Designing the Behavior of Interactive Objects

Marco Spadafora
Design Department, Politecnico di Milano
Milan, Italy
marco.spadafora@polimi.it

Victor Chahuneau, Nikolas Martelaro, David Sirkin, Wendy Ju
Center for Design Research, Stanford University
Stanford, USA
{vch, nikmart, sirkin, wendyju}@stanford.edu

ABSTRACT
To design proactive and autonomous interactive objects, designers deal with the design of the object's behavior. In this paper, we propose a design method, called *Personality*, to help designers develop interactive objects' behaviors with a focus on aesthetics of interaction; the method focuses on tangible and bodily interaction, and it includes four main steps. The "unguided improvisation" step consists of an initial interplay with the interactive object in order to size up the interaction; a brainstorming step, in which we use stereotypes of personalities to create metaphors, to support the discussion around, and the description of, possible behaviors; the "guided improvisation" step iterates over several improvisation sessions to act out interaction scenarios and behaviors; and the behavior synthesis step, in which we provide a final description of the object's behavior. To illustrate *Personality* we will describe the sofa-bot case study. We will report a lab study, in which we observed people reaction to the different behaviors of the sofa.

Author Keywords
Interactive object behavior; robotic furniture; aesthetics of interaction; design method;

ACM Classification Keywords
H.5.m. Information interfaces and presentation: Miscellaneous.

INTRODUCTION
Interactive objects around us are becoming more autonomous and proactive—in a way, smart. Thanks to the information they share on the web, their sensors and the developing of AI, these objects are no longer isolated, and their behavior can be increasingly dynamic [29][19][16]. Given so, the behavior of an object and the way this behavior is expressed—i.e. motion, audio, etc.—becomes extremely relevant in the definition of the overall experience that a user has interacting with the object.

TEI '16, February 14-17, 2016, Eindhoven, Netherlands

 ISBN 978-1-4503-3582-9/16/02 $15.00

DOI: http://dx.doi.org/10.1145/2839462.2839502

Designing the behavior of an interactive object requires understanding and handling a large number of variables linked to: the function of the object (*what-level*), the way the function is accomplished (*how-level*) and the way a user experiences that function (*why-level*) [7]. Traditionally HCI uses a paradigm based on "efficiency" to drive the design process, but recently integrated an aesthetics approach [3][13][18][1] as a way to design the behavior from an experiential, rather than a functional, point of view. By analyzing previous work related to the design of interactive objects' behaviors, we discovered research acting on the *how-level* [11], on the *how-level* and its relation to the *why-level* [10], a more holistic approach toward the design of an object's behavior, to create a meaningful aesthetic experience [22], and a method using a framework to describe human personality applied to robots [17].

In analyzing the work cited above, we found a lack of tools to design the behavior in a consistent way, and felt the need to define an inner logic to refer to in order to make consistent choices during the design process. We propose to extend previous methods with the use of metaphors along the design process in order to "picture" the inner logic [9]. In detail, we describe a method we have developed that metaphorically applies a human stereotype of personality to the interactive object in order to design its behavior. To describe a stereotype of personality, we used the big five personality traits [20] [5]; consequently, we ascribe those traits to the interactive object in order to describe its behavior. The method has been employed multiple times in different design groups, diverging according to people's backgrounds and years of experience in the design field. At the same time, a previous version of the method has been applied to different kinds of interactive objects, such as mobile applications and interactive lamps [27] as well as robotic sofa and drones.

In this paper, we will draw a conceptual background of the use of aesthetics of interaction in the design of the behavior of an interactive object. We will describe our method to design consistent behavior by applying stereotypes of personality. Then, we will report a case study in which we used this method to design different behaviors of the same robotic sofa. To conclude, we will describe a semi-controlled study in which we observed participants' abilities to perceive the consistency of the behaviors designed and, in general, their experience interacting with the sofa-bot.

THE AESTHETICS OF INTERACTION

Aesthetics of Interaction is a largely debated theme in the world of interaction design, over the latest few years [1][2][3][4][6][13][14][26]. The main goal of aesthetics research in this field is to overcome the "efficiency paradigm," which has largely driven the design choices in the interaction design realm for the last few decades. As a starting point, [28] underlined how the concept of efficiency and the concept of aesthetics are strongly correlated when we deal with interactive elements. As Norman would say "*attractive things work better*" [18].

When dealing with interactive objects, we deal with Pragmatist Aesthetics. This kind of aesthetics underlines "*how people experience the world dialogically as embodied subjects*" [3]. According to [23], we cannot give a definition of Pragmatist Aesthetics in words, but we can relate it to the experience that a user lives and we can identify some elements that characterize it. It has practical use and intrinsic value, in the sense that it is not just beauty in itself, but it is also instrumental. It loses its meaning without its socio-cultural context, therefore it has social and ethical dimensions. It is strictly related to form, in this case form is not a concept related to statics and physicals attributes of an object, but to dynamic aspects of the interaction which define the dialogue between object and user; it is related to the intellectual, but also to the bodily dimension of the human being, which is physically involved in the aesthetics experience [22]. Given this description of Pragmatist Aesthetics and its correlation with aesthetics of interaction, we agree with [22] saying that an aesthetics approach is more relevant nowadays that we deal with the design of "smart" interactive objects. Smart objects have characteristics such as autonomy and proactivity, which transform their behavior from static to dynamic and evolve over time, which makes even more relevant the concepts of form considered as a dynamic element of the interaction, and of the bodily dimension of the human being involved in the interaction [26].

RELATED WORK

We can state that the dynamic aspects of form defined by Pragmatist Aesthetics are a combination of intangible formal attributes of the interaction. Some researchers concentrate on the identification and definition of those attributes. Of particular relevance are works by Lim, et al. [11] [12] and Lenz, et al. [10]. Lim, et al. focused on the 2D space, and they define the formal attributes of interaction as "*interactivity attributes*." Their goal is to establish a design language for thinking and describing interaction, "*enabling designers to see and manipulate the invisible quality of the interaction.*" Lenz, et al. use the term "*Interaction Vocabulary*" to identify the set of formal attributes of the interaction that are closely related to tangible interactive objects. Their goal is not only the identification of the attributes, but also the understanding of how they relate with the experience perceived by the user. Taking inspiration by Hassenzahl [8], they distinguish between different approaches to aesthetics of interaction dealing with the *how-level* and the *why-level*. Hassenzahl defines the *how-level* as "*the concrete way interactions with the material are arranged to put functionality into action,"* such as *"turning a knob, pressing a lever, using a voice command,*" and the *why-level* as "*what makes use meaningful to people,"* such as "*feeling close to someone* or *being stimulated during a long wait."* According to their method they use the *Interaction Vocabulary* to describe and to design the *how-level* of the interaction and they demonstrate how it relates to the *why-level*, which they consider as the experiential level of the interaction. Both works by Lim, et al. and Lenz, et al. focus on interaction design in general. We argue that while using formal attributes of interaction to design the interaction with a smart object, we are actually designing the behavior of the object and how this behavior takes places.

Ross, et al. [22] have a more comprehensive approach to the design of an object's behavior; they not only consider the dynamic formal attributes of interaction, but also the other characteristics of Aesthetics of Interaction such as the social and ethical dimension and the bodily dimension. To do so, they use improvisation sessions allowing 1) an investigation of interactive objects as social entities [21] and 2) the use of body movements to sketch meaningful interactions.

The integration of different tools and the use of improvisation sessions are highlighted also in the *embodied design improvisation* technique [24]. Sirkin and Ju underline how, using embodied design improvisation, we can shape those immaterial and non verbalized aspects in the design of gestures and behaviors.

Particularly relevant is also the work by Meerbeek et al. [17] that uses the Big Five personality traits theory to describe robots' personality, in addition to a combination of design tools previously described in the other methods.

METHOD

In our design process, which we named *Personality*, we are building upon work by Ross and Wensveen [22], as well as Sirkin and Ju [24], which employs personality as a concept in designing interaction. In these approaches, the designers underline the concept of sketching interactions by using our body as a design tool through the use of "improvisation sessions," which helps to shape the bodily dimension of the aesthetics experience. However, we add to these methods the use of metaphors throughout the entire process.

As suggested by Lakoff, we use metaphors "*to understand and to experience one thing in term of another;"* by doing so we not only describe the thing, but we conceptualize it and we are able to associate to it a structure and a functioning [9]. Previous studies on how people interact with interactive objects such as proactive and autonomous robots, underline that people tend to use a metaphorical language to describe the robot. Sirkin, et al. [25] report a

high number of people associating their mechanical footstool to a pet, ether a dog or a cat, and sometimes to a little kid [21]; their consideration on this finding is that "*Robotic furniture may become its own genre, but for now, we may be in a transitional phase where people can more easily make sense of its actions by comparing it to familiar (real or fictional) interaction partners*." Building on the conceptual metaphor they create, people are able to create a mental model of how the autonomous robot will act.

Given so, as suggested by Sirkin, et al., designers should consider the metaphor in the design of a robotic object in order to facilitate people understanding the robot's behavior. In addition, we believe that metaphors are also fundamental for designers to describe, to talk and to give shape to the intangible attributes of the interaction that form the behavior of an interactive object. Metaphor has generally played an important role in the description of fuzzy ideas and therefore is a strong design tool. In traditional furniture design, metaphors are used, both in a verbal and in a graphic way—i.e. mood-board—to convey the formal attributes of an object. For example, a sentence like "*this chair is like a cloud*" carries a description of the color, the shape, the softness of the material.

The use of metaphors becomes even more important in the design of the behavior of an interactive object, given the fact that we deal with intangible attributes. Indeed we believe that metaphors can help designers to define the inner logic that drives design choices within the design process. Metaphors, created through the use of stereotypes of personalities, help the selection of the formal attributes of the interaction [10] based on a logic—the stereotype of personality—and this will help the designer to convey the experience imagined, and consequently it will facilitate the perception of a consistent behavior of the object by the user. Within the design process, we focus on the use of video to record and analyze the interaction, and to transfer knowledge developed from one step to the other [15].

Unguided improvisation

The first step of *Personality* consists of an open-ended improvisation session with the goal to size up the interaction. Every interactive object—whether it is a lamp, a sofa or a drone—is of course different by function, shape and appearance; for this reason it can elicit different kind of natural gestures and behaviors. Often those behaviors are implicit and difficult to elicit without a real interaction with the object [24]. We see as fundamental for the designer to observe people engaging in a natural interaction with a prototype better if on a 1:1 scale, and to video record the interplay. It is useful as well for the designer to engage in this activity to better understand people's movements and possible behaviors of the object; in particular it is useful to understand the physical limitation of the object such as minimum or maximum velocity of movements, degrees of freedom, etc. This knowledge will help us overcome physical limitations of the object, while designing how the object can, or should, express a behavior.

Brainstorming Personalities

As Sirkin, et al. [25] underline, we tend to build metaphors by comparing an interactive robot to a familiar entity; by looking at possible recognized cultural and social entities to refer to, we decided to work on a human stereotype of personality as a reference point [21]. Stereotypes of personalities are socially recognized and simplified descriptions of being and behaving, therefore they are ideal for designers to "picture" a consistent behavior and to associate to an interactive object; at the same time they include a certain degree of ambiguity, which allows designers to build on the description, to discuss and to brainstorm. Given so, we create a metaphor by associating a stereotype of personality to a smart object in order to design the behavior of the object itself.

We created a set of stereotypes of personality, each of which is described according to the Big Five personality traits. Each of the five traits is represented by two opposite poles: (1) openness to experience by the tendency to be *imaginative, independent, and interested in variety* versus *practical, conforming, and interested in routine*; (2) conscientiousness by the tendency to be *organized, careful, and disciplined* versus *disorganized, careless, and impulsive*; (3) extraversion by the tendency to be *sociable, fun-loving, and affectionate* versus *retiring, somber, and reserved*; (4) agreeableness by the tendency to be *softhearted, trusting, and helpful* versus *ruthless, suspicious, and uncooperative*; and (5) neuroticism by the tendency to be *calm, secure, and self-satisfied* versus *anxious, insecure, and self-pitying*. Each stereotype of personality is visualized in a card as represented in the image below (fig. 1).

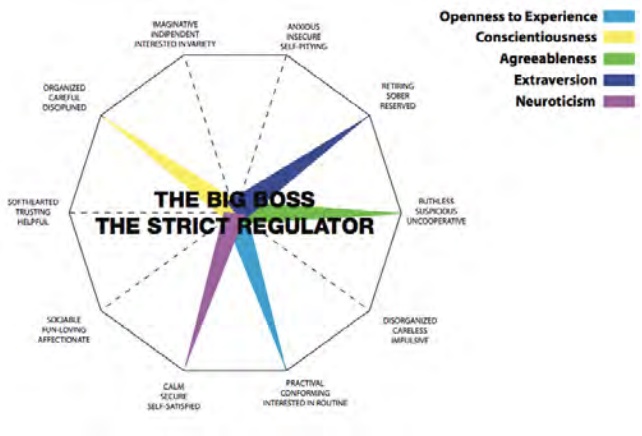

Figure 1. Each axis of the wheel represents a personality trait, every stereotype has different polarization of the same trait.

Within a brainstorming activity, we ask designers to select a stereotype of personality they want to apply to the interactive object; consequently we ask them to brainstorm and describe possible interaction scenarios and behavior of

the object according to the personality traits of the stereotype. To help the description, we suggest that participants use interactive attributes listed in the *Interaction Vocabulary* [10]. The output of the brainstorming activity should be a textual description of the behavior of the object and a series of sketched storyboards regarding how the behavior takes place.

Guided Improvisation

The brainstorming activity is followed by a second improvisation session. We defined this second session as *guided* because it consists of performing the interaction scenarios and behaviors according to the scripts and storyboards designed in the previous phase. In order to obtain the best results, we recommend involving experts such as dancers and performing artists in this activity, who can better interpret scripts and storyboards. This phase is based on a Wizard of Oz technique. Indeed we recommend dividing the design team into pairs. Within the couple, one person will be in charge of acting as the interactive object by "driving" it according to the stereotype of personality applied to it. The best option is to have a high definition prototype in order to deal with real technical constrains. The other person will interpret the user and his/her reaction to the behavior of the object.

The output of this step should be a video containing a collection of interactive moments between the object and the user. It should describe a draft of the overall behavior of the object.

Behavior synthesis

The last step of the *Personality* method is a synthesis of the information collected in the previous steps. It is made of: (1) an analysis of the general descriptive text and storyboard designed in the brainstorming phase, and (2) an edited version of the video representing relevant interactive moments between the object and the user, as they emerge from the guided improvisation session.

In our vision, this material should be sufficient as output of the design process; consequently it should be interpretable and act as a guide if the person or group generating the specifications differs from the person or group implementing it.

CASE STUDY: SOFA-BOT

To implement and refine the *Personality* method, we followed a *research through design* process, applying the method to design the behavior of a moving robotic sofa, which we called sofa-bot.

Overview

Sofa-bot is part of a larger research arc on interactive everyday objects. The main goal of the research is to understand how people interact with everyday objects that move expressively. Sofa-bot is able to move backward and forward and to rotate on its central axis. It is controlled over a distance through a web interface. The challenge to design consistent interactive behavior—expressed through the movements of sofa-bot— and the possibility to control it over a distance, made this an ideal object to apply the *Personality* method. It is important to underline that at the moment of applying the method, sofa-bot was already built and functioning as described in the following paragraphs. *Personality* was applied to design the behavior and had a minimum impact on the physical design itself, even if we consider this aspect as an important topic to eventually explore in successive researches.

System description

Sofa-bot is a regular Ikea Klippan loveseat, with the standard legs replaced by two casters and two large wheels. The wheels are attached to a power-wheel drivetrain driven by an Arduino microcontroller. The microcontroller and the on-sofa camera are connected to a single-board computer, which transmits data back and forth over Wi-Fi to the control station. The control interface consists of four basic movement buttons (go forward or backward, rotate right or left), wiggle movement buttons and speed controls.

Design team participants

The design activity took place at different moments in time, and involved a variable number of participant depending on the design phase. The main design team involved in the entire design process was composed of six experts with different backgrounds such as human-computer interaction, computer science, design methods and design management. They are trained to work together and are constantly involved in research about human interaction with autonomous robots, from cars to robotic furniture.

Setting

The design process took place in a multifunctional large space. It afforded different settings according to the kind of activity: screens and tables were used during the brainstorming, while the dimension of the space was useful for the improvisation sessions.

Activity

Unguided improvisation

In the unguided improvisation session, we simulated interactions with sofa-bot multiple times, involving people external to the design team. A typical session would be structured as follows: one of the members of the design team would take the control of the sofa, while a user was asked to interact with it to accomplish some simple tasks—e.g. drive the sofa from one place to another. The entire session was video recorded to be analyzed later on. By driving the sofa, the member of the design team was able to perceive the expressive potentiality and the limitations of the sofa-bot. In particular, we realized that was difficult to create movements such as wiggle on the central axis or a fast, short and repetitive forward/backward movement. For this reason we programmed those movements directly into sofa-bot and added two buttons on the interface to activate them. On the user side we observed the tendency to direct sofa-bot over a distance using large movements of the arms, avoiding a direct contact with it (fig. 2).

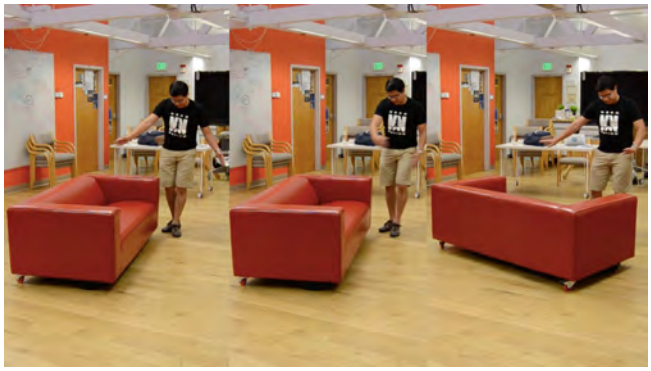

Figure 2. Images from an unguided improvisation session.

Brainstorming personalities

Brainstorming personalities and guided improvisation activities were organized for a one day workshop. During the personality brainstorm, six members of the design team were each given a card describing one stereotype of personality, as represented in Figure 1, together with a schematic representation of the *Interaction Vocabulary* [10]. The stereotypes of personality chosen for this design session were: *The Loving Parent*, *The Risk Taker*, *The Big Boss*, *The Beauty Seeker*, *The Attention Craver* and *The Model Student*. Each participant was asked develop sofa-bot according to the stereotype of personality assigned, using the Interaction Vocabulary, and to create sketches of possible interactive scenarios. This first task lasted about 20-25 minutes. A brainstorming session followed, during which each participant explained his/her description of the sofa-bot's behavior according to the selected stereotype. Other participants built upon that description and the interaction scenarios, helping to enrich them.

We discovered that it is particularly helpful to maintain a personal task during this first session, as designers need the time to familiarize themselves with the stereotype of personality. We observed some of them associating that stereotype to a real or fictional character, or recalling other stereotyped images similar to the one suggested. For example, the designer working with *The Risk Taker* stereotype of personality associated it to a poker player.

Guided improvisation

During the guided improvisations sessions, the six members of the design team worked in pairs to share the detailed description of the behavior designed for the sofa-bot and planned how to act out an interaction scenario to perform the behavior. In each session the designer of a specific behavior controlled the sofa-bot while the other member of the pair interacted with it. Other robotic experts and designers participated to the session as active audience members or third actors involved in the scenes. The entire guided improvisation session was video and audio recorded.

Each session turned into an active brainstorming moment, where designers had the possibility to share their thoughts and to shape the behavior, thanks to the insights elicited by the interaction with sofa-bot. Some behaviors of sofa-bot were enriched and better described, while other completely new behaviors emerged (fig. 3).

Figure 3. The Risk Taker Sofa-bot is slowly approaching and getting attention from a possible busy user.

The result of the session was a video collection of sofa-bot's behaviors according to each stereotype of personality.

Behavior synthesis

As last step, two members of the design team reviewed and analyzed materials collected in the previous steps. As a result, the team produced (1) a detailed textual description of the behavior according to each stereotype, and (2) a video for each stereotype with a collection of interactive moments (fig. 4). In particular, the output of the design process was represented by the design of six different behaviors of the sofa-bot according to the stereotype of personality presented in the first phase.

Figure 4. Some screen shots from the video describing the behavior of the Loving Parent sofabot.

Results and reactions

Generally designers involved in designing the different behaviors of sofa-bot through the *Personality* method commented positively the experience. They reported how using stereotypes gave them the base to concretely discuss and design the behavior. For example: "*…these allowed me to think in a concrete manner about how the personality might be expressed…*" or "*I like that the tool makes people think extreme—based on the personality prompt, you consider interactions that you might never think about….*"

In the same survey they provided suggestions on how to improve the method. Their main issue was related to the

juxtaposition of the stereotype name and the representation of the traits on the wheel. Some suggested trying an alternative version of the card in which there is only the selection of the traits and not a name associated to it. Possibly people could associate their own name to the traits and feel more confident in the use of the stereotype. Others suggested adding more flexibility to the tool, allowing designers to modify some traits of the stereotype. In a specific case, one suggested "*…to make a software tool where you could slide values for the basic traits up and down and see what personality matches pop up*…."

On one hand, adding more flexibility to the tool will allow designers to become more familiar with it; on the other hand, it can also become a way for designers to easily overcome the limitations that we believe to be essential to stimulate more wild thinking. Finding the right balance will be among the goals for the next iterations of the method.

USER STUDY ON SOFABOT

In order to evaluate the behavior designed, we decided to run a qualitative study. The main goals of the study were the following: to understand if users are able to recognize a pattern behind the behavior of sofa-bot; to verify if the users define the behavior of sofa-bot as consistent; and to attest if users are able to recognize differences between the sofa behaviors designed using different stereotypes. The study was conducted using the Wizard of Oz technique.

Participants

We recruited 13 participants from the university community and ran the study over three days. Seven of the participants were female and six were male, 11 of them between 19 and 24 years old, 2 between 55 and 60. Each session, including the interaction with sofa-bot and an interview, required an average time of 30 minutes to complete. Participants were compensated with a $12.50 Amazon gift card.

Procedure

Sofa-bot was placed in a classroom alongside other furniture usually in the venue—i.e. chairs, tables and stools—including three non-robotic caster-mounted sofas of similar appearance. The furniture in the room was set up in a fixed initial position and participants were asked to rearrange the room by moving the furniture to a final position described on a paper map. The participants were told that one piece of furniture in the room is an autonomous robot, but the specific piece of furniture was not designated. The reason for providing the participant with a task was that we wanted to create a situation in which the user's focus was not only on sofa-bot. Indeed, we wanted the user to interact directly with sofa-bot, but at the same time to collaborate with it. We mounted four overhead cameras in the room and an additional camera under the sofa to get a first-person view. A Wizard, located in an adjacent room and having access to live views of all the cameras (but not sound), controlled the sofa's movements. After the participants interacted with the sofa and arranged the room in the correct configuration according to the map, we conducted a follow-up semi-structured interview. The interview included general questions about the interaction experience and questions about the perceived behavior of the sofa. Specifically, the participants were provided a list of opposing adjectives and asked to explain whether the behavior of the sofa was biased in one direction or the other. We recorded videos from all of the cameras during the interaction and participants' voices during the interviews.

Wizard's responsibilities

The wizard controlled the sofa according to a single predefined personality for each participant. The personalities selected were: *The Risk Taker* sofa-bot, *The Big Boss* sofa-bot, and *The Loving Parent* sofa-bot. We ran an average of 4 participants for each personality. The person controlling sofa-bot was involved in the entire design process and specifically gave a strong contribution in synthetizing the results of the design process during the *Behavior Synthesis* step. He was asked to go through the final output of the design process, to familiarize with scripts and videos of each personality and to select 3 sofa-bot personalities to perform in the study. The wizard aimed to act a consistent personality among all 4 participants by following the set of behaviors while adapting to the specific interaction with the user. We asked the wizard to evaluate on a scale from 1 to 5 every time his own performance, this allowed to evaluate the user feedbacks according to how the wizard rated his performance in the specific case.

Analysis of results

Videos from the interaction between sofa-bot and participants and a collection of interviews were analyzed by four members of the design team. As a first step, two of them went through the audio from the interviews, highlighting participants' comments and quotes, and later on, together with the other two members, analyzed videos, selecting interesting interaction moments to support the results from the interviews.

DISCUSSION

The structure and procedure of the study is intended to stimulate people interacting with the sofa-bot. The setting of the room and the presence of other furniture contributed to creating a familiar environment, and participants perceived sofa-bot as an object belonging to this environment. However, there were some aspects that we believe will require further consideration in a potential, successive iteration of the study. In interviews, most participants described the interactive experience as positive, but we observed some behaviors that highlighted stressful moments. Some participants avoided interacting with sofa-bot by focusing on the task, and we observed a tendency in those cases to overuse the map, looking at it for extended periods in order to avoid direct contact with sofa-bot. Another consideration might be the selection of the participants. One thing that we observed, at first during the study and later by analyzing the data, is that people with strong technical backgrounds such as mechanical or

electrical engineering students, were very curious to understand how the object works from a technical point of view, and their interaction with the object was compromised by their tendency to solve the "enigma" they faced. Four out of the 13 participants belonged to this category. The remainder of the participants confirmed the tendency of people to perceive interactive objects as social entities [21], and consequently, they were more open to interact with sofa-bot and to perceive behaviors.

Intentionality and Consistency of the behavior

Among the participants who perceived sofa-bot as a social entity—i.e. 9 out of 13—all clearly recognized a level of intentionality in the actions of sofa-bot. Sentences like "*it was doing its own stuff*," "*it made me smile, and I thought it was doing it on purpose*" or "*is not as mature as an human being, but it is definitely independent*" support this concept. At the same time, we noticed that these same participants recognized a pattern behind sofa-bot's behavior for all the three different personalities: "*I had fun, I thought it had a personality, a fun personality*," "*pretty consistent behavior—with its own personality*," "*quickly understood what it was trying to do*." Users were able to create a mental model of the behavior of sofa-bot and this helped in their understanding how to use it and interact with it.

Perception of different behaviors

As explained before, we used three different behaviors of sofa-bot out of the six designed. As a starting point in the design output, *The Risk Taker* sofa-bot was metaphorically described as a poker player, who hides its intentions, but is trembling to act on opportunities; these are some sentences used by participants interacting with this sofa-bot personality: "*it was anxious until we got to know each other*," "*it had a pattern but was not always clear*." *The Big Boss* sofa-bot in the design output was described as pushy, with a tendency to impose itself and to give instructions. This is the way people described the behavior of sofa-bot after interacting with this personality: "*it is not listening, if it has good mood can help*," "*it challenges you*," "*it was telling me what to do, but I didn't want to listen*," "*it brought my attention on what to do, it made me redirect my focus*." *The Loving Parent* sofa-bot at the beginning was described as ready to help, able to take care, following you to make sure everything is okay. Participants interacting with it described it as follows: "*it was helping me reorganize the room," "I didn't feel alone*," "*it was following me and it agreed with what I was doing*," "*it was an assistant, an helper*," "*it had the purpose of helping me*," "*he wouldn't sit until I get everything done*," "*it observed me*." From the quotes described above, it is evident that people perceived sofa-bot in a different way according to the different behavior it was performing.

Building a relationship

One of our concerns was that people would feel frustrated by standing in front of an interactive object without knowing how to interact with it. Some participants, in detail 5 out of 13, confirmed this hypothesis by expressing their frustration both during the interview, by admitting that they didn't want to interact with sofa-bot and that they weren't able to understand how it worked, and during the performance, by clearly avoiding sofa-bot. But the majority of participants started with a feeling of frustration and sometime even fear, but ended up understanding the behavior of sofa-bot and, more importantly, this brought in same cases the creation of a strong relationship.

During the interviews, participants reported sentences like: "*we went through so much together, we became buddies*," "*I got a lot more comfortable with it*," "*I set on it because at the end we had a deeper connection*," "*I was talking to it even if I realized it wasn't listening*," "*I got to know it better and at the end I felt it was cool*," "*I felt it like a friend*," "*I think it would be a good friend, he seems kind of cool*" (fig. 5).

Figure 5. A participant sitting on sofa-bot at the end of the task to check if everything was done right. He claimed he sat on it because they built a relationship while working together.

CONCLUSION

In our research, we proposed *Personality* as a method to design consistent behavior for interactive objects. *Personality* focuses on the use of metaphors based on stereotype of personality to design the behavior. Thanks to the design of the behavior of a robotic sofa, we were able to demonstrate how the use of metaphors and stereotype of personality facilitate and enrich the design process, allowing designers to base their design choices on a strong inner logic while designing the behavior. Thanks to a qualitative study, we demonstrated that the behaviors, designed by applying the proposed method, were perceived as consistent by users interacting with sofa-bot. That is, users were able to recognize different behaviors designed according to different stereotypes of personality. As such, we believe that our method can contribute to the design of more involving and richer experiences, even if only to build on the motion capabilities of interactive objects.

ACKNOWLEDGEMENT

The authors thank collaborators Brandon Hightower, Giada Baldessarelli, Jan Auernhammer, Rebecca Currano and the Center for Design Research and d.school at Stanford University for hosting the design activities and the study. Thanks also to the interaction design community at CDR,

Bill Verplank and Aleta Hayes for their feedback on the method. This work was partially supported by the Joint Open Lab "S-Cube" Telecom Italia S.p.A. – Innovation division Italy and Stanford MediaX.

REFERENCES

1. Jeffrey Bardzell. 2009. Interaction criticism and aesthetics. *Proceedings of the 27th SIGCHI Conference on Human Factors in Computing Systems*, 2357–2366.
2. Tom Djajadiningrat, Ben Matthews, and Marcelle Stienstra. 2007. Easy doesn't do it: Skill and expression in tangible aesthetics. *Personal and Ubiquitous Computing*, 657–676.
3. Salvatore G. Fiore, Peter Wright, and Alistair Edwards. 2005. A Pragmatist Aesthetics approach to the design of a technological artefact. *Proceedings of the 4th decennial conference on Critical computing between sense and sensibility - CC '05*, 129–132.
4. Mads Nygaard Folkmann. 2010. Evaluating Aesthetics in Design: A Phenomenological Approach. *Design Issues 26*, 40–53.
5. L R Goldberg. 1990. An alternative "description of personality": the big-five factor structure. *Journal of personality and social psychology* 59, 1216–1229.
6. Lars Hallnäs and Johan Redström. 2002. From use to presence: on the expressions and aesthetics of everyday computational things. *ACM Transactions on Computer-Human Interaction 9*, 106–124.
7. Marc Hassenzahl. 2010. *Experience Design: Technology for All the Right Reasons*.
8. Marc Hassenzahl. 2011. User Experience and Experience Design. *Lecture Notes in Computer Science*, 1–19.
9. G. Lakoff and M. Johnson. 1980. *Metaphors we live by*. The University of Chicago Press.
10. Eva Lenz, Sarah Diefenbach, and Marc Hassenzahl. 2013. Exploring Relationships Between Interaction Attributes and Experience. *Proc. DPPI 2013*, 126–135.
11. Youn Kyung Lim, Sang Su Lee, and Da Jung Kim. 2011. Interactivity attributes for expression-oriented interaction design. *International Journal of Design* 5, 3, 113–128.
12. Youn-kyung Lim, Sang-su Lee, and Kwang-young Lee. 2009. Interactivity Attributes : A New Way of Thinking and Describing Interactivity. *CHI'09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 105–108.
13. Paul Locher, Kees Overbeeke, and Stephan Wensveen. 2010. Aesthetic Interaction: A Framework. *Design Issues 26*, 70–79.
14. Jonas Lowgren. 2009. Toward an articulation of interaction esthetics. *New Review of Hypermedia and Multimedia 15*, 129–146.
15. W. Mackay. 1988. Video prototyping: A technique for developing hypermedia systems. *Conference Companion of CHI*, ACM Press.
16. Stefano Marzano. 2003. *The new everyday: Views on ambient intelligence.* 010 Publishers.
17. Bernt Meerbeek, Martin Saerbeck, and Christoph Bartneck. 2009. Iterative design process for robots with personality. *... on New Frontiers in Human-Robot ...*, 94–101.
18. Don Norman. 2002. Emotion & design: attractive things work better. *interactions 9*, 36–42.
19. Donald A Norman. 2007. *The Design of Future Things*.
20. W T NORMAN. 1963. Toward an adequate taxonomy of personality attributes: replicated factors structure in peer nomination personality ratings. *Journal of abnormal and social psychology* 66, 574–583.
21. Byron Reeves and Cliff Nass. 1996. *How people treat computers, television, and new media like real people and places.* CSLI Publications and Cambridge university press.
22. Philip R. Ross and Stephan A G Wensveen. 2010. Designing behavior in interaction: Using aesthetic experience as a mechanism for design. *International Journal of Design* 4, 2, 3–13.
23. Richard. Shusterman. 2000. *Pragmatist aesthetics: Living beauty, rethinking art.* Blackwell, Oxford.
24. David Sirkin and Wendy Ju. 2014. Using Embodied Design Improvisation as a Design Research Tool. *International Conference on Human Behavior in Design*, 1–7.
25. David Sirkin, Brian Mok, Stephen Yang, and Wendy Ju. 2015. Mechanical Ottoman : How Robotic Furniture Offers and Withdraws Support. *HRI '15 Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*, 11–18.
26. Marco Spadafora, Annamaria Andrea Vitali, and Margherita Pillan. 2015. Objects are not slaves. Envisioning an Aesthetic approach to the design of interactive Smart Objects. *Cumulus Conference The Virtuous Circle*.
27. Marco Spadafora. 2015. Objects Personality a Tool to Chase an Aesthetics Approach in the Design of Smart Objects. *DeSForM 9th International Conference on Design and Semantics of Form and Movement*.
28. N. Tractinsky, a. S. Katz, and D. Ikar. 2000. What is beautiful is usable. *Interacting with Computers* 13, 2, 127–145.
29. M. Weiser, R. Gold, and J. S. Brown. 1999. The origins of ubiquitous computing research at PARC in the late 1980s. *IBM Systems Journal 38*, 693–696.