Bodystorming exteroceptive stimulation to train body awareness

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ABSTRACT

Body awareness is essential to execute movements as well as for our perception and interpretation of the world. Hence, it also influences the experiences we make when interacting with a user interface. In comparison, an underdeveloped body awareness can cause low self-control, a lack of self-confidence and the inability to relate oneself to the external world. The aim of this study is to identify application areas of supportive technology in this context and derive design implications for it. In this study (N=5), we use bodystorming workshops and open interviews in the instructed physical training context of equestrian vaulting to explore how and in which way exteroceptive stimulation influences body awareness. The results show that especially participants' body awareness by proprioceptive sensation was increased through the stimulation which further led to quicker reactions as well as an improved perception of wrong body positions and movement executions. Thereby, exteroceptors concerning haptic and tactile feedback are overall the most preferred for triggering and training body awareness.

KEYWORDS

body awareness, proprioception, exteroception, design guidelines, design space

1 INTRODUCTION

Body awareness is essential to learn and execute movements [31] as well as for our perception and interpretation of the world by contributing to our motor control [1, 3, 24], self-consciousness and mindfulness [8, 10, 12, 18]. Also, [21] point out that a well-developed body awareness increases the quality of an interaction experience. Still, interaction design lacks design implications or an overall design process for training tools to develop and train a person's body awareness. This is an increasing issue as today's technology and standard of living support a physically inactive lifestyle which provoke low-developed body awarenesses.

In this study, application areas of supportive, interactive technology are identified that influence body awareness, which is meant to support, change, challenge, enhance, augment or complement it. Further, various types of sensory stimulation are applied to determine what kind of exteroceptors would be preferred by users where in which way at what time. Terminologies like exteroception are defined in the background section for this study, including related work. Two bodystorming workshops with 5 and 4 participants, including unstructured interviews were conducted. As physical training supports the development of body awareness, this study is framed into the instructed, physical training of equestrian vaulting. Equestrian vaulting can be explained as gymnastics on a horseback and is done not only for professional athletes, but also for therapeutic reasons [7, 29]. It requires good body control and perception as athletes are not only challenged by their own movement, but also have to incorporate and deal with the movement of the horse and, in group exercises, of other team members. The sport offers a variety of training scenarios and exercises which supported the exploring character of this study. All workshops were conducted at the training area, a riding arena, including all available equipment of which more details are presented in the method chapter. Results include several application areas of interactive technology to train the body awareness as well as design implications for them. Thereby, application areas are determined in relation to the various types of sensations as well as physical and mental abilities. Overall, they concern the training of proprioception, body control, coordination abilities and consciousness of the body-space relationship, self-awareness through others and by the ability of embodying music. Changes in the environment by adding artefacts, limiting space or changing the texture of surfaces as well as vibrating impulse generators in various sizes showed the greatest influence in a participant's performance. A list of gathered outcomes is presented in the results section.

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The findings contribute to the field of interaction design by opening up the design space for instructed physical training and responses broadly to the question how to design for such a context. Furthermore, as tactile as well as haptic stimuli showed the greatest effect due to, as perceived by the participants, a more natural integration into a course of movement than other stimuli by which they would have to divide attention, many opportunities for further research projects open up through the study. Suggestions on potential proceedings are presented in the conclusion and future works part.

2 BACKGROUND

Considering the various types of sensation in this study, the background introduces the definitions of how each type is understood within this context. Additionally, related work includes an overview of the current status within HCI as well as compares it to the status in the area of rehabilitation.

Theoretical Background

Body awareness is hereby understood as the perceived embodiment of one's self [8, 30] based on interoception, exteroception and proprioception. Interoception relates to body internal sensations like hunger or tiredness and are closely intertwined with emotions [6, 13]. In comparison, exteroception includes all consciously and unconsciously perceived, external stimulation of the body [11, 14]. Lastly, proprioception comprises somatic senses that determine body part positions to each other as well as to its surroundings. Positioning the body in relation to space is based on mixed exteroceptive and propriocetive stimuli [2, 22]. Additional types of body awareness, as e.g. Berlucci and Aglioti [4] present, are defined by the perceived body movements and body structures of others which are partly copied and incorporated or related to the concepts of self-consciousness and mindfulness [8, 12, 18, 19]. Costantini [12] emphasizes that we experience everything through our bodies and hence, the identification with ourselves. Hutchinson and Sinner [18] add a second type of self-consciousness which depends on the outer image that we feel society has of us. Cebolla et al. [8] and Kabat-Zinn [19] define the concept of mindfulness as consciously controlling and steering the own mind and actions. Hence, mindfulness depends on body awareness, but also influences the level of body control.

Related Work

In HCI, training body awareness with interactive technology has been rather little discussed, even though Levisohn and Schiphorst [21] as well as Christou et al.[10] pointed out the importance of a well-developed body awareness for interaction design. Nunez-Pacheco and Loke [26] continue this argumentation by further mentioning the lack of available training tools. Interactive technology is already applied to train a person's body awareness in the area of rehabilitation in e.g. [17, 32]. Thereby, training tools target, e.g. body posture and balance [9, 17, 32]. Chen et al. [9] and Grewal et al. [17] applied virtual reality and succeeded in improving the participants' balance abilities and vestibular system. However, as Peerdeman et al. [28] mention, solutions in rehabilitation often lack the consideration of user experience design causing issues in the treatment process. Within HCI, Neumark [25] approached the topic from a more aesthetic perspective by converting participants' heartbeats into mandalas in video projections and real time sonification. Others also focused on making interoceptive senses and body functions more perceivable. Khut and Poonkhin [20] conveyed the autonomous nervous system outside the body, so that participants could watch and perceive it through projection and sound. Results show that participants felt like they got to know themselves better. Also, Forkmann et al. [16], Filippetti and Tsakiris [15] as well as Forkmann et al. [16] focussed on making the physiological state of the body transparent and discussed further the processing of emotions. Another perspective on the topic was taken by Warren et al. [33] by attempting to close the gap between outer image ("objective reality") and self-image. Therefore, they applied vibration sensors to equestrians while horse riding and provided tactile feedback at concerned body parts that were physically not in the correct position, however perceived as such. One of their learnings was that it was crucial to give the feedback in real-time at the concerned body part. Lastly, Wilde et al. [34] attached light arrays on participants to emphasize the range of as well as the occupied space of movements and the body. The additional visual body extension increased the awareness of the effect of body movement in space, and hence, the body awareness.

3 METHOD

This study applies bodystorming workshops and unstructured interviews as qualitative research methods. Reasons to select a method of embodied interaction design is that this research area targets the design of interactive technology towards an embodied experience. Accordingly, the method reflects on the importance of the physical, human body, the space and the artefacts in the space by including a more movement-based interaction approach as well as by conducting the method either in the space where a design should be used in or in a simulated copy of it [23, 27]. Unstructured interviews were additionally conducted to gather participants' opinions about the various bodystormed approaches. Both workshops took place at the same riding arena with the same participants. In total 5 participants joined the first workshop of which all knew each other and had experiences in equestrian vaulting as active athletes. For the second workshop all

Figure 1: Bodystorming workshop including the horse. The horse's attention on a regular canter depended on the constant attention by the coach on it. Hence, the vaulter felt through embodiment the relationship between horse and coach.

but one rejoined. By asking the same participants for a follow up session, they were already familiar with the method which proofed to be an advantage when including the horse in the bodystorming of the second workshop. As each had a different connection to the sport Table 1 gives an overview about the varying background. In the further paragraphs, the participants are addressed by the number presented in the table. All participants or their legal guardians gave their consent to participating in the study and to share gathered recordings.

Unstructured interviews and the think-aloud method were conducted throughout the workshops at any time that researchers wanted to know more about the participants' intentions of applying a certain artefact or about the effect it had. Often, the interviews resulted in to a group discussion, especially if it was about discussing further or alternative solutions to a presented problem. By including unstructured interviews, researchers also assured to gather each participant's opinion.

The introduced equipment in the bodystorming workshops was selected in regard to their characteristics of stimulating either visual, auditory or tactile senses, such as LEDs, a vibrating dog collar, a sand cushion, a softball, magnetic tape, etc. Additionally to the interactive objects and the normal vaulting equipment, we provided moderator cards with key words about different sensual stimulations as potential inspiration if participants would feel stuck. Further, recording devices were used in the form of a gopro camera and a sound recording device.

The first workshop aimed at identifying and understanding potential problems for vaulters when training on the barrel horse individually. Further, by interacting with the introduced equipment, the goal was to identify what sensory in- or output at what place, exercise and time could support the training. Thereby, various sensory in- and output was discussed and tried out by participants to identify the required intensity and the preferred type of feedback. Participants played around with different textures and volumes by placing the softball or the sand cushion at various places along the body and the barrel horse for altering the subjective perception. The vibrating dog collar and the LEDs were similarly used with varying effect. All together, alterations in the experience of doing vaulting exercises were made by emphasizing body parts, extending body parts, by synchronizing movements, de-familiarization or changing the space of a movement by adding artefacts.

The main goal of the second workshop was based on the results of the previous workshop, to bodystorm more in depth the vaulter's body awareness in various exercises on the barrel horse as well as the real horse. Thereby, the focus was put on the external perspective on the performing vaulter, such as by other vaulters or the coach, as well as on freestyle exercises which also includes the embodiment of music. Including the real horse (see Figure 1) required to split the workshop into two parts. In the first part, bodystorming was conducted on the cantering or walking horse, while the second part took place on and around the barrel horse.

Workshops were analysed by reviewing recordings several times and clustering all argumentations, issues, usability aspects and used material qualities. In the following step, themes were defined and compared again to the reviewed material. The thematic analysis by Braun and Clarke served as guideline [5] in regard to familiarization with the data, initial coding, identification of themes, review of them and theme definition. Defined and reoccurring themes were abstracted to more general themes that could also be applied in other areas than equestrian vaulting. The same was conducted for the design implications.

4 RESULTS

Workshops' results provide various application areas in which interactive technology could support the training of body awareness. Thereby, different forms and colors of LEDs were applied mainly to emphasize angles and lines along the body. Shared perception of emphasizing parts led to joint attention and hence, an easier common understanding of the performance. Feedback from others to the vaulter was given by vibration or verbally. Therefore, the vibrating dog collar was attached to body parts that the vaulter tended to lack body awareness. Accordingly, a learning process needed to happen first, before participants decided on the location of where to put it. For training the individual's awareness, haptic and tactile stimuli were perceived as more supportive

No.	Background	Experience with Equestrian Vaulting	Years of Experience	Gender	Age
1	High School Student	Active in national competitions, team and individual	6	female	15
2	High School Student	Trainings assistant	6	female	15
3	Circus pedagogic	Active in team competitions and coaching teams	10	female	34
4	Coach	Former active in group competitions and individual + coaching teams	9 active + 30 coaching	female	47
5	Bachelor Student of Engineering	Resigned about 6 year before from group competition	5	male	27

Table 1: Participants' experience in equestrian vaulting ranged from 5-30 years. The varying backgrounds allowed creative suggestions (No. 3) with the expertise of how to implement these suggestions into prototypes (No. 5).

("Das hilft ammeisten. Dann brauche ich mich nicht auf etwas extra konzentrieren" - "This supports the most. Then I don't need to concentrate on anything else", No. 5). Not only mentioned by participants that this would be the preferred form of feedback, it also showed during the various bodystormed explorations. A change of texture to extend or hinder some body parts as well as duck tape that led to skin stretch provided consistent reminders to certain body parts during a whole course of movement. Also, the introduction of an additional haptic feedback for rhythm finding allowed participants to direct their attention to executing a movement and rather sub-consciously perceive the input immediately. A restriction was thereby mentioned in the need to place the output directly to the concerned body part as any other position would require learning for which a course a movement leaves no time to do.

Application Areas

In the following, the areas are presented in relation to the observed situations.

Perception of correct body positions: This area relates to precisely align angles, lines and forms of the whole body and hence, are based on the perception of the proprioceptive senses of stretch and contraction.

Vestibular system: Disorientation and imbalance are relevant, reoccurring issues considering the limited, available space. It is related to the area above.

Self-identification and relation: Aiming at a mindful embodiment of oneself through the combination of consciously perceiving interoception and proprioception.

Conscious control: Additionally to train self-relation, controlling the mindfully perceived body is the next level challenge.

Coordination of movements: Training the cognitive abilities towards multitasking and managing attention as well as the movement-time relationship.

Outer image: Sharing the perception of and opinion about a person's performance by a second, external person.

Horse-Vaulter-Coach Relationship: Nonverbal communication through another living being can extend, but also interrupt messaging. Hence, stabilizing communication ways through interactive technology offers another application area.

Implications for Interactive Technology

Each application area offers a variety of training possibilities and tools. Overall identified guidelines and design suggestions are derived as follows:

Emphasize body parts and positions: Emphasising angles and incisive body parts enables to perceive performances out of the peripheral in more details for coach and athlete.

Guide movement in relation to space and time: Limit available space for movement or emphasize the theoretic course of movement in space before and while the practical execution.

Harmonization with external factors: Intensifying exteroceptors or translating the received external stimuli into another type of sensory stimulation improves cooperation abilities as well as social relationships.

Re-direct conscious perception: Redraw attention to certain body parts in individually defined time intervals.

Make interoceptions transparent: Create understanding and self-identification through the transparency of interoceptions.

Enable joined attention: Provide a communication basis and platform to create a common understanding of performances.

Reduce cognitive load: Create clear and intuitive feedback - considering the very limited (real-)time to decode and consider it.

Focus on tactile and haptic sensation: Haptic of tactile stimuli is the most preferred in this context. Therefore, a change of texture, altering space or conducting various forms of haptic input provides a broad play area for interactive technology.

5 DISCUSSION

Current research toward training body awareness with interactive technology is still lacking design implications, guidelines and principles that facilitate the creation of embodied interaction related technology. By focusing on the training of body awareness, this study contributes with concrete application areas of interactive technology. Additionally, design implications are derived for the stimulation of exteroception, interoception and proprioception. Former studies emphasized a lot the need to design for body awareness or to include in their designs, such as Levisohn and Schiphorst

[21], Christou et al. [10] and Nunez-Pacheco and Loken [26]. Also, Turmo Vidal [31] showed that for learning movements, body awareness is essential, but also point out that "the design space of sensory augmentations to improve and support physical training remains narrow". Hence, this study contributes to tackling the problem in a small and particular physical training context. In regard to tangible interfaces, any tangible interaction is embodied and hence, influences body awareness as well as depends on a certain level of development of body awareness. Movements to interact with a tangible interface require learning as well as a certain understanding and meaning-making of it. Thereby, the learning process as well as the design of a tangible interface benefit from the here presented design implications. Whereas in most use cases, hands are used as the main contact area with an UI, in physical training, hands are very often occupied within a course of movement with holding a racket, a ball or just by keeping the body in balance. This requires the development of new types of tangible interfaces, especially considering that tactile and haptic feedback were the most preferred in the current study. While in rehabilitation such interfaces partly exist, they often lack of good user experience design and hence, cause troubles in the practical context and application [28]. However, while we can apply the derived design implications to influence our body control, behavior, coordination and perception in the given context, for the general validity more in-depth studies are required for each of the identified aspects.

6 CONCLUSION AND FUTURE WORK

Overall, this qualitative and explorative study succeeded in identifying various types of body awareness and how to influence them in the instructed physical training context of equestrian vaulting. While the results are satisfactory for this study, it also shows its limitations. For proofing a training effect, a long-term study would be required, which includes comparable measurements. Further, equestrian vaulting is rather a niche sport, so that it would be interesting to compare the gathered results to other sports.

In proceedings to the study results, the preferred type of tangible or haptic stimuli in comparison to other exeroceptive sensations would have been validated to determine the degree of interruption on athletes' attention. Other project suggestions relate to adapting tangible interfaces to guide a course of movement in 360° around the full body. Thereby, conceptual as well as computational models need to be developed that further consider the space-time dependencies. Or wearables could be explored that re-draw attention to a certain body part which an athlete tends to unconsciously and unwillingly forget in a course of movement. Additional research could be conducted in testing (smart) material prototypes in form of altered or new training artefacts which reduce or intensify their supporting characteristic according to the number of repetitions or fitness level. Lastly, as most research in regard to making interoceptive sensation transparent, applied sound and visualizations, it would be interesting how a tangible interface could do the same.

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