Stay on the Boundary: Artifact Analysis Exploring Researcher and User Framing of Robot Design

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ABSTRACT
In recent years, HCI researchers have increased their focus on studying the power relationships between researchers and users, and developing methodologies for eliciting design ideas that are sensitive to existing epistemic hierarchies in technology design. The differential value given to expert versus lay knowledge is a central factor in these debates. We apply Artifact Analysis, developed to help designers handle the complexity of digital artifacts, as a method to explore how experts and non-experts understand and frame robots, a technology characterized by significant complexity. Our results show that both non-expert users and expert researchers have knowledge that is significant to future robot development, but they focus on different aspects of the technology—users address mediated and interaction complexity while researchers focus on internal and external complexity. We also found that robots function as boundary objects between experts and users, and suggest that one task designers can perform is to "stay on the boundary" and mediate between the different ways in which experts and non-experts frame emerging technology to develop designs that benefit from insights from both user and researcher perspectives.

Author Keywords
Artifact Analysis; Epistemic hierarchy; Boundary Objects

ACM Classification Keywords
H.5.2 User Interfaces: Evaluation/Methodology.

INTRODUCTION
HCI researchers have recently increased their reflexive awareness of [1] and interest in the power dynamics and hierarchy among experts and non-experts as stakeholders in technology design. Users are often considered to be less knowledgeable than technology experts and are placed in passive roles as informants in the design process, rather than playing more active roles as co-designers. Researchers, in contrast, are valued for their technical knowledge and positioned as being able to provide technological solutions for users' problems. The HCI community has been developing appropriate methodologies to counter such hierarchies between researchers and users, especially in the ICT4D[4] and Co-Design literature [9]. However, few studies explore how designers can approach the design process in ways that are sensitive and critical of existing hierarchies between researchers and users while also practically apply insights from critical and social studies to the development of emerging technologies.

We use Artifact Analysis as a methodology to explore and reflect critically on the ways in which expert robotics researchers and non-expert users approach everyday robot design. We focus on robotics as a historically technology-driven field, which is increasingly turning to everyday user applications and therefore requires more diverse user input in design[7]. We particularly focus on the following questions: What knowledge do researchers and users bring to bear when discussing robots for everyday use? How do they use their interpretations to frame robot design? What stance can designers take to counter existing hierarchies between users and researchers in robot design?

This paper presents an Artifact Analysis of everyday robotic technologies performed with participants who are researchers/experts in robotics and participants who are non-experts and potential users of robotic technologies. By analyzing how users and researchers critique and categorize existing robots, we can reveal how they interpret and frame these complex digital artifacts. We further suggest that digital artifacts can be understood as boundary objects [8] that have different meanings for researchers, who interpret them as research objects, and users, who see them as everyday artifacts. Based on these results, we see one of the challenges of robot design as mediating between these perspectives and suggest designers can position themselves at the boundary between researchers and users to be responsive to existing epistemological hierarchies and to incorporate the knowledge of both groups in design.

ARTIFACT ANALYSIS OF ROBOTS

Artifact Analysis as Method
As a counterpart to user evaluations in the lab, researchers have been using ethnographic studies to observe how

CHI 2014, April 26 - May 01 2014, Toronto, ON, Canada

http://dx.doi.org/10.1145/2556288.2557395

people use technology in natural settings [2; 3] and to suggest design implications based on situated interactions (e.g., seeing a family as a group of users). However, technology designers need not only to understand the modes and contexts of technology use, but also to design objects with specific properties and shapes [5]. To address this challenge in the realm of complex digital artifacts, Janlert and Stolterman proposed Artifact Analysis as an analytical tool designers can use to contend with complexity as part of design [5]. They suggest that digital artifact complexity should be understood as composed of multiple loci of complexity. Complexity can be located and caused by internal complexity (i.e. due to the internal workings of the artifact), external complexity (i.e. due to the complexity of the interface), mediated complexity (i.e. due to the complex nature of the task or environment). The distribution of complexity between these loci, leads to an overall interaction complexity [5].

Artifact analysis was originally developed for interaction designers, but we extend it to explore how various stakeholders, namely researchers and users, frame robotics as an example of digital technology. We use the different forms of complexity[5] to categorize how our participants describe and critique robots, and to point out differences, similarities, and complementarities of their viewpoints that can inform robot design. In describing our study, we refer to participants as researchers/experts and users/non-experts, and to the broader HCI community as designers. We are specifically interested in understanding how robotics researchers with diverse backgrounds—designers, social scientists, computer scientists—and various users approach robots. While we do not generalize from our results to designers more broadly, we hope that the methodological approach will contribute to the HCI community interested in the relationship between users and researchers and in critical and collaborative methods for technology design.

Participants

The study was conducted with 6 robotics researchers/experts (male: 3, female: 3, average age: 29) and 8 users/non-experts (male: 4, female: 4, average age: 56). Participants in both groups were chosen to represent diverse backgrounds. Users included a university student in his 20s, a 40-year-old bakery worker with no higher education experience, and a nursing home resident in her 70s with a masters in design, among others. To represent the interdisciplinarity of robotics research, we recruited researchers with backgrounds in computer science, psychology, human-robot-interaction, and mechanical engineering. Although some of our researcher participants were more sensitive to user perspectives than others as a matter of discipline, our results show that as a group their views on robots differed from those of non-expert users.

Study Procedure

In line with the Artifact Analysis method, the interviews focused on picture cards depicting currently available industrial, research, or commercial robots. The task for each interviewee was to discuss and critique each picture of a robot (e.g., favorite and least favorite part, robot's possible function and use) and to group the pictures of robots based on criteria they found relevant. The visual materials and the procedures of critiquing and categorizing the robots enabled participants with different backgrounds to talk about the robots in their own terms.

Materials: Cards with Robot Images

The 27 6x6 inch cards mostly used full-body pictures of robots (26/27) with no additional textual information or context provided to minimize outside influence on user interpretations and allow participants to interpret the digital artifacts in their own terms. Most of the robots we chose (24/27) were designed for everyday use and were diverse in regards to design principles (e.g., uncanny valley [6], minimal design), level of humanlikeness (e.g., Geminoid (figure. 1: top left); Snackbot (figure. 1: top middle)), and function, such as assistive robots for elderly (e.g., Care-o-bot (figure.1: top left), education robots for children (e.g., Papero (figure 1: down left)), and therapeutic robots (e.g., Kaspar). We also included examples of 'social robots' designed for natural interaction with people (e.g., Kismet (figure 1: down middle)) and robots with different form factors, such as minimalist Muu (figure 1: down left), a robotic flower, an autonomous car, a robot ball, and industrial robots.

Figure 1. Sample cards (top left: Geminoid, top middle: snackbot, top right: Care-o-robot, lower left: Papero, lower middle: Kismet, lower right: Muu)

Task: Critiquing and Categorizing Robots

Our main elicitation strategy in the study was asking participants to critique and group the robots according to categories that made sense to them. There was no set number of groups they were asked to create. While grouping, participants compared and contrasted the robots to describe what they saw as their common properties (categories). This provided a simple yet meaningful method of understanding what participants knew about robots and how they framed them in their own mind. All participants were able to participate in and complete this task.

While we allowed the participants to discuss and categorize the robots without limitations, we did ask some questions to encourage researchers and users to think of robots in a user-centered way. We asked all participants about possible contexts of use and users for each robot as the first step in the robot critique (e.g., "Can you guess where the robot can be used, and who could use the robots?" or "What do you think the robot is for?"). Both researchers and users therefore had multiple opportunities to comment on all four forms of complexity relevant to artifact analysis, so their answers realistically would depict their framing of robots.

RESULTS

Our results show that the two groups of participants, expert robotics researchers and non-expert potential users, had different perspectives on robots and applied different forms of knowledge to the study task. The difference in the knowledge between the groups did not come from their depth of knowledge, as might be expected in comparing experts and non-experts, but from the different ways in which the two groups epistemically situated robots. Researcher comments focused on internal and external complexity, while user comments focused on interaction complexity. Even when they were explicitly asked about users and contexts of use, researchers emphasized scientific knowledge about robots rather than developing a more use-oriented perspective.

Epistemic Framing of Robots by Researchers

Researchers participating in our study generally approached robots as scientific objects developed through considerable efforts by their peers. Researchers were understandably knowledgeable about ways to manage internal complexity (e.g., which algorithms were used) and external complexity (e.g., degrees of freedom of arms) of robots. However, research participants focused less on addressing interaction complexity (e.g., what would be appropriate ways of interaction between users and technologies in actual context) and mediated complexity (e.g., possible applications and scenarios of technology use), even in cases when they were specifically asked to do so.

In our study, the technological knowledge of researchers sometimes restricted their imagination and critique of technology design. Researcher participants were familiar with most of the robots we presented through demo videos, articles, or personal experiences. Half of researchers tried to advocate for the intentions of researchers who were renowned in the robotics field, rather than critiquing them. Three researchers who had experience with robots in person discussed the robot not as an object for everyday life but as a research accomplishment. Two researchers considered the interview as a test to examine their knowledge in the field. The reaction of researcher participants shows how scientific knowledge can limit critique and creativity regarding the potential uses of robots.

Scientific distinctions also affected how researchers framed robots in relation to users. The robot car was an interesting example. Most (4/6) of the researchers felt uncomfortable calling autonomous cars robots. This artifact sparked researchers to discuss their definition of robots, as in this case of R2, who was majoring in cognitive science:

R2: Uhm … my conception of what makes a robot entirely depends on my experience. … I am not exactly sure what is responsible my own mind to create a category (of a robot). But… obviously it's shaped in such a way that I use "robot" to describe specific things, which is cultural. (a HRI researcher majored in cognitive science)

When categorizing the robots, researchers generally developed groupings based on their own research topics. A researcher (a HRI researcher majored in interaction design) studying a therapeutic robot for seniors with dementia divided robots depending on their ability to provide emotional support to users. A researcher (a HRI researcher majored in health informatics) studying facial expressions of a robot made groups based on the facial expressivity of each robot. Also, every researcher had a group of robots they placed in the uncanny valley[6] as entities that are almost-but-not-quite human- or animal-like and therefore "creepy." This category was not used by non-experts, and signifies an academic framing of robots.

Epistemic Framing of Robots by Users

Non-expert participants interpreted robots in terms of their everyday potential or imagined use. Their comments focused on the mediated complexity of robots (e.g., how humanoid robots can be used for certain purposes and tasks in specific contexts) and interaction complexity (e.g., what type of interaction are appropriate and reasonable in certain circumstances), but not on internal complexity (e.g., the internal workings of the robot) and external complexity of robots (e.g., complexity of interface). Unlike the researchers, users thought the robot car was the most useful robot. The car was familiar enough for non-experts so that they could imagine using it in their everyday life. The academic definition of robots was not important to users, rather they appreciated being familiar with the modes of interaction with a robot, so they could control the robot and understand its functions without difficulties.

All non-expert participants had one group of robots that they defined as fitting into their everyday lives, such as a domestic appliance or assistant group. Non-expert participants described applying robots in everyday life in more ways than researchers (e.g., Can you guess where and how this robot is used? What is your favorite and least favorite part considering the context?). Finding applications for robotic technologies has long been a difficulty for robotics and was even mentioned by our researcher participants as a primary concern. Non-expert participants surprised us by liking Geminoid that was considered “too humanlike” by researchers and therefore likely to be rejected by users according to the uncanny valley theory. One of our participants, a 75-year-old male nursing home resident with no technology education and no previous experience with robots, explained that a humanoid shape of Geminoid (e.g., very humanlike face) allows him to feel more in control. That does not mean he would like to interact with Geminoid emotionally, but that familiar design components can decrease interaction complexity.

DISCUSSION AND CONCLUSION

Artifact Analysis focuses on artifacts themselves with an open procedure (e.g., compare and contrast). As a method originally developed for designers, when used to explore our participants’ epistemic framing of robots, it allowed them to describe technology in ways that are meaningful to them. Thus, all participants, regardless of their knowledge level, were able to actively participate in the analysis process by using their existing knowledge about technology to develop their epistemic framing. Using artifact analysis as a method, we realized that researchers’ framing of robots can be somewhat restrictive in terms of dealing with interaction complexity, while users’ contextual knowledge allowed them to envision creative and appropriate ways of interacting with and using robots in the context of daily life. Our finding contrasts with the dominant epistemic hierarchy in robotics, which privileges professional knowledge by researchers. While the ability of users to imagine wider everyday uses of robots can be (and has been) seen as technological naiveté, we suggest it is an opportunity for reimagining the potential for future robot design. We also suggest that these perspectives provide complementary, though sometimes conflicting, material that can be further synthesized by designers.

As a result of exploring the different epistemic framings of robots by researchers and potential users, we suggest that digital artifacts can be conceptualized as *boundary objects* [8] between different stakeholders in robot design, in our case robotics researchers and users. Researcher participants situated robots within the conceptual space of *academic inquiry* first and foremost, while non-experts treated robots as objects for *everyday use*. Both perspectives are necessary to develop practical design solutions in robotics. We suggest that, by becoming aware of this difference in framing robots and the complementary expertise of users and researchers on different aspects of robot complexity, designers can bridge the gap between these perspectives and place themselves on the boundary between researchers and users. In this process, they will also have to contend with the challenge of mediating between the contradictory visions of researchers and users of robotic technologies.

Before conducting our study, we had misgivings about using Artifact Analysis as a method for eliciting non-experts’ knowledge about robots, since it is a less controlled method of study. However, all participants were capable of performing artifact analysis. Non-expert participants were in fact more open to defining appropriate interfaces for controlling robots than researcher participants, whose perceptions were sometimes limited by preconceived scientific concerns. The high possibility of miscommunication using different languages could be seen as a disadvantage of this method, but the difficulties actually helped us realize that our knowledge and ways of dealing with the complexity of robots as researchers is restricted. Consequently, we would like to suggest artifact analysis as a pragmatic way of exploring design possibilities of complex digital technologies, such as robots, in a way that shares control and responsibility in design with users and gives them a voice in conceptualizing new technologies. We also suggest that including the frameworks of users in design allow robot designers to be sensitive to and critical of existing epistemological hierarchies.

REFERENCES

1. Bardzell, S. 2010. Feminist HCI: taking stock and outlining an agenda for design. In *Proc. of CHI 2010*, ACM Press, 1301-1310.
2. Forlizzi, J. and Disalvo, C., 2006. Service robots in the domestic environment: a study of the Roomba vacuum in the home. In *Proc. of HRI 2006*, ACM Press, 258-265.
3. Grinter, R., Edwards, W.K., Newman, M., and Ducheneaut, N., 2005. The work to make a home network work. *In ECSCW 2005*, Springer., 469-488.
4. Irani, L., Vertesi, J., Dourish, P., Philip, K., and Grinter, R.E., 2011. Postcolonial computing: a lens on design and development. *In Proc. CHI 2010*, ACM Press, 1311-1320.
5. Janlert, L.-E. and Stolterman, E., 2008. Complex interaction. ACM Trans. *Comp.-Hum. Inter.* 17, 2, 1-32.
6. Mori, M., 1970. The uncanny valley. Energy 7, 4, 33-35.
7. Šabanović, S. 2010. Robots in society, society in robots - Mutual shaping of society and technology as a framework for social robot design. *IJSR* 2, 4, 439-450.
8. Star, S.L. and Griesemer, J.R., 1989. Institutional ecology, `translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Soc. Studies of Sci*. 19, 3 , 387-420.
9. Vines, J., Clarke, R., Wright, P., Mccarthy, J., and Olivier, P., 2013. Configuring participation: On how we involve people in design. *In Proc.of CHI 2013*, ACM Press, 429-438.