Designing for perceptive qualities: 7 showcases

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ABSTRACT
In this paper we describe seven showcases, namely ‘BeTouched’, ‘Dawe & Valle’, ‘Wonderturf’, ‘IN2WACO’, ‘Blow!’, ‘ShyLight’ and ‘PeR’, that give relevant insights on how to design for perceptive qualities in artifacts. Designing these perceptive qualities hypothetically enables a person to engage in a reciprocal perceptive interplay with the artifact: perceptual crossing between person and artifact can happen. This paper is part of an ongoing research in which we designed, built and evaluated several artifacts with perceptive qualities and in which we discovered a set of design notions. The theoretical model and the design notions involved in this research-project are introduced. The showcases illustrate and give value insights on the application of the theoretical model and the design notions.

Author Keywords
Perceptual Crossing, Research through Design, Design Showcases, Perceptive Qualities, Product Behavior

ACM Classification Keywords
H5.m. Miscellaneous.

General Terms
Design, Theory

INTRODUCTION
In our ongoing research-project we investigate how to design for perceptive qualities in artifacts. Parallel to our research several student-projects were initiated. These projects and shorter assignments are conducted around a framework of a theoretical model and a set of design notions we discovered in the ongoing research process [2]. The outcome and process of the showcases is used to get a better understanding of the model and to get insights on the relevance and extensibility [7] of the design notions. The projects give a quite broad range of installations and products that inform different aspects of the overall theory.

We picked seven showcases that are strong examples or gave strong clues on the implementation of our theoretical framework. First we present the theoretical background of the ongoing research-project and the framework: the theoretical model and accompanying design notions. Then the showcases are discussed. Note that these are student design-projects that are conducted in line with the ongoing research-project.

Theoretical Background
The theoretical departure of the research-project is the phenomenology of perception [13] and ecological psychology [10]. Especially the work of Maurice Merleau-Ponty inspired and grounded the research. He describes perception as inherently interactive and participatory. He states that perception is a reciprocal interplay between the perceiver and the perceived [1]. The hypothesis is that when attributing perceptive qualities to an artifact it can engage in a reciprocal interplay of perceiving and being perceived. This phenomenon is referred to as perceptual crossing [12,13] and is believed to be essential to get a feeling of sharing a common space, i.e., to feel involved. In simpler words: I can perceive the artifact perceives me and the artifact perceives me perceiving it. This phenomenon of, I can see you seeing me and you can see me seeing you, is very obvious between people. We investigate if and how we can design perceptive qualities in an artifact for perceptual crossing between a person and the artifact to happen and to positively influence the person’s feeling of involvement with the artifact in their common space [2]. In this common space also other events can be present and can influence the interplay between person and artifact.

It is not the aim of this paper to describe our research process. We like to show how related design-projects inform the research and illustrate its relevance and extensibility. The starting point of these design projects is the theoretical framework that we developed within the research-project. The design notions are the result of a Research-trough-Design process in which we designed and evaluated several experienceable prototypes in a controlled experiment (described elsewhere [2]). The design notions are a means of inspiration and input for the synthesis of new designs.

Theoretical Model
Figure 1 shows the theoretical model of the person (subject), the designed artifact with perceptive qualities (object), the event happening in their common space (event) and the perceptive connections between them. As one can see in the perception of the event, perception is here considered active [10] and is the result of the actions one undertakes and of the sensory feedback this results in, and
vice versa. The actions the object undertakes towards the event are part of the perceptive activity the subject perceives of the object (the dashed lines in the model). Theoretically this also works the other way around.

The perception of each other is also active. The lower lines are a simplified representation of what happens and show the reciprocal interplay, i.e., perceptual crossing, between subject and object. Figure 2 shows the two lower lines of the model presented in figure 1 in more detail. The actions the subject undertakes to perceive the object are part of the perceptive activity the object perceives. This also works the other way around (the dashed lines in fig. 2). The perception of each other crosses.

**Focus the Senses**

For living organisms it seems natural to concentrate their senses in the direction of the stimuli, e.g., you close your eyes and turn your ear in the direction of the sound as to better perceive the acoustic event. Sensing and acting are embodied. In other words, perception is active as it is a result of actions we undertake and the sensory feedback this results in, and vice versa. To design an artifact, a body, that is more than just a following entity, the idea of focusing the senses should be integrated in the artifact.

**Active Behavior Object**

By the implementations of this design notion the artifact is capable of perceptually motivated perceptive activity. If the body is just a following entity this might indicate that indeed the body is sensing and acting but it is questionable if this is a perceiving body. Perceptual crossing namely heavily depends on explorative movements and also on the ability to escape from each other’s perception [9]. Therefore the body should adopt this active, explorative behavior. The body should adopt active and explorative behavior to scan the environment. This is like living organisms that scan the environment for events, e.g., you turn your body and head to look around the room to see whether someone is there. The artifact should also adopt this explorative behavior when focusing on something. For example to experience the surface of the tabletop one will not just touch but also move one’s fingers over in an exploratory fashion. In similar way your eyes are always in action to perceive (micro-saccadic movements of the eyes). Perception is active [10,13].

**Subtleness**

The actions we undertake to perceive are smooth: we turn our head in a continuous movement to look at what is behind us. Both in the physical appearance and in the algorithm it is essential to create subtleness by taking into account this sustained continuous nature of perceptive actions.

**Reaction to an External Event**

The addition of an external event will enrich the common history the person can build with the artifact in the course of their interaction. When you interact with someone events in the environment shape and influence the interplay, e.g., music, noise, light or object can influence your interaction with someone. We found that the addition of an external event amends the course of interaction between the artifact and the person sharing a common space [2].

**Detecting Active Behavior Subject**

We are living organism showing active and explorative movements to perceive. The designed artifact should detect these movements. The artifact has to be enabled to detect active behavior of the subject to recognize one as an intentional subject rather than an object in the environment.

**Reflecting Contextual Noise**

When one is in a dialogue with someone else, one’s perception is focused on the other. However this neither
means there is no contextual sensory input, nor does it mean that one doesn’t undertake any action to get other sensory input. Especially when the sensory input reaches a certain level, for example when something makes a lot of noise or when a movement is sudden and quick one reacts to this event, so will the artifact. The sensors used in the artifact should allow for a certain level of ambiguity that adds to the aesthetics of the behavior. One should balance this reflection of contextual noise with the control one has over the design.

Course of Perception in Time
This notion refers to experience and thus to the awareness of bygone perception and the anticipation of future perception. The implementation of this notion is complex and implies that the artifact relies on history and anticipates on what could happen next. The implementation of, as it were, experience will enhance the richness of actions and expressivity of the artifact in relation to the subject’s activity.

SEVEN SHOWCASES
We are still in the process of investigating and refining the design notions. Besides our own design work in the research-project the design notions are used as inspiration and input for synthesis in related student design-projects. Trying and analyzing these experienceable showcases give us strong clues on the relevance of the design notions; moreover they provide insights on how to develop them further. Each of these seven showcases gives strong clues on how to implement the framework in an artifact through designing. Some of the cases are more complex and open new doors to reflection on system design [9] where other cases are a showcase of the aesthetics of the perceptive activity itself.

The showcases result from three different kinds of projects. Three of the cases are the result of a one-week module “Sensual Dynamics” for master students at the department of Industrial Design, Eindhoven University of Technology. In this module the students explored the sensing and acting part of perception and for example explored qualities like privacy, distance and reciprocity of perception. In a final assignment the students designed an artifact that engaged the person in a rich sensorial and active interplay with an artifact exploring such a qualities of perception.

Three other showcases are the result of a one-semester design project (14 weeks). In this project the student was introduced to the phenomena of perceptual crossing. By reading several papers and a workshop in which the student explored the design of PeP+ the student got familiar with the framework. The brief of the project was broad: the student was free to explore different aspects like applying the theory in context or exploring the aesthetics of perceptive activity.

One last showcase is the direct result of our research-project. For each showcase we will describe the artifact. After the gained insights are discussed. For each of the showcases you can find an illustrative movie on the Perceptive Qualities webpage [5].

BeTouched!
BeTouched! has been designed during the one-week module, “Sensual Dynamics”. The students that designed BeTouched! focused on the concept of ‘reciprocal touch’ and were assigned to design an artifact that could engage the person in a rich experience in which the interplay of touching and being touched is explored.

The artifact the students designed exists out of several flexible bodies. All these bodies are touch-sensitive by the integration of a capacity sensor at both the front as back of the body. They are enabled to act as they are connected to a servomotor at the bottom. Figure 3 gives an impression of the artifact.

When one of the bodies is touched on the front it really let itself been stroked. It moves forward, in the direction of your hand, you are touched back. At the backside the body is more ticklish. The body immediately moves away from your touch. When one of the bodies is being touched the other bodies will start moving to draw your attention: they also want to be touched (Active Behavior Object).

Figure 3. Impression BeTouched!
Beautiful about this artifact is that the form does most of the work. The shape and material of the body enhance the dynamics of the servomotor tremendously and give the body a continuous and sustained movement (Subtleness). This makes that it really feels that the body actively lets itself being stroked.

Sensing and acting are very strongly embodied: the sensors move along with the body (Focus the Senses). As we will see in other showcases one can also make use of a static matrix of sensors and actuators different from these moving bodies. When it is ticklish it moves away from the touch, literally getting the senses away from the hand. And when it likes to get stroked, on the front, it really moves it senses towards the hand, moving the whole length of the sensitive area along the hand.

The different bodies behave actively to show the subject they can perceive and become more active when another body is being touched (Active Behavior Object). One of the bodies broke in the process and so just lied in between the other ones. Remarkable is that also this non-functioning seems to be an active state, meaningful in a sense that it seems to actively retrieve from the interaction. This active request for attention and active participation without functioning brought us to consider the different bodies as different artifacts that together form a system. When the subject actively interacts with one of the bodies this event is perceived by the other bodies. And in their turn they are perceived as an event by the subject: asking for attention. Although it is out of scope to discuss a phenomenological approach on system design we would like to show how we analyzed the system by the theoretical model presented in figure 1. It shows how going through different iterative processes bring forward tangible, intended or not intended examples for further research.

Figure 4 proposes a first model of the system BeTouched. The separate bodies are the objects. The subject can engage in a reciprocal interplay with an object that is an event to the other objects (Reaction to External Event).

It is not that much that they perceive the subject but they perceive the act of one of them being touched. On their turn they together become an event, perceived by the subject, as they ask for attention.

Dawe and Valle
The installation Dawe and Valle is the result an individual design project in the first semester of the Master course. The installation Dawe and Valle explores the dialogue between two objects.

Dawe is a sheet made out of paper containing integrated light sensors and speakers. As these are beautifully integrated within the paper, made by the student oneself, the sensors and actuators become one body together with the paper sheet (Focus the Senses).
The opponent is Valle, a set of two bodies with a long slender limb that ends in a bigger, round shaped form that faces Dawe (figure 7). These bodies are made of paper as well. The bodies move as they hang from the ceiling attached to a servomotor. The parts facing Dawe hold a microphone. Behind Valle a bright light is placed so they create a shadow on Dawe. Figure 5 and figure 6 give an impression of the installation; figure 7 gives a descriptive overview.

Dawe produces long (musical) notes at random moments. When a change in light is detected it starts to crackle, the sound it produces becomes more evident. Valle, as it moves around, influences the sound by changing the light conditions. On its turn, when Valle picks up a peak in the volume it will jump up. Causing the light conditions to change quickly. As a result Dawe and Valle get into a dialogue that is perceivable for the subject, who therefore becomes a third participant in the interplay.

The intensity of the dialogue influences how invited the subject feels to participate. The presence of the subject in the common space is of immediate influence as the subject causes a change of light. Touching Valle or making sound will make the two bodies jump, actively responding to and inviting action from the subject (Detecting Active Behavior Subject). Very striking is that while you interact with one the other is necessarily involved.

One of the major design opportunities we see in designing perceptive qualities in objects is that subjects come to understand the intelligible connections that different systems create in our environment. Although Dawe and Valle is a quite poetic installation, it shows how the quality of dynamics and the quality of perceptive activity can be meaningful and engaging. People who tried the installation sometimes really felt they were interrupting the two in their dialogue and really needed to act to get in an active interplay with one of the two, if not both.

Figure 8 shows the theoretical model as it applies to Dawe and Valle. The perceptual crossing between Dawe and Valle is an event we can observe, in which we perceive their presence, i.e. their ability to perceive. For example, once we engage in active interplay with Dawe, Valle becomes an event, to me (Reaction to External Event).

**Figure 8. Descriptive model on the system Dawe and Valle.**

**Blow!**

The artifact Blow! is also a result of the one week design module ‘Sensual Dynamics’. The students were given the assignment to design an artifact that would engage the subject in a rich experience exploring the quality of ‘distant touch’.

The ‘reciprocity of touch’ is a more natural quality as we can only touch something because we are touchable; to touch always means to be touched. This has a very local and private character. In this assignment the students were challenged to think through technology about touch in a more open and distant form without losing the embodiment of acting and sensing and without losing the reciprocal quality of touch.

**Figure 9. Impression of Blow!**

The students designed Blow! an artifact that is able to detect the subject activity of blowing and that acts by blowing hot air itself.
The students were still developing the behavior of the artifact while the first people were interacting with it, on the spot. In first instance their design was a very reactive, not that much a perceptive entity: it would blow back at you when you blew on the sensor. Once the artifact obtained some own initiative (Active Behavior Object) the quality of the interaction immediately enriched.

Although the students did a very good attempt in reaching an experience of touching something on a distance, using air as mediator, the fact that sensor and actuator (Focus the Senses) were clearly disembodied makes that the reciprocity of this distant touch could have been stronger.

When blowing on the sensor, that is right under the actuator, the artifact will show perceptive activity by blowing back (figure 10.1).

Yet because of the placement of the sensor the air hits your forehead instead of the two streams of air (of artifact and person) actually meeting each other. If the placement of where I blow is where the artifact acts the two forces would meet. It is in this resistance that perceptual crossing would happen. In other words then I could feel the artifact touching me, even on a distance, while I’m touching it (Figure 10.2). The arrows that are presented in figure 10.2 are similar to what is described by figure 2.

**Wonderturf**

This artifact is the result of a fourteen-week individual design project conducted in the final semester of our Bachelor course. The student that designed Wonderturf explicitly explored how the theory of perceptual crossing can be applied in a more functional context or product (compared to the other discussed showcases).

Wonderturf is a pressure sensitive artificial turf. The grid of pressure sensors is used to detect activity of intentional subjects. The artifact can, for example, distinguish between people who are just wondering around or are playing soccer (Detecting Active Behavior Subject). Based on this, the artifact undertakes different actions by means of light projected on the turf.

**Figure 10. Disembodiment of the sensor and actuator (1) makes to the perception of subject and object not really cross. If the sensor would be located at the same spot as the actuator (2), perceptual crossing can happen.**

**Figure 11. Impression Wonderturf**
The perceptive body makes itself known in the form of a spot that welcomes and invites the person to actively use the turf. For a group of people it might create an outline in which they can sit. When it detects people playing with a ball it offers them a field to play on.

This artifact shows a strong concept of a context-aware and context-creating product. It touches upon the idea that if an artifact is able to detect perceptive activity of and show perceptive activity to the subject (Figure 1), the artifact and the subject are enabled to perceive intentionality. In a system like Wonderturf, it becomes evident how designing perceptive behavior can result in an interface for more than just one function or situation. Wonderturf is a dynamic interface that adapts to multiple events and to multiple users.

**IN2WACO**

This artifact is also the result of a fourteen-week individual design project conducted in the final semester of the Bachelor course. The student who designed IN2WACO focused on the aesthetics of dynamics that makes the person perceives the presence of a perceiving entity.

IN2WACO is an INflatable and INteractive WAll COvering. It is a textile with inflatable parts that act as one body. The person is detected by means of light sensors. Both sensors and actuators are placed in a static grid. The inflatable parts are controlled in sections of a few bodies. Movement in one section is depending on another and so become one body. It differs from BeTouched! in which the different bodies were clearly separate actors in the system. The student explored different relations between the sections showing the richness of the dynamic properties.

The way the air pressure is integrated makes that there is a rich palette of dynamics one can use. Blowing air in at once creates a quick and explosive movement and slowly filling the sections gives a more harmonious flow. Playing with the rhythm and direction shows the rich aesthetic possibilities of the behavior (Subtleness).

The student struggled with the placement of the sensors. First the sensors were placed next to the area of the inflatable sections. As in the example of Blow! the disembodiment of sensing and acting made the artifact merely a reactive entity, not a perceptive one. Placing the sensors in the same area completely changed the quality in interaction. Yet the embodiment of sensing and acting can be enriched.

**ShyLight**

ShyLight is also designed as part of the one week ‘Sensual Dynamics’ module. The students that designed ShyLight were given the assignment to engage a person in a rich experience with the artifact exploring the reciprocity of sight.

The artifact is a light that is able to turn in the horizontal plane. It is equipped with a webcam that can detect the presence and dynamics of people. It sets out to find movement and thus a person but if you come too close it moves away. Once you look at it, it really gets shy and the light turns off. The artifact is situated in a dark room.

The most fascinating aspect of this artifact is that when the light gets shy and turns off, it really escapes from perceiving the person (Focus the Senses). For the webcam to detect a person the light has to be on otherwise it is too dark in the room. So when the light goes off it really cannot see the person anymore. To try and see if the person is there the artifact has to turn on its light again or it can move and dare to look in a different direction (Active Behavior Object).

The integration of the webcam and actuator actually are at the basis of this embodiment of sensing and acting (Focus the Senses). They are naturally embodied as the sensor moves along with the actuator. When we want to look behind us we need to turn, which prevents us to see forward. This is, for example, different form IN2WACO and PeR (discussed after).

In IN2WACO and PeR there is a static matrix of sensors and actuators and the focus when designing perceptive behavior is more on the algorithm. However the use of a matrix of static sensors covers a wider range of design applications, as there are no moving parts. Moreover the artifact is set apart form anthropomorphic shape: the emphasis is really on the dynamic qualities (the behavior) of the artifact.

Although it is almost inescapable to use human and animal references when talking about behavior, when designing it should be about the perceptive activity and not the shape. The ShyLight incorporates a strong embodiment of sensing.
and acting but the pitfall of making an 'eye' lurks. The way the students integrated sensing and acting by turning off the light when you come to close is therefore in our opinion a far more beautiful way of embodying sensing and acting (Focus the Senses).

PeR
PeR, short for ‘perception rug’, is designed by the first author and is a direct result of the ongoing research on how to design for perceptive qualities in objects [3,4]. PeR is designed parallel to PeP, introduced in the section Design Notions. One of the reasons to design a second artifact is to show how theory can manifest in artifacts that blend into our environment.

PeR is a hand-knotted rug with integrated touch sensors and light-conducting nylon threads. PeR is a high density, high pile carpet: it invites to touch. Between the threads used for the basic rug a conducting fiber is integrated. These conductive fibers are connected to a capacity sensor and so function as a matrix of sensor areas. The nylon thread has similar properties as glass fiber and is able to transport light. The matrix of LEDs that is placed directly under the rug emits light into the nylon fiber.

PeR perceives the touch of a person and shows perceptive activity by means of a body of light. PeR can for example follow you or stay at a humble distance, when you are not interesting enough it will explore the environment (Active Behavior Object).

We think that the level of integration of textile and electronics is strong in this artifact. The aesthetics of the material and the aesthetics of the electronics really reinforce each other. Consequently in the interactive experience the light really moves in the carpet: you touch the light not the threads. In the algorithm a lot of emphasis is put on how the light adjusts its position to create a continuous and sustained movement (Subtleness).

PeR can be seen as a platform to design perceptive behavior. We played with the dynamic properties of the light body like speed, distance and direction of the light body and also with its physical properties like its shape and its size which in turn influence the dynamic properties immensely.

Figure 14. The light turns off when the person looks at ShyLight

Figure 15. Interaction with PeR
DISCUSSION
We introduced our research-project on how to design for perceptive qualities in artifacts. From the theoretical background we described the resulting theoretical model and designed a physical hypothesis, PeP. In the ongoing research we tested this hypothesis in a controlled experiment in order to generate design relevant knowledge. In the ongoing research we discovered a number of design notions relevant for designing perceptive activity in an artifact. Here we discussed seven showcases that give valuable insights on our framework of the theoretical model and the design notions. In the process of these design-project the theoretical framework is used as a means of inspiration and a tool for synthesis.

Embody of Sensing and Acting
The main aspect, appearing in several of the showcases is the embodiment of sensing and acting. Although it is not necessary that they are physically embodied, like in ShyLight, there should be a direct coupling between the two. BeTouched! and PeP are good example in which sensing and acting are well integrated. In both cases we see that the aesthetics of material and the way it is used, and the aesthetics of the electronics are well balanced and reinforce each other. In both, people feel perceived. Contradictory IN2WACO and Blow! were in their first iteration very much reactive and not perceptive. Analyzing Blow! gives very strong clues on where and how perceptual crossing can happen (Figure 10). The force of two airstreams of artifact and person make that there is a perceptive reciprocal interplay.

The object showing active behavior
We have also seen that the active behavior of the artifact itself is very much influencing if people recognize its presence: its ability to perceive. When Blow! started to show its own activity it immediately became inviting. Very strong on this aspect is the installation Dawe and Valle. The active behavior in relation to each other makes that the two engage in an active dialogue. People do not just perceive the action and reaction but people perceive the dialogue itself; they perceive the crossing between them.

Detecting the person
A lot of opportunities lie in enriching the active behavior of the artifacts detect of the subject. It is only in Wonderturf that this aspect is exploited. It becomes evident that the approach of perceiving and showing perceptive activity ultimately will enable the person and the artifact to perceive intentionality. In PeP for example different behaviors like following and staying at a humble distance are designed but these are not yet differentiated in relation to the activity of the person. One can very well imagine that stroking, hitting, touching with the tip of the finger or with the whole hand is detected by the artifact and elicits different activity from the artifact. The bodies of BeTouched show how powerful different activity can be. Making a distinction between moving towards the hand and away from the hand results in two different very meaningful behaviors.

Function and Context
Wonderturf is the only showcase discussed here that, compared to the others, brings forward a strong idea about context and function. In Wonderturf the aesthetics of the dynamics are somehow underexposed. Opposite to IN2WACO in which exploring the aesthetics is the main objective. To us it has been very valuable to get an idea of what is perceptual behavior and what is perceptual crossing between person and artifact by exploring and investigating purely the perceptual behavior without any preset function. A next step will be to move to concrete context and function. For example, we recently have been running a final master project [6] in which the theoretical model and design notions are the basis for rethinking way-finding in hospitals.

System thinking
Besides valuable insights, examples and experience of how the design notions manifest themselves we also got valuable handles for extending our theoretical model. As we are aiming on designing dynamic interfaces that adapt to multiple events, people and evolve in time we slowly move from designing for interaction between a person and a product to designing for interaction in systems. In these systems not only the connection between persons and artifacts are interactive, the connections between different artifacts are as well. We should consider the loci of interaction in such systems; both for control and to perceive what a system is capable of and for a new dynamic form language that accommodates action-centric interaction [9]. BeTouched! unintended gave very valuable insights on how our theoretical model applies to system design. Dawe and Valle show that the activity between artifacts can become very meaningful and understandable to us.

Besides the insights that are directly valuable for our research-project we also hope to show that making means trying, means experiencing, means knowing. The design-projects show the relevance and the extensibility [7] of the generated knowledge in the research-project. All these short and longer design projects are treated as valuable iterations in our Research through Design process and make this theory become affective.

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