Design qualities for Whole Body Interaction – Learning from Golf, Skateboarding and BodyBugging

Jakob Tholander
Mobile Life Centre, Stockholm University
Forum 100, 136 40 Kista, Sweden
jakobth@dsv.su.se

Carolina Johansson
Mobile Life Centre, SICS
Box 1263, 164 29 Kista, Sweden
lina@sics.se

ABSTRACT
What is it that is makes swinging a club to hit a ball so captivating and fun that people spend their whole lives perfecting that one movement? In this paper we present how we, rather than to invent something off-line in a lab, have returned to the real world to get inspiration and studied full body movement activities with non-digital artefacts that have track records of ensnaring and hooking practitioners for a life time, golf and skateboarding. We have also looked at a new interactive movement device called the BodyBug. We explore how the skilled use of the artefacts puts people in contact with and let them experience the world in an essentially new way. We identify and present 8 design qualities for Whole Body Interaction, based on people's performances in these activities. The interdependency between user, artefact and physical environment was a primary driving forces behind rich, sustained and graceful interaction with the artefacts.

Keywords
Movement, body, embodiment, experience, interaction

ACM Classification Keywords
H5.m Information interfaces and presentation

GENERAL TERMS
Design and Human Factors

INTRODUCTION
Performing different kinds of bodily movements is central to interaction with technology and has naturally been a part of HCI research for a long time [3]. In most cases, the movements designed for have had functional or cognitive purposes, such as clicking a button to confirm an action or dragging and dropping an object on the screen. More recently however, experiential aspects of bodily engaging interactions have come into focus through notions such as aesthetic interaction [23] and *whole-body interaction* in consecutive workshops at CHI [6, 7]. In such interactions, the bodily action itself is focused upon, not only as a means to efficiently perform something, but as a means and as part of the experience itself. As often in sports and aesthetic performances and many Wii- and dancing games, the playful bodily actions are joyful to perform in themselves and not only carried out for the purpose of performing actions in the game [12]. Movement-based activities, such as dance and artistic performance, have also opened up new and creative spaces in design methodology. Body and movement are being viewed as creative materials in design, for instance in Hummels et al's notion of move-to-get-moved to engage in movement based design [10], Djajadiningrat et al perspectives for bodily engagement in tangible interaction [5], Loke & Robertsons *making strange* method for defamiliarizing designers with their preconceptions about movement [14], and Schiphorst's use of first-person methodologies such as *experience modelling* [17]. Frameworks such as Fogtmann et al's *kinesthetic interaction* [9], and Larssens' the *feel dimension* [13] have contributed with perspectives on interaction for an increased sensitivity to aspects such as kinaesthethics and haptics in designing technology for body and movement. There are the numerous explorations of technology that illustrate new ways of increasing bodily involvement in interaction, such as Fagerberg, Ståhl and Höök's eMoto pen for bodily emotional expression [8], or Zigelbaum et al BodyBeats for dance-based music creation [23].

This growing interest in addressing the body in interaction design has provided important insight into the felt experiences of interaction, but the field is still struggling with understanding human experience in so called *whole-body interaction.* This raises questions concerning what we actually mean by whole-body interaction and what would it mean to design for experiences that do not reduce humans to only cognitive, only emotional, or only physical beings? How can we design joyful and personally engaging bodily interaction that unfolds in a moment-to-moment process between artefact and user? Our work attempts to shed light on these issues through a study that puts body, world and artefact as one integrated system at centre stage, and by focusing on how these aspects together contribute in shaping people's experiences and meaning making in

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whole-body interactions. We do so by tapping into an, within HCI, unexplored space of movement- based practices that evolve around the use of specialized artefacts, for instance in sports and music. Many studies outside of HCI have focused upon similar issues [20, 2]. However, we look at our findings *through the lens of interaction design and HCI* in order to shed light on how aspects of human-artefact interaction could inform and inspire design of interactive technology for movement-based interaction.

We have investigated two very popular and loved practices with non-digital artefacts: skateboarding and golf, and contrasted practitioners of these practices, to users of the BodyBug, an interactive device designed for movement [16]. Building on earlier analysis [21], and by analysing and contrasting findings from these three setting we have teased out eight interactional qualities that were of critical importance for people's deep engagement and skilled reflection in these activities.

- Interaction that connects to physical space
- Counterintuitive interaction
- Bodily feedback
- Harmonizing modalities in interaction
- Open-ended response
- One size fits all – action not upgrade
- The devil is in the details
- Appreciating failure

We argue that these can provide designers and researchers with new perspectives and be used to explore new design directions for whole-body and movement based interaction. We are not making an outright comparison between the three activities since golf and skateboarding involves participants in well-established practices, while the users of the BodyBug are beginners of a novel prototype. Instead, we have used the three settings to contrast and provide perspectives in thinking about qualities of movement-based interaction.

ANALYTICAL STARTING POINTS

We take our theoretical and analytical inspirations from phenomenology and pragmatist philosophy typically represented by Merleau-Ponty [15] and Dewey [4]. Merleau-Ponty laid out the foundations for a body-centred view on perception and experience, and how these are phenomena the gets constructed through peoples' active engagement with the world around us, rather than through an outside stimulation of impressions on to our perceptual apparatus. In a related fashion, Dewey, emphasized the holistic character of human experiences as something that cannot meaningfully be broken down into discrete events in a separation of body from mind. Maxime Sheets-Johnstone [19] further builds on Merleau-Ponty's phenomenology, emphasizing the non-separability of thinking from action by developing the notion of *thinking in movement.* Other similar work but with emphasis on the role of artefacts for carrying out particular actions is Ingold's wonderfully detailed description of the complexity and multitude of actions involved in sawing a plank [11]. He shows how the whole body, including its relation to the artefact and the involved physical materials, make up a delicate system in the performance of an action.

Engaging with these theoretical perspectives in our analysis encouraged us to dig deep into how seemingly small details affect the overall interaction. Furthermore, this has also led us to look at how body, artefact, and world aspects come together in forming the full experience of the participants.

STUDIES OF GOLFERS, SKATERS AND BODY BUGGERS

STUDY AND METHOD

We selected golf and skateboarding for our studies because they are both activities involving interaction with a non-digital artefact. They also engage people in full body movement, but in quite a different fashion, which gave us a breath in perspective on our research topic. Golf is one of the most widely spread club-and-ball sports and has been played since the 17th century. As a result there is a well-established golf culture with a professional language for talking about movements and the technique for hitting different kind of shots. Golf clubs (see a version of a driver in Figure 1) are nowadays made of steel or different kinds of graphite materials and come in many different kinds, specialized for purposes such feel, ease of use, and distance.

Skateboarding is in regards to golf a relatively modern and new sport. It started sometime back in the 1950s when surfers bored of having no waves put wheels on wooden boards and started skating empty pools. Skateboarding has a strong culture; some might even say it's a lifestyle. The skateboard (as seen upside down in Figure 2) is typically a designed wooden or plastic board combined with two trucks connecting the four wheels to the board.

The third activity in our study involved a technical device developed for movement-engaging interaction – called the Bodybug [1]. The BodyBug, a tamagotchi-like gadget (seen in Figure 3 with its eyes looking left) is a physical interactive device that climbs on a string and feeds and responds to bodily movements. It interacts with the player by its eyes or screen, making sounds and by moving along the string. An accelerometer senses the user's movements and a display on the back shows text and illustrations and

Figure 1. Golf club (a driver) positioned to hit a golf ball. Photo: kulicki http://www.flickr.com/photos/wkulicki/4010582747/

Figure 2. A skateboard. Foto by: □□□□ http://www.flickr.com/photos/dancingpapa 2007/3674686610/

has buttons for navigating games.

The studies were performed in the settings where the activity ordinarily takes place - on the golfing grounds, in a skateboarding hall, and a dance hall - with an open-ended approach trying to capture the central aspects of body-artefact-movement relationships. We observed and video filmed participants, trying not to interfere with the session's natural course. Semi-structured interviews were conducted after the activity, focusing on the participants' experiences and own explanations about body and movement, including issues of balance, rhythm, and fluency as well as their relationship to the artefacts used for their activity. In both skateboarding and golf an educational setting was chosen, as this ensured similar structure of the respective sessions, and were ordinary golf or skating session. The golfers and skaters were differently skilled - from novice to very experienced.

At the skateboarding hall high school students were having their twice-a-week skating classes. The students were practicing for four hours with a teacher present in the hall. About 15 skaters participated at each of the two occasions. Golf was studied at the practicing facilities of a golf club where we attended five different private lessons in which a teacher was working with one or two golfers during 30-60 min periods. For studying the BodyBug we invited six participants to a dance studio. We decided to have them join the hour long session led by the researchers in pairs, as this would allow us to keep focus on each participant while still giving them the possibility of interacting with each other while playing. An initial 5-10 min introduction was followed by 30 min of the participants interacting with the BodyBug through five of the games.

Our analysis has involved a detailed analysis of video clips and interviews. Apart from the theoretical starting points for our analysis, our interpretations of the participants' activities and movements have also been grounded in our own bodily experiences, taking an *empathic stance* in developing our understanding [22]. Rather than presenting results from the three settings separately, we mix examples from one or more of the activities to in order to highlight similarities, differences and common themes.

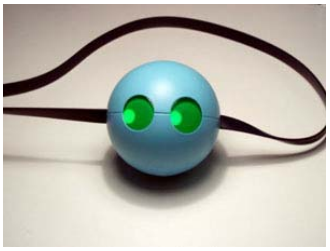

Figure 3. The body bug.

MOVING BODIES - MOVING ARTEFACTS

The first topic that golfers and skateboarders brought up when talking about their activities was the sheer joy they experienced from performing their activities. Skaters expressed the importance of the physical surroundings, as well as the social aspects of skateboarding together with friends either outside or indoors. When asked why they liked skateboarding, *because it's such a great community spirit, such a great crowd. We cheer each other on* and another echoed; *fun, because one has so many friends, and all have the same interest.* Similarly, golfers highlighted the role of nature and being out in the open when asked what was so great about golf, *it's a feeling of happiness, in a way. Being out in the often magnificent nature, to get to move and meet really nice people.* Another golfer said, *it's partly the outdoor experience, to be outdoors, in nature.*

There are of course many reasons to this but one of particular relevance regards how people in golf and skateboarding get to experience the world in a way that is very specific to those activities. The artifacts that they meet the world through, transform how they sense and experience the physical space around them. A handrail is not only a handrail for the skater; rather, in interaction with the skateboard the handrail becomes an object that structures the specific actions it takes to perform a trick. This led us to start exploring the particular ways that golf clubs and skateboards allow people to experience the world in new ways.

Connecting to and sensing physical space

So one important aspect of the experiences of skaters and golfers regards how their practices and artefacts allow them to become connected to the *physical environment,* and the importance of that connection for accomplishing the actions that make the activities joyful, such as challenging tricks with the board or advanced golf shots. One of the skaters talked about her view of the physical space through what she called *surfaces* such as slopes, ramps and rails and how skateboarding was largely about being able to feel these in successfully riding the board and carrying out tricks. She said, *one has to feel where you go, how you go, how the bends are and so on [..] the surfaces [..] you feel it if you go in the bends.* See Figure 4 for skaters typical examples of managing and sensing the different physical spaces of a skateboarding hall.

One of the ways that this feeling occurs is via the actual physical connection between the skater and physical space mediated by the skateboard. Sensing physical properties of the environment such as slopes, edges, and bumps is

Figure 4. Skating on various physical surfaces.

primarily achieved via the properties of the skateboard and how these allow the skaters to sense the behaviour of the skateboard and its reactions to properties of the surfaces. There are many facets to this interaction which is often expressed in the small nuances that the skaters bring up when talking about their experiences. For instance, one of the boys gave us a lengthy explanation of how new shoes had to be wore down before they allowed him to get the exact feel that he was searching for. *When they are new they are hard, and down here (points to inside of sole) then it feels edgy and you feel away from the board.*

But just as important as physically sensing the surfaces, is the skaters' ability to 'read' the physical environment using their eyes and ears. This is not achieved only through the immediate contact with the board, but also through other means of experiencing the environment. Attentive looking and listening reveals properties of space that is not revealed through physically sensing the board. They pay attention to how the noises change when riding over different surfaces and how the differences between concrete, asphalt, wood and steel necessitates adjustments in body positions. Perceptual modalities such as hearing and vision make up a large part in achieving the delicate moment-to-moment configurations of their bodies with respect to skateboard, the surface, and the surrounding space, that is necessary for performing a particular trick or just riding down the street.

Another aspect of how skaters orient to physical space was their close attention to the activity of peers in the surrounding activity. Even though there was little explicit communication on how to manage the activity, they constantly observed fellow riders and wordlessly interweaved with one another, skating between other riders' paths in a graceful manner and never crashing into each other although many skaters were sharing the same surface.

In a similar fashion, we could also see how the golfers paid attention to how to adjust their actions to the properties of the physical space, for instance, by being sensitive to the feeling in the hands from a bad shot, or the 'non-feeling' in the body of a good shot. Just like the skaters, it is through the interaction with the artefact and through the activity as a whole that the golfers were put in touch with the physical world. These gave them opportunities to feel and reflect on their movements, and interpret the outcomes of their shots.

Counter-intuitive actions in physical space

Helena, a skater, said, *for example, if you go in a bend. If you go upwards then you can't lean upwards. Most people do that in the beginning but then the board goes away. You have to find this system of balance, how you should lean or how you should push.* She here points to another aspect of what it means to do bodily performances in physical space. Riding the skateboard in a smooth fashion that works along with the shifting conditions of the physical space may often have to be conducted in way that initially feels counterintuitive.

To keep good balance and nice flow you need to lean away from the ramp towards the ground (as demonstrated in Figure 5 by Mike skating up a steep ramp) – which initially feels counterintuitive for most people since it counteracts your body's sense of avoiding to fall. The ability to assess and experience the pull of gravity, and centripetal and centrifugal forces, in order to effectively adjust their bodily position is thus a necessary skill in skateboarding.

Similarly to many of the counterintuitive actions of the skaters, golfers also spent time on trying to learn to perform physical actions that were not in line with what they felt were natural. They talked about having to learn to trust a movement to be correct even though it was experienced as awkward and counterintuitive to begin with. For instance, when they had brought the club all the way back in their swing, they were instructed to start their downswings not with their arms but with their hips, which is not what might be expected when trying to perform an action with an artefact that you hold in your hands. See Figure 6 where Sara's hips are turned right in the first photo and in the second they are facing straight forward, while having still only completed ¼ of the swing.

To develop a feel for and interpret how the physical circumstances affect their performances, the golfers spent time practicing, and were instructed on, how to carry out the actions required to hit the ball from up, down or side slopes and from different surfaces such as thick grass or packed sand. In Figure 7 the instructor is showing with her body the importance of being aware of the direction of the slope and to develop a way to adjust the position of the body accordingly by leaning with the slope.

Figure 5. Illustrating the role of being aware of and adjusting body position to the slope of the ground.

Figure 6. Sara practicing on how to start her downswing by a drive from her hips.

Figure 7. Illustrating the role of being aware of and adjusting body position to the slope of the ground.

Thereby learning to feel through, and being sensitive to, how the movement of the artefact will be affected by the particular circumstance provided by the physical environment.

Fine-tuning of bodily action

Sabina, a 17-year old student, who had been skateboarding only three times as part of a school project, described to us what she was looking for when observing some of her much more experienced friends riding their boards, *I am trying to see how they twist the board and how they place their feet. It's like they switch position of the feet from having been standing like this. Then, when they make half the trick only one foot end up on the board*. Considering the limited time she had been skateboarding it was impressing to hear how she attended the fine details in the footwork of her friends and the impact this had on the tricks they were performing. In further looking at our data, we decided to look closer at the role played by such small details for how the interactions unfolded.

Similarly to Sabina, a 17 year-old boy who were commenting on one of his friends, emphasised the delicate nuances in the relationship between body and skateboard, and how very subtle bodily movements had a significant and often critical influence on the movement and control of the board: *the tiniest things is about body movement, turning the shoulders with the board, how you stand, the placement of the feet, everything.* He illustrated this by pointing out the importance of the four screws on top of the board and how he used these to orient and position his feet on the board (see the four screws visible on the board in front of the shoe in first photo of Figure 8). In a similar fashion the golfers paid a great deal of attention to different aspects of body posture and how hands, wrists and arms were used and positioned for different kinds of shots. For instance, during one of the classes we observed the instructor and student spent significant time and effort on adjusting the position of the right thumb on the grip of the club (see second photo in Figure 8 where the instructor is bending in close to adjust the grip by millimetres). Throughout this interaction the thumb was repositioned less than a centimetre in total. This seems like a minor detail but was experienced by the student as having significant consequences for the performance of the overall swing.

This sensitivity to nuances and tiny details in body position, body movement, and material circumstances in both skateboarding and golf illustrates how these aspects cannot be seen in isolation from one another. They must be understood as integrated facets of a constantly changing relationship between body, artefact and physical space in the making and unfolding of experience. Engaging in these activities is about attending to this as an integrated system, and not about specific manipulation of an artefact. The artefact itself provides a response that is given meaning by the user's skilled moment-to-moment interpretation and bodily reconfigurations.

Immersive interaction with the BodyBug

Among BodyBug users, interaction and movement was also often engaged, sustained and graceful with user, artefact, and physical surroundings working as complimentary aspects in the interaction. In such cases they engaged in a continuous interaction with a focus on movement and with response from the BodyBug integrated with those actions. For instance, in one of the games Melinda (harmoniously jumping with the Bug in Figure 9) was quite soon able to jump together with the BodyBug in a fashion that retained a particular rhythm, so that the feedback from the BodyBug guided her in the interaction. She was also able to repair and get back to the rhythm when the flow of interaction was lost. She pointed out, *at first I was just jumping without knowing, but then it started to feel like there was a rhythm there, that one was supposed to hit the beats … and if you did that, you did better. [..] If you lost the rhythm you kind of had to catch up with it.*

Figure 8. Fine tuning the positioning of the feet according to the screws on the board, and adjusting the position of the thumb when gripping the golf club.

However, like all interaction, the flow might get interrupted and users need ways of gracefully repairing and re-establishing the interaction. What we repeatedly observed was that such processes of repair tended to be problematic in interaction with the BodyBug, as the participants' focus ended up almost exclusively on the instructions on the screen of the BodyBug or on its eyes (see Figure 10 of Lars paying close attention to the screen of the BodyBug). This made it difficult for the participants to connect to, stay aware of, and attune themselves to the shifting conditions of the surrounding physical and social space. Johanna said, *because I'm very guided by this [pointing at the BodyBug] it follows that one doesn't really have an eye on the room in general.* We observed how they were close to bumping into each other and thus not being aware of one another, nor of the physical space around them, as expressed, *it feels a bit… inside. That one is in one's own sphere*.

While this immersed the player in their own sphere of focused and intimate interaction it also made interactions problematic. There was a lack of interactional resources for the users to take the necessary actions to connect to and continuously respond to the shifting conditions and properties of the surrounding space. In particular it seemed like the possibility of moving together with the BodyBug became difficult when users' vision got preoccupied with information from the screen, since their vision was also required for attending to other aspects of the interaction.

Visual dominance in Bodybug interaction

The BodyBug has four modes of communicating: through audio by different noises and tunes, visually by text on the small display or direction cues from the eyes, and through moving on the string it is attached to. As discussed above most participants used the visual feedback as the primary way of attending to the responses of the Bug.

The responses provided by the BodyBug are derived from a pre-defined ideal pattern such as a specific rhythm, a direction, or a pace of the movement. The feedback to the user thereby depend upon if their action match that pattern or not. Most of the users experienced difficulties in interpreting the feedback and adjusting their movement in order to converge towards the ideal movement. This was especially difficult for fast-paced moment-to-moment non-verbalized movements.

Jenny, a dancer highly skilled in movement but without much experience with novel technologies, illustrates some of the issues she experienced when moving with the BodyBug. *I stared myself blind at it because I didn't realize how to push because I thought that it had something to do with how I treated the ball.* [..]. *It felt like I did what I thought and then I probably did too much movement and then it felt like I wasn't in control. It felt like I had outsmarted it [..] but I don't know, or if I did right or wrong [..].*

Figure 9. Melinda finding the rhythm when jumping with the BodyBug.

Jenny talks about her repeated attempts in searching for responses that could guide her in interpreting her movements in relation to the BodyBug and her trying to find cues that she could use as a guide towards a correct movement. This figuring the bug out, as discussed later in the paper, was partly done at the cost of actually engaging in the movement itself with the responses as resources. Critical to successful use of the BodyBug for Jenny, was to be able to build a meaningful whole of the different responses, and to integrate that in the moment-to-moment process of moving around with the artefact.

In a similar fashion Paulina said, *it was a little bit difficult to understand when I did right or wrong because I couldn't look at the display when spinning around*. Given the very small screen and the domination of the visual aspects of the interaction it became problematic to continue moving with the BodyBug.

Even though other participants paid more attention to the audio cues, they also described how the visual form of communication drove attention away from the audio at several occasions. In performing a jumping game one woman admitted to *sneaking a peak* at the display even though she was also listening to the audio feedback for the rhythm to jump in. This was one source of the frustration they expressed over that the feedback did not match what they felt was actually a correct move.

In contrast, in skateboarding, the importance of being able to use vision for several purposes was emphasized. For instance, one of the boys commented on when his friends were playing a game where the participant challenges each other to do different tricks. He told us, *when you come towards a hurdle, like an edge, you have to look up and down, first between your feet, and then you go on feel and*

Figure 10. Trying to interpret visual feedback from the BodyBug

look where you go. Here, vision was used to coordinate the body with respect to the board and physical space.

Feedback to the body

Apart from the specific feedback given by the artefact, there is another strong additional response in golf and skateboarding that deeply influences the users' action: bodily feedback. After hitting the ball with the club there is nothing in the club itself that indicates the outcome of the shot. The golfer cannot look at the club to see if it indicates 'correct shot' or 'wrong direction'. Neither does it audibly say 'great" or 'bad'. Rather, to arrive at their own subjective outcome of the shot, golfers combine a series of different feedbacks. The golfer of course watches where the ball goes, hopefully in the desired direction. Then there is also the sound from the club hitting the ball, as one golfer explained that by listening to the sound you can hear if it was a clean hit or a less good one ('clink' vs. 'clonk'). The golfer also gets a bodily response from the club. When hitting a bad shot the golfer feels it in the hands, with vibrations travelling up the wrist, past the elbow, and felt all the way up in the shoulder. By hitting a good shot, there was what one golfer called 'the non-feeling', *when you make a good shot, then it doesn't feel anything at all. [..] It is free of strain.*

Similarly a skater gets a strong bodily feedback when for example landing on the board after a jump. A skater might land with the board tilted or with only one foot on the board making it hard to stay in balance. Even when landing with two feet on the board, seemingly perfect for a spectator, the skater may feel that the balance was not perfect or that the feet were not correctly placed on the board. These are strong bodily responses, but responses that can only be interpreted by the skater.

In golf and skateboarding the response of movement with the artifact comes out of how the action is applied to the physical world and how the user interprets and experiences the response of the action. Right or wrong therefore depends on the aim and the circumstances. A key aspect of such process is that there is *openness in the response* that allows for *wide range of possible interpretations*, similar to Sengers' & Gaver's notion of staying open to interpretation in design [18].

Response for skill development

In golf and skateboard, the very same artefact, provide possibilities for performing and appreciating both quite simple and highly advanced actions, no matter whether it is a first-time user of a skateboard or someone highly skilled in doing advanced tricks (see Figure 11 for both skilled and novice use of the same type of board). A complete beginner and a pro like Tony Hawk more or less skates on the same board, with the same basic properties, no additions are made such as extra wheels or similar. Similarly, in golf, both expert and novice use basically the same club, nothing new like an extra handle is introduced when you reach handicap 10. Of course there are many significant differences in the qualities of a skateboard, such as size,

Figure 11. Skilled skateboarder controlling the skateboard in a trick on the ramp (left) vs beginner trying to find the balance on a flat surface (right)

shape, kind of wheels, as well as in golf clubs that come with different shafts, materials, and club head design.

However, the primary means for increasing the difficulty or the complexity of experiencing these artefacts comes from the ways people are able to use them in different situations and for different purposes, such as doing tricks on rails in skateboarding or hitting a shot with a particular trajectory and spin on the ball in golf. It does not come from a development of the artefact as such. Rather, increasing skill comes from the users engaged moment-to-moment fine-tuning of balance, posture and ability to perform physical movements in interplay with the artefact and the surrounding space. In this manner the artefacts can be seen as of the *'one size fits all'*-type where skilled action, rather than upgraded artefacts, make more complex usage possible The very same artefact is thus enjoyed by both novice and expert and the development of expertise involves discovering how the qualities of the artefacts can be used and appreciated for different kinds of movement.

Such skill development involves an *appreciation of failure* of their actions and a feeling of getting closer and closer to achieving one's goal and becoming more skilled. In golf and skateboarding, there is a strong appreciation in 'almost making it'. Skills of bodily awareness does not here come out only as a general skill but is closely tied to the specific practices of each particular activity.

Artefact-focused interaction

Like we discussed above, we often saw how users of the BodyBug got immersed in a focused interaction that they expressed as being joyful and stimulating, as seen in Figure 12 with Jenny moving gracefully with the BodyBug. One important source of this kind of interaction is in the character of the feedback of the BodyBug. It contributed to producing what we call an *artefact-focused interaction*. In such interaction, the users let go of what happened in the world around them in favour for a deep engagement with the artefact itself.

This artefact-focused interaction yielded another specific interaction quality, which was not present in the interaction with the golf club or skateboard, namely the feeling that the Bug was alive. This notion of interacting with a living thing was expressed by Jenny, *it feels like it's a friend sort of, that gives love and sound and stuff, it's like a small guy.* The BodyBug became the Buddy-Bug as the participants

ascribed some kind of aliveness to the BodyBug, to a larger extent than people commonly do to other technical devices, such as a PC or a mobile phone. *It feels like it's a buddy, sort of, that gives love and sound and stuff and there is this little figure there.* They spoke about trying to please it, wondering whether it liked their movements or not and trying to figure out what it was thinking. *It felt very unpredictable, it was very hard to anticipate what it would think of my movements* - one participant said when asked if he were in control. The artefact was something the participants communicated with during their movements, often using a language that would suggest it as something alive: *It said bravo on the display and it sounded happy. It said pling-e-ling and was feeling good.*

The fact that the BodyBug was experienced as an object with some kind of agency, contributed to the considerable attention paid and time invested from the participants in trying to figure out its behaviour, as described earlier by Jenny, *for me it required a lot of brain capacity to try to figure out and understand this little thing*. However, trying to figure out the BodyBug reached beyond its mere functional properties and the Bug was seen as an object with capacity to act on its own, with some sort of self-agency, *I tried to figure out how it thinks.* This intellectual aspect of the Bug was also mentioned when asking one participant what made the Bug exciting, *that it was a new thing, trying to understand how it works,* therein making the BodyBug more intellectually engaging than a non-digital artefact, with exciting dimensions to the interaction with the artefact itself and not only the activity it mediated.

The notion of the BodyBug being alive seemed to be one essential factor in what motivated movement with the Bug. BodyBuggers talked about the purpose of their movements to please the BodyBug, in order to get points in the game, not for their own personal satisfaction of experiencing a flowing movement. As one player expressed her control over her movements, *I exaggerated the movements, I did too much*. Other participants expressed their beliefs that they had also done too much movement, *I felt like I tried to make it happy*, which again shows that participants' often moved to please the BodyBug rather than themselves. In this immersion the participants moved to please the bug - the bodily engagement, the artefact and the physical space were separated rather than integrated aspects of the interaction. It was experienced as an interaction in which the feedback *evaluated* whether a movement was right or wrong, without leaving room for the users' personal and subjective interpretation. It became difficult for the user to continuously move together with the artefact in a fashion that could unfold in a moment-to-moment fashion.

Movement focused interaction

In the movement-focused interaction of golf and skateboarding things were quite the opposite. Obviously, they perform their actions for a particular purpose and to get the artefact to behave in a certain manner, such as to get the club shaft to lean in specific direction or to reposition

Figure 12. Jenny gracefully dancing with the BodyBug.

the body weight with respect to the centre of the board. However, such aspects rarely came into focus when the users talked about their movements. Rather, movement was the focus of the activity, not the artefact itself.

In the kind of interaction that golfers and skaters engaged in, they were *movement- and body-focused*, while still continuously being bodily engaged with and staying connected to the social, material and physical circumstances they interacted in. In such use the artefacts allow the participants to be continuously engaged in an activity and in an interaction that does not shield them from the material, physical, and social environment in which they act. The artefact supports them in making such aspects an integrated part of their experience. As we have shown here, a key aspect of such interaction regards the possibilities to physically manipulate and sense the artefact and how different perceptual modalities enable such a process.

DESIGN INSPIRATIONS FOR MOVEMENT-BASED INTERACTION

We would now like to take a step back from our findings and discuss how they can be made relevant in the design of whole-body experiences and movement based interaction. We acknowledge the difficulties in taking these understandings of bodily practices such as golf and skateboarding, and transforming them into design relevant knowledge. We are instead using our findings to formulate a number of potentially inspiring design qualities that can expand the design space for bodily engaging and movement-based interaction. These may be used in practical design work as well as for looking at and analysing whole-body and movement-based interaction.

In all three activities that we have looked at, the artefacts that they revolve around provide potentially exciting possibilities for people to engage with and experience the world in ways that would not be possible without the artefact. The skilled use of the artefacts is what makes the activity possible, and in a sense redefines what the environment in which they use these mean to them. In the kind of interaction that golfers and skaters engaged in, they were *movement- and body-focused*. They were continuously engaged with bodily movements while at the same time staying connected to the social, material and physical circumstances they were interacting in. In quite a contrary fashion, interaction with the BodyBug was *artefact-focused*. Such use of the artefacts engaged them in an immersive and personal interaction engagement with the artefact with a focus on their relationship with the device as such.

Since, we are particularly interested in movement-based interaction we would like to emphasise some fundamental aspects of our findings. The first aspect regards the possibility for users to get and stay *connected to the physical environment* and how artefacts can support them in sensing and interacting with aspects of the physical world, and thereby enable them to construct a new set of meaning of objects in their physical environment. The second regards the role played by *complementary perceptual modalities* for user's to engage in a moment-to-moment fine-tuning of bodily action with respect to physical space by engaging different perceptual modalities in the process. The third regards *the role of the open-ended* character of the feedback that artefacts provide to movement, and how this allows users to by themselves interpret and reflect on the meaning of the response they are getting. This supports a movement-focused interaction with possibilities for a deep connectedness between our bodies and the physical world.

Based on this we have outlined the following eight interactional qualities for whole-body movement-based interaction.

1. **Interaction that connects to physical space**
   Allow users to experience *engaged interaction with the physical environment.* This regards how to support users to continuously connect to, and experience their physical surrounding in a moment-to-moment fashion. Such interaction involves possibilities for users to adapt their actions to the responses of the artefact, in interplay with the physical surrounding at each particular moment of the interaction. Artefacts that engage users in such a process need to provide resources that allow them to gracefully repair breakdowns for the dynamics of engaged movement to continuously unfold.
2. **Counterintuitive interaction**: Explore *counter-intuitiveness as an interaction resource for bodily experience and movement.* Counter-intuitive movement may be a compelling means for a rich, sustainable and evolving interaction, building a challenging complexity in the interaction for the user to learn to master.
3. **Bodily feedback**: Explore *the feedback provided by the body itself from different kinds of movements in space*. Bodily feedback is fundamental to how we experience the world, and must thereby be viewed as essential for design of bodily interaction. It may work as an inspirational source of personal and subjective experiences as well as allowing for openness in the interpretation of the action performed.
4. **Harmonizing modalities in interaction**: Explore how different *perceptual modalities allow users to connect and integrate their bodies, artefacts and the physical environment* in interaction. Designing for perceptual modalities to be used in a complimentary fashion facilitates a continuous attention on the activity and fine-tuning of bodily action. Overly dominant use of one modality may block the user from the surrounding world. Instead, users must be given possibilities to use the same perceptual modality for different actions.
5. **Open-ended response**: Explore user *feedback to movement that open up for individual interpretation.* Such feedback aims for experiences shaped by how artefacts are applied to the physical world and the possibilities for a rich array of interpretations. Open-ended responses to movement invite the users' to a rich range of possible interpretations of their engagement with the artefact and the world. 'Outcome' of an activity is not to be determined by the output of the system, but by users' subjective interpretation of their actions in the world.
6. **One size fits all**: Explore how to design for the principle of *one size fits all*. This regards how skill in action and complexity in movement, rather than additional properties or upgrades of the artefact itself, is what makes increasingly advanced actions possible. Such skill development evolves from the complexity of the actions of the users, rather than differences in properties of the artefacts themselves. This allows users to grow together with their artefacts, and engage with movement-based artefacts in a way that can be increasingly developed and mastered over time.
7. **The devil is in the details.** Explore *minute aspects of interaction* and how these can be included and have impact on in the overall performance of the activity. Allow for small changes in handling the artefact to significantly influence the result and the outcome of the action. Subtle interaction may produce a skill-based complexity that gives the user a pride in mastering.
8. **Appreciating failure:** Explore how *to allow interaction with the artefact to be appreciated* also when a user does not fully succeed in their intended action. This involves an appreciation of failure of actions, a feeling of getting closer and closer to achieving one's goal, becoming more skilled, and the strong enjoyment experienced in 'almost making it'.

REFLECTIONS – DESIGNING WHOLE-BODY MOVEMENT-BASED INTERACTION WITH ARTEFACTS

The interdependency between user, artefact and physical environment was one of the primary driving forces behind the rich, sustained and graceful interaction that we saw in golf and skateboarding, and in successful uses of the BodyBug. Through the interaction qualities that we propose, we hope to contribute to a perspective on interaction that can inspire researchers and designers to

explore technology that contribute to a deep connectedness between the whole human being and the physical world in which we live and act. The qualities obviously relate to ideas formulated in other contexts and for other purposes but here we specifically situate them in the context of whole-body interaction. We would also like to emphasise the importance played by our theoretical engagement with phenomenological perspectives in analysing our findings and formulating the design qualities. Through the perspectives of Ingold [11] and Sheets-Jonstone [19] we have been able to view interaction as a process that happens in and through movement in a dynamic, evolving, non-discrete process. In such a process, there is no separation of thinking from action and expression. In such view on human action, sensing the world and acting in it, do not belong to two separate domains, but are part of the same experiential world.

CURRENT AND FUTURE WORK

Current work involves investigating how to apply the qualities presented in this paper in practical design for whole-body movement interaction. We have for example been looking at how to use these in different contexts such designing for rich and long-period lasting interactions, for interactions in fast pacing surrounding, and to design for interaction that brings together the digital realm and movement in the physical world in novel ways.

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