom-up. Thus we did not come into the process with preconceived categories or specific aspects to look out for. We made sure that at least one embodied design expert covered

Project	Method	Code
ACHIEVE	Somaesthetic field trips	Ach1
	Somaesthetic body scan and body mapping	Ach2
Design of a playful interactive supermarket environment for children to foster a transition to healthier and more sustainable food consumption.	Generative bodystorming	Ach3
	Role-playing and improvisation	Ach4
	Online re-enactments	Ach5
	Puppeteering	Ach6
	Wizard of Oz + Informances	Ach7
KOMPAN Workshop	What can I do with this?	KOM1
Concept ideation for outdoor fitness equipment for playful fitness training. Participation of students along with designers from the playground company.	Video sketching	KOM2
	Play moods and quality cards	KOM3
	Explore the movement aspect	KOM
	Action mock-up	KOM5
	Play in context	KOM6
Astaire [38, 39, 72]	Warm-up games	Ast1
	Playing off-the-shelf VR and MR games	Ast2
Design of a collocated MR dance game for two players: one inside and the other outside VR.	Embodied exploration and bodystorming with the affordances of MR	Ast3
	Embodied exploration and bodystorming with off-the-shelf VR games	Ast4
	Embodied explorations to fine-tune the game	Ast5
Super Trouper [37, 38, 40–42, 61, 62]	Warming-up to introduce and sensitize participants to tech and exercises	SuT1
Methods for training body awareness and control in children with motor difficulties, combining circus training and interactive technology.	Training sessions turning into participatory Embodied Sketching	SuT2
	Bodystorming with experts	SuT3
	Bodystorming with cards	SuT4
Magic outFit [25, 39, 55]	Dynamic body maps and keywords to characterise energising moments	MoF1
Design of wearable technologies for sensorial changes of body perceptions to support physical activity.	Barriers to physical activity cards	MoF2
	Somatic dress-up for movement and sensation awareness	MoF3
	Brainstorming based enactment	MoF4
Sense2makeSense	First-person sensorial exploration and materialization of data representations	S2M1
Explorations in opening the design space of immersive multisensorial data representation.	Dolls to facilitate feeling and acting like your persona	S2M2
	Body and sensory cards to inspire ideation	S2M3
	Videoprototype to capture design and scenario	S2M4
LearnSPORTtech [58–63]	Embodied explorations of technology use	LSt1
Design of wearable technology to support sports and fitness practices through sensory feedback.	Technology sensitization	LSt2
	Sensory Bodystorming	LSt3
Tangibles [64, 65]	Field studies and short ethnography	Tan1
Co-design for upper limbs therapy for children with CP employing interactive tangibles.	Interaction Relabelling applied in co-design	Tan2
	Acting out movements	Tan3
DigiFys [3]	Long-term play engagement intervention in outdoor play	DiF1
Research in children's outdoor play and interactive installations to support it.	Short-term play engagement intervention in outdoor play	DiF2
Diverging Squash [27]	VR Bodystorming	DiS1
Single-player VR game inspired by racket ball.		
GIFT [67]	Sensitising towards human practices	GIF1
Museum experiences enriching physical exhibitions with digital content on smartphones.		
Online Course in Embodied Interaction [68]	Online Bodystorming	OEI1
Course in Embodied Design adapted to be taught online during the COVID-19 pandemic.		

Table 1: Characterized Projects and Methods. Acronyms: CP: Cerebral Palsy; MR: Mixed Reality; VR: Virtual Reality.

each technique, and also that every technique was characterized by at least two people.

3.2 Categorization

Once we had the sticky notes as working material, the first four and the last authors gathered for a big initial categorization session lasting over 3 hours in a room of approximately $50m^2$. This happened collaboratively, on-site, and preserving the bottom-up approach. We arranged the sticky notes in the space, placing them randomly all over half of the room floor, independent from other notes from the same technique or project. A small and relatively cryptic code was used in the notes to later be able to trace them back to their respective method and project. We proceeded to simultaneously traverse the space reading and surveying the notes, and looking for patterns and similarities between notes.

As this activity continued, new categories started to emerge. We grouped relevant notes in particular areas of the space and made the group aware of their existence—e.g. "There's a group about Objects in this area!"—, to which the rest responded by bringing relevant notes they were aware of. During the process, these clusters would transform, grow, get divided into subcategories, or be integrated as subcategories of others. Interconnections with other categories were also drawn either through making use of proximity to indicate their closeness or through colour threads indicating relations between notes and categories. Finally, we documented the resulting map of categories with photos. We had a debrief session to talk about the experience and our insights during the process, concluding that some categories still needed revision and further connection with relevant others.

Next, the first and second authors performed subsequent categorization sessions, revising big, unfocused, or complex categories at the level of notes, finding overarching categories and their relations to each other, and also deepening and refining the findings from the first big session. This allowed for an increased level of detail and led to finding clusters within categories, merging clusters that were closely related, naming and revising the names of clusters, and surfacing interconnections. Further, subsequent sessions were needed to trace back which methods and projects were involved in each category. In the end, 17 categories emerged from the process. We introduce them in Section 4.

4 CATEGORIES AND GROUPS

A total of 17 main categories emerged from the 41 movement-based design methods reported by the facilitators of 12 movement-based interaction design projects. We arranged them into five groups: *Design Resources*, *Activities*, *Delivery*, *Framing*, and *Context*. These categories and groupings are not orthogonal, meaning several of them can characterise a given method or project. In this section, we briefly introduce the emerging groups and categories. For the sake of space and scope, we will only focus on *Design Resources* in Section 5.

4.1 Design Resources

This is the main emerging group of categories, on which we will focus in this paper. It contains *Movement* (5.1), *Space* (5.2), and *Objects* (5.3). In Section 5, we will elaborate on them, describing, discussing and exemplifying each category and sub-category, and proposing action points grounded in the insights we found.

4.2 Activities

The *Activities* group contained the categories of *Design Phase*, *Methods*, *Acting Out*, *Sensorial exploration*, and *Crafting*.

4.2.1 *Design Phase.*

We found that movement-based methods were used across different *Design Phases*. They helped not only in **Sensitizing** and **Inspiration** but also in the **Iteration** and **Evaluation** stages of the design process. As such, they were adopted for the **Divergent** and **Convergent** phases of the design process. Additionally, some of the projects leveraged existing **Technologies** during these activities.

4.2.2 *Methods.*

We categorized under *Methods* several references to already-existing design and research methods. Regarding **Research**, we found some references to field studies and ethnography. Concerning design, we found several references to classical **Interaction Design** techniques like (1) Brainstorming, (2) Scenarios and personas, (3) Participatory design, (4) Wizard of Oz, and (5) Puppeteering. Additionally, there were mentions of already existing **Embodied Design** and movement-based methods, especially the use of Embodied Sketching [39] and bodystorming [38, 44, 49, 62]. We identified **Warm-up** techniques across projects, as an important component of embodied methods.

4.2.3 *Acting Out.*

Methods in our corpus used *Acting Out* to come up with, materialize, and iterate design ideas, or as part of a convergence process. It allowed participants to flesh out, experience and see key action sequences. Role-playing was used to iterate ideas in the following ways: by testing ideas within a particular situation and adjusting it iteratively; by tapping into human-like interactions, e.g. exploring different social roles; or by filtering and indicating improvements. It was also used to achieve joint sense-making as a group and to share ideas. Role-playing was mostly reported to be done in combination with improvisation.

4.2.4 *Sensorial Explorations.*

We grouped under *Sensorial Explorations* notes regarding activities aimed towards increasing awareness of specific sensing modalities like vision, hearing or touch, either individually or in the form of multisensory feedback. They were used to inspire or iterate designs, and typically made use of bodystorming—particularly Sensory Bodystorming [62]—using physical probes with characteristic tactile and sound qualities.

4.2.5 *Crafting.*

Crafting was adopted to create prototypes of interactive experiences, controllers and costumes while making use of readily available materials.

4.3 Delivery

Delivery contained the categories of *Facilitation*, *Planning and Logistics*, and *Documentation.*

4.3.1 *Facilitation.*

As part of the *Facilitation* category, we obtained the following list of **Facilitation Tasks** described and utilized across several projects: (1) Arranging the meetings, (2) Curation of materials—objects, references, words—to use and explore, (3) Creation of a safe creative space, (4) Communication of activities,

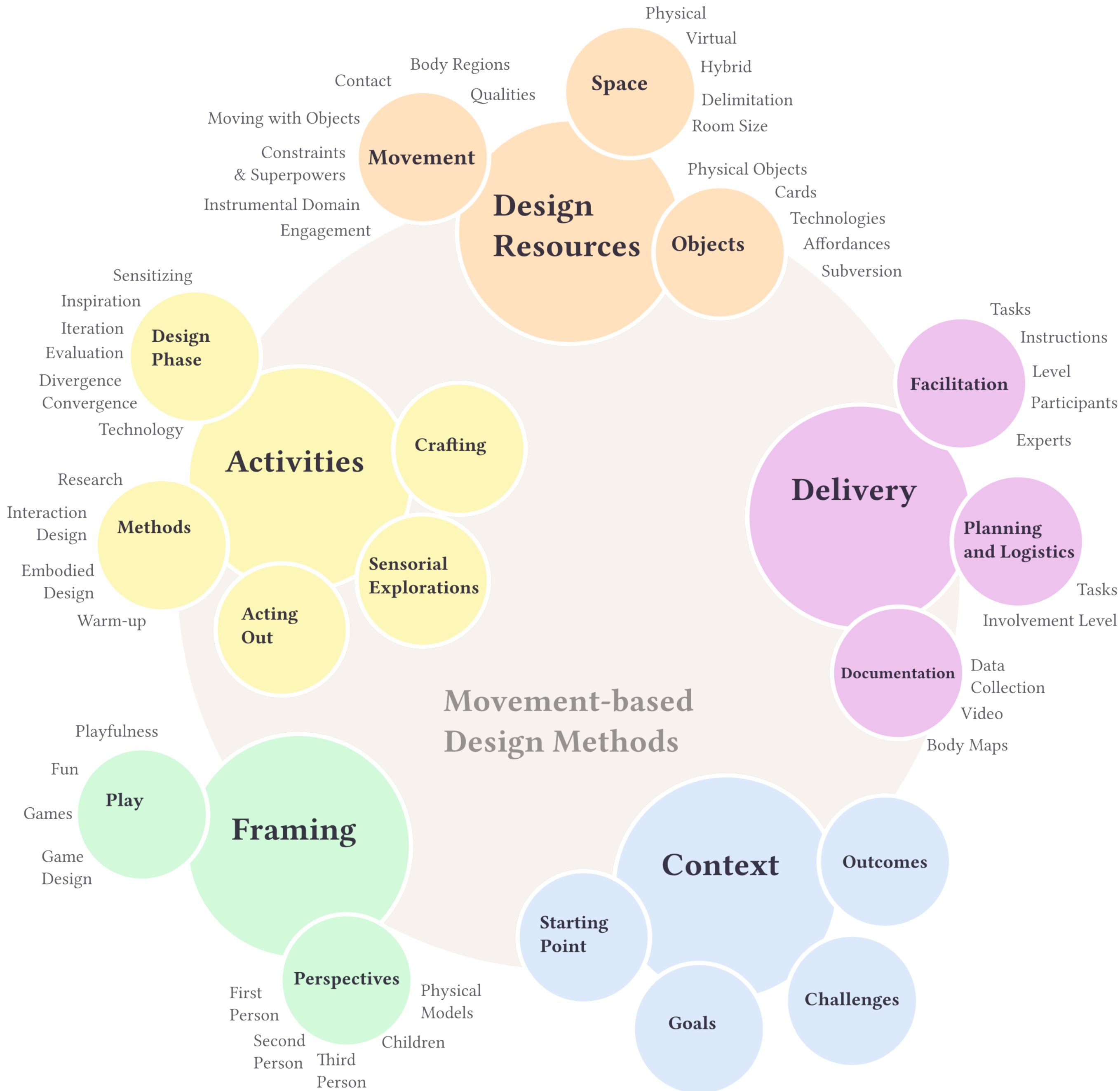

Figure 1: Overview of the groups, categories and subcategories we found.

(5) Time tracking, (6) Supporting the flow of ideas, (7) Suggesting possibilities and alternatives, (8) Encouragement of participation, (9) Monitoring of energy and engagement levels, (10) Balancing between playfulness and goal-oriented mindsets, (11) Guiding and demonstration of actions, (12) Guiding discussion and reflection, (13) Lightweight documentation, (14) Providing Safety measures.

Additionally, we found several mentions of having a pre-defined set of **Instructions** or rules for the facilitators or the participants to follow. These allowed a fluent development of the activities because they (1) Promoted a clear sequence of events, (2) Allowed focusing on specific creative guidelines, (3) Helped to coordinate when facilitators were part of the process, and (4) Helped facilitators to feel more confident during the process.

Regarding the involvement of the facilitators, there was a variation in the required **Facilitation Level** that was reported for each method in our corpus. Noteworthy, methods that used digital technologies reported needing more time, energy and resources. Finally, we found some reflections that considered the context of the **Participants** of the design methods, either as a target audience or as designers in the project. The projects prioritized the accommodation of different participant backgrounds, abilities, needs and limitations. We found these considerations concerning physical movement and also the use of digital technologies. Methods in which **Experts** were participants, tended to emphasize co-creation with them. It was apparent how their skills and knowledge were leveraged, for example by providing detailed feedback, developing or introducing technologies, or guiding somatic and movement-based activities.

4.3.2 Planning and Logistics. An important complement to *Facilitation* (4.3.1) was the category of *Planning and Logistics.* Regarding **Planning and Logistics Tasks**, we found and grouped considerations and reflections regarding the following: (1) Activity preparation: selection of methods, scripting of the sequence of events for the sessions, requirements listing; (2) Preparation of resources like props and cards, e.g. by designing, printing, obtaining, arranging, and carrying them; (3) Management of space and time for the activities; (4) Setup and use of digital technologies, experiences or assets; (5) Preparation and deployment of documentation strategies and equipment; and (6) Consideration and mitigation of safety and legal risks.

Methods varied in the **Involvement Level** they required for planning and logistics. A low involvement level occurred when there was a low requirement for resources, when these resources were easily available, when the facilitators or participants had high expertise, or when the activity had relatively low stakes. Conversely, methods that used complex technologies and setups like Virtual or Mixed Reality experiences, or methods that used several *ad hoc* elements such as custom-made cards or body maps, reported requiring considerable effort in planning and logistics.

4.3.3 Documentation. We found that *Documentation* of activities was an important component in the Delivery of the movement-based design methods we analyzed. In this category, we grouped considerations regarding **Data collection** in general and the use of video and body maps in particular. **Video** recording was leveraged not only as a way to have an archive of evidence to evaluate after the activities but also as a creative medium for participants to prototype their ideas. **Body Maps** were adopted several times for participants to observe and communicate their body states, sensations or wearable prototypes across stages of the activities and design process.

4.4 Framing

Framing contained the categories of *Play* and *Perspectives.*

4.4.1 Play. Under the *Play* category, we grouped notes regarding playfulness, fun, and game design. Several projects had **Playfulness** either as a design goal or as a resource to instigate engagement and curiosity. Similarly, a few projects involved the concept of **Fun** as a goal or as a resource within their design methods. One way of fostering fun was to include pre-existing **Movement-based games** in the design activity. Finally, we found that some projects focused their movement-based methods on playing with and exploring, ideating and iterating key actions that were envisioned to be at the core of the designed activity. We found that these were related to core mechanics in **Game Design** and embodied core mechanics in playful activity-centric design [34, 66].

4.4.2 Perspectives. The perspective participants would take in relation to the target audience would emerge as an important consideration. We found methods that worked from a **First**, **Second** or **Third-person** perspective, and even some that combined them [54]. This category also covered users' perspectives, which were strongly related to the target group of the design. Specifically, **Children** were supported using several techniques with technology (e.g. using perspectives in VR in ACHIEVE) and without. Finally, we found a category related to **Physical Models** and how they allowed for first- and third-person perspective shifts.

4.5 Context

Some notes related very specifically to the *Context* of projects we studied, in their motivations and results. *Starting Points* and *Outcomes* were strongly tied to the given projects. The range of possible *Goals* for projects and the movement-based methods they used included the following: understanding; reflection; focus; embodied core mechanics; and changes in physical activity, behaviour or self-perception. Finally, some common *Challenges* faced during these methods and projects included social and ethical concerns, levels of expertise in relevant areas, the management of engagement during activities, and the use of VR together with all its technical requirements.

5 DESIGN RESOURCES IN DETAIL

We found three main categories that we grouped under the name of *Design Resources*: *Movement* (5.1), *Space* (5.2) and *Objects* (5.3). In this section, we describe and exemplify the subcategories that compose them. Even though categories and subcategories emerged from notes originating in specific projects and methods, we sometimes include relevant and applicable examples from other sources in the corpus. In Section 6 we elaborate on a list of actionable recommendations for each one of them.

5.1 Movement

Methods in our empirical material were chosen based on their prominent use of movement. However, a distinctive category for *Movement* still emerged, encapsulating important body and movement aspects at focus: **Movement Qualities** (5.1.1), **Body Regions** involved (5.1.2), and physical **Contact** (5.1.3). Additionally, this category included strategies and external elements that supported movement: **Moving with Objects** (5.1.4), and **Constraints and Superpowers** (5.1.5); as well as particular considerations when working with movements in **Instrumental Domains** (5.1.6), such as training and rehabilitation. Finally, it covered a possible outcome of using movement, **Engagement** (5.1.7).

5.1.1 Qualities. Methods focused on experiencing, exploring, understanding, and working with particular **Movement Qualities**, such as movement trajectory, tension, or pace. **Movement Qualities** initially emerged as a sub-category from notes on the project of Sense2makeSense and the methods Ast4, LSt1, S2M3 in particular. Common in all the projects is that movement qualities were targeted in their future designed experience. Methods focused on elucidating and experiencing these aspects first-hand to obtain a seed to inspire subsequent or concurrent ideation activities.

Some activities centred on working with a particular focus of attention regarding **Movement Qualities**, which were often related to the sensory and body experience in relation to the self, others, and the surrounding space. For example, there was a focus on bodily and proprioceptive sensations, body orientations in relation to the space and others, and proxemics [10, 18, 24]—physical, social, and cultural resources of action that can be useful in the design of technology [28, 35].

5.1.2 Body Regions. We found two main groups of methods regarding the **Body Regions** involved during movement: those that were open to and instigated movement with the *whole body*—like LSt3, S2M3, or most of the methods from Magic outFit—and those that prioritized the movement of *particular body areas*, specifically the upper limbs—such as MoF1 S2M1, S2M2, S2M3, Tan2, or Tan3. In LearnSPORTtech, there was an involvement of the whole body. For example, the explorations of the technology in yoga focused on how the body was affected by the contribution of each limb in relation to the chest [58].

Regarding upper limb movements, we found a couple of different cases. Tangibles involved activities related to specific kinds of motor impairments that targeted the upper limbs. Alternatively, methods that focused on the movement of upper limbs also involved some traditional design and research activities in Interaction Design that are typically performed by hand, e.g.: drawing, sorting cards and crafting.

Some projects alternated between the use of the whole body and specific regions. For example, in Sense2makeSense, participants built a physical model of their prototype on a reduced scale and used small toys to enact a scenario. They used their bodies to capture and represent body actions that were not able to produce by the toys. Hence, these were classical Interaction Design activities that were used in a way that involved physical enactment.

5.1.3 Contact. Physical **Contact** emerged as a subcategory of movement due to the Ast4 method from Astaire [72]. It was the only project that *explicitly* targeted social interaction involving physical contact. The design researchers described physical contact both as a design target and a key aspect shaping the design process.

Nonetheless, physical contact was present in other projects. For instance, physical contact was used in the form of physical collaboration and assistance to put on, modify, and adapt design materials and prototypes on the body. As an example, in Magic outFit, participants helped one another to "dress up" as the persona they were trying to feel like and enact. The enacting participants would request certain sensations from other participants, who would facilitate them through physical contact and engagement—e.g. poking, caressing, tapping, etc.

Additionally, contact was sometimes used to conduct the target activity. For example, in the Super Trouper project, instructors and researchers helped the children engage with the activities by offering support when needed, for example providing a hand for extra support when the children walked the tightwire.

5.1.4 Moving with Objects. Many projects used *objects* as design resources and goals in their methods. Hence *Objects* emerged as a whole category in its own right (5.3). **Moving with Objects** focus on the relationship between objects and movement in doing and acting, as originally found in the Ast3, KOM1, KOM and Tan2 methods. These instances belonged to projects that had an emphasis on exploring possible movements done in combination with objects. We found that wearables in Magic outFit were the design goal and objects were used to craft and simulate them. Objects were used to explore the sensations they produced and whether they invited movement or supported self-awareness. They allowed delving into other physical, cognitive, and emotional effects.

Objects were frequently used to explore, experience, generate and reflect on key physical and social actions [34] of the intended experience and their effects on it. For example, in Ast4, designers used objects as props to explore moving together with indirect physical contact, playing a variation of the Virtual Reality game *Audioshield* with two players. One player was inside VR while the other was outside. Players placed themselves side to side—in an I formation position [35]—, holding a controller in their outer hand and the end of a single toy golf club in the inner hand, closer to one another. The golf club connected them. The player in VR had to move and guide the other player to score. This allowed design researchers to explore how this kind of movement made them feel socially and physically, how it worked as a way to score, and how much they felt like dancing—a core design goal.

5.1.5 Constraints and Superpowers. We found several instances of movement explorations around **Constraints**—limiting in one way or another the poses, movements, or actions that otherwise would be feasible in a participant—, and around what we called **Superpowers**, i.e. poses, movements, and actions that a participant would not be able to do in principle. This category emerged from the Tangibles project in general and the Ast3, Ast4, DiS1, S2M2 and Tan3 methods in particular.

Constraints were used as creative prompts, to explore and subvert possibilities tied to particularities of objects and environments. For example, mainstream VR experiences tend to hijack the senses of the VR user—mostly vision, but also touch, and hearing—and their presence from the physical space. Astaire worked towards subverting these trends and exploring the design space of collocated mixed-reality play with a two-player dance game. Embodied explorations in the design process involved constraining and providing access to senses, actions, and physical or virtual worlds [72].

Alternatively, **Constraints** emerged from practical reasons due to instrumentality or the objects and models that were used during the activity. Tangibles is an example of the former because the target rehabilitation exercises required movements in specific directions. An example of the latter is S2M2, where Playmobil toys were used to enact a scenario involving an immersive environment with multisensory data representation. The mobility of the toys imposed constraints over the movements that could be explored from this third-person perspective. This was overcome through first-person involvement, i.e. physically engaging with those actions the toys were unable to enact. This is linked to the *Perspectives* category (4.4.2)

Over and above, several projects worked with exploring capacities, sensations, and possibilities beyond the participants' current repertoire both in the physical and virtual worlds. In the physical world, Magic outFit used MoF4 to bodystorm how to mitigate and transform the current sensations of participants using external stimuli produced by different objects. In the design of VR experiences, these explorations of possibilities of action turned to the extreme when investigating **Superpowers**. For example, in Diverging Squash, designers altered the physics of the VR world—gravity and bounciness of a ball—to explore a new way of playing squash. In ACHIEVE's methods Ach3 and Ach4, designers explored being a child both in the physical world through changing bodily stance and posture, and in the VR world through changing the dimensions of the world in comparison to the participant's avatar. This is linked to the *Perspectives* category (4.4.2) and resonates with previous works regarding changing individual and social perception and action, for example, that of McVeigh-Schultz and Isbister [32].

5.1.6 Instrumental Domain. While a free exploration of movement was pervasive throughout the projects in the portfolio, some of them focused on particular *embodied core mechanics* [34] that were necessary for the user, like Astaire. This happened in the context of applications where movement belonged to an **Instrumental domain** such as training or therapy. In the case of Tangibles in general, and Tan3 in particular, researchers were interested not in the free exploration of movement possibilities but in the recontextualization of specific, instrumental movements.

The design context in which a project was developed was often behind an explicit focus on instrumental goals. In KOMPAN Workshop the objective was to make the physical fitness training more playful and thus more intrinsically motivated. They were aiming for a combination of instrumentalized training parameters such as exertion, strength, flexibility, coordination, motor skills, gravity, resistance, and power, combined with play characteristics. As another example, projects in LearnSPORTtech focused on instrumental values of particular practices of training—such as yoga or weightlifting— and targeted particular exercises within those practices.

5.1.7 Engagement. Participants typically engaged well with the movement-based design activities by involving their bodies and frequently interacting with one another. In our empirics, participants tended to feel good and comfortable with themselves and with one another, and there was usually high energy and a feeling of togetherness after embodied design sessions. **Engagement** as a sub-category emerged from the general description of Astaire and Magic outFit and the methods MoF1 and KOM1.

The energy of the participants was carefully considered in several projects, alternating between higher and lower energy activities, and activities involving the body in different ways. For example, in Magic outFit, co-designers carefully interwove less physically and socially active activities with the main movement-based activities. In particular, more reflective and quieter activities such as filling body maps or brainstorming using sticky notes were used as a way to change the focus—e.g. from recalling to acting, from acting to listening; from generating ideas, to documenting them; and so on—, and to rest and recover energy. Consider that energy management is one of the facilitation tasks enumerated above (4.3.1).

5.2 Space

We found several considerations around the use of *Space*, which could be either **Physical** (5.2.1), **Virtual** or a **Hybrid** of both (5.2.2). Additionally, we identified factors concerning the **Delimitation** (5.2.3) and **Room size** (5.2.4) of the space to use during the development of the activity.

5.2.1 Physical Space. In our corpus of data, projects used different types and scales of **Physical spaces**. In some cases, very specific and project-relevant places were used, often in instrumental domains (5.1.6) where there was an overarching goal behind the design. This goal could be more or less playful. For example, LearnSPORTtech employed yoga and fitness studios, and KOMPAN Workshop resorted to the Athletic Experimentarium, a combination of a track and field stadium, obstacle course, parkour installations, and a cross-fit area. Specific places were also important in open and playful-oriented projects, like DigiFys, which focused on outdoor play environments. Plus, in VR-related projects, such as ACHIEVE, Diverging Squash and Astaire, appropriate rooms with VR equipment were essential. The choice of location was due to their relevance to the target application domain or the needs in logistics or materials to conduct the design activity.

However, we also found that methods used more generic spaces, which were adapted by facilitators and design researchers for the activity at hand. For example, in LearnSPORTtech, activities were organised both in a room transformed into a training space with basic yoga equipment and in the target place: a dedicated gym equipped with weights, machines and yoga mats. The former was chosen as it gave control and access to designers—e.g. it allowed them to organise and change the space during the process—, while the latter offered control and access over the process to target users which were instructors and practitioners.

In a middle ground, Super Trouper used a school gym hall, which incorporated some physical training equipment used during warm-ups—e.g. mats, balls, hoops, a vaulting horse, etc.—, and which was further equipped by the circus instructors and co-designers with circus-specific equipment such as a tightwire, trapeze, balance board, etc. Additionally, the design research team incorporated the technology—multiple wearables—and research equipment like cameras.

Finally, DigiFys reported both its methods DiF1 and DiF2 as being located outdoors and in public. While this was necessary given the project's focus on designing and observing behaviour in playgrounds, it posed limitations to what ideation activities could be done, and in particular, this required a more lightweight approach to facilitation.

5.2.2 Virtual and Hybrid Spaces. On one hand, **Virtual space** emerged as a category from the Astaire project and the Ach1, Ach3, Ast2, Ast3, Ast4, DiS1 and S2M1 methods. On the other, **Hybrid space** emerged from ACHIEVE, Astaire, Diverging Squash, and Online Course in Embodied Interaction as projects and from the Ach3, Ast3, Ast4 and DiS1 methods. Notice how some of these methods appear in both categories. VR emerged as a particular and distinctive space in the following projects: ACHIEVE, Diverging Squash, Astaire, and Sense2makeSense. The last two focused more or as much on the physical than the virtual space.

In Sense2makeSense, the physical space was used to leverage important sociospatial considerations to design an immersive and multisensory experience for VR. In contrast, the design goal of Astaire was set in the hybrid space: providing a fun and interesting play experience for a player in VR and out. Both projects involved both the physical and virtual worlds.

In Ast2, off-the-shelf VR experiences and games were used to sensitize designers. Additionally, in Ast4, they worked as design resources to help inspire, explore, and come up with interesting play ideas through transgression and re-appropriation. In both the ACHIEVE and Diverging Squash projects, custom 3D environments were designed and used for the activities. Some of these environments employed custom physics and behaviours, which required the added effort of 3D modelling, programming, testing, setting up, and onboarding, and also the added requirements of appropriate equipment and physical space. This is connected with the *Facilitation* (4.3.1) and *Planning and Logistics* (4.3.2) categories.

Projects using virtual spaces were also aware of and considered the role of the physical space. In some of them, the simultaneous exploration of the physical space was intrinsic to their goals. For example, in ACHIEVE a hybrid space was created by adding tracked physical shopping carts to the experience. This allowed the designers to employ tangibly embodied feedback in the virtual environment while also developing a meaningful connection to the physical space and collaborators. In this way, students outside VR would interact with students inside by aligning their physical and virtual positions. Students were able to see their fellows' virtual perspectives on screens in the mixed-reality space. Additionally, physical props such as different food types were used in the embodied improvisational interactions.

In other cases, the hybrid space emerged out of necessity, like in the Online Course in Embodied Interaction, a course that needed to be conducted online due to COVID-19 pandemic restrictions but that otherwise would have benefitted from participants being in the same space [68]. In that setting, individual participants connected through videoconferencing software but conducted the bodystorming activities—physical games, exploration of materials, movements in space, etc.—from their rooms at home. Students reported curating the space to be shown, which gave them control over the presentation of such an intimate space. They felt the safety supported by their spaces. The familiarity of objects in their space allowed them to engage and ideate straightforwardly. While the physical space became the main place of bodily action the online space became the place for social interaction, thus creating a hybrid form of bodystorming. This approach integrated two of the method's main considerations, space and social interaction, from different perspectives.

5.2.3 Delimitation. We found that the **Delimitation** of working space was a relevant consideration across methods in our corpus. This category emerged from Ach1, Ach3, DiF1, DiF2, DiS1 and GIF1; and also from the GIFT project in general. We found the category was related to the concept of *frames* by Goffman [17], and the concept of *the magic circle of play* in game design and game studies [19, 46]. Frames refer to social conventions and expectations structuring and organizing our experience. The *magic circle of play* refers to a special time and space created when playing that is governed by different rules and understandings than in the everyday world [12, 46, 53]. Similarly, embodied design methods seem to seek and foster a distinctive frameset apart from ordinary life in which particular kinds of physical and social action that might be weird or unusual in everyday contexts are sought and supported.

At times, special spaces emerged as participants engaged in the design or play activity. For example, in Astaire, a demarcated round-shaped stage emerged where players in and outside VR interacted. The rest of the team stayed around acting as a participative audience, commenting and assisting when needed. Contrastingly, in other projects, a good deal of attention was paid to boundary objects and marks helping physically demarcate areas to focus attention, understanding, intention, and action [12]. Sometimes the limits of the space were physically indicated through the arrangement of furniture and objects in the room, and sometimes by marking spaces on the floor with tape. For example, in GIFT, several activities included pretending to be in a museum. Delimiting the space with barriers representing different rooms served to signal what space was standing in for the museum as a whole. Further, it encouraged a high level of social interaction between participants in a focused space.

Delimitation of the physical space was at the core of the design goals of DigiFys. The designers not only wanted to install interactive playground equipment but to create a space that would foster particular movements, paths and behaviours between play stations. As such, landscape architects worked together with interaction designers, and natural materials such as bushes, flower beds and paths were designed to delimit the interaction space, promoting movement and social interaction in certain areas and limiting access to other areas. Finally, furniture emerged as a delimiting spatial boundary in some projects, even if unintended. For example, in ACHIEVE, the designers expected the furniture to be used by the students as a design material. However, students initially understood furniture as fixed elements in the space.

5.2.4 Room Size. Considerations in delimitation were related to the space requirements regarding **Room Sizes** across projects. These requirements first appeared in our corpus in the GIFT and Online Course in Embodied Interaction projects, and in the Ach3, Ast1, Ast2, Ast3, Ast4 and DiF1 methods. For example, we found that GIFT reported having low requirements for space, and Astaire reported needing only a big enough space to move and run around. In contrast, ACHIEVE reported needing a large room for their bodystorming sessions due to their video recording setup and because of health measures regarding COVID-19. DigiFys, by contrast, needed events to be run in authentic environments. Because the material and spatial conditions were in focus for these studies, selecting authentic environments that were representative of different types of places—a playground, in this case—became a central consideration. Similarly, Super Trouper required big halls—a circus hall and a primary school physical education hall—because its design activities involved multiple large objects and furniture such as mats and mattresses, trapezes, benches, and trellises that could not be placed elsewhere.

An interesting compromise regarding room size and engagement (5.1.7) comes from Magic outFit. The researchers had a problem of interference caused by the two groups being in the same room.

On the one hand, they wanted to have all participants in the same space for sharing the materials and interacting, but on the other hand, the two groups interacting with sound interfered with each other ideation process. Sometimes the room was too noisy and did not allow participants to hear well some of the more subtle sounds, especially when the sound objects were applied to body parts or space far from the ears, like close to the feet.

5.3 Objects

Objects emerged as one of the most prominent categories in the categorization. Most of the techniques relied on the use of objects, which ranged from tangible, **Physical objects** (5.3.1)—including a special focus on **Cards** (5.3.2)—to **Technologies** of different sorts and fidelity (5.3.3). In the following, we cover this range and conclude by articulating two properties and strategies around the use of objects: **Affordances** (5.3.4) and **Subversion** (5.3.5).

5.3.1 Physical Objects. The use of **Physical objects** was very common across the projects. For instance, we found them in notes regarding Ach3, Ach6, Ast3, DiF2, KOM3, LSt1, LSt3, MoF4, S2M1, Tan2, and Tan3, and also in the general descriptions of GIFT and LearnSPORTtech. Physical objects were frequently described as common, simple, readily available, and low cost, meaning that they were cheap to buy or create and that they did not need to be necessarily handled with special care. We observed that because of how they were used, the objects were not destructively transformed, and when they were, they were easy to replace. All of this made these objects malleable, adaptable, and highly transformative and provided them with a strong resignification power. For example, as we mentioned earlier in the *Moving with objects* sub-category (5.1.4) regarding Ast4, a toy club for playing pretence golf was momentarily torn apart: The clubhead was removed and the shaft was used to extend the reach of the controllers.

Objects were key for divergent design as crucial prompts for ideation. They were often essential in multidisciplinary contexts involving experts and novices. For example, both in Magic outFit and Online Course in Embodied Interaction, simple objects supporting different sensory qualities—textures, shapes, weights or sounds—, enabled people with and without a technical background to generate ideas for future sensing and actuating technologies.

Idea materialization using objects played a strong role in convergent phases of ideation, involving building mock-ups. These acted as "quick and dirty" *experience prototypes* [8] that allowed other participants to get a sense of the target experience. For example, in S2M1, participants within a team used objects to individually come up with ideas for multisensory immersive data representation. These ideas were then shared among the group and iterated together in the rest of the activities from Sense2makeSense.

Additionally, objects were used to prototype the space in which the activity would take place and explore ideas involving spatial elements. For example, in Ast3, cardboard boxes were used to explore an idea involving a hybrid obstacle course with physical and digital obstacles.

We observed very deliberate decisions regarding what kinds of elements to bring to use during the methods that involved objects. For instance, objects were chosen for a given method due to one or more of the following: (1) Tactile or other sensory properties, (2) Shape and size, (3) Similarity to other objects, e.g. to create models at scale in S2M2, (4) Composability and how they could work as building blocks or crafting material, (5) Interactive capabilities via electronics or mechanics as a way to simulate future technology, (6) Evocative properties, e.g. complex mechanisms to inspire movement, (7) Affordances—see below (5.3.4), or (8) Availability and low cost.

In most cases, the objects that were used were common crafting materials and everyday objects, such as cardboard boxes, tape, sticks, balls, toys, lights, toys, dolls, hand puppets, children's musical instruments, glue guns, pipe cleaners, cardboard, scissors, knife, sponges, modelling wax, foam cardboard, straws, plastic mugs, barbecue sticks, adhesive tape, a stapler, a multi-head screwdriver, a Rubik's cube, and small boxes with magnetic closing. Crafting materials were essential to transform and resignify other kinds of objects.

Brought-in objects were also domain-related, like sports equipment in KOMPAN Workshop and Super Trouper. These objects were essential to support ideation considering domain-specific practices.

5.3.2 Cards. Paper **Cards** were a special class of physical objects used across methods in different ways. The projects that used cards were KOM5, LearnSPORTtech, Magic outFit, Sense2makeSense and Super Trouper. Specifically, the methods from which this category emerged were KOM3, KOM, KOM5, KOM6, MoF1, MoF2, MoF3, S2M2, S2M3, S2M4 and SuT4.

Cards were used across projects to represent the following categories: (1) Actions or embodied core mechanics in Sense2makeSense and KOMPAN Workshop; (2) *Movement qualities* (5.1.1) in KOMPAN Workshop, Magic outFit, Sense2makeSense, Super Trouper; (3) Tactile or auditory qualities in Magic outFit; (4) *Body parts* (5.1.2) in Sense2makeSense, (5) Moods, existing sports and games, technologies for interactivity—sensors and actuators—, and physical activity contexts in KOMPAN Workshop, (6) Scenarios in Super Trouper; (7) Design goals—e.g. barriers to physical activity to beat—in Magic outFit; and (8) Different uses of technology in practice in Super Trouper.

Regarding objectives, uses, and rules, the cards were used in the following ways across methods: (1) Prompts to inspire and guide movement or experiences in general; (2) Visual reminders of possibilities and considerations useful to design; (3) Aids in ideation or reflection; (4) Creative modifiers of current explorations; and (5) Means of documentation of design constructs.

We found that cards were used according to different mechanics. In some cases, the cards were used by the participants as a way of getting a random design prompt. This was implemented through shuffling and drawing from a deck in KOMPAN Workshop, or by scattering cards on the floor and picking up one in Magic outFit. This created some spatial requirements to consider, as previously discussed in *Physical Space* (5.2.1). In other cases, the facilitators or participants would choose the cards after careful consideration. For instance, in Magic outFit, participants chose the card with a keyword that best described how they had felt, and in KOMPAN Workshop, designers added action modifiers that they considered interesting to introduce variations. Additionally, there were occurrences where cards could be modified on the spot. This happened in Magic outFit and Sense2makeSense, which featured blank or wild cards for the participants to fill in using sticky notes.

In several projects, card use was carefully timed in the schedule of design activities. For example, in Magic outFit, cards depicting barriers to engaging in physical activity set up the design goal by being used before the design and enactment stages. As discussed above in *Engagement* (5.1.7), when card usage was combined with activities that engaged the whole body, some friction would appear and movement creation would be hindered.

Regarding the design of the cards, they were often minimalistic containing a few keywords or an image in the form of a picture or an icon. Cards with keywords would often have a defining and focusing character while cards with imagery would be used to inspire and evoke. Images came either from stock pictures and icons or from in-house designs. Cards often featured categories identified either with colours or with printed icons. This allowed for quick identification in the design activities. It is worth mentioning that cards in all projects were highly visual and assumed sighted participants. Hence, without further modifications, the studied cards present an important accessibility barrier for participants with visual impairments.

5.3.3 Technologies. **Technologies** with different levels of fidelity, high or low, were present in several of the movement-based design methods of our corpus. Specifically, this category emerged from the following projects: Astaire, Diverging Squash, Magic outFit, Super Trouper and Tangibles; and from the following methods Ach7, Ast3, Ast4, DiF1, KOM5, LSt1, LSt2, MoF3, S2M1, S2M2 and SuT3. On the lowest end of this technological fidelity range, we could find "fake tech": props or cards that represented and substituted a specific device or functionality during the activity. Such elements were often used when the details of implementation were still not known or needed, or when the cost of logistics for the existing technology would be prohibitive for the given design stage. For example, in KOM5, a set of technology cards—see *Cards* (5.3.2) above—was used when building physical mock-ups of the ideated interactive interventions. The focus was on experiencing the 1:1 scale of the mock-up and not on testing the proposed interactivity.

In contrast, some projects included already working technology in their methods, such as LearnSPORTtech, Magic outFit and Super Trouper. For instance, LearnSPORTtech used a series of wearables—Training Technology Probes, or TTPs—that had been designed and implemented in the context of yoga and circus training, and then deployed them in embodied explorations of weightlifting [61]. In other projects, the technological element was central in the form of Virtual Reality. This was the case of projects including Astaire and Diverging Squash, which employed VR both as the design goal and the vehicle to design. In ACHIEVE, similarly to the work of Weijdom [69], designers used VR to facilitate embedding and placing virtual objects, lighting, sounds, and video screens within a virtual supermarket as a vehicle to design.

5.3.4 Affordances. A key element that we found when analyzing the use of objects across these movement-based design methods was the concept of **Affordances** [16, 23, 31]. In our empirics, affordances mostly referred to physical actions allowed and invited by an object or environment [43]. Further, they had a strong focus on *materiality* and material aspects. This category emerged from the projects of Astaire, GIFT, KOMPAN Workshop and LearnSPORTtech, and the Ach3, Ach4, Ach5, DiS1, MoF3, Tan2, and Tan3 methods.

Affordances were considered when selecting objects to bring to design activities for the actions—core mechanics—they would possibly inspire. For example, in Magic outFit, designers included stress-release balls to invite explorations around squeezing. Additionally, affordances emerged to reflect creative emergent behaviour in the design sessions supported by objects, which was instrumental in design. For example, in ACHIEVE the participating students pushed a shopping cart but could also physically sit in it while simultaneously puppeteer a virtual character in VR. Even when interacting in a virtual space, such affordances steered the ideation process.

5.3.5 Subversion. Some methods were focused on finding new uses for objects and technologies that were designed with a specific purpose: **Subversion** emerged as a sub-category from Ast3, Ast4, Ast5, KOM1, LSt1, LSt2, S2M1, SuT2, SuT3, Tan1 and Tan2. These new uses were either the objective of the project in general or a way to aid in the ideation process. We discussed above in *Technologies* (5.3.3) an instance of LearnSPORTtech that exemplified the former: embodied explorations in LSt1 leveraged Training Technology Probes that were initially developed for yoga [58] and which were brought to weightlifting to find out new uses in this other physical training practice [63]. An example of subversion aiding in the ideation process is Ast4, which, as we mentioned above in *Virtual and Hybrid spaces* (5.2.2), used existing VR games as platforms to explore different game mechanics and affordances of VR equipment.

6 ACTION POINTS AND RECOMMENDATIONS

The following is a list of action points, insights and recommendations focused on the categories and subcategories of the *Design Resources* group (5). We include references to other categories that are relevant to the recommendations of a given subcategory.

6.1 Movement

6.1.1 Movement Qualities.

- Focus on direct experience and explore targeted movement qualities, both of which can be fruitful in design [14]. While they might be common and present daily, they are not frequently in focus. Hence, it might be difficult for design researchers to work with them without experiencing them first-hand. Elucidate and carefully articulate those qualities in close connection with the target application domain, users and practice.
- Body orientations and proxemics [10, 18, 24] might also go unnoticed despite being used on a daily basis [35]. They need to be explicitly brought to the forefront of design activities if they are meant to be used as design resources.

6.1.2 Body Regions.

- While movement-based design methods typically promote full-body engagement, consider alternating the focus and action between the full body and particularly relevant body parts. This is a bodily way of zooming in and out of the target activity and sensory experience, and of balancing first- and third-person *perspectives* (4.4.2). Further, for some design activities, it makes more sense to focus on particular body areas [20]. This is particularly the case when they are at focus on the target application domain (e.g. [37, 63]). Consider: *Which kind of bodily involvement are we designing for? Are there key body parts at focus?* If so, make them relevant during the design activities.

- Consider that body engagement and gestures may organically emerge as designers design, e.g. when gesturing to clarify a sketch or the usage of a prototype [2, 4]. However, if the aim is to use them as design resources, facilitation may help in this regard. You can instruct designers when to engage with particular kinds of gestures and body parts for a specific purpose.

6.1.3 Contact.

- Physical contact does not come naturally to everyone, and some people might prefer not to engage with it. Hence, it is important to communicate beforehand—e.g. in consent forms and descriptions of the activities—the expected level of engagement on this front.
- An important *facilitation task* (4.3.1) is to make sure one enables a safe space, based on trust and consent, to explore physical contact at the level that is appropriate for each participant. A good way of doing this might be through warm-up activities and *games* (4.4.1), although the needs might be different depending on the people who are involved. See more considerations for facilitation in the work by Reidsma et al. [45].
- When physical contact is a target design goal (e.g. [29]), make sure you include it in all *design phases* (4.2.1) of the process so that it exists at the core of the resulting ideas.

6.1.4 Moving with Objects.

- When the target design focuses on designing technological artefacts to support particular movements objects can help to imagine them [39]. Of particular interest are their *affordances* (5.3.4), which can be explored, *subverted* (5.3.5), and extrapolated to that future design.

6.1.5 Constraints and Superpowers.

- Explore the use of VR to impose or remove physical constraints on objects and the world, and to take *perspectives* (4.4.2) and explore abilities beyond your own. This might entail engaging with already available worlds or creating worlds of your own.

6.1.6 Instrumental Domain.

- Make sure to develop a thorough understanding of the instrumental values and goals in the targeted practice. Additionally, make sure to understand the targeted movement, its *qualities* (5.1.1) and typical "rights" and "wrongs" (e.g. [63]). A good understanding of the practice can also help designers challenge the norms and disrupt the practice and its movements if that is desired.
- This understanding will allow you to come up with design ideas that fit well and support the practice, its instrumental values, and its ecology of physical, digital, and sociospatial elements.

6.1.7 Engagement.

- Engagement with movements, others, objects and the space is essential in movement-based design activities and should be at the core of the design and *facilitation* (4.3.1) of those activities. Engagement is a catalyst for idea generation [70]. It also supports group cohesion, and in turn, positively impacts the design process.
- Expectations regarding engagement in movement-based activities should be tailored to the people who are participating, based on their previous experiences and physical abilities. These expectations should be communicated and there should always be the option to disengage.
- Participants may not always notice the energy they are spending and how this might be affecting them. Hence, it is important to *plan* (4.3.2) ahead and manage the engagement of the group by alternating between activities with different energy levels, e.g. those in which the body is more intensely performing, with others that are less demanding. Rest and recuperation are as important as high-energy activities. Ideally, the aim is to arrive at a state of flow [11].
- During *planning* (4.3.2), consider and explicitly address the risks of physical injury that could arise from involvement in activities. Aim towards minimizing those risks by consulting with experts. We believe it might be beneficial to make sure there is someone on site that could be a first aid provider in case it is needed.

6.2 Space

6.2.1 Physical Space.

- Dedicated spaces help *frame* [17] the activity as something different and separate from other activities, which in turn can support engagement and a feeling of safety. Both of these are essential in movement-based design methods. Private and separate spaces can support participants to engage physically and socially by reducing exposure to access or sight from third parties, which otherwise may negatively affect how participants move and engage.
- Embodied design activities typically require non-trivial *facilitation* (4.3.1) and *logistics* (4.3.2) of physical and social elements. For example, facilitators could need to bring physical objects and technologies for the methods and their documentation or arrange the space in particular ways. All this might be easier in a controlled space. However, you should always gauge your space needs concerning the project goals. Domain-specific spaces are a great asset to the contextual emergence of ideas and to test and iterate ideas against a relatively realistic sociospatial context.

6.2.2 Virtual and Hybrid Space.

- Projects focused on designing VR experiences can benefit from design activities heavily involving the physical world, like bodystorming. These bring the advantage of leveraging the already existing physical context and *physicality of objects* (5.3.1) to come up with interesting ideas from immersive,

multisensory, and social perspectives without the necessity of implementing anything in VR just yet.
- A low-cost yet interesting design resource to sensitize and inspire designers to start ideating from VR is using already existing off-the-shelf experiences. They allow exploring and subverting existing affordances and supported embodied core mechanics [72].
- In the cases when existing VR might fall short of this, consider creating custom 3D environments that provide designers control over important design elements, like physics and object behaviour. This approach entails considerable effort in *facilitation* (4.3.1), *planning and logistics* (4.3.2) including the design and implementation of the VR platform.
- When activities involve the privacy of the homes, make sure to be supportive of the curation of the space [68]. Also, allow for diverse sharing control mechanisms—such as being able to disconnect audio and camera if needed—, and be flexible with in-and-out participation by providing ways for participants to keep engaged even if they need to momentarily "disappear" from the stage—e.g. through chats. Further, make the most of familiarity with objects and space by encouraging participants to bring interesting ideation *objects* (5.3) before the session.

6.2.3 Delimitation.

- Embodied design activities require a certain degree of physical and social exposure and engagement that are out of the ordinary compared to everyday social situations. Therefore it is useful to frame and *facilitate* (4.3.1) these situations as something different, out of the ordinary, and even *play*-like (4.4.1). This can lower the stakes and the threshold for engaging physically and socially.
- Boundary objects and marks can help greatly demarcate these special places where embodied action happens in general. These marks, together with relevant *objects* (5.3) and materials can also help mark areas for particular actions, e.g. space for crafting, and another for scenario enactment. Consider that certain objects, such as furniture, are typically understood as boundary objects. If they are meant to act as something else, like design material, make sure to signal this to the participants (e.g. through "house rules," demonstration and example, etc.)

6.2.4 Room Size.

- As part of your *planning* (4.3.2), strike a good balance regarding room size: big enough to not interfere with other participants' body and movement explorations and small enough to support creative transference and sharing of resources.
- Pay special attention to situations using sound as design material, for the capacity of sound to traverse the space. If sharing a space is needed among different working groups, consider bringing headphones or employing turn-taking.

6.3 Objects

6.3.1 Physical Objects.

- Design researchers who want to start working with movement-based design methods could start collecting and curating a *bodystorming basket* of simple and diverse objects like those mentioned above (5.3.1). Important objects to include in the basket are e.g. toys, crafting materials, sports equipment, textiles, and affixing materials to place objects on the body.
- Consider our list of kinds of objects (5.3.1) as a guideline for aspects to look for in your *bodystorming basket* including tactile properties, shape, size, similarity, composability, interactive capabilities, evocative properties, *affordances* (5.3.4), and cost.
- Objects work both for focusing and disrupting attention. If working with objects is at the centre of the design activity, *plan* (4.3.2) ahead and schedule time to explore them freely before using them to build or design. As something to consider as part of your *facilitation tasks* (4.3.1), you may design warm-up or sensitizing activities early in the session to familiarize participants with them (e.g. [40]).
- Objects can work both for divergent and convergent *design phases* (4.2.1). They work great as prompts for ideation, allowing one to materialize and share ideas among people with different backgrounds and expertise. They can also work great in convergent stages, to refine, test, and share future experiences in the form of *experience prototypes* [8].

6.3.2 Cards.

- Interacting with cards entails engaging physically in particular ways: e.g. bodily orienting towards the cards, handling and manipulating the cards, and paying attention towards them. Therefore, in your *planning* (4.3.2), consider how the cards can be integrated within the broader movement-based activity. A possible strategy to include cards in embodied design activities involves turn-taking: engaging with cards before or after a main bodily engaging activity. Another strategy is through *facilitation* (4.3.1), where a person takes the primary role of handling the cards and making them available for others engaged in more physically-demanding activities.
- Creating *ad hoc* card resources can be an intense design research activity regarding *facilitation* (4.3.1), *planning and logistics* (4.3.2). Make sure to build in time to design and iterate them along with people in the team.

6.3.3 Technologies.

- Simulate digital technologies using *physical objects* (5.3.1) in your *bodystorming basket*, or by crafting them with cardboard and paper. A person in the team can also *act out* (4.2.3) the technology [39]. Alternatively, add simple electronic gadgets—e.g. from bazaars, pet shops or children's play stores—to your *bodystorming basket* that can help think about the interactivity and feedback of technology.
- Deploying already existing and functional technology in any stage of development can allow designers to assess its potential, identify shortcomings that could lead to meaningful iterations, inspire thinking in new directions, or generate ideas for completely new technologies.

6.3.4 Affordances.

- When curating objects for your *bodystorming basket*, think about the affordances they support. Known interaction design methods like Interaction Relabelling [13] make use of this consideration and recommend using mechanical gadgets with moveable bits and pieces.
- Dare to explore how to make the most of the affordances of *physical objects* (5.3.1) and *technology* (5.3.3) but also consider *subverting* (5.3.5) them. *Facilitation* (4.3.1) will be key in this regard by supporting *estrangement* [70]. For more inspiration see the work by Djajadiningrat et al. [13], Wilde et al. [70], Zhou et al. [72].
- When the focus is on physical activity beyond hand manipulation, think broadly about how certain objects may support particular postures and bodily orientations [15] that might be of interest to the project.

7 GENERAL REFLECTIONS, LIMITATIONS AND FUTURE WORK

Movement-based design methods exhibit properties that are less common in other forms of ideation. In particular, the physicality of these methods requires important considerations related to the bodily engagement of participants, as well as to space and materiality. This poses challenges and opportunities not seen in classical ideation activities. Therefore, those who have not experimented with these kinds of methods might find them intimidating.

In 2.2, we discussed related previous works that result in categorizations of movement-based design methods: Andersen et al. [1] and their typology of seven foci, Wilde et al. [70] using an analyzing framework based on estrangement, and Loke and Robertson [26] proposing a design methodology based on choreographic tools. Despite their relevance, we contend that these works are not an ideal entry point for the design researcher who wants to start using movement-based methods. Contrastingly, we provide a practical guide for them by focusing on surfacing tacit knowledge from a group of experienced researchers. We focused on the area of *Design Resources* (5) because of how practical they are. Additionally, through the *Action Points and Recommendations* (6) we tightly connected the design resources to the categories of *Facilitation* (4.3.1) and *Planning and Logistics* (4.3.2). In this way, novices can find a clear route to start experimenting with movement-based design methods.

We acknowledge that our work provides knowledge that is articulated and shared in a written format, which is not enough to engage with and facilitate these kinds of methods. Movement-based design methods require hands-on involvement and a first-person perspective on the moving body that is not usually integrated (yet) into the mainstream formation of an Interaction Designer. In this sense, we would like to emphasize the concept of Somatic Conoisseurship [48] as a lens with which to involve experienced somatic practitioners in HCI design processes, and the work on Soma Design [20, 22, 71] as a way to develop one's sensibilities and self-knowledge. Obtaining first-hand experience in movement practices is crucial for involving the first-person perspective emphasized by this kind of design practice [21].

Our Methodology (3) used a bottom-up approach, was practice-based, and led to a comprehensive set of results. We contend that our results have validity due to the following considerations. First, our original corpus of data came from several projects of different authors and the reported movement-based design methods that they used in practice. During the initial characterization process, we used perspectives both from two experts in the field and from two students in training. This allowed for the emergence of characteristics relevant to different levels of expertise. Additionally, we worked with a loose set of guidelines so that the characteristics that emerged would tend to be divergent. We decided on the names and boundaries of emerging categories and subcategories based on consensus combining these different levels of expertise. Finally, the insights, action points and recommendations we share are based on these empirics and are tied to previous work.

An important limitation of our work is that we only focused on one group of categories. Even though we attempted to connect the *Action Points and Recommendations* (6) with other categories, there is still work to do to expand on all of them and their implications. In this way, our work offers a palette of possibilities that we acknowledge are not exhaustive or definitive. Additionally, we articulated the action points based on our tacit knowledge and references. They worked for us, but their generative capacity for others needs to be proven. Future work can expand or challenge what we presented here.

Finally, we also acknowledge the limitation of our corpus, as it is not necessarily representative of *all* movement-based design processes. We argue that it being part of an international design research consortium with a focus on movement-based design is illustrative of different approaches to these methods, but we recognize that having started from another corpus of data we could have obtained a different set of categories and action points.

8 CONCLUSION

This work adds to the Interaction Design and HCI body of works on movement-based design methods (e.g. [1, 26, 38, 39, 49, 70]) intending to provide a practical guide for novice and seasoned designers. We developed an empirically-based characterization of design resources as employed in movement-based design methods.

The relevance of this work is in its focus on developing design resources in movement-based design methods with illustrative examples that can be of interest to the reader. We contribute action points that we argue are suitable for use in practice. These can be considered design recommendations that can help others think about or get started with movement-based design methods in their practice. To the best of our knowledge, there is no existing work on embodied design methods that attempts to cognitively "lower the threshold" for getting started with these methods, which can be intimidatory for novices. Hence, we contend that it is novice designers looking to get started with movement-based design methods the ones who might benefit the most from our contributions. We acknowledge that this work is not enough to overcome the barrier of engaging hands-on, and first-person with movement in Interaction Design. However, we intend that this map of considerations helps to clear up the space so that what is left is mostly to start moving and experimenting.

The seasoned designer will identify that the action points are not *groundbreaking*—rather, they encapsulate and articulate existing tacit knowledge of embodied design. However, we also believe that seasoned designers can find utility in our work: using our categories as a live palette of possibilities that can inspire them, and as a document to help them argue for or against particular design choices.

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