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Empathic concern and the effect of stories in human-robot interaction

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***Abstract*— People have been shown to project lifelike attributes onto robots and to display behavior indicative of empathy in human-robot interaction. Our work explores the role of empathy by examining how humans respond to a simple robotic object when asked to strike it. We measure the effects of lifelike movement and stories on people's hesitation to strike the robot, and we evaluate the relationship between hesitation and people's trait empathy. Our results show that people with a certain type of high trait empathy (empathic concern) hesitate to strike the robots. We also find that high empathic concern and hesitation are more strongly related for robots with stories. This suggests that high trait empathy increases people's hesitation to strike a robot, and that stories may positively influence their empathic responses.**

I. Introduction

Robots are increasingly entering into new contexts in people's lives. As we create more collaborative spaces where robots are purposed to interact with humans, we need to better understand the role and importance of people's emotional responses when engaging with robotic technology. In this study, we explore whether lifelike movement and stories might affect people's empathy for a robot. Because empathy may influence people's reactions to robots [6, 7], exploring its effects and causes can assist in improving design and implementation of robotic technology.

Physical movement of robots is often assumed to drive people's projection of lifelike qualities onto robots [13, 29]. If people relate to a robot's lifelike movement on an emotional level, then such movement could increase their empathy for the robot.

Personified stories and stories of experience may also engender empathy for robots. Robots that people become emotionally attached to are often given human names [1, 27, 23]. Entities that are given personified names and stories may therefore elicit more empathy than unassociated objects.

Living entities, which grow and change over the course of their lives, can be thought of as complex stories embodied in biological matter [9]. A robot that changes over time through experience could be perceived as being more similar to living entities than an unchanging robot. If similarity increases people's tendency to empathize [33], then a robot with an experience story could elicit more empathy than a robot without a story.

Empathy is generally considered to be the ability to experience and understand what others feel [10]. We reason that if a person were to feel empathy for a robot, they would hesitate to strike the robot when asked to do so. Our study measures the effect of lifelike movement and stories on people's hesitation to strike a robot. If empathy is the cause for hesitation, then it also stands to reason that those with greater tendency to empathize with others, i.e. trait empathy, would empathize with the robot more and consequently would hesitate more. Accordingly, we also evaluate the relationship between hesitation to strike a robot and the subjects' trait empathy.

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II. Related Work

A. Artificial agents as social actors

We know from prior work that humans tend to project lifelike qualities onto artificial agents. Nass et al. have shown that we treat computers as social actors [19, 16], and others have shown similar perceptions of virtual characters [14, 24] and robots [5, 11, 31, 18, 27]. Bartneck, Van Der Hoek, et al. demonstrated that increased intelligence and amiability of robots contributes to increased perception of animacy [4]. Perceived animacy relates to humans?" tendency to form emotional attachments to virtual characters [17, 21] and robotic objects [3, 4, 23, 28, 6, 13].

B. Stories

Personification and stories may influence the suspension of disbelief in a machine's inanimacy [12], adding to people's tendency to treat robots as social actors. Walker and Glenn claimed that people place a high emotional value on objects with back-stories [30]. We are interested in understanding if people empathize with objects that have back-stories, and in particular where the object, a robot in our case, is the subject in the story.

C. Negative treatment of robots

Several studies have shown that people have negative reactions when artificial agents and robots are mistreated. Slater et al. replicated the famous Milgram experiment [15] with virtual characters as the recipients of shock treatment and showed that subjects responded as if they were shocking real human beings [26]. In the area of negative treatment of robots, Bartneck et al. measured subjects' hesitation to switch off a robot they had interacted with, showing that the robot's intelligence had a strong positive effect on hesitation to switch it off, in particular if the robot acted agreeable [4]. In an earlier study by Bartneck et al., subjects were asked to strike a robot they had interacted with. The study indicated (with some limitations) that subjects struck a robot fewer times when the robot displayed intelligent behavior [3]. These two experiments were concerned with the effect of people's perception of intelligence, while our study is interested in storytelling and correlations between hesitation to strike a robot and trait empathy. Riek et al. showed people videos of robots with various anthropomorphic attributes (on a scale from mechanical to humanoid) being "mistreated" by humans [20]. Subjects were asked how sorry they felt for the individual robots and were asked to chose which robot they would save in an earthquake. Based on the subjects preferring the humanoid robots over the mechanical robots, Riek et al. postulate that anthropomorphism causes empathy towards robotic objects. These studies are an important foundation, but our work adds validity by comparing hesitation to strike a robot to subjects' trait empathy. This serves to indicate that we are measuring an emotional hesitation rather than hesitation because of perceived value of the robot (which could be a higher perceived value when a robot is assumed to be intelligent).

D. Negative treatment of robots and empathy

In a study by Rosenthal-von der Pütten et al., subjects were also asked to view videos of "robot torture" [22]. The study assessed participants' physiological arousal and self-reported emotions as well as using the Interpersonal Reactivity Index [8] to test for subjects' trait empathy. Rosenthal-von der Pütten et al. found increased physiological arousal and negative emotions for the torture video as compared to the normal video, as well as a correlation between subjects' reactions and trait empathy. This is an interesting first step towards understanding the role that trait empathy plays in humans' perceptions of robots. However, there may be a significant difference between watching mistreatment of robots on a screen and interacting with robots in physical space. For example, Bainbridge et al. demonstrated that compared to virtual presence, a robot's physical presence increases unconscious human perception of the robot as a social partner [2]. Seo et a. recently showed higher empathy for a virtual versus physical robot. [24]

Building on much of the above work, our study tries to better understand emotional reactions and their causes by testing the effect of movement and stories on people's hesitation to strike a robot.

III. Method

To test our hypotheses, we conducted a between subjects experiment with six conditions (3x2). Because we were interested in the effect of lifelike movement and two different stories, the six conditions are the cross product of two factors, one with two levels (movement, no movement) and the other with three levels (no story, personified story, experience story). In the experiment, participants were asked to observe a Hexbug Nano [32], a small robotic toy, and then strike it with a mallet.[1]

In order to assess subjects' trait empathy, we used a standard test in psychology called the Interpersonal Reactivity Index and measured subjects' scores on the three subscales fantasy, empathic concern, and personal distress. Items on the fantasy scale measure the tendency to identify with characters in movies, novels, plays and other fictional situations. Empathic concern measures a tendency to experience compassion and concern for others. Items on the personal distress scale measure a tendency to feel fearful, apprehensive, and uncomfortable when witnessing negative experiences of others [8]. Given the limited nature of the Hexbug robot, we omitted the highly cognitive subscale of perspective taking in the interest of brevity.

[1]This experiment was reviewed and approved by MIT's Internal Review Board

A. Hypotheses

H1: *Hesitation to strike a robot will be greater for moving than for non-moving robots.*

H2A: *Hesitation to strike a robot will be greater for robots that have a name and personified backstory, as opposed to robots with no story.*

H2B: *Hesitation to strike a robot will be greater for robots that have a backstory describing the robot's prior experiences, as opposed to robots with no story.*

H3: *Hesitation to strike a robot will be greater for subjects with high trait empathy scores, as opposed to subjects with low trait empathy scores.*

H4: *The effect of stories on hesitation will be more pronounced for subjects with high trait empathy scores, as opposed to subjects with low trait empathy scores.*

B. Participants

A group of 101 subjects recruited via university mailing lists participated in the experiment. Of the subjects, 48 self-identified as female, 52 as male, and 1 as other. The age range was 18-57 years old ($\mu = 29, sd = 9.7$). Subjects were randomly assigned to one of the 6 conditions resulting in 16-18 subjects per condition. The subjects were given a Hexbug Nano for their time and participation.

C. Experiment Setting and Conditions

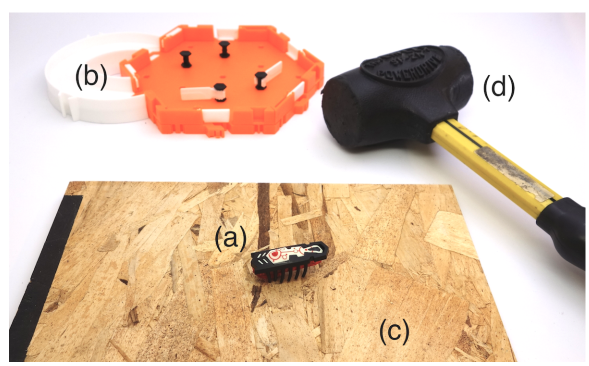

Fig. 1. Experiment Materials: (a) Hexbug Nano, (b) Confined space for movement, (c) Board with hidden magnet for immobilizing Hexbug, (d) Mallet

The subjects were informed that they were participating in a human robot interaction study but did not know they would be asked to strike a robot. Sessions in the experiment area were videotaped. The robot was on a table confined within a partition where it was able to move around. There was a mallet in the room concealed from the subjects' view. Subjects were reminded that they may stop the study at any time.

In the control condition (non-movement, non-story), the experimenter asked the subjects to observe a motionless Hexbug in the partition. After this, the experimenter moved the Hexbug to a board on the same table (onto a magnet that held it in place, allowing for easy aim). Then the experimenter revealed the mallet, placed it in the subject's dominant hand, and instructed the subject to "strike the object with the mallet."

In the movement conditions, subjects first observed a moving Hexbug and were then similarly instructed to "strike the object with the mallet."

In the story conditions, the subjects first observed a moving or non-moving Hexbug and were then given a text on a piece of paper to read. For the personification story, they were given the following text: *"This is Frank. Frank is really friendly but he gets distracted easily. He's lived at the Lab for a few months now. He likes to play and run around. Sometimes he escapes, but he never gets far. Frank's favorite color is red. Last week, he played with some other bugs and he's been excited ever since."* Keeping in line with the personification element of the story, the subjects were then instructed to strike "Frank" with the mallet.

For the experience story, subjects were given the following text: *"This object has been around the Lab for a few months now. If you had come by before, you would have seen it moving around on the floor. It gets around but doesn't go too far from the lab. Last week though, it got out of the building and has been behaving oddly ever since."* The subjects were then instructed to "strike the object with the mallet."

The experiment was over once the subject followed the instruction and struck the Hexbug or did not comply.

Post-experiment, the subjects were asked to fill out a survey, including the empathy test. Because the Interpersonal Reactivity Index measures trait empathy, administering the test after the experiment is not assumed to have an effect on subjects' scores.

D. Measures

We timed the relative hesitation or refusal of the subjects to strike the Hexbug as the main dependent variable. We measured hesitation time as the interval between the end of the instructions to the time the subject struck. If the subject asked a question indicating they had not understood what they had been instructed to do (e.g. "Did you say you want me to track it?", not "Will it hurt him?"), we took the time interval from the end of the experimenter's answer to the strike time as hesitation time. The time was coded from the captured video session. If the subject asked a question, the time was then coded by two independent coders (Krippendorff's $\alpha = 0.96$). We took the mean of the two coded times as the hesitation time. If a subject did not strike the robot, we considered this to be greater hesitation than the maximum measured hesitation and set the value at 1 second more than the maximum. The rank-based tests in the analysis are not affected by any particular value for the difference as long as it is positive.

We also asked participants to fill out a post-experiment survey to capture a self-assessment of reasons for hesitation, and basic demographical information, as well as the three subscales of the Interpersonal Reactivity Index.

IV. Results

A. Hesitation

We analyzed the measured hesitation across story and movement conditions. We first tested for normality of the distribution using the Shapiro Wilk test. The hypothesis that the data was normal was rejected ($p < 0.001$), so we analyzed the data using non-parametric ranked based tests (Mann-Whitney, Spearman and ranked ANOVA).

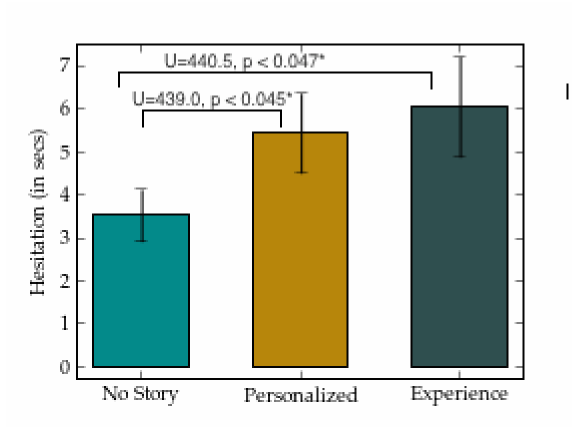

Fig. 2. Mean hesitation (in secs) of different story conditions across all movement conditions. Error bars show SD of mean.

We tested our hypotheses that movement and story conditions will increase hesitation (H1, H2A, H2B) using 1-tailed Mann-Whitney tests. We found that subjects hesitated significantly longer for the personified story conditions compared to the non-story conditions across all movement conditions (H2A) ($\mu_{personification} = 5.44s, \mu_{non\_story} = 3.53s; U = 439.0, p < 0.045$). Similarly, subjects hesitated significantly longer for the experience story condition compared to the non-story condition (H2B) ($\mu_{experience} = 6.06s, \mu_{non\_story} = 3.53s, U = 440.5, p < 0.047$) (Fig. 2). There was no significant difference between the two story conditions. Movement vs. non-movement conditions across all story conditions showed no significant changes in mean ($\mu_{movement} = 4.84s, \mu_{non\_movement} = 5.13s$) (Fig. 3). These results show support for our story hypotheses (H2A and H2B) but not for our movement hypothesis (H1).

In post-hoc analysis, we examined the interaction of the story and the movement factors. The greatest hesitation difference between story and non-story occurs when the object is not moving (Fig. 4). Movement attenuates the effect of stories while increasing the hesitation for non-story conditions. There was no significant difference between the two story conditions in either of the movement conditions.

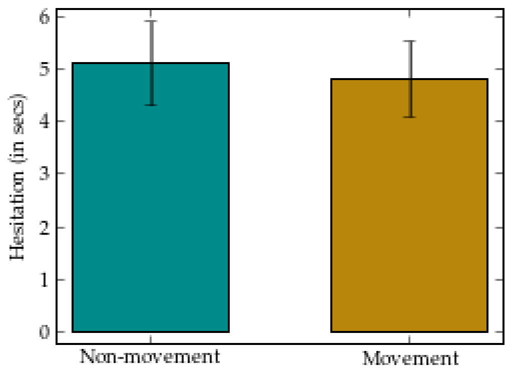

Fig. 3. Mean hesitation (in secs) of different movement conditions across all movement conditions. Error bars show SD of mean hesitation.

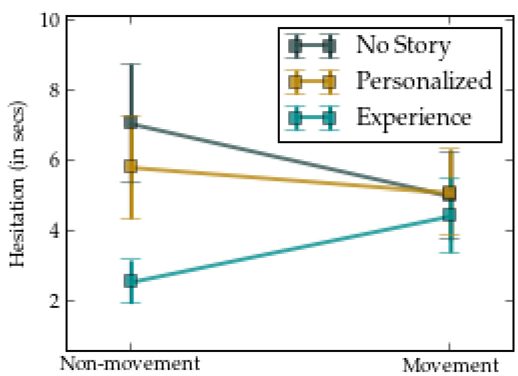

Fig. 4. Interaction of movement x story conditions showing mean hesitation and SD of mean.

We combined the four story conditions into two (movement and non-movement stories) to increase power and clarity of our analysis (Fig. 5).

Per our hypotheses (H1, H2A, H2B), four comparisons of hesitation are of interest: movement vs. non-movement for each of the two story conditions, as well as story vs. non-story for each of the two movement conditions. The results, summarized in Table I, show that there is significant difference in the measured hesitation between story and non-story condition for the non-movement case ($\mu_{story} = 6.45s, \mu_{non\_story} = 2.58s; U = 151.0, p < 0.004$; significant at $\alpha = 0.05$ after Bonferroni correction for 4 comparisons). We will return to these results in the discussion section.

B. Empathy

We had hypothesized that subjects with higher trait empathy would hesitate longer in striking the hexbug. (H3) We divided subjects into two equal sized groups of high and low empathy around the median value for each empathy subscale. Of the three subscales, we found that those with high scores on empathic concern (EC) hesitated significantly longer ($\mu_{high-EC} = 6.39s, \mu_{low-EC} = 3.55s; U = 900.0, p <$ 0.005; significant at $\alpha = 0.05$ after Bonferroni correction for 3 comparisons). The other subscales Fantasy (FS) and Personal Distress (PD) do not show any significant changes in hesitation (Table II).

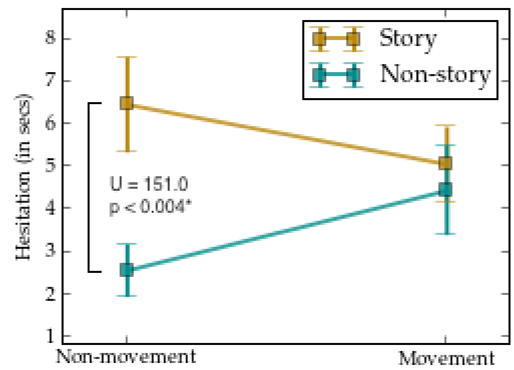

Fig. 5. Interaction of movement x story conditions showing mean hesitation and SD of mean.

TABLE I

MEAN HESITATION FOR STORY X MOVEMENT

	Story	Non-story	Mann Whitney U, p
Movement	5.05s	4.44s	$U = 281.5$, $p < 0.384$
Non-movement	6.45s	2.58s	$U = 151.0$, $p < 0.004*$
Mann Whitney U, p	$U = 437.5$, $p < 0.086$	$U = 124.5$, $p < 0.178$	

For the rest of the empathy analysis we look at just the two non-moving conditions (story vs non-story) where we see the greatest difference in the measured interaction. EC is moderately correlated with hesitation in the story condition (Spearman's $\rho = 0.37$) but weakly negatively correlated (Spearman's $\rho = -0.12$) in the non-story condition (Fig. 6).

To understand the effect of interaction of stories with empathic concern, we performed a two-way ANOVA-on-ranks test with Has-Story (Story and Non-Story) and EC as the independent variables and rank-transformed hesitation as the

TABLE II

MEAN HESITATIONS FOR HIGH AND LOW EMPATHY SUBJECTS FOR EMPATHY SUBSCALES

IRI Subscale	High Empathy	Low empathy	Mann-Whitney U, p
FS	5.59s	4.33s	$U = 1230.5$,$p < 0.385$
EC	6.39s	3.55s	$U = 900.0$, $p < 0.005*$
PD	5.56s	4.26s	$U = 1160.5$, $p < 0.249$

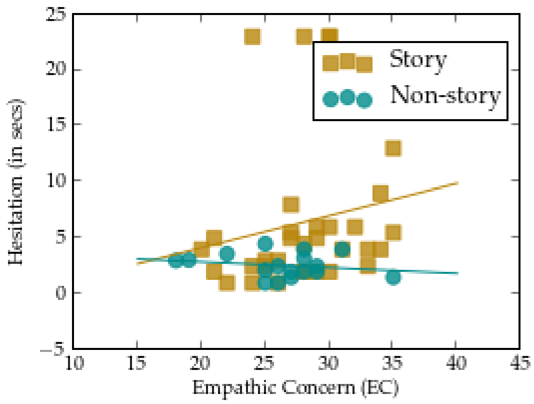

Fig. 6. Scatter plot of hesitation versus EC for non-movement data colored by story condition. Approximate regression lines are shown for illustrating difference in relationship between EC and hesitation for the story and non-story conditions.

dependent variable. ANOVA-on-ranks showed a significant main effect of has-story ($F(1, 49) = 8.92, p < 0.005$) and significant interaction of EC with Has-Story ($F(1, 47) = 4.315, p < 0.044$).

We found no significant gender effect on subjects' hesitation to strike the robots.

V. Discussion

We hypothesized that hesitation to strike the robots would be greater for story conditions compared to non-story conditions (H2A + H2B). Our results confirm that stories can have an impact on people's reactions to robots. This has implications for design. Designing robotic technology that can accrue experience or is personified could influence users' perception of robots and increase users' emotional responses to robots. Also, introducing robots with stories could facilitate adoption of robotic technology if stories help people relate to robots on an emotional level.

Interestingly, our first hypothesis (H1) was not confirmed. Lifelike movement is considered to have an influence on human perception of robot animacy, yet our results for the movement conditions were mixed, particularly in relation to the story conditions. We saw the greatest difference in hesitation between story and non-story for non-moving robots, but the difference became insignificant in the moving case (Fig. 3.) We have two potential explanations for this. First, we could have been measuring two different types of reactions, depending on whether a subject has a strong aversion to insects or not. Some of the responses in our survey mentioned a dislike for cockroaches or bugs. Because subjects perceived the Hexbug as very insect-like, it is possible that people with low tolerance for insect-like movement reacted differently than people with high tolerance, creating conflicting effects. However, Fig. 3 indicates that there may be a more interesting relationship between story and movement. Another potential explanation is a disappointment of the subjects' behavioral expectations of the robot. Paepcke and Takayama have demonstrated that setting people's expectations low rather than high for a robot's competence leads to less disappointment and more positive evaluation of the robot [18]. Because the Hexbug movements are very simple, it is possible that there was a disconnect between what the subjects believed the robot to be capable of based on our stories, and the behavior of the moving robot they were observing.

Consistent with our third hypothesis, we showed that those with high empathic concern hesitated more in striking the robot. (H3) This suggests that subjects' hesitation was a result of empathy for the robot. Prior studies in this area have had difficulty distinguishing between emotional hesitation and subjects hesitating for other reasons, for example because they did not want to damage something of perceived value. In our study, if the perceived value of the robot was greater for our moving or story conditions (because people attributed more intelligence or technical sophistication to the robot), this could have led to a similar hesitation effect. However, the fact that we find subjects with greater tendency for empathic concern hesitated more suggests that at least empathy is implicated in the hesitation.

Furthermore, for non-moving robots, we found a positive correlation between empathy and hesitation in the story condition and weak negative correlation for the non-story condition. Moreover, our analysis shows that there is significant interaction between empathic concern and stories on hesitation. These findings support our hypothesis that the effect of stories on hesitation is more pronounced for subjects with high trait empathy scores, as opposed to low (H4). This suggests that stories engender empathy, which results in hesitation. Adding descriptive color to our analysis, one question in our post-experiment survey asked subjects to describe in their own words why they hesitated. Many of our subjects used empathic terms to explain their hesitation, for example "I had sympathy with him after reading his profile because I am also here in the Lab for a few month. [*sic*]"

A study conducted by Rosenthal-von der Pütten et al., in which subjects watched videos of robots, showed a correlation between subjects' fantasy scores and their responses to the robots being mistreated [22]. While this study may not be directly comparable to ours in many aspects (because conducted under different settings), it is interesting that our study finds subjects' behavior to correlate with empathic concern, rather than fantasy. The fact that our subjects fell into a different category on the Interpersonal Reactivity Index indicates that we could be dealing with a different type of empathy. Further research may prove to support the suggestion that there is a divide between virtual and physical in how humans perceive and respond to robots [2], and also that emotional reactions to physical robots are not just guided by fantasy and imagination.

While our study confirmed some of our hypotheses, we also raise interesting questions for further study. For example, testing our first hypothesis yielded unexpected results. We are unable to fully explain the relationship between movement and stories in the setting of our study, and we believe this question may deserve some attention. We also believe that the difference between virtual and physical interaction with a robot deserves further exploration. Previous work and some of our result suggest that people's emotional responses may differ, depending on whether they are engaging with a robot in physical space or on a screen.

Our study is one of very few to explore the relationship of natural trait empathy and human responses to robotic objects. We believe there is much more to be done in this area. Better understanding the factors that influence human's emotional responses to robots is relevant to improving design and facilitating the implementation of robotic technology in different contexts.

VI. Conclusion

The objective of this study was to examine the effect of stories and movement on people's hesitation to strike a robot. People hesitated significantly more when asked to strike a robot with a personified or experience story, compared to robots without stories. We also found that people with high trait empathic concern hesitated significantly more to strike the robot across all conditions. In addition, we found a stronger relationship between empathic concern and hesitation for robots with stories compared to robots without stories. Our analysis shows that there is significant interaction between empathic concern and stories on subjects' hesitation to strike a robot. These results suggest that stories engender users' empathy for robots.

VII. Acknowledgement

We would like to thank Goren Gordon and Haben Michael for insights and help with our analysis. We are also particularly grateful to Jin Joo Lee and Samuel Spaulding for their feedback on the paper. This research was possible thanks to a donation of Hexbug Nanos by First Labs, Inc. Some robots were harmed in this production.

References

[1] K. Andra, "A robot, slave or companion species? The naming practices and culture of robotics competitions," Masters thesis, University of Sydney, 2011.

[2] W. A. Bainbridge, J. Hart, E. S. Kim, B. Scassellati, "The effect of presence on human-robot interaction," in RO-MAN, 2008, pp. 701-706.

[3] C. Bartneck, M. Verbunt, O. Mubin, and A. Al Mahmud, "To kill a mockingbird robot," in ACM/IEEE Human robot interaction, 2007, pp. 81-87.

[4] C. Bartneck, M. Van Der Hoek, O. Mubin, and A. Al Mahmud, "Daisy, Daisy, give me your answer do! Switching off a robot," in ACM/IEEE Human robot interaction, 2007, pp. 217-222.

[5] C. Breazeal, "Toward sociable robots," in Robotics and autonomous systems, 42(3), 2003, pp. 167-175.

[6] J. Carpenter, "The quiet professional: an investigation of U.S. Military explosive ordnance disposal personnel interactions with everyday field robots," Dissertation, University of Washington, 2013.

[7] K. Darling, "Extending legal protection to social robots," in Robot Law, R. Calo, M. Froomkin, and I. Kerr, Eds., Edward Elgar, forthcoming 2015.

[8] M. H. Davis, "The effects of dispositional empathy on emotional reactions and helping: a multidimensional approach," in J Pers 51(2), 1983, pp. 167-184.

[9] K. Dautenhahn and C. Nehaniv, "Artificial life and natural stories," in International Symposium on Artificial Life and Robotics, 1998, pp. 435-439.

[10] J. Decety and C. Lamm, "Human empathy through the lens of social neuroscience," in The Scientific World Journal, 2006, pp. 1146-1163.

[11] B. R. Duffy, "Anthropomorphism and the social robot," in Robotics and autonomous systems 42(3), 2003, pp. 177-190.

[12] B. R. Duffy and K. Zawieska, "Suspension of disbelief in social robotics," in RO-MAN, 2012, pp. 484-489.

[13] H. Knight, "How humans respond to robots: building public policy through good design," Brookings Report, 2014.

[14] R. McDonnell, S. Jrg, J. McHugh, F. Newell, and C. O'Sullivan, "Evaluating the emotional content of human motions on real and virtual characters," in ACM Symposium on Applied Perception, 2008, pp. 67-74.

[15] S. Milgram, Obedience to authority: an experimental view, Tavistock, London, 1974.

[16] C. Nass, Y. Moon, J. Morkes, E. Y. Kim, B. J. Fogg, "Computers are social actors: a review of current research," in: Human values and the design of computer technology, B. Friedman, Ed., University of Chicago Press, 1997, pp. 137-162..

[17] C. Nass, K. Isbister, E. J. Lee, "Truth is beauty: researching embodied conversational agents," in: Embodied conversational agents, J. Cassell, Ed., MIT Press, Cambridge, 2000, pp. 374-402.

[18] S. Paepcke and L. Takayama, "Judging a bot by its cover: an experiment on expectation setting for personal robots," in HRI, 2010, pp. 45-52.

[19] B. Reeves and C. Nass, "The media equation: how people treat computers, television, and new media like real people and places," Cambridge University Press, Cambridge, 1996.

[20] L. D. Riek, T. C. Rabinowitch, B. Chakrabarti, and P. Robinson, "How anthropomorphism affects empathy toward robots," in HRI, 2009, pp. 245-246.

[21] A. M. Rosenthal von der Pütten, N. C. Krämer, J. Gratch, S. H. Kang ??It doesn?t matter what you are!? explaining social effects of agents and avatars," in Comput Hum Behav 26(6), 2010, pp. 1641-1650.

[22] A. M. Rosenthal von der Pütten, N. C. Krämer, L. Hoffmann, S. Sobieraj, and S. C. Eimler, "An experimental study on emotional reactions towards a robot," in Int J of Social Robotics, 5(1), 2013, pp. 17-34.

[23] M. Scheutz, "The inherent dangers of unidirectional emotional bonds between humans and social robots," in: Robot ethics: the ethical and social implications of robotics, P. Lin, K. Abney, and G. A. Bekey, Eds., MIT Press, 2011, pp. 205-221.

[24] B. J. Scholl and P. D. Tremoulet, "Perceptual causality and animacy," in Trends in cognitive sciences 4(8), 2000, pp. 299-309.

[25] S. H. Seo, D. Geiskkovitch, M. Nakane, C. King, and J. E. Young, "Poor thing! Would you feel sorry for a simulated robot? A comparison of empathy toward a physical and a simulated robot," in ACM/IEEE Human-Robot Interaction, 2015, pp.

[26] M. Slater, A. Antley, A. Davison, D. Swapp, C. Guger, C. Barker, N. Pistrang, and M. V. Sanchez-Vives, "A virtual reprise of the Stanley Milgram obedience experiments," in PLoS ONE 1(1), 2006, p. e39

[27] J. Y. Sung, L. Guo, R. E. Grinter, and H. I. Christensen, "'My Roomba is Rambo': intimate home appliances," in 9th Intl Conf on Ubiquitous Computing, 2007, pp. 145-162.

[28] S. Turkle, "A nascent robotics culture: new complicities for companionship," in AAAI, 2006.

[29] S. Turkle, "In good company? On the threshold of robotic companions," in Close Engagements with Artificial Companions: Key Social, Psychological, Ethical and Design Issues, Amsterdam, The Netherlands: John Benjamins Publishing Company, 2010, pp. 3-10.

[30] R. Walker and J. Glenn, "About the Significant Objects Project," 2009, available at http://significantobjects.com/about/ (accessed February 23, 2015).

[31] C. Yan, W. Peng, K. M. Lee, S. A. Jin, "Can robots have personality? An empirical study of personality manifestation, social responses, and social presence in human-robot interaction," in: ICA, 2004.

[32] http://www.hexbug.com/nano (accessed February 23, 2015).

[33] M. H. Davis, Empathy: A social psychological approach, Westview Press, Boulder, CO, 1996.