Ambiguity and Open-Endedness in Behavioural Design

Boon, Boudewijn; Rozendaal, Marco; Stappers, Pieter Jan

DOI
10.21606/drs.2018.452

Publication date
2018

Document Version
Final published version

Published in
Proceedings of DRS 2018

DRS Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Ambiguity and Open-Endedness in Behavioural Design

BOON Boudewijn*; ROZENDAAL Marco C. and STAPPERS Pieter Jan

Delft University of Technology
* Corresponding author e-mail: M.J.B.Boon@tudelft.nl
doi: 10.21606/drs.2018.452

Design is increasingly concerned with changing people's behaviours. A common characteristic to behavioural design approaches is their *directionality*: products provide clarity about or guidance towards the designer's intended behavioural outcome. In this paper we propose an alternative perspective that emphasizes *ambiguity* (i.e. affording multiple interpretations) and *open-endedness* (i.e. affording multiple courses of action). We build on two design cases in pediatric healthcare in which the aim was to stimulate young children's physical activity during hospitalization. Instead of commonly used exercise-based approaches, our focus was on physical activity in the form of spontaneous and unstructured play. We describe how interactions with ambiguous and open-ended playthings gave rise to intended behavioural outcomes. The findings are explained by drawing on Activity Theory, suggesting products can direct and leave things open on different levels of interaction. With our contribution we open up a new design space for behavioural design that reconciles designer's intentions with end user's appropriation.

appropriation; design for behaviour change; openness; research through design

1 Introduction

There is an increasing awareness in design research and practice that products are not merely *functional* to end users (i.e. products as *tools* or *means to an end*), but that they also *mediate* people's everyday life in sometimes unexpected ways (i.e. products as *mediators*; e.g. see Nardi & O'Day, 1999; Verbeek, 2005). Several design approaches have emerged that make use of this mediating capacity of products, aiming to achieve desirable changes in people's behaviour. A common strategy in these approaches is to deliver products that are clear in their purpose or that guide end users through a specific course of action towards some desirable outcome. In this paper we explore an alternative direction in which leaves room for end user's meaning making and self-directed action.

To shed some first light on such an alternative approach, let us take the metaphor of a restaurant. Think of the dishes available and their descriptions in the menu card. Restaurant A might offer traditional dishes, with the ingredients clearly indicated. Restaurant B, on the other hand, might

serve more experimental dishes, with limited information about the ingredients. The latter situation may result in curiosity or wonder among the guests, prompting questions such as “What is this ingredient?”, “What’s this flavour?” or “How should I eat this?” In other words, Restaurant B offers a setting that gives rise to *ambiguity*: they invite meaning making and may result in various interpretations. Now consider how Restaurant C might offer a single menu of three courses versus Restaurant D having multiple dishes lined up at a buffet. In the second case, guests have the freedom to compose their menu and, if they desire so, go for a second round. The buffet of Restaurant D is more *open-ended*: it leaves open multiple courses of action.

The aim of this paper is to show how ambiguity and open-endedness, as described above, can be valuable assets when designing for behaviour change. In other words, returning to the metaphor: we explore whether and how restaurants can promote, for example, healthy or sustainable food choices, while leaving room for people’s self-direction and meaning making. This effort potentially opens up new possibilities for behavioural design to create space for end user’s appropriation.

2 Behavioural design and directionality

Over the years several approaches and tools have emerged in the fields of HCI and design research that can facilitate designers in changing behaviours of end users. Examples are persuasive design (Fogg, 2003), design with intent (Lockton, Harrison, & Stanton, 2010), or design for X behaviour, where X refers to a specific domain of interest, such as sustainable or socially responsible behaviour (e.g. Tromp, Hekkert, & Verbeek, 2011; Wever, van Kuijk, & Boks, 2008). Here we will use behavioural design as an umbrella term for these approaches, which are all in some way concerned with changing behaviours of end users as resulting from interactions of a designed product or environment. We see behavioural design as part of a broader field we label as *intentional design*, hinting at the wide range of intentions for change that designers might have, such as enhancing the experience of end users (Hassenzahl et al., 2013), encouraging reflection (Hallnäs & Redström, 2001), or regulating mood (Desmet, 2015).

A characteristic that is common to behavioural design approaches is their *directionality*. Ideally, users have a specific interpretation of a product’s purpose or message (i.e. products provide *clarity*) or they engage in a specific course of interaction (i.e. products provide *guidance*) as intended by the designer (e.g. see Jelsma, 2000; Lockton et al., 2010; Wever et al., 2008). For example, pedometer apps are generally designed to clearly indicate the amount of steps taken and, in some cases, how this relates to the advisable amount. A speed bump is a clear barrier for a driver to slow down. Or consider the ‘Never Hungry Caterpillar’ in a study by Laschke, Diefenbach and Hassenzahl (2015); this extension cord is designed in the form of a caterpillar that expresses its suffering when the device it is connected to is switched to stand-by modus. The purpose of the design was to improve energy behaviours and the study showed how most users had interpreted it accordingly. In these examples, clarity and guidance increase the likelihood for intended behaviours to occur. The designs are successful in their directionality insofar as they correspond with some concern of the end user. Road signs, for example, might trigger concerns about the safety of others, whereas a speed bump is more likely to raise worries concerning the bottom of the one’s car (see Tromp et al., 2011; Waelbers, 2011). In both situations, the design *directs* drivers to lower their speed.

In the above cases, it is desirable that end users obtain a clear understanding or intuition of what is the desirable or only way to go. This is very reasonable for a designer to pursue, in particular when designing for situations of risk or urgency. In many situations, however, it might be the case that there is no such need for directionality; it might even work counterproductive due to its restrictiveness or inability to engage users. Here designers might benefit from a more facilitative approach that leaves room for end users’ meaning making and self-direction. In this paper we discuss *ambiguity* and *open-endedness* as particularly relevant concepts for such an approach.

3 Ambiguity and open-endedness

Whereas traditionally design developed as a discipline that delivers clear and functional, or *usable,* products, the value of openness in design is increasingly acknowledged. From this point of view, a central question is how design can leave room or account for users' *appropriation* – i.e. the interpretation and use of a technology beyond its original design intention (Höök, 2006). Several open design approaches and relevant concepts have been proposed that might help designers to design for appropriation. Below we focus on the concepts of *ambiguity* and *open-endedness*, which offer a clear contrast to our earlier discussion of directionality in the form of clarity and guidance.

3.1 Ambiguity in design

Ambiguity refers to the possibility of something giving rise to multiple possible meanings. Similar to Gaver et al. (2003), we see ambiguity as a property of the relationship between an artefact (e.g. its accuracy of feedback or clarity of purpose) and end users (e.g. prior experience, norms, values or worldview).

The literature discusses several ways in which ambiguity may emerge and how it can be designed for. Gaver et al. (2003) illustrate how ambiguity may arise out of the way information is presented, out of an experienced incompatibility between artefact and context, or out of the interpreter's personal relationship with an artefact. Sengers & Gaver (2006) propose a number of design strategies to allow for multiple interpretations. For example, a designer could consider gradually unfolding new opportunities for interpretation or thwarting any consistent interpretation. Furthermore, they distinguish various levels of interpretation, from "What does this button do?" to "What is this system intended to be used for?" or "What role can it play in my life?" (Sengers & Gaver, 2006, p. 100).

3.2 Open-endedness in design

Open-endedness refers to something not having a planned ending and affording multiple courses of action. Similar to ambiguity, we view open-endedness as a property of the relationship between an artefact (in particular in terms of possibilities for action) and its user (e.g. prior experience, current needs, or behavioural dispositions).

In the literature we find several ways in which design can be open-ended. Moran (2002) introduces Everyday Adaptive Design, referring to the design activities that end users might engage in to adapt technologies for their own purposes. Designers can facilitate such activities by designing 'pliant technologies' that are modular or underspecified. Along similar lines, Seok et al. (2014) describe non-finito products as being intentionally unfinished, leaving room for creativity of end users in solving their problems. In the context of designing for children's play, de Valk (2015) describes open-ended play as play without predefined rules, leaving room for improvisation. She discusses ambiguity in interactive playthings as a way to achieve diverse ways of playing. Rozendaal et al. (2011) explore how open-endedness can be operationalized in design by tapping into a different human needs and bodily interactions to open up various routes to attain intended outcomes.

3.3 Ambiguity and open-endedness in behavioural design

It appears that the qualities of ambiguity and open-endedness are in opposition to the directionality common to behavioural design. This paradox surfaces in the words of Gaver et al. (2003, p. 235): "the [ambiguous] artefact or situation sets the scene for meaning- making, but doesn't prescribe the result." Contrastingly, the central purpose of behavioural design is the prescribing, or at least promoting, of particular interpretations or results. Similarly, it might be said, an open-ended product or situation does not guide the user towards a particular course of action. Instead, open-endedness might be better described as multi-directional.

In the following section we illustrate how this paradox of openness versus directionality is only apparent. We draw on two design cases in which the aim was to stimulate children's physical activity in hospital settings. Per design, we describe the intentions behind it, followed by a detailed

description of product characteristics that contributed to ambiguity and open-endedness, and how this, in turn, stimulated physical activity.

4 Design cases: Fizzy & Stickz

We reflect on two design cases that are part of an on-going 'research through design' project (Stappers, 2007) in the context of paediatric oncological healthcare. The main motivation behind the project is the following issue: chronically with cancer, due to their disease and treatment, often show low levels of physical activity. This inactivity potentially hampers children's physical development. In particular during hospitalization, children tend to engage in very little physical activity (e.g. Winter et al., 2009). A common approach in healthcare to deal with this issue is to involve children in exercise programs. Product and game designers have contributed to such exercise-based solutions, in particular in the form of *exergames* – games that require a certain level of exertion from the child (e.g. see Janssen et al., 2017; Sinclair, Hingston, & Masek, 2007). Exergames are particularly useful for therapeutic purposes (e.g. setting specific parameters) and may provide engaging experiences that keep children comply with the program. However, exercise programs and exergames are often structured in the exercises that they offer and the rules that are involved. This makes them less suitable for young children whose physical activity is characterized by short bouts of activity and generally occurs in the form of spontaneous and unstructured play (see Boon, Rozendaal, van den Heuvel-Eibrink, van der Net, & Stappers, 2016).

Stimulating physical activity in the form of free play, or what we refer to as *physical play*, became our primary target in the project. In the design process, two directions emerged. One was inspired by the concept of 'loose parts' – objects that can be moved and manipulated in children's play (Daly & Beloglovsky, 2015; Nicholson, 1971). Examples of loose parts are leaves, branches, pinecones, and pebbles that children may find in a park, but also screws, buttons, toothpicks or paper clips fall within this category. Common to loose parts is that they do not dictate a particular purpose or use to the playing child, leaving room for their imagination and creativity. The concept of *Stickz* was based on this idea: Stickz form a collection of large branch-shaped objects that invite to be carried and dragged around and that afford a variety of play activities (Figure 1). A second direction was inspired by Gibson's observation that the "richest and most elaborate affordances" are provided by animals of which the movements are spontaneous and self-initiated, or *animate* (Gibson, 1979, p. 135). We designed such animate qualities into an everyday toy, namely a ball. This resulted in Fizzy: a pro-active robot ball who's behavioural repertoire invites children to playfully interact with it and who's shape invites playing with it as a ball (Figure 2).

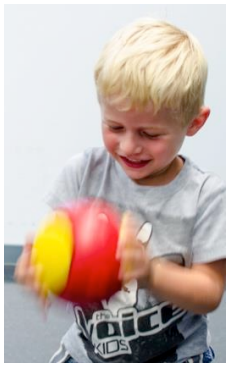

Figure 1 (left) Child constructing with Stickz. Figure 2 (right) Children running after Fizzy and Fizzy shaking wildly.

Below we describe the concepts in more detail. By reflecting on our fieldwork in hospital settings, we show how the prototypes of Fizzy and Stickz gave rise to ambiguity and open-endedness and how this contributed to stimulating physical activity. The intentions behind both designs are summarized in Table 1, distinguishing the underlying motivation or aim of the designs, the target

behaviour that was thought to contribute to this aim, and the primary means (in particular, product characteristics) that were initially expected to contribute to this behaviour.

Table 1 Design intentions behind Stickz and Fizzy

	Stickz	**Fizzy**
Motivation	Stimulating young children's physical development, in particular when this development is threatened by disease and treatment	
Target behaviour	Physical play: physical activity in the form of spontaneous and unstructured play	
Means	Collection of large, loose and branch-shaped objects, inviting gross motor activity during pretend- and constructive play	Ball with behavioural repertoire, inviting children to follow it around and engage in ball play (e.g. throwing, kicking, rolling)

4.1 Stickz

Stickz is a collection of soft branch-shaped objects that affords physical play through their sheer size and weight, in combination with their transportability. They are a translation of the sticks children may find in forests and parks, with which they can engage in pretend play (e.g. stick as sword) or as construction material (e.g. building a hut). Prototypes of Stickz were introduced to a semi-public waiting area in the hospital. In total, 21 children between the age of 2 and 7 years old participated in the study, including 12 boys and 9 girls, resulting in 3 hours and 32 minutes of playtime that was recorded on video and analysed. Children consisted of 17 childhood cancer patients and 4 siblings.

4.1.1 Openness and directionality in Stickz

Stickz were primarily ambiguous in terms of their relation to their context. Parents and children were often referring to Stickz as a forest or branches. Some parents and staff members referred to the Stickz, or interactions with Stickz, as messy (e.g. a physiotherapist says to a child "You're making a mess of it!"). The Stickz seemed somewhat out of place in a hospital environment that is normally more structured and organized. This ambiguity sometimes gave rise to hesitation to initiate interaction. For example, when a boy asked his mother what Stickz were, she told him it was art, and continued to move along. A second way in which Stickz gave rise to different interpretations was through their shape; these were interpreted in various ways during children's pretend play. Children used Stickz as guns, water guns, walking sticks, or pretending they are a character, such as a giant spider. Stickz were open-ended by giving rise to various play activities (e.g. pretend play, constructing, colour sorting). However, this effect was limited as constructing was the predominant activity that children engaged in. Despite this predominance, children could self-direct their play within the activity of constructing and pursued a variety of goals (e.g. building a hut, apple tree, or constructing for the sake of constructing). See Table 2 for a summary of Stickz' role in giving rise to ambiguity and open-endedness.

To a large extent, children were physically active through the collecting of Stickz and subsequent activities of constructive play. Both these types of activities required full body movements of the children. Children had to lift, carry and place large Stickz, requiring continuous exertion of the trunk and leg muscles for stability while walking. Collecting also occasionally involved throwing the Stickz from a distance. While constructing, children were often walking around the construction to decide upon where to place the next Stick. As constructions were built, children walked around or crawled underneath them; this, however, took up relatively little time. Scattered loose Stickz were sometimes used in a functional and experimental way: they invited various swinging and balancing movements. Some forms of pretend play with Stickz were intensive, involving running around, shooting at each other, and falling on the floor.

We suggest ambiguity and open-endedness in the interactions with Stickz contributed to children's physical activity in two ways. First, open-endedness of constructive play activities resulted in

children engaging with Stickz for a relatively long time. During this time, children engaged in collecting and carefully placing Stickz, involving physical activity in the form of lifting, transporting and placing. Also other activities required such exertion, as Stickz were often first collected beforehand (e.g. first collecting and then sorting according to colour). A way in which Stickz' ambiguity contributed to physical activity was by affording a particular kind of pretend play that involved running, using Stickz as pretend guns. A way in which ambiguity of Stickz seemed to discourage physical activity, was by being too unfamiliar or out of context, as reflected in interpretations of Stickz being art. To conclude, open-endedness in combination with the shear size and weight of the Stickz gave rise to multiple courses of action that resulted in a variety of physical activities. Ambiguity of shape resulted in playing with Stickz as pretend objects, such as a vacuum cleaner, gun or walking stick; these activities particularly involved locomotion.

Table 2 Characteristics of Stickz and Fizzy that explain ambiguity and open-endedness in interactions

	Stickz	**Fizzy**
		
Ambiguity	Stickz are messy and seem out of place in a slick and sterile hospital environment. Stickz, due to their shape, leave room for multiple interpretations.	Fizzy can be interpreted both as ball and creature. Fizzy's behaviour can be interpreted in multiple ways.
Open-endedness	Stickz afford multiple activities, such as constructive play, play fighting, pretend play, etc. In constructive play, Stickz allow a variety of constructions to be built. In pretend play, Stickz allow a child to play out various narratives	Fizzy affords multiple play activities, such as ball play and creature play. In ball play, Fizzy affords rolling, kicking and throwing. In creature play, children can explore and engage with Fizzy in their own way (e.g. following, keeping captive)

4.2 Fizzy

Fizzy is a pro-active robotic ball that invites physical play through its behavioural repertoire. It wiggles to get attention, rolls away when it is approached, shakes heavily when it is caught or picked up, and purrs when it is caressed. Fizzy was designed as a stimulating agent, creating space for young children's physical play in the confines of a patient room. Ideally, Fizzy invites the child to leave the room and meet other Fizzy's and children throughout the hospital. A Wizard of Oz prototype of Fizzy was introduced to children during planned visits in patient rooms. In total, 7 children between the age of 3 and 6 years old participated in this study, including 3 girls and 4 boys, resulting in 3 hours and 2 minutes of playtime that was recorded on video and analysed. All children were childhood cancer patients.

4.2.1 Openness and directionality in Fizzy

Children attached various meanings to Fizzy during play. The two main roles of Fizzy were that of a *ball* and that of a *creature*. These two roles disclosed a variety of play activities, ranging from throwing, rolling and kicking the ball towards one another (role of *ball*), to following, catching and caressing Fizzy (role of *creature*). Children easily shifted from one role to another in an almost continuous stream of play activities. Other roles that Fizzy played were that of a sensory object, used

for sensing and massaging, and a technical object, used for examination and experimentation (e.g. weighing Fizzy or theorizing about Fizzy's functioning). Another level of ambiguity emerged as children engaged with it as a creature. Children speculated or gave different interpretations of the meaning of the wiggling (e.g. "It's saying 'No, I'm not coming!'"), shaking ("He doesn't want to be caught!" or "That feels funny!"), purring (e.g. "He farted!" or "He's purring like a cat!" and "He really likes this [stroking]…") and rolling away behaviour (e.g. "Where does he want to go?" or "Bad ball!"). See Table 2 for a summary of Fizzy's role in giving rise to ambiguity and open-endedness.

For most children, Fizzy triggered various interactions that resulted in different forms of physical activity. Children crawled, walked and ran while following or chasing Fizzy throughout the patient room. Other common activities were rolling, kicking, or throwing the ball to one another. Some parents mentioned that their child had been exceptionally active. For example, a father expressed how his daughter had been "more active than the last four days [in the hospital] altogether!" For the older children (5-6 y/o) Fizzy was often too slow to be able to get away from the child, which resulted in less following behaviour, and subsequently less locomotor activity.

We suggest ambiguity and open-endedness in the interactions with Fizzy contributed to children's physical activity in three interrelated ways. First, the fact that Fizzy had a variety of roles attached to it, resulted in a rich diversity of successive play activities. This diversity of activities, involving both active and passive forms of interacting, kept the play engaging over a longer period. Second, the dominant roles of Fizzy stimulated physical activity: Fizzy as creature stimulated following and subsequently locomotion (walking, crawling, and running), whereas Fizzy as ball invited ball play that involved projection and catching (throwing, kicking, and rolling Fizzy towards one another). Third, Fizzy's pro-activeness resulted in curiosity and attention of the child, keeping the child engaged and inviting him or her to play.

5 Openness and directionality: a multi-level perspective

The above design cases illustrate that ambiguous and open-ended products can lead to intended behavioural outcomes. Furthermore, Fizzy and Stickz show that qualities of openness can *enhance* behavioural outcomes: the designs engaged children by offering multiple interpretations and they resulted in multiple courses of action that involve physical activity. Below we draw on Activity Theory to explain our findings, and show how openness and directionality occurred simultaneously in the interactions with Fizzy and Stickz.

Activity Theory offers an approach to interaction design that understands technology use in the context of human *activities*. Activities are viewed as being hierarchically structured, consisting of the *activity* itself*,* the *actions* that contribute to the activity, and the *operations* required for the activity and actions (Kaptelinin & Nardi, 2006, pp. 62–64). Activities concern the *motives* of people – i.e. the objects that excite or stimulate the subject. In play, the motive of the activity is located in the activity itself (e.g. playing hide and seek, for the sake of playing hide and seek). Actions are instrumental to activities, and are *goal-oriented* (e.g. selecting a suitable hiding place in order to decrease the likelihood of being spotted). Operations are routine processes that are oriented towards the *conditions* for action (e.g. running towards the hiding spot and changing to a squatting position).

Interesting for our purposes is that the hierarchical structure of activity allows us to view *openness and directionality as working on different levels.* With this multi-level perspective we can explain our findings with Fizzy and Stickz as follows: on the level of activity interactions were more open; children interpreted the designs in different ways over time (e.g. Fizzy as ball or as creature) and consequently engaged in many different play activities (e.g. ball play and creature play). On the level of actions, interactions were open as well: a variety of actions were possible within the activities (e.g. in creature play, following Fizzy, keeping it enclosed or trying to catch it). On the operational level, however, interactions were more directed towards physical activity: following Fizzy implies locomotion and trying to catch it requires additional coordination and agility. To summarize, while

children could self-direct on the level of activity and action, many of these activities and actions required gross motor operations (see Figure 2).

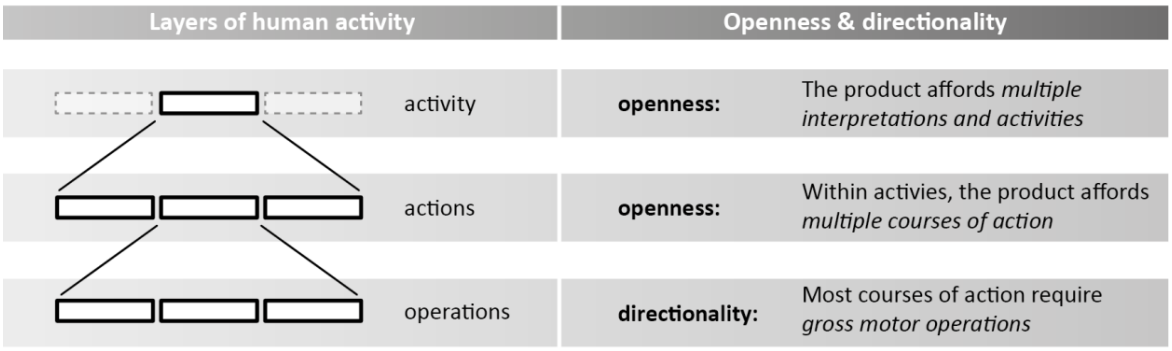

Figure 2 Interactions with Fizzy & Stickz are open on the level of activity and actions, and directed at the level of operations. The left part of this figure is adapted from Kaptelinin & Nardi's (2006) depiction of the hierarchical structure of activity.

6 Discussion and conclusion

This paper has shown that intended behavioural outcomes can be achieved and even reinforced by ambiguous and open-ended interactions with products. In one case with Stickz, we found that ambiguity might also work counterproductive by discouraging initial interactions. Overall, however, Fizzy and Stickz invited children to play, giving rise to various interpretations and play activities, while also stimulating children's physical activity. We explained our findings by drawing on Activity Theory: by conceptualizing behaviour as *multi-layered activity*, we showed how Fizzy and Stickz were directional on the operational level and ore open on the level of action and activity.

A central question is whether our findings are applicable to other contexts. An obvious limitation of our study is the fact that the design cases were concerned with stimulating children's physical activity in the form of free play – a phenomenon that is inherently open in terms of meaning making and possibilities for action. For other phenomena or target behaviours ambiguity and open-endedness might be less appropriate qualities. For example, driving behaviour is restricted by many rules and requires clear information for the driver. As mentioned earlier, in these kinds of urgent or risky situations ambiguity and open-endedness will probably work counterproductive. The same goes for formal or sombre settings or for end users who cannot easily bring about a state of creativity or spontaneity.

Another reason to question the generalizability of our findings is concerned with the *level of specificity* of the target behaviour. Physical activity as target behaviour is relatively broad; there are many different ways of being physically active, as illustrated in the interactions with Fizzy and Stickz. This makes an open approach to behavioural design quite appropriate and feasible. Other target behaviours can be more specific, for example, by being related to a specific product. When a designer is set to redesign a toilet button in order to increase water saving behaviour, applying ambiguity and open-endedness might not be of much help. The concepts might be better applicable in systems approaches to designing for change that move beyond individual products and users and shift the focus to, for example, social practices (Kuijer & de Jong, 2012) or ecologies (Mazé & Redström, 2008).

Future steps can shed light on some of the above limitations and on the scope within which designing for ambiguity and open-endedness makes sense. In particular in design for physical activity and non-sedentary behaviour we see possible applications. Two existing concepts point out the potential merits of this direction. The SweatAtoms system (Khot, Mueller, & Hjorth, 2013) gives 3d printed feedback to users about their physical activities, based on heart rate. One of their ideas is depicted in Figure 2, in which the feedback comes in the form of what might be perceived as an elegant flower-like ornament. At the same time, the data is still recognizable and interpretable in the

3d printed object. This dual role potentially gives rise to various meanings that users attach to it. SweatAtoms do not only allow for multiple interpretations, but are, in potential, extremely open-ended: users are given the space to experiment in everyday life to change their physical activity patterns. A second example is “The End of Sitting” by artist Barbara Visser and studio RAAAF in the Netherlands (see Figure 4). This concept for a work environment encourages changing work position and posture. The workspace as a whole is a perfect example of open-endedness, offering many possibilities for different postures, while being directional in discouraging sedentary behaviour (i.e. sitting and remaining in a single posture for a long period of time).

Figure 3 (left) SweatAtoms by Khot et al. (2013). Figure 4 (right) The End of Sitting by Barbara Visser and Studio RAAAF; photo by Jan Kempenaers. Both images are reprinted with permission.

Besides the potential of open-endedness and ambiguity in designing for physical activity, we are unsure about their application in other behavioural domains. We have particular interest in the direction of Design for Sustainable Behaviour, as this domain deals with behaviours of which the effects are less tangible and less embodied for end users, linking to more systemic and abstract issues such as climate change. Ambiguity, open-endedness, or other qualities of openness might prove to be relevant in facilitating more sustainable behaviours while simultaneously offering engaging experiences and respecting end user’s autonomy. To conclude, this paper has shown an alternative approach to behavioural design that reconciles directionality of the designers and appropriation by end users. We hope this contribution invites designers and design researchers to explore possibilities for openness to contribute in their behavioural domain of interest.

Acknowledgements: The work presented in this paper is part of the research project “Meedoen=Groeien!” – a collaboration among the Dutch Rehabilitation Fund, Princess Máxima Center for pediatric oncology, and Delft University of Technology. The Dutch Friends Lottery finances this project. We would like to thank Marry van den Heuvel-Eibrink (Princess Máxima Center for pediatric oncology) and Janjaap van der Net (Wilhelmina’s Children’s Hospital) for their contributions to the study. Furthermore, we thank Richard Bekking at idStudioLab for his technical support in building the Fizzy prototype.

7 References

Boon, B., Rozendaal, M., van den Heuvel-Eibrink, M. M., van der Net, J., & Stappers, P. J. (2016). Playscapes: A design perspective on young children’s physical play. In *Proceedings of IDC 2016 - The 15th International Conference on Interaction Design and Children*. http://doi.org/10.1145/2930674.2930713

Daly, L., & Beloglovsky, M. (2015). *Loose Parts: Inspiring Play in Young Children*. St. Paul: Redleaf Press.

de Valk, L., Bekker, T., & Eggen, B. (2015). Designing for social interaction in open-ended play environments. *International Journal of Design*, *9*(1), 107–120.

Desmet, P. M. A. (2015). Design for mood: Twenty activity-based opportunities to design for mood regulation. *International Journal of Design*, *9*(2), 1–19.

Fogg, B. J. (2003). *Persuasive Technology: Using Computers to Change What we Think and Do*. San Francisco: Morgan Kaufmann Publishers.

Gaver, W. W., Beaver, J., & Benford, S. (2003). Ambiguity As a Resource for Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 233–240). New York, NY, USA: ACM. http://doi.org/10.1145/642611.642653

Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.
Hallnäs, L., & Redström, J. (2001). Slow technology - Designing for reflection. *Personal and Ubiquitous Computing*, *5*(3), 201–212. http://doi.org/10.1007/PL00000019
Hassenzahl, M., Eckoldt, K., Diefenbach, S., Laschke, M., Lenz, E., & Kim, J. (2013). Designing moments of meaning and pleasure. Experience design and happiness. *International Journal of Design*, *7*(3), 21–31.
Höök, K. (2006). Designing familiar open surfaces. *Proceedings of the 4th Nordic Conference on Human-Computer Interaction: Changing Roles*, (October), 242–251. http://doi.org/10.1145/1182475.1182501
Janssen, J., Verschuren, O., Renger, W. J., Ermers, J., Ketelaar, M., & van Ee, R. (2017). Gamification in Physical Therapy: More Than Using Games. *Pediatric Physical Therapy*, *29*(1), 95–99. http://doi.org/10.1097/PEP.0000000000000326
Jelsma, J. (2000). Design of behaviour steering technology. In *International Summer Academy on Technology Studies* (Vol. 2, pp. 121–132). Graz.
Kaptelinin, V., & Nardi, B. A. (2006). *Acting with Technology: Activity Theory and Interaction Design*. Cambridge: The MIT Press.
Khot, R. A., Mueller, F. F., & Hjorth, L. (2013). SweatAtoms : Materializing Physical Activity. *Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*, 1–7. http://doi.org/10.1145/2513002.2513012
Kuijer, L., & de Jong, A. (2012). Identifying Design Opportunities for Reduced Household Resource Consumption: Exploring Practices of Thermal Comfort. *Journal of Design Research*, *10*(1/2), 67–85.
Laschke, M., Diefenbach, S., & Hassenzahl, M. (2015). "Annoying, but in a nice way": An inquiry into the experience of frictional feedback. *International Journal of Design*, *9*(2), 129–140.
Lockton, D., Harrison, D., & Stanton, N. A. (2010). The Design with Intent Method: A design tool for influencing user behaviour. *Applied Ergonomics*, *41*, 382–392.
Mazé, R., & Redström, J. (2008). Switch! Energy ecologies in everyday life. *International Journal of Design*, *2*(3), 55–70.
Moran, T. P. (2002). Everyday adaptive design. *Proceedings of the Conference on Designing Interactive Systems Processes, Practices, Methods, and Techniques - DIS '02*, 13–14. http://doi.org/10.1145/778712.778715
Nardi, B. A., & O'Day, V. L. (1999). *Information Ecologies: Using Technology with Heart*. Cambridge: The MIT Press.
Nicholson, S. (1971). How NOT to Cheat Children: The Theory of Loose Parts. *Landscape Architecture*, *62*, 30–34.
Rozendaal, M., Vermeeren, A., Bekker, T., & de Ridder, H. (2011). A Research Framework for Playful Persuasion Based on Psychological Needs and Bodily Interaction. In *Human Behavior Understanding* (pp. 116–123). Berlin: Springer-Verlag.
Sengers, P., & Gaver, B. (2006). Staying open to interpretation: engaging multiple meanings in design and evaluation. *Proceedings of the 6th Conference on Designing …*, 99–108. http://doi.org/http://doi.acm.org/10.1145/1142405.1142422
Seok, J., Woo, J., & Lim, Y. (2014). Non-finito products: a new design space of user creativity for personal user experience. *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems*, 693–702. http://doi.org/10.1145/2556288.2557222
Sinclair, J., Hingston, P., & Masek, M. (2007). Considerations for the Design of Exergames. In *Proceedings of the 5th International Conference on Computer Graphics and Interactive Techniques in Australia and Southeast Asia* (pp. 289–295). New York, NY, USA: ACM. http://doi.org/10.1145/1321261.1321313
Stappers, P. J. (2007). Doing Design as a Part of Doing Research. In R. Michel (Ed.), *Design Research Now: Essays and Selected Projects* (pp. 81–91). Basel: Birkhäuser Basel. http://doi.org/10.1007/978-3-7643-8472-2_6
Tromp, N., Hekkert, P., & Verbeek, P.-P. (2011). Design for Socially Responsible Behavior : A Classification of Influence Based on Intended User Experience Nynke Tromp , Paul Hekkert , Peter-Paul Verbeek. *Design Issues*, *27*(3), 3–19.
Verbeek, P.-P. (2005). *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. University Park: The Pennsylvania State University Press.
Waelbers, K. (2011). Doing Good with Technologies: Taking Responsibility for the Social Role of Emerging Technologies. *Philosophy of Engineering and Technology*, *4*.
Wever, R., van Kuijk, J., & Boks, C. (2008). User-centred design for sustainable behaviour. *International Journal of Sustainable Engineering*, *1*(1), 9–20. http://doi.org/10.1080/19397030802166205
Winter, C., Müller, C., Brandes, M., Brinkmann, A., Hoffmann, C., Hardes, J., … Rosenbaum, D. (2009). Level of Activity in Children Undergoing Cancer Treatment. *Pediatric Blood & Cancer*, *53*(3), 438–443.

About the Authors:

Boudewijn Boon is a PhD candidate in design research, interested in designing for change and applying and improving research through design methodology. His publications fall in the domains of design for health and sustainable living.

Marco Rozendaal is assistant professor of Interaction Design. In his work, he explores new interaction design paradigms engendered by emerging technologies, such as the IoT and AI, to understand their social opportunities and ethical implications.

Pieter Jan Stappers is professor of Design Techniques, focusing on tools and techniques to support designers in the early phases of the design process. His publications focus on the topics of user research, especially 'contextmapping', and research through design methodology.