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Ross, P.R.; Wensveen, S.A.G.

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Designing Behavior in Interaction: *Using Aesthetic Experience as a Mechanism for Design*

Philip R. Ross* and Stephan A. G. Wensveen

Department of Industrial Design, Eindhoven University of Technology, Eindhoven, the Netherlands

As design moves into the realm of intelligent products and systems, interactive product behavior becomes an ever more prominent aspect of design, raising the question of how to design the aesthetics of such interactive behavior. To address this challenge, we developed a conception of aesthetics based on Pragmatist philosophy and translated it into a design approach. Our notion of Aesthetic Interaction consists of four principles: Aesthetic Interaction (1) has practical use next to intrinsic value, (2) has social and ethical dimensions, (3) has satisfying dynamic form, and (4) actively involves people's bodily, cognitive, emotional and social skills. Our design approach based on this notion is called 'designing for Aesthetic Interaction *through* Aesthetic Interaction', referring to the use of aesthetic experience as a design mechanism. We explore our design approach through a case study that involves the design of intelligent lamps and outlines the utilized design techniques. The paper concludes with a set of practical recommendations for designing the aesthetics of interactive product behavior.

Keywords – Aesthetic Interaction, Behavior Design, Design Approach, Dynamic Form, Ethics, Industrial Design, Innovation.

Relevance to Design Practice – This paper presents a design approach that helps design aesthetics of interactive product behavior and reach innovation in interactive product design.

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Introduction

Aesthetics is essential to Industrial Design. The concept of aesthetics in design is often related to the nice looking shape of a product, a trendy color scheme, or a pleasant surface texture. It is also commonly viewed as a way to express a socio-cultural message, e.g., a specific lifestyle, through the use of form and material (Muller, 1997). Such notions of aesthetics have a strong and fruitful tradition in Industrial Design, but the field is changing. Products are becoming ever more networked, adaptive, context-aware and pro-active as envisioned by Aarts & Marzano (2003) and we increasingly integrate such intelligent technologies into our everyday lives. An essential characteristic of intelligent products and systems is that they portray behavior in interaction. Designing such products and systems requires an aesthetic that goes beyond traditional static form aspects. It requires a new language of form that incorporates the dynamics of behavior. There is more to this than simply giving form to the behavior of these devices. Human-product or human-system interaction is reciprocal, with multiple parties behaving and influencing each other. If a device behaves in a specific manner, a person may respond in a specific manner and vice-versa. Aesthetics should cover this interplay since a beautiful product is of little use if it elicits unpleasant, inappropriate, ugly or even inhumane interactions. We argue that once we start designing the aesthetics of *interactive* behavior, a social and ethical dimension is introduced as well. The work of Verbeek (2005) on Technological Mediation shows that the way a device behaves influences a person's response to it. Ling (2004) vividly describes how the adoption of mobile phones changed the way we manage our social relations, for example. In the context of highly integrated Ambient Intelligent products and systems, their impact on everyday life is not trivial and to assess what influence is desirable, ethical considerations come into play. The way we want our products and systems to influence us is in the end an ethical consideration, a matter of values. In our view, aesthetics can be a powerful design driver that helps connect dynamic form, social and ethical aspects. To explain why we think aesthetics can have this power, we turn to the philosophical tradition called Pragmatist Aesthetics (Shusterman, 2000).

Pragmatist Aesthetics

Central to Pragmatist Aesthetics is the aesthetic experience. There is no final definition of what an aesthetic experience is because according to Dewey this experience is impossible to describe accurately with words (Shusterman, 2000, p. 55). However, a number of principles can be outlined that characterize the Pragmatist approach to aesthetics. Firstly, for Pragmatists, the aesthetic has practical use, next to intrinsic value. This means that although an aesthetic experience is valuable in itself, it is

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***Corresponding Author:** p.r.ross@tue.nl

instrumental in daily practice as well. An aesthetic experience 'invigorates and vitalizes us' and thus helps us achieve the ends we pursue (Shusterman, 2000, p. 9), much like singing a song helps workers perform hard labor. Secondly, the aesthetic experience of an object cannot be understood without its socio-cultural context. An object's meaning and value change with the constantly altering context of experience, between cultures, between persons and even within persons. Thirdly, form is inextricably linked with the aesthetic experience. This form is not seen as static spatial relations, but as a 'dynamic interaction of elements' (Shusterman, 2000, p. 7). Form in an aesthetic experience has 'deep … roots in organic bodily rhythms and the social conditions which help structure them' (Shusterman, 2000, p. 199). An example is the way the experience of tempo in music can be related to heart rate. Dewey characterizes the 'satisfying form' of an aesthetic experience in several ways. He gives one characterization with the terms 'cumulation, tension, conservation, anticipation, and fulfillment' (Shusterman, 2000, p. 7). Fourth, the Pragmatist argues that the whole human being is actively involved in the aesthetic experience, both the intellectual and bodily dimension. Pragmatists identify the often-ignored role of the body in aesthetics. For instance, Shusterman asks why dancing to music is not considered as an aesthetic experience.

Petersen, Iversen, Krogh, & Ludvigsen, (2004) apply Shusterman's Pragmatist Aesthetics in the design of interactive products and systems. They advocate incorporating the socio-cultural background of people in design and capitalizing on people's mind and body in interaction. Their design work aims to elicit Aesthetic Interactions, stressing the dynamic aspect of Pragmatist Aesthetics. Petersen et al. agree that aesthetics has an instrumental dimension 'related to actual human needs, values, fears, etc'. Aesthetic Interaction in their view 'promotes curiosity, engagement and imagination in the exploration of an interactive system' (Petersen et al., 2004, p. 275). Petersen et al.'s designs are directed at eliciting a special kind of interaction experience that is engaging, intriguing, invigorating and serendipitous, although the form dimension of aesthetic experience is not explicitly treated in their framework.

Dr. ir. **Philip Ross** (1978) studied Industrial Design Engineering at Delft University of Technology. In 2004, Ross started at the department of Industrial Design at Eindhoven University of Technology as a PhD candidate. During the spring semester of 2006, he was a visiting researcher and teacher at Carnegie Mellon University's School of Design in Pittsburgh, USA. He completed his PhD research on the 'Ethics and aesthetics in intelligent product and system design' in 2008. This thesis explored how to incorporate ethics in the design of intelligent systems, focusing on interactive lighting systems. Philip Ross currently works as assistant professor in the Designing Quality in Interaction group at Industrial Design in Eindhoven. He is also active in the TU/e Intelligent Lighting Institute, researching socially intelligent lighting environments. Ross was keynote speaker at DeSForM 2009 (Design and Semantics of Form and Movement conference), and gives presentations and workshops in an international context.

Dr. ir. **S. A. G. (Stephan) Wensveen** (1970) is assistant professor at the department of Industrial Design at Eindhoven University of Technology. He studied Industrial Design Engineering at Delft University of Technology, where he was one of the initiators of the ID-Studiolab design research studio. He started his research on the relationship between emotions, expressivity and product design in 1999. He gained his PhD in 2005 with his thesis, which aimed to bridge the tangible interaction, affective computing and product design communities. His thesis (co)-developed design methods and articles are part of many international design curricula. Since 2005, he has served on multiple conference review committees and was keynote speaker at DPPI'07 (Designing Pleasurable Product and Interfaces conference) and SIDeR'08 (Student Interaction Design and Research conference). His current interests are in using the power of design to integrate research, education and innovation, especially in the areas of textiles and electronics.

Our Approach to Aesthetics

Pragmatist Aesthetics covers ground that is closely related to the challenges of dynamic form and the social and ethical implications of product behavior in interaction. Our approach to aesthetics is an adaptation of the four principles of Pragmatist Aesthetics outlined in the previous section, combined with Petersen et al.'s notion of Aesthetic Interaction. The following states the resulting four central principles of our notion of Aesthetic Interaction. Aesthetic Interaction is an experienced interaction with a product or system that:

- **has practical use next to intrinsic value.** Aesthetic Interaction is rewarding in itself (intrinsically valuable), but also of practical use (instrumental). Experiencing beauty is a worthwhile experience, but only treating beauty in that way fails to do justice to its power. Norman (2002) coined the phrase 'attractive things work better' to point to the practical use of beauty in design. Moreover, beauty, or the expectation of beauty, can inspire and invite us to act, and invigorate us as Shusterman (2000) described. Designing for Aesthetic Interaction is designing for a beauty that is rewarding in itself and makes a practical difference at the same time.
- **has social and ethical dimensions.** Not everyone will find the same things beautiful. And a particular thing will give the same person an experience of beauty or not, depending on the situation. The experience of aesthetics depends on a broad range of socio-cultural factors, such as people's values, personality, situation and history (Locher, Overbeeke, & Wensveen, 2010). Since aesthetics has practical consequences, such as the power to influence our behavior, it also has an ethical dimension. Designers need to consider what kind of behaviors they want to invite with their designs.
- **has satisfying dynamic form.** Form in the dynamic sense is an inherent part of Aesthetic Interaction and differs from the traditional concept of form used in design. Form in design often relates to static aspects of products, like shape and color. Form in Pragmatist Aesthetics is dynamic and opens design up to the dynamics of product and person behavior in interaction. Designing for Aesthetic Interaction includes striving for satisfying form in the dynamics of interaction.
- **involves the whole human being.** Hummels, Djajadiningrat, and Overbeeke (2001) offer a way to involve the whole human being in design by respecting human skills. Their research identifies four main categories of human skill as relevant for interaction: cognitive, perceptual-motor, emotional and social skills. As Shusterman remarked, the experience of beauty is not limited to intellectual contemplation of beauty. This intellectual beauty is the kind one experiences when encountering an elegant mathematical proof, for example. Aesthetic experience also involves bodily skills, such as the experience of beauty that comes from mastering the technique of playing a challenging part on a musical

instrument. Aesthetic experience also involves our emotional sensitivity and state. The experience of beauty can change our emotional state, but its emergence also depends on it. It also relates to our social skills. We can experience beauty in a social interaction. The commonly used sentences 'Don't be ugly' and 'That is a beautiful thing you did' testify to this social dimension of aesthetic experience. Designing for Aesthetic Interaction in our view should respect and involve these four categories of human skills.

From Theory to Practice: *The Intelligent Lamp Case Study*

The question at this point is how designers can use these four principles of Aesthetic Interaction to create intelligent, 'behaving' products. We conducted a research-through-design case study that explored how to incorporate the four principles into design. In the study, we designed and analyzed intelligent reading lamps, attempting to implement the four principles in two ways. Firstly, the lamps were given a goal beyond only giving light. We aimed to design lamps that invited Aesthetic Interactions that related to specific values (principle 2). Secondly, we created a new design approach that used the experience of Aesthetic Interaction as a tool for exploration. The next sections explain this case study in more detail and treat the utilized design techniques.

The Design Goal for the Lamps

We took Aesthetic Interaction as the design goal for our intelligent reading lamps. The lamps we set out to design would not only give reading light, but would also invite Aesthetic Interaction. Principle 2 states that Aesthetic Interaction has a social and ethical dimension, involving, among other things, people's values. We decided to use human values (Schwartz, 1992) to characterize the interactions we wanted to elicit with the lamps. Human values are defined as follows: 'Values (1) are concepts or beliefs, (2) pertain to desirable end states or behaviors, (3) transcend specific situations, (4) guide selection or evaluation of behavior and events, and (5) are ordered by relative importance' (Schwartz, 2004). Examples of values are Creativity, Helpfulness and Social Power. We sought to design intelligent lamps that would invite, for example, helpful, creative or socially powerful behaviors from the people interacting with them as well as providing reading light.

Design Approach

We felt that we needed a new design approach to infuse design activity with the four principles. We stated in the four principles that Aesthetic Interaction involves practical use, dynamic form, social and ethical implications, and involves the whole human being. A traditional technique like sketching would not be optimal for exploring dynamic form (principle 3). One could involve dynamic form by making dynamic animations, but such a design technique would not live up to principle 4, which seeks to involve the whole human being. An animation would not reach the richness of the physical world and it would not allow the human being to apply their full perceptual-motor skills. Last but not least, as Frens (2006) remarks, interaction is too rich and complex to explore with any non-interactive medium. These considerations brought us to devise a new design approach that we call Designing for Aesthetic Interaction *through* Aesthetic Interaction. The approach consists of three concrete steps:

- Step 1: Creating behaviors through acting out choreographies.
- Step 2: Specifying behavior in dynamic form language.
- Step 3: Implementing dynamic form in experiential prototypes.

These steps are only briefly described in the current paper. A more detailed account of each step is available in Ross (2008). The description of each step ends with reflection on how it fits the four principles of Aesthetic Interaction.

Step 1. Creating Behaviors through Acting Out Choreographies

As stated earlier, behavior in interaction is too rich and complex to design on a static medium like paper. Already in this first step, we worked in an experiential way and aimed to involve the four kinds of human interaction skills (principle 4) in the design process. We asked professional dancers, specialized in modern improvisational dance, to participate in this step. Dancers can be socially and emotionally expressive in using their body and have the vocabulary to reflect on what they do with their bodies in terms of form (principle 3). We conducted an experiment in which the dancers acted out intelligent lamps and created the behaviors we were looking for in interaction with participants. In other words, we gave the dancers the same goals we set for our to-be-designed intelligent lamps. We designed light objects for the dancers that were adjustable in brightness and that could be easily to attach to the body so that they would feel like part of their body (See Figure 1).

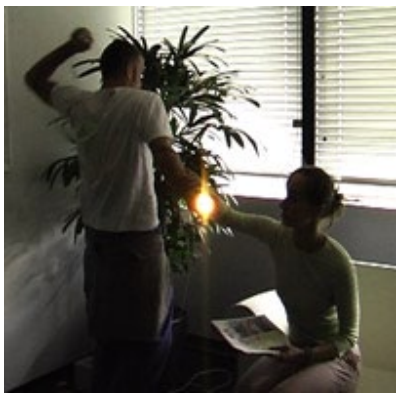

Figure 1. The dancer, standing on the left side, rehearses his strategy for interaction. The light object is attached to his right hand. He can adjust the light's brightness using his thumb, which does not interfere with the expression of the rest of his body.

The one-day experiment consisted of two parts. During the morning session, the dancers created and rehearsed their strategies for behavior. We selected a set of eight mutually contrasting values for the dancers to work with. In the afternoon, their behavioral strategies were tested with a group of participants

who interacted with the dancers and filled in a questionnaire about the interactions afterwards. Both sessions took place in a context resembling a living room, to account somewhat for social context (principle 2).

The morning session used a variation on Klooster and Overbeeke's Choreography of Interaction technique (2005). We instructed the dancers not to speak and only use their bodies as a means of interaction. The resulting dancer strategies were like 'structured improvisations'; they had a general strategy in terms of their qualities of movements, but also practiced how to fit that plan to unexpected actions of the participants without loosing the original character of the interaction.

In the following, we describe two of eight dancer behaviors using scenes from the experiment to illustrate the approach. These two strategies, which turned out to be successful in the afternoon's evaluation experiment, were created for the values Helpful and Social Power. For more details, see Ross, Overbeeke, Wensveen, and Hummels (2008).

Eliciting Social Power in Interaction

Figure 2 shows scenes from the experiment in which the dancer-lamp tries to elicit Social Power in the interaction with the participants. The dancer-lamp's social strategy was to make the participant feel powerful by taking on a humble attitude, like a servant. The dancer-lamp tried to continuously anticipate the actions of the participant and to create optimal lighting on the magazine for reading. During the entire interaction, the lamp took on a slightly bent posture to be physically subservient.

Eliciting the Value Helpful in Interaction

Figure 3 shows how the dancer-lamp elicited helpful behaviors in interaction.

Reflection in Terms of the Principles of Aesthetic Interaction

The dancers used perceptual-motor, emotional, cognitive and social skills in their creative process (principle 4: involving the whole human being). Note the contrast with a traditional technique like sketching, which makes much less use of social skills and the full body. The resulting interactions also involved the bodily and social skills of the participants. The Choreographies created by the dancers sought to elicit value-related interactions with the participants. The experiment achieved this goal in several cases, indicating the successful application of the ethical dimension of Aesthetic Interaction (principle 2). The dancers reported afterwards that the process of creating the Choreographies was particularly enjoyable (principle 1: intrinsic and practical value). They explicitly searched for a satisfying dynamic form. Their Choreographies had a beginning, middle and end, and were carefully crafted in terms of the qualities of their movement. At one point, they just 'felt right', which marked the completion of the strategy (principle 3: satisfying dynamic form).

Step 2. Specifying Behavior in Dynamic Form Language

The aforementioned experiment produced a number of product behaviors in interaction that successfully invited people to behave

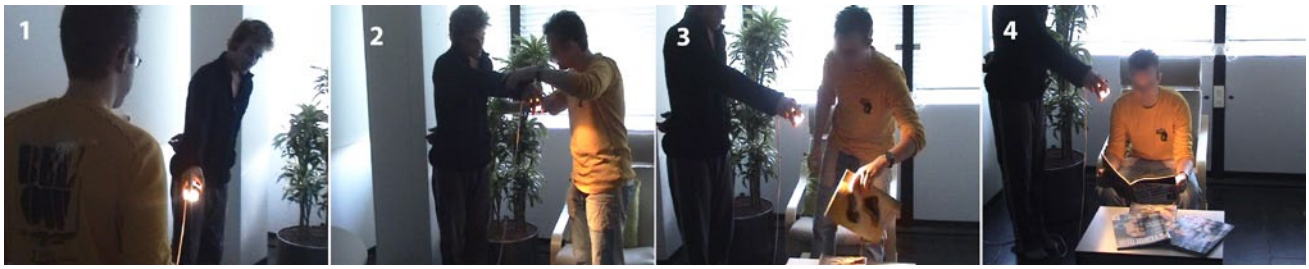

Figure 2. Scenes from the experiment show how the dancer-lamp (the dancer in black) tries to invite powerful behaviors from the participant in interaction. 1. The dancer-lamp (right person) lights the ground before the steps of the participant, anticipating where he is going. 2. The posture of the dancer-lamp (left person) is slightly inclined. It allows easy adjustment. 3. The dancer-lamp automatically highlights the magazines when the participant reaches out to select what to read. 4. The dancer follows the magazine with his light while the participant is seated, giving optimal light without the need for the participant to manipulate him.

Figure 3. Scenes from the experiment in which the dancer-lamp invites helpful behavior from the participant. 1. The participant stands in front of the dancer-lamp in this picture and reaches for the light to switch it on. 2. The dancer-lamp drops its light object, which now hangs loosely from its arm. 3. When the participant tries to reinstall the light object, the dancer-lamp becomes unstable. The participant helps keep it standing. 4. The dancer-lamp finally stands after a series of near breakdowns.

according to a specific value. We wanted to learn from these behaviors and translate them into a format tailored to the design of our intelligent lamps. The dancers used bodily expression to serve the social goal of eliciting value related behaviors from the participants. Translating these strategies into the design of interactive lamps required a translation mechanism to map behavior from one body (human) to another (lamp). We chose to focus on dynamic form—an essential element of Aesthetic Interaction (principle 3)—as the translation mechanism, but before we could describe the dancer strategies we needed to create a dynamic form language. This resulted in the Interaction Quality Framework described briefly below.

The Interaction Quality Framework

To find a dynamic form language, we turned to the world of dance and Laban Movement Analysis (Hackney, 1998; Laban & Lawrence, 1947). Laban Movement Analysis is a rich set of elements that *qualitatively* describes movements. This contrasts with a more geometrical language like Vaughan's (1997). For example, LMA does not characterize movement in terms of physical speed like Vaughan's language, but in terms of whether the movement has a leisurely character, 'Sustained Time' in LMA vocabulary, or an urgent character, 'Quick Time'. LMA can form a bridge between the 'literal' physical movements of a person or device and the social implications of this movement. For example, doing something urgently (Quick Time) or leisurely (Sustained Time) is relevant in social terms. The difference between Quick and Sustained movements is also present in the actual bodily movements. Used in this way, LMA serves as a link between form, social relevance (principle 2 and 3) and bodily expression (principle 4).

LMA is an elaborate set of qualities, some not relevant to our purpose. Our Interaction Quality Framework includes a selection of LMA qualities, supplemented with qualities that we devised for our purpose. Figure 4 shows the Interaction Quality Framework, including short explanations of the qualities. It is beyond the scope of this paper to treat the framework in detail, but it has the following main qualities:

- ***Effort*** describes the use of energy. It is 'the feeling-tone, the texture' of movement (Hackney, 1998, p. 219). An example of an Effort quality is whether a movement has Quick Time or Sustained Time, or Free Flow or Bound Flow (uncontrolled vs. controlled movements).
- ***Body*** describes how the whole body is organized (body posture), which parts are moving (Body Parts Involved) and how physical contact is made (External Connections).
- *Kinespheric Reach* gives information about the size of the movement sphere, whether it is within or outside personal space.
- ***Shape Qualities*** pertains to the shape the body makes and how this shape changes. For example, whether the body opens up to the other or closes itself off. Or whether the body advances towards the other or retreats.
- ***Initiative*** indicates who generally causes the other to move and who generally reacts to the other's movements.
- ***Interaction Dynamic Development*** describes how the energy develops in the interaction. For example, is the interaction rhythmical? Is there an increase or decrease of energy?

The framework includes three perspectives on an interaction: the behavior of the product (Product perspective), the person (Person perspective) and the unity of product and person (Unity perspective). This last view needs some clarification. In dance, it is common to regard an interaction between multiple dancers as a whole with its own expression. We apply such a view to human-product interaction. Product and a person are treated as an expressive unity, a single body that moves. Viewing them as a single body helps pinpoint interaction qualities that would normally remain unnoticed. The qualities in the framework help characterize the behavior of this unity. For example, if a person and a product turn away from each other, they open up to the environment. In the framework, this is the Opening Shape Quality.

Towards Dynamic Form Design Criteria

We used the Interaction Quality Framework to analyze the three most successful dancer-participant interactions from the Light Dancer experiment in terms of dynamic form. We translated all behavior into dynamic form for Product, Person and Unity. Four designers who had received elementary LMA training systematically undertook the translation in a rating experiment. Ross (2008) describes this experiment in detail.

We turned only the Product dynamic form into design criteria, this being easiest to control in the design process. Our intention was to design lamps that would behave with the same dynamic form (movement qualities) as the dancers they were modeled after. In the following, we will limit our treatment of this process to the product behavior inviting Helpful participant behavior.

Criteria for Inviting Helpful Behaviors

The set of criteria for lamp behavior that should invite a person to become helpful consists of 12 specific Interaction Qualities. For example, the criteria includes Sustained Time (leisurely movements), Free Flow (outpouring, fluid movements) and Causing Initiative (the lamp causes the person to move). We can see clear links between these criteria and the dancer Choreography described in Figure 3. For example, instability is present in the criteria Sustained Time and Free Flow. Asking for help causes the participant to move, which is indeed described in the Initiative criterion.

Reflection on the Principles of Aesthetic Interaction

This second step heavily emphasized the principle of satisfying dynamic form (principle 3). This emphasis was a consequence of our interest in the question how to design aesthetics of interactive product behavior. The LMA qualities link physical aspects of movement to social relevance and form, which ties into principle 4 (involving whole human being) and principle 2 (social and ethical implications). The training of the designers who did the dynamic form analysis consisted of both looking at interactions

	Interaction Effort	Body Attitude	Shape Qualities	Kinespheric Reach	Initiative	External Connections	Body parts involved	Interaction Dynamic Development	Comments
	What is the characteristic dynamic quality of movement in the whole interaction?	What is the characteristic body posture in the whole interaction?	How does the body change shape in relation to the other?	What is the reach of space around the body spanned by the movements?	Are the player's movements generally a reaction to the other player's movements or are they causing the other player to move?	What body parts are the connecting points between the two players? Note that connections can also exist without actual physical touch (tension).	List all body parts that are actively involved in interaction with the other player. Active means: - Causing the other to move - Used to initiate his/her own movements - Used by other in interaction. Note: exclude the parts used solely to interact with the chair and magazine.	Indicate how the energy develops in the interaction. Think specifically of movement and force. In drawing the line, take into account aspects like increase or decrease on the whole, smoothness or sharpness of changes, and regularity or irregularity.	Write a comment when you think an additional aspect of movement needs to be included. Or write any other remark here.
Product	Quick/N/Sustained/Alt (Time) N = Neutral Alt = Alternating: use when both qualities occur approx. an equal number of times, else make a choice.	Make a simplified drawing of the most characteristic body posture. Use a maximum of 4 lines.	Opening/N/Closing/Alt (extending away from or flexing towards the body center)	Near/Middle/Far 'Far' is approx. maximum reach possible for the body, 'near' is approx. minimum reach.	Causing/Reaction/Alternating Use 'Alternating' when an approximately equal amount of movements of this player is a reaction and a cause.	List the body parts that are used to form the connection to the other player. In case of multiple connections list multiple parts. Select from: Light/Eyes/Head/Neck/Shoulder(s)/Chest/Upper Back/Arm(s)/Forearm(s)/Wrist(s)/Hand(s)/Finger(s)/Lower Back/Abdomen/Waist/Leg(s)/Foot(Feet) Multiple entries are possible.	Select from: Light/Eyes/Head/Neck/Shoulder(s)/Chest/Upper Back/Arm(s)/Forearm(s)/Wrist(s)/Hand(s)/Finger(s)/Lower Back/Abdomen/Waist/Leg(s)/Foot(Feet) Multiple entries are possible.	Draw a line characterising the dynamic development of the interaction.	
	Strong/N/Light/Alt (Weight)		Advancing/N/Retreating/Alt (in saggital plane)						
	Free/N/Bound/Alt (Flow)		Rising/N/Sinking/Alternating (vertical plane)						
	Indirect/N/Direct/Alt (Space)		Enclosing/N/Spreading/Alt (horizontal plane)						
Person	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same options as 'Product', but applied to the person.	Same line as above, but applied to the person.	
Unity	Same options as above, but applied to unified body.	Same options as above, but applied to unified body. Make sure all elements are connected.	Same options as above, but describe the shape qualities of the unified body in relation to the target, which is the magazine.	Near (actions occur close to the center of the unified body)/Middle/Far (actions occur at maximum reach from the unified body centre)	/	/	/	Same line as above, but applied to the unified body.	

Time
quick: urgent, quick, instantaneous, staccato
sustained: leisurely, gradual, lingering, prolonging

Weight
strong: powerful, forceful, firm touch, impactful
light: airy, delicate, fine touch, buoyant

Flow
free: outpouring, fluid, released, liquid
bound: controlled, careful, contained, restrained

Space
indirect: multi-focused, flexible attention, all-around awareness, all-encompassing
direct: single-focused, channeled, pinpointed, lazer-like

Figure 4. The interaction quality framework.

and a physical movement session to get sensitive to movement qualities. As such, the activity of rating involved a rich set of human skills (principle 4). The social context (principle 2), which was the simulated living room, was kept constant for experimental reasons.

Step 3. Implementing Dynamic Form in Experiential Prototypes

In this step, we explored how to implement dynamic form criteria in the designs. Two intelligent reading lamps were designed with advanced sensing and actuating capabilities so that they had the ability to portray all three behaviors created by the dancers. The lamps were called 'AEI', designed by the first author, and 'Luxger' designed by Industrial Design bachelor student Rutger Menges. Figure 5 shows the final prototypes of both lamp designs. The lamps are research prototypes, used for testing our design approach and philosophy. They look like actual products, but are not explicitly designed for everyday use in a home. In the current paper, we only discuss the AEI lamp.

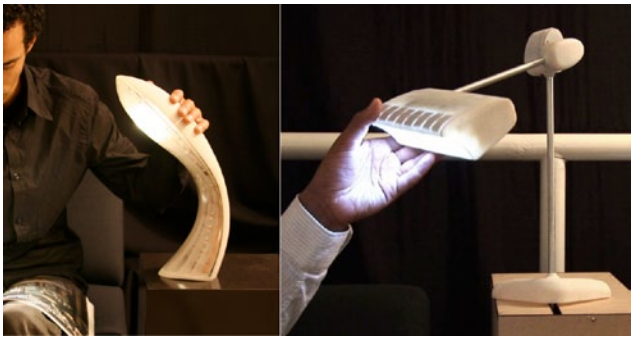

Figure 5. AEI lamp (left) and Luxger (right).

Main Steps in This Process

To account for the four principles of Aesthetic Interaction, we approached design for behavior by iteratively creating, experiencing and refining interactive prototypes in a context that resembled the targeted context. As in the dancer experiment, all aspects of Aesthetic Interaction (involvement of the whole human being, dynamic form, social implications, instrumentality) remained infused throughout the unfolding design process. Here, we can only give a very brief account of the design process, which roughly consisted of three steps:

- Creating and evaluating a 'lo-fi' experiential prototype
- Final body and sensory-motor system design
- Implementation of dynamic form criteria in behavior design.

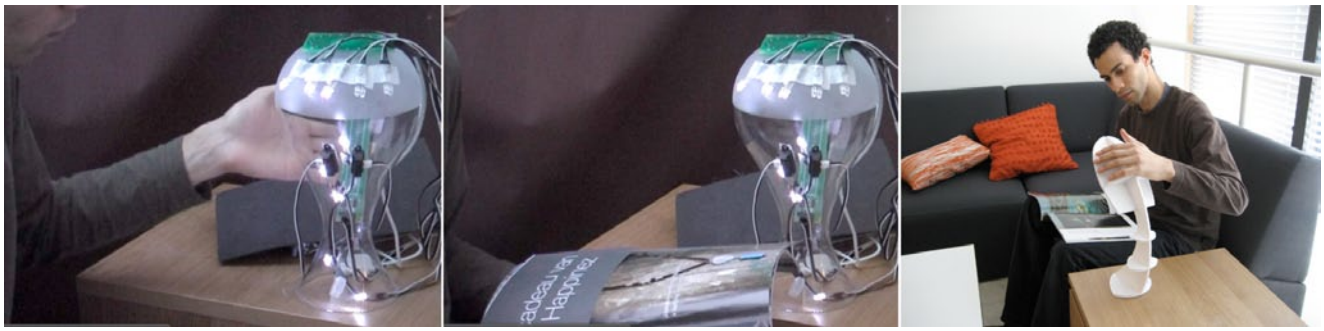

Figure 6. Left two pictures: This first lo-fi prototype of the lamp consisted of a glass vase turned upside down, equipped with touch sensors, distance sensors and LEDs. The bottom of this prototype, the reservoir of light fluid, contained LEDs that subtly faded in and out. This dynamic pattern suggested breathing, which in turn suggested life. Stroking the glass upwards or downwards moved the light fluid up or down. With the horizontal row of LEDs on top, the lamp was able to direct light to a piece of reading material in its vicinity. A set of try-out behaviors was implemented with this lamp and evaluated in an expert review in a living room lab context. Right picture: This picture shows an evaluation of the desired physical lamp form, using a cardboard model. This evaluation was also done in a living room lab context.

Figure 7. Left picture: Consecutive stages of the final lamp body design. The lamp body developed into an organic physical shape to invite and suit hand gestures on its surface. Much attention was given to the definition of the shape and its material. Right picture: The lamp body with its sensory-motor system. Its form was designed to be neutral, but versatile enough to be able to portray all three behaviors specified in the criteria. A touch sensitive area and a Power LED matrix were implemented at the back and front of the lamp respectively. The lamp also had a camera that allowed it to detect the position of nearby reading material.

The concept for the intelligent reading lamp was that of a glass container holding a 'living light liquid'. When the container is touched by a hand, the liquid moves towards the hand and sticks to that location. It radiates light beams perpendicular to the hand. By moving the hand over the container, the light from the liquid can be directed onto an object such as a book. The light liquid can also move pro-actively, choosing to direct its light onto objects in its vicinity. Figures 6 and 7 show the first two phases of the design process, i.e., creating and evaluating the lo-fi experiential prototype and the product body design.

Implementation of Dynamic Form Criteria in Behavior Design

At this point, the lamp had its final body with its sensing and actuator capabilities and some basic software functionalities. The next step was to design and detail the behaviors specified in the dynamic form design criteria. In light of our 'Aesthetic Interaction *through* Aesthetic Interaction' design approach, we aimed to involve actual experience of interaction as much as possible throughout this step. The following discusses the design process of the Helpfulness behavior to illustrate characteristics of such a behavioral design process. Ross (2008) gives a more detailed description of the design process of this and other behaviors.

Designing the Behavior Targeting Helpfulness

We start with a description of the resulting behavior. The sequence of images in Figure 8 shows the AEI lamp's behavior in interaction. To view the movie, please visit www.idemployee.id.tue.nl/p.r.ross/thesis. The lamp asks for help by showing the intention to light the person's reading material, although it cannot do so without a little push upwards from the person. The light spreads from the bottom part of the lamp and jumps up at regular intervals when a person approaches it (phrase 1 and 2). But it cannot reach the top part of the lamp, where it needs to be to light the person's reading material. On receipt of a little push upwards from the person, it eagerly follows the person's reading material (phrase 3 and 4). After a while it grows tired, falls downwards again (phrase 5) and asks again for a little help to get back up (phrase 6 to 8).

An important characteristic of the design process was the close relation between designing for dynamic form, the actual implementation using the sensory-motor system of the lamp (programming its behavior) and the social implications of the behaviors. We illustrate these relations by means of a detailed example. One of the dynamic form criteria was 'Free Flow', from the 'Interaction Effort' column in the Interaction Quality Framework, which suggested that the movements should have a fluid, outpouring character (contrasting with a fully controlled and restrained movement). The idea came up to implement this quality through a social scenario in which the light spot would eagerly try to follow a person's reading material, but it would grow tired after a while and fall downwards. Falling has a Free Flow Effort quality. To implement the quality Free Flow in this movement, the first author programmed the laws of gravity into the light spot behavior. When experiencing this gravity behavior, it turned out that the movement looked too much like a deliberate downwards movement. This gave the wrong impression in social terms; it did

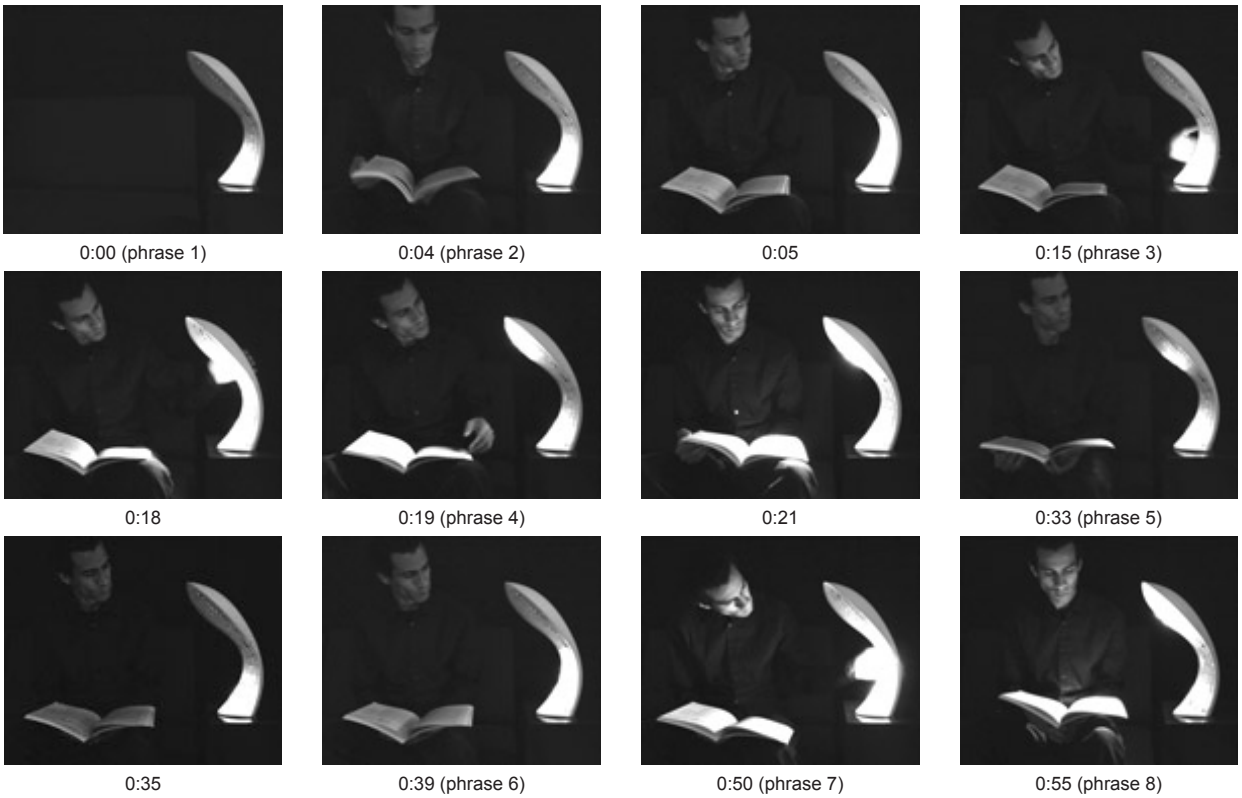

Figure 8. Snapshots of lamp behavior in interaction targeting the value Helpful. The snapshots are accompanied by a time indication in seconds and the phrase number. A film clip of this interaction is available at www.idemployee.id.tue.nl/p.r.ross/thesis.

not seem to require help. To fix this, the gravity constant in the software was decreased, which made the falling effect slower and therefore stronger. Experiencing this revised behavior inspired the idea to create the jumping behaviors described in phrase 2 of Figure 8.

This specific example shows how we moved from dynamic form (Free Flow) to an idea about social behavior (falling down out of tiredness). A sensory-motor system implementation was done first (modeling and programming the gravity). Trying this out allowed the authors to evaluate the behavior in terms of its social implications (did the movement seem intentional or not?). The experience of the behavior urged the first author to go back to the sensory-motor implementation to tweak the constants in the model.

Reflection on the Behavior Design Process in Terms of Aesthetic Interaction Principles

This design exercise taught us the extent of mutual dependence between the dynamic form level (principle 3), the Sensory-Motor Implementation level (bodily skills from principle 4) and the Social Implications level (principle 1 and 2). Continuous switching between these aspects of design characterized the process. Figure 9 providing a schematic representation of this. Iteratively experiencing implementation was an essential part of the process. This allowed the evaluation of design decisions made on one level from the perspective of the other levels. Furthermore, experiencing an implementation also brought new ideas, e.g., playing around with the light spot in the gravity mode inspired the 'jumping behaviors' in the lamp.

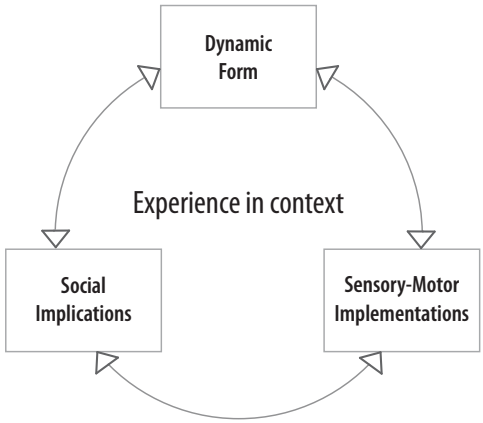

Figure 9. The mutual influence of the three levels of behavior in interaction in the design process.

Reflecting on the resulting design, we see that its interaction indeed richly capitalizes on human skills. For example, the lamp involves our bodily skills much more than traditional lamps and it asks for social sensitivity throughout the interaction. Furthermore, a rating experiment on the lamp behaviors showed that the dynamic form criteria were implemented well in the behaviors, which means the Interaction Quality Framework offers a useable form language for designers of behavior. In a lab evaluation experiment, the lamp's behavior turned out to influence interaction in social terms, but a 'causal' relation between dynamic form and values could not be quantitatively affirmed. We think that finding this relation requires long-term studies in a person's real-life context, rather than a lab context. More importantly, we can see that the design approach based on the four principles of Aesthetic Interaction resulted in innovative 'behaving' designs that invited interactions embodying these four principles.

General Conclusions

In this final section, we briefly summarize our theoretical and design approach, we reflect on the design approach and resulting designs, and translate our findings into practical recommendations for designing behavior.

Summary

At the outset of this paper, we identified two challenges for the design of intelligent products and systems: the challenge of dynamic form and a challenge of social implications. To cope with these challenges, we formulated a conception of aesthetics specifically for intelligent product design based on Pragmatist philosophy. Aesthetic Interaction principle 1 indicates that aesthetics in interaction has practical use next to being intrinsically rewarding. Principle 2 stresses the need to incorporate social and ethical implications. Principle 3 identifies the role of satisfying dynamic form. Principle 4 argues for designing for the whole human being. We devised a design approach based on these four principles. We named it *Designing for Aesthetic Interaction* through *Aesthetic Interaction* because the process leading towards the desired interaction design shares many characteristics with the desired interaction design itself. In the current paper, we focused on designing the dynamic form of product behavior.

We have presented a case study about designing the behavior of intelligent lamps to show a possible way to design behavior through Aesthetic Interaction. The case study consisted of three steps. Step 1 created behaviors through acting out choreographies. This step formulated a social goal, in this case inviting value related behaviors in interaction. Dancers created and acted out choreographies, aiming to prompt specific, value related behaviors from participants. In step 2, a language of dynamic form was developed and the choreographies were described using that form language. This made it possible to 'abstract' the dancers' behavior to enable its translation into the behavior of intelligent lamps with their totally different body. This occurred in Step 3, encompassing the building and evaluation of experiential prototypes of intelligent lamps.

Reflection on the Design Approach

Throughout the paper, we have reflected on how the activities in the separate steps related to the four principles. Each step presented a different way to turn the four principles of Aesthetic Interaction into practice, but each step shared the use of aesthetic experience as a design mechanism. Design for Aesthetic Interaction, with its bodily, cognitive, emotional, social and dynamic form implications, involves taking design decisions on each of these levels. The place where all these levels come together is in the

actual experience of interaction, which is why we ensured that experience was present as much as possible throughout the design process. In our case, even in the very beginning of the process, design was done through aesthetic experience and sensitivity by means of choreographies. In the design of the lamp's behavior, experience was a guiding principle from the beginning (lo-fi prototypes) to the end (final lamp body and behavior design). The experience of people other than the designers was present throughout the process. Each step was evaluated by having participants experience and reflect on actual interactions.

In our case study, dynamic form had a prominent role, even being used as the main criterion for designing behavior. The goal of the interactions was stated in terms of social implications, i.e., values. We could have also used the social strategies of the dancers as criterion. For example, we could have used a criterion such as 'my lamp has to invite powerful behaviors by taking on a serving attitude.' The reason we gave dynamic form such a prominent role was that a good form language for designing product behavior was not yet developed and we saw form as essential to any kind of design. This prominent role gave us the opportunity to research the role of form in designing behavior in a focused way.

We believe that the designs resulting from this approach are innovative and invite interactions that feature many aspects of Aesthetic Interaction. We hypothesize that the design approach was instrumental in achieving this result. As in any design process, the techniques used influence the outcome. It is unlikely that we could have reached *this kind* of designs by using a traditional technique like sketching only.

Reflection on the Resulting Designs

The resulting designs of the case study are research prototypes, rather than products ready for the market. The designs proved their use as vehicles for exploring how to design behavior in Aesthetic Interaction, but may be less suitable for use in a real-life context. The lamps would certainly need to be adapted in another design iteration before being ready for real-life use. In light of a Knowledge Valorization program in the Netherlands (STW Valorisation Grant, 2010), we did such iteration on the AEI lamp. We took the 'Social Power' behavior and simplified it. With help of a market research bureau, we investigated market acceptance using an online survey with 500 participants in the Netherlands and Spain. First indications are that with adaptations, the lamp has potential in the market.

Our conclusion is that the presented design approach in this paper should not be seen as a finished design process in case designing products for the market is the goal, but it can be a useful part of a larger process of innovation.

Tips for Putting the Four Principles to Practice

We conclude with a set of practical recommendations for designing product behavior in Aesthetic Interaction, based on our theoretical framework and our case study.

- **Use aesthetic experience as a design mechanism:** Try to get as close to the desired aesthetic experience as possible, from the very beginning to the very end of the design process. Behavior in interaction with its dynamic form is too rich and dynamic to design on non-interactive media like paper, or even on-screen simulations. Experiencing real interactions opens up the full richness of such real interactions. Such holistic experience provides the possibility to reflect on all levels of the design challenge. Furthermore, it is motivating to have the rewarding aesthetic experiences throughout the design process.
- **Work in the social context:** Work in context throughout the design process to get a feel for the social implications of your design already at an early stage. In our case study, we took only a limited part of the social context into account and simplified it for experimental reasons. Our second principle of Aesthetic Interaction shows that the scope of social context can be much broader, including, for example, people's history, real life situations and personality.
- **Make dynamic form explicit:** The dynamic form component in the design of interactive 'behaving' products is often overlooked. Design has a strong history of traditional, static form languages, but designing the dynamics of behavior is new. A traditional form language offers a way to make specific qualities of a design explicit. It helps analyze existing designs in terms of form, increases sensitivity to these qualities and in that way also helps in the synthesis of new designs. A dynamic form language applies to product behavior and helps analysis and synthesis in similar ways to a traditional form language.
- **Involve the whole human being throughout the design process:** There appears to be symmetry between the skills that are put into the design process and the way the resulting design involves skills in interaction. In our process, we tried to infuse all four categories of human skills in the design process from the beginning onwards. At the outset, we asked dancers to input their bodily and improvisational skills into our design process. As a result, the dancers managed to create interactions that involved the skills of the participants they interacted with in a way that fitted the design goals. In the prototyping phase of the case study, skills were used in a different way. Nevertheless, sensitivity to bodily, emotional, social and cognitive aspects was essential to evaluate and develop the prototypes. In short, designing for skills requires skills. So infuse the design process with skills.

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References

1. Aarts, E., & Marzano, S. (2003). *The new everyday. Views on ambient intelligence*. Rotterdam: 010 Publishers.
2. Frens, J. W. (2006). *Designing for rich interaction: Integrating form, interaction and function*. Eindhoven, the Netherlands: Eindhoven University of Technology.

3. Hackney, P. (1998). *Making connections* (2nd ed.). New York: Routledge.
4. Hummels, C. C. M., Djajadiningrat, J. P., & Overbeeke, C. J. (2001). Knowing, doing and feeling: Communicating with your digital products. In *Proceedings of Interdisziplinäres Kolleg Kognitions- und Neurowissenschaften* (pp. 289-308). Günne am Möhnesee, Germany: Interdisziplinäres Kolleg.
5. Klooster, S., & Overbeeke, C. J. (2005). Designing products as an integral part of choreography of interaction: The product's form as an integral part of movement. In L. M. G. Feijs, S. Kyffin, & B. Young (Eds.), *The 1st European workshop on Design and Semantics of Form and Movement* (pp. 23-55). Newcastle: Northumbria University.
6. Laban, R., & Lawrence, F. C. (1947). *Effort* (4th ed.). London: MacDonald & Evans.
7. Ling, R. (2004). *The mobile connection: The cell phone's impact on society.* San Francisco: Morgan Kaufman Publishers.
8. Locher, P., Overbeeke, C. J., & Wensveen, S. A. G. (2010). Aesthetic interaction: A framework. *Design Issues, 26*(2), 70-79.
9. Muller, W. (1997). *Vormgeven. Ordening en betekenisgeving*. Utrecht: Lemma BV.
10. Norman, D. A. (2002). Emotion and design: Attractive things work better. *Interactions, 9*(4), 36-42.
11. Petersen, M. G., Iversen, O. S., Krogh, P. G., & Ludvigsen, M. (2004). Aesthetic interaction: A pragmatist's aesthetics of interactive systems. In D. Benyon, P. Moody, D. Gruen, & I. McAra-McWilliam (Eds.), *Proceedings of the 5th Conference on Designing Interactive Systems* (pp. 269-276). New York: ACM Press.
12. Ross, P. R., Overbeeke, C. J., Wensveen, S. A. G., & Hummels, C. C. M. (2008). A designerly critique on enchantment [Special issue on experience, enchantment, and interaction design]. *Journal of Personal and Ubiquitous Computing, 12*(5), 359-371.
13. Ross, P. R. (2008). Ethics and aesthetics in intelligent product and system design. Eindhoven, the Netherlands: Eindhoven University of Technology.
14. Shusterman, R. (2000). *Pragmatist aesthetics: Living beauty, rethinking art*. Oxford: Blackwell.
15. *STW Valorization Grant* (n.d.). Retreived June 7, 2010 from http://www.stw.nl/programmas/valorisationgrant/
16. Schwartz, S. H. (1992). Universals in the content and structure of values: Theory and empirical tests in 20 countries. In M. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 25, pp. 1-65). New York: Academic Press.
17. Schwartz, S. H. (2004). Basic human values: Their content and structure across countries. In A. Tamayo & J. Porto (Eds.), *Valores e trabalho* [Values and work]. Brasilia: Editora Universidade de Brasilia.
18. Vaughan, L. C. (1997). Understanding movement. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 548-549). New York: ACM Press.
19. Verbeek, P. P. (2005). *What things do - Philosophical reflections on technology, agency, and design*. University Park, PA: Pennsylvania State University Press.