The Impact of the Robot Appearance Types on Social Interaction with a Robot and Service Evaluation of a Robot

Sonya S. Kwak[1]

[1] Department of Industrial Design, Ewha Womans University, Seoul, Korea

Abstract

Background Robot's appearance types could be classified into human-oriented and product-oriented. Human-oriented robot appearance resembles human's appearance whereas product-oriented robot appearance maximizes the robot's dedicated functions. In this study, we compared the two robot appearance types and investigated the impact of the two robot appearance types on perceived social presence, sociability, and service evaluation of a robot.

Methods We excuted a 2 (robot appearance types: human-oriented vs. product-oriented) within-participants experiment design (N=24).

Results Participants felt more social presence to a human-oriented robot than a product-oriented robot. Moreover, they perceived a human-oriented robot as more sociable than a product-oriented robot. On the other hand, participants were more satisfied with the service provided by a product-oriented robot than a human-oriented robot.

Conclusions We investigated the effect of the robot appearance types on robot's perceived social presence, sociability and service evaluation. Human-oriented robot appearance was effective on social interaction between a person and a robot while product-oriented robot appearance was effective on service satisfaction. Implications for design of robots in emotion-oriented situation and task-oriented situation are discussed.

Keywords Human-oriented Robot, Product-oriented Robot, Robot Appearance Types, Service Evaluation, Sociability, Social Presence

Citation: Kwak, Sonya S. (2014). The Impact of the Robot Appearance Types on Social Interaction with a Robot and Service Evaluation of a Robot : *Archives of Design Research, 27*(2), 81-93.
http://dx.doi.org/10.15187/adr.2014.05.110.2.81

Received Mar. 26. 2014 **Reviewed** : May 10. 2014 **Accepted** : May. 11. 2014
pISSN 1226-8046 **eISSN** 2288-2987

1. Introduction

DiSalvo et al. (2002) illustrated the characteristics of a robot with humanness, productness, and robotness. Robot's appearance types could be divided into two types based on these robot's characteristics (Kwak et al., 2014): Human-oriented vs. Product-oriented. Human-oriented robot appearance is designed to resemble human's appearance while product-oriented robot appearance is designed to maximize the dedicated functions of the robot.

In the field of Human-Robot Interaction (HRI), several studies have been done on the impact of the two robot appearance types on quality social interaction between a person and a robot. For example, Hegel et al. (2008) demonstrated that a human-oriented robot was more effective on joy and sympathy of a person than a product-oriented robot. Bartneck et al. (2010) found that people engaged more in emotional communication with a robot when interacting with a human-oriented robot than a product-oriented robot. These studies showed that human-oriented robot appearance is more effective for quality social interaction between a person and a robot than product-oriented robot appearance. Based on this, we state that similar results would be revealed in regards to social presence of a robot which is a critical determinant for substantive emotional engagement with a robot (Choi et al., 2014).

However, it needs to be investigated whether a human-oriented robot could also be effective in reagrds to the service evaluation of a robot. Louis Sullivan (1986) has asserted the "Form Follows Function" principle. The principle suggests that the appearance of a product should be designed based on its intended function. Based on this principle, we state that the match between the expected function derived from its appearance and the actual function of the robot could affect the evaluation from users. In the case of a human-oriented robot, since it has humanlike appearance, users could have high expectations regarding the function of a robot. However, the actual function of a human-oriented robot could not be matched to the expected function as today's robotic technology is out of reach. On the other hand, in the case of a product-oriented robot, since it has a similar form of an ordinary product with autonomous function, the actual function is likely to be matched to the expected function.

This study compared a human-oriented robot and a product-oriented robot, and explored which type is more effective on social interaction with a robot and service evaluation of a robot.

2. Related Works

2.1. Robot Appearance Types

According to the study by DiSalvo et al. (2002), robots have the characteristics of humanness, productness, and robotness. Based on the robot's charcteristics, robot's appearance types could be classified into two types (Kwak et al., 2014). One is robot appearance with emphasis on humanness which is designed to resemble human's appearance, and the other is robot appearance with emphasis on productness which is designed to maximize the dedicated functions. In this paper, we define robot appearance with humanness as a *human-oriented robot* and robot appearance with productness as a product-oriented robot. Fong et al. (2003) suggested that robots' embodiment could be categorized into four, including anthropomorphic, zoomorphic, caricatured, and functional. In our definition, anthropomorphic, zoomorphic and caricatured robot embodiments which resemble living organisms such as a human or an animal correspond to human-oriented robot appearance whereas functional embodiment which resembles the ordinary product corresponds to product-oriented robot appearance.

As many studies in the field of HRI have proposed that the resemblance of robots toward humans is essential to facilitate rich social interactions between people and robots (Breazeal, 2002; Friedman, Khan, & Hagman, 2003), many human-oriented robots have been developed, such as Kismet, Robovie, and Nexi. Kismet is developed to express emotions by facial expressions like humans (Breazeal, 1999). Robovie is a humanoid developed to communicate with people using vision and audio sensors (Ishiguro et al., 2001). Nexi is a humanlike robot which possesses human-centric communication and interaction abilities (Personal Robots Group, 2008).

Figure 1 Examples of the Human-oriented Robots

On the other hand, product-oriented robots, such as AUR, SenseChair, Shimon, and robotic drinking glasses have been developed as intelligent products that are laden with robotic technologies based on the existing products. AUR is an intelligent desk lamp which autonomously tracks people's movement and shed light (Hoffman, 2007). SenseChair is an intelligent assistive chair which perceives a user's sitting patterns and provides specific information by ambient displays (Forlizzi et al., 2005). Shimon is the robotic marimba player which interacts with people to create novel musical outcomes (Hoffman & Weinberg, 2010). Robotic drinking glasses are intelligent drinking glasses which comes closer to get filled when a user starts filling a glass and goes back to their initial position (Rey et al., 2009).

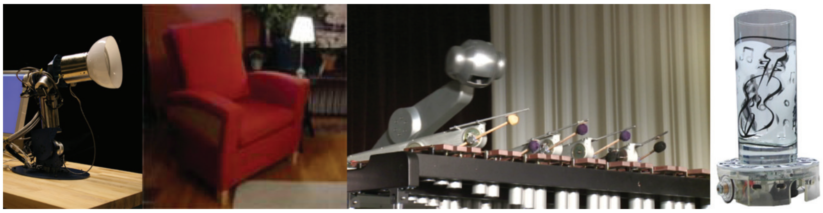


Figure 2 Examples of the Product–oriented Robots

2.2. Perceived Social Presence and Sociability of a Robot

Although the concepts of human- versus product-oriented robot appearance types were not explicitly used, a few studies investigated the effect of these two robot appearance types on quality social interaction between a person and a robot. For example, Hegel et al. (2008) has shown that a human-oriented robot was more effective in eliciting a joy and sympathy from the people who interacted with the robot than a product-oriented robot. Walters et al. (2009) has shown that people perceived a human-oriented robot as more intelligent than a product-oriented robot. Moreover, a study by Bartneck et al. (2010) showed that people were more embarrassed in medical examination when examined by a human-oriented robot than a product-oriented robot. These studies showed that human-oriented robot appearance is more effective for enriching social interaction between a person and a robot.

Social presence which has been originally defined as the concept of being with another social being (Heeter, 1992) could lead people to substantively engage in communication with a robot (Heeter, 1992; Choi et al., 2014). As social presence plays a significant role in user's social response toward the machine (Lee & Nass, 2006), the impact of the robot appearance types on social presense needs to be investigated.

Recent study by Kim et al. (2014) explored the impact of robot appearance types on social presence of robots and intention to donate in motivating donation situation. The results showed that people felt more social presence and were more willing to donate to a human-oriented robot than a product-oriented robot. Since Kim et al. (2014) found that a human-oriented robot was more effective for increasing social presence when motivating donation, we believed that social presence of a human-oriented robot would also be perceived higher than a product-oriented robot when providing household services. In addition, according to Heerink et al.'s study (2008), the amount of perceived social presence of a robot is related to the amount of perceived sociability of a robot. These analyses led to the following hypotheses:

H1. A human-oriented robot is perceived as having more social presence than a product-oriented robot.

H2. A human-oriented robot is perceived as more sociable than a product-oriented robot.

2.3. Service Evaluation of a Robot

Although previous studies showed that a human-oriented robot is more effective for quality social interaction between a person and a robot than a product-oriented robot, it needs to be investigated whether the similar results would be obtained in regards to the service evaluation.

In the field of industrial design, many researchers have debated the issues of what determines the form of a product (Crilly et al., 2008; Crilly, Moultrie, & Clarkson, 2009). The principle of "Form Follows Function" by Louis Sullivan (1896) gives an answer to this matter. It states that the appearance of a product is determined by the objective of the product: to deliver a certain function or benefit. The principle asserts that the appearance of a product should be designed based on its intended function (Nasar, Stamps III, & Hanyu, 2005). From this perspective, in the case of a human-oriented robot, its humanlike appearances could yield user's high expectations regarding the function of a robot. However, as today's robotic technologies could not fully imitate the behaviors of humans, the actual function of a human-oriented robot is not likely to be matched to the expected function, resulting in the user's negative evaluations. On the other hand, in the case of a product-oriented robot, as it is designed focusing on the deliverance of dedicated functions by applying autonomy to the ordinary product, the actual function is likely to be matched to the expected function. This will result in receiving a positive feedback from consumers.

Kwak et al. (2014) demonstrated that product-orieted robot was more effective for consumers' evaluation and purchase intention toward a robot than a human-oriented robot. Thus, we predict that the service provided by a product-oriented robot will be more accepted by users than that provided by a human-oriented robot. These analyses led to the following hypothesis:

H3. A product-oriented robot is evaluated higher on service evaluation than a human-oriented robot.

3. Study Design

In order to examine the effect of the two robot appearance types on people's acceptance of a robot, we used a 2 (robot appearance types: a human-oriented robot vs. a product-oriented robot) within-participants experiment design.

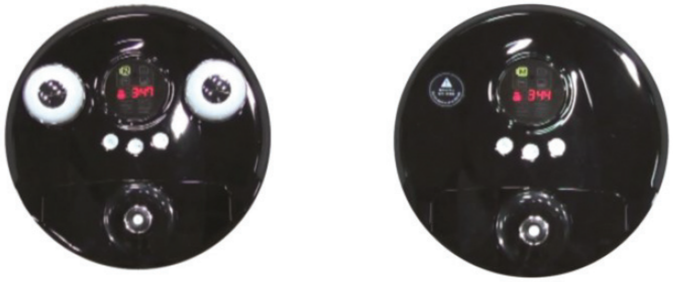
3.1. Participants

Twenty-four university students or graduate students (10 male and 14 female) who have high technology acceptance participated in the study.

3.2. Materials

As a vacuum cleaning robot is one of the most successful and the longest available domestic robots in market (Sung et al., 2008), a vacuum cleaning robot, Iclebo from Yujin Robot was used in the experiment. The robot can-navigate the place autonomously and provide a cleaning service.

The independent variable, the robot appearance types, was manipulated by attaching robot eyes. In a human-oriented robot appearance condition, a vacuum cleaning robot with two eyes was shown to the participants. In a product-oriented robot appearance condition, a vacuum cleaning robot without eyes was shown to the participants as shown in Figure 3. The other components were the same across the conditns.



a) b)

Figure 3 Robot Stimuli (a: Human-oriented, b: Product-oriented)

3.3. Procedure

Participants were welcomed to the lab and were shown a video clip of either a human-oriented robot or a product-oriented robot, in random order. The vacuum cleaning robot, Iclebo was introduced in the beginning of the video. After the short introduction, the robot started cleaning the classroom. During cleaning the classroom, the robot could not clean the classroom completely due to the furniture, and it asked help from the user as shown in Figure 4. After participants saw a video, a questionnaire for each stimulus was administered. They evaluated a robot's impressions and service.

Figure 4 Scenarios (a: Human-oriented, b: Product-oriented)

3.4. Measures

The post experimental survey was composed of 12 Likert-type items, which were combined into three scales. The three scales were social presence, sociability, and service evaluation.

Social presence was an index of four items, which were drawn from Heerink et al.'s research (2008). The four items were "When interacting with a robot, I felt like talking to a real person," "It sometimes felt as if a robot was really looking at me," "I can imagine a robot to be a living creature," and "Sometimes a robot seems to have real feelings." Participants indicated their answers on 7-point Likert scales ranging from "Yes" to "No." The index was very reliable ($\alpha = .89$).

Sociability was an index of five items, which were drawn from Powers et al.'s research (2005). The five items consisted of bipolar adjectives in a 7-point Likert scales, which were "cheerful, friendly, optimistic, warm, and happy." The index was very reliable ($\alpha = .92$).

Service evaluation was an index of three items, which were drawn from Lee et al.'s research (2010). Three items in the survey measured the participants' evaluation of the service by using 7-point Likert scales. Participants rated whether the robot gave good or poor service (1 = "very poor" and 7 = "very good") and how much they were satisfied with the service (1 = "completely dissatisfied" and 7 = "completely satisfied"). We also measured how likely they would use the service again (1 = "would avoid using the service" and 7 = "would want very much to use the service"). The index was very reliable ($\alpha = .82$).

4. Results

We investigated the impact of the robot appearance types on social presence, sociability, and service evaluation of robots. Statistical analyses were conducted using the paired *t*-test.

4.1. Socal Presence

In the case of social presence, as predicted by H1, a significant effect of the robot appearance types on perceived social presence of robots was found, $t = 2.903$, df = 47, $p = .003$ (one-tailed) (see Fig. 5). Participants perceived more social presence to a human-oriented robot ($M = 4.13$, $SD = .65$) than a product-oriented robot ($M = 3.79$, $SD = 1.20$).

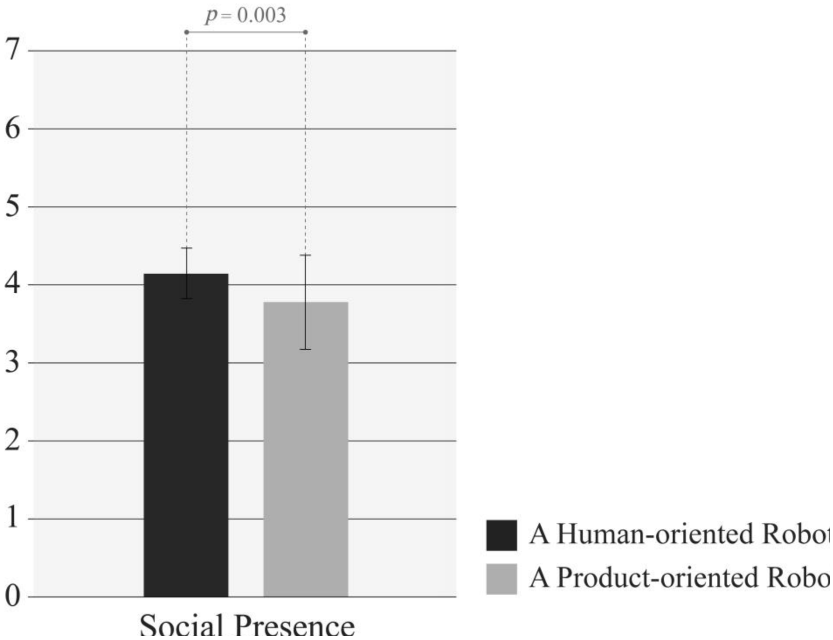


Figure 5 The Impact of the Robot Appearance Types on Perceived Social Presence

4.2. Sociability

In the case of sociability, as predicted by H2, a significant effect of the robot appearance types on perceived sociability of robots was found, $t = 1.816$, $df = 47$, $p = .038$ (one-tailed) (see Fig. 6). Participants evaluated a human-oriented robot ($M = 3.92$, $SD = .78$) as more sociable than a product-oriented robot ($M = 3.68$, $SD = 1.38$).

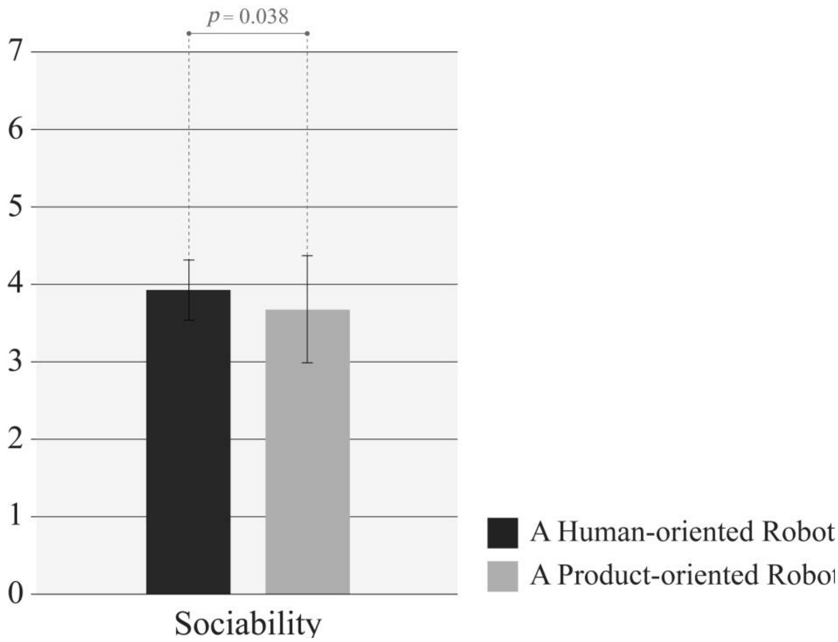


Figure 6 The Impact of the Robot Appearance Types on Perceived Sociability

4.3. Service Evaluation

In the case of service evaluation, as predicted by H3, a significant effect of the robot appearance types on service evaluation of robots was found, $t = -14.045, df = 47, p = 0.00025$ (one-tailed) (see Fig. 7). Participants were more satisfied with the services of a product-oriented robot (M = 4.26, SD = .56) compared to a human-oriented robot (M = 2.94, SD = .56).

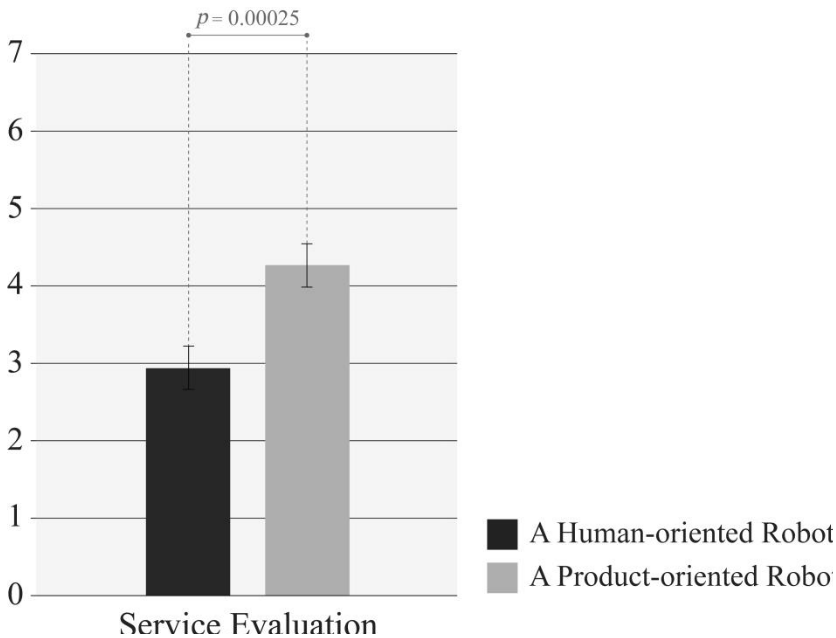


Figure 7 The Impact of the Robot Appearance Types on Service Evaluation

5. Discussions

5.1. Summary and Interpretations of Results

H1, H2, and H3 were supported by the data. As predicted by H1, participants felt more social presence to a human-oriented robot than a product-oriented robot. This demonstrates that human-oriented robot appearance was more effective for people's perceived social presence of a robot.

Consistent with H1, participants perceived a human-oriented robot as more sociable than a product-oriented robot, supporting H2. This implies that a human-oriented robot appearance is effective on quality social interaction between a person and a robot.

On the other hand, as predicted by H3, participants satisfied more with the service provided by a product-oriented robot than a human-oriented robot. This indicates that a human-oriented robot is less effective on service evaluation of a robot than a product-oriented robot.

5.2. Implications

The study results showed that even though human-oriented robot appearance was more effective for social presence and sociability than product-oriented robot appearance, the opposite result was revealed for the service evaluation of a robot. This means that the higher quality of social interaction with a robot does not always lead to the higher satisfaction of the services provided by a robot. These results provide interesting implications for the design of a robot. In the case of robot design where quality of social interaction with a robot is emphasized, human-oriented robot appearance is recommended while in the case of robot design where functionality and service efficiency are emphasized, product-oriented robot appearance is recommended.

The results of this study are somewhat different from the previous study by Kim and her colleagues (2014), in which examined the impact of the robot appearance types of a donation motivating robot on social presence of a robot and motivating donation. They demonstrated that human-oriented robot appearance was more effective for motivating donation as well as increasing social presence of a robot.

In the case of a donation motivating robot, the robot does not provide any specific service, but only function of a robot is appealing to people's emotion for motivating donation. On the other hand, in the case of a vacuum cleaning robot, the robot provides cleaning service. In emotion-oriented situation in which emotional attachment between a person and a robot is needed without specific function of a robot, a human-oriented robot was effective for overall evaluation (motivating donation) as well as social presence. On the other hand, in task-oriented situation in which specific function of a robot needs to be delivered, a human-oriented robot was effective for social presence while a product-oriented robot was effective for overall service evaluation (cleaning). This is consistent with the design of rehabilitation robots. In the case of emotion-oriented situation, such as in motivating rehabilitation, a human-oriented robot is widley used while in the case of task-oriented situation, such as in supporting people's walking by robotic limbs, a product-oriented robot is used.

5.3. Limitations

There are several limitations in this study. First, our participant pool was limited to university students. Replicating this study with people of different-ages, backgrounds, and cultures is needed. Second, our robot was one type of a vacuum cleaning robot. Future studies need to be done using various types of robots. Third, as robot appearance types showed different results depending on the situations, future studies should explore the effect of the appearance types in various situations.

6. Conclusions

The objective of this study was to investigate the effect of the robot appearance types on perceived social presence, sociability, and service evaluation of a robot. People felt more social presence and sociability to a human-oriented robot than a product-oriented robot. On the other hand, people were more satisfied with the service provided by a product-oriented robot than a human-oriented robot. The results suggest that a product-oriented robot could be effectively used for increasing service efficiency of a robot while a human-oriented robot could be effectively used for enhancing social interaction between a person and a robot.

References

1 Bartneck, C., Bleeker, T., Bun, J., Fens, P., & Riet, L. (2010). The influence of robot anthropomorphism on the feelings of embarrassment when interacting with robots. *Paladyn Journal of Behavioral Robotics, 1*(2), 109-115.

2 Breazeal, C. (1999). Robot in society: Friend or appliance? *Proceedings of Agents99 Workshop on Emotion Based Architectures*, 18-26.

3 Breazeal, C. L. (2002). *Designing sociable robots*. Cambridge: MIT Press.

4 Choi, J. J., Kim, Y., & Kwak, S. S. (2014). Are you embarrassed?: The impact of robot types on emotional engagement with a robot. *Proceedings of the 9th ACM/IEEE International Conference on Human Robot Interaction (HRI'14)*, 138-139.

5 Crilly, N., Good, D., Matravers, D., & Clarkson, P. J. (2008). Design as communication: Exploring the validity and utility of relating intention to interpretation. *Design Studies, 29*(5), 425-457.

6 Crilly, N., Moultrie, J., & Clarkson, P. J. (2009). Shaping things: Intended consumer response and the other determinants of product form. *Design Studies, 30*(3), 224-254.

7 DiSalvo, C. F., Gemperle, F., Forlizzi, J., & Kiesler, S. (2002). All robots are not created equal: The design and perception of human-oriented robot heads. *Proceedings of the 4th Conference on Designing Interactive Systems (DIS'02)*, 321-326.

8 Fong, T., Nourbakhsh, I., & Dautenhahn, K. (2003). A survey of socially interactive robots. *Robotics and Autonomous Systems, 42*(3-4), 143-166.

9 Forlizzi, J., DiSalvo, C., Zimmerman, J., Mutlu, B., & Hurst, A. (2005). The sensechair: The lounge chair as an intelligent assistive device for elders. *Proceedings of the Conference on Designing for User Experiences, 31*.

10 Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2008). The influence of social presence on acceptance of a companion robot by older people. *Journal of Physical Agents, 2*(2), 33-40.

11 Heeter, C. (1992). Being there: The subjective experience of presence. *Presence: Teleoperators and Virtual Environments, 1*(2).

12 Hegel, F., Krach, S., Kircher, T., Wrede, B., & Sagerer, G. (2008). Understanding social robots: A user study on anthropomorphism. *Proceedings of the 17th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN'08)*, 574-579.

13 Hoffman, G. (2007). *Ensemble: Fluency and embodiment for robots acting with humans*. Ph.D. dissertation, Massachusetts Institute of Technology, MA: Cambridge.

14 Hoffman, G., & Weinberg, G. (2010). Shimon: An interactive improvisational robotic marimba player. *Proceedings of the CHI 2010 Extended Abstracts on Human Factors in Computing Systems (CHI'10)*, 3097-3102.

15 Ishiguro, H., Ono, T., Imai, M., Maeda, T., Kanda, T., & Nakatsu, R. (2001). Robovie: An interactive human-oriented robot. *Industrial Robot: An International Journal, 28*, 498-503.

16 Kim, R. H., Moon, Y., Choi, J. J., & Kwak, S. S. (2014). The effect of robot appearance types on motivating donation. *Proceedings of the 9th ACM/IEEE International Conference on Human Robot Interaction (HRI'14)*, 210-211.

17 Kwak, S. S., Kim, J. S., & Choi, J. J. (2014). Can robots be sold?: The effects of robot designs on the consumers' acceptance of robots. *Proceedings of the 9th ACM/IEEE International Conference on Human Robot Interaction (HRI'14)*, 220-221.

18 Lee, K. M., & Nass, C. (2004). The multiple source effect and synthesized speech: Doubly disembodied language as a conceptual framework, *Human Communica-*

tion Research, 30,182–207.

19 Lee, M. K., Kiesler, S., Forlizzi, J., Srinivasa, S., & Rybski, P. (2010). Gracefully mitigating breakdowns in robotic services. *Proceedings of the 5th ACM/IEEE International Conference on Human Robot Interaction (HRI'10)*, 203–210.

20 Nasar, J. L., Stamps III, A. E., & Hanyu, K. (2005). Form and function in public buildings. *Journal of Environmental Psychology, 25*(2), 159–165.

21 Personal Robots Group. (2008). *MDS overview*. Retrieved March 25, from Personal Robots Group: http://robotic.media.mit.edu/projects/robots/mds/overview/overview.html.

22 Powers, A., Kramer, A. D., Lim, S., Kuo, J., Lee, S. L., & Kiesler, S. (2005). Eliciting information from people with a gendered humanoid robot. *Proceedings of the 14th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN'05)*, 158–163.

23 Rey, F., Leidi, M., & Mondada, F. (2009). Interactive mobile robotic drinking glasses. *Proceedings of the Distributed Autonomous Robotic Systems, 8*, 543–551.

24 Sullivan, L. (1896). The tall office building artistically considered. In Isabella Athey (Ed.), *Louis Sullivan, kindergarten chats and other writings*. New York: George Wittenborn.

25 Sung, J. Y., Grinter, R. E., Christensen, H. I., & Guo, L. (2008). Housewives or technophiles?: Understanding domestic robot owners. *Proceedings of the 3rd ACM/IEEE International Conference on Human Robot Interaction (HRI'08)*, 129–136.

25 Walters, M., Koay, K., Syrdal, D., Dautenhahn, K., & Boekhorst, R. (2009). Preferences and perceptions of robot appearance and embodiment in human-robot interaction trials. *Proceedings of the New Frontiers in Human-Robot Interaction, Symposium at the AISB09 Convention*, 136–143.