Robots are Always Social: Robotic Movements are Automatically Interpreted as Social Cues

Hadas Erel
Media Innovation Lab (miLAB)
Sammy Ofer School of Communications
IDC Herzliya, Israel
Hadas.Erel@miLAB.idc.ac.il

Tzachi Shem Tov
Media Innovation Lab (miLAB)
Sammy Ofer School of Communications
IDC Herzliya, Israel
Tzachi.shem.tov@miLAB.idc.ac.il

Yoav Kessler
Ben-Gurion University of the Negev
Beer-Sheva, Israel
kesslery@bgu.ac.il

Oren Zuckerman
Media Innovation Lab (miLAB)
Sammy Ofer School of Communications
IDC Herzliya, Israel
orenz@idc.ac.il

ABSTRACT

Physical movement is a dominant element in robot behavior. We evaluate if robotic movements are automatically interpreted as social cues, even if the robot has no social role. 24 participants performed the Implicit Associations Test, classifying robotic gestures into direction categories ("to-front" or "to-back") and words into social categories (willingness or unwillingness for interaction). Our findings show that social interpretation of the robot's gestures is an automatic process. The implicit social interpretation influenced both classification tasks, and could not be avoided even when it decreased

KEYWORDS

Social robots; Automatic processes; Robotic gestures; Implicit Association Test

CHI '19, May 2019, Glasgow, Scotland

ACM ISBN 978-1-4503-5971-9/19/05.
https://doi.org/10.1145/3290607.3312758

Figure 1: The abstract robotic object, designed as a dome with a ball rolling on it.

.

participant's performance. This effect is of importance for the HCI community as designers should consider, that even if a robot is not intended for social interaction (e.g. factory robot), people will not be able to avoid interpreting its movement as social cues. Interaction designers should leverage this phenomenon and consider the social interpretation that will be automatically associated with their robots' movement.

INTRODUCTION

Robots are designed to take various roles in daily life, including social roles. People's tendency to anthropomorphize inanimate objects [3] is utilized by robot designers, and various robots are designed to generate social cues, including robots for home, workplaces and therapy [3, 8, 10].

Social interaction involves both verbal and non-verbal cues. A robot's physical movement is commonly perceived as a social non-verbal cue, that increases the robot's acceptance and enhances understanding of the information conveyed by the robot [3]. However, using robots for social interaction is criticized for involving deception and potentially exploiting vulnerable populations. Social cues provided by a robot may lead to over-identification that will bias users' judgment. Thus some researchers insist that the mechanic nature of robots should be salient [2]. This perception is based on an underlying assumption, that user's social interpretation of a robot's gestures is a conscious, controlled process that designers can eliminate by using machine-like designs or by introducing robots as machines and not as companions. This assumption is challenged by empirical findings indicating that people have a strong tendency to anthropomorphize objects and to automatically perceive the world through a social lens [3, 11].

Previous studies that evaluated people's perception of non-verbal cues performed by a robot, provide initial support for the natural tendency to anthropomorphize a robot's movement or action. Brain imaging studies have indicated that the mirror neurons system, responsible for understanding intentions and empathy, is activated by the sight of both human and robotic actions, with no significant differences between them [5]. In addition, studies evaluating perception of non-humanoid robots indicate that it is possible to design gestures that will be consistently perceived as social cues even when the gestures cannot be directly mapped to human behavior [1].

In this study, we test the possibility that a robot's movement is automatically perceived as a social cue. To increase validity, we evaluate this hypothesis using a previously-published, non-humanoid, abstract robot, that has no association to human or animal. We assess the automatic social interpretation of this robot's movement independently of human-like behavior and human-like appearance.

RELATED WORK

The tendency to attribute social intent to inanimate objects was previously indicated by animation and Human-Robot Interaction studies.

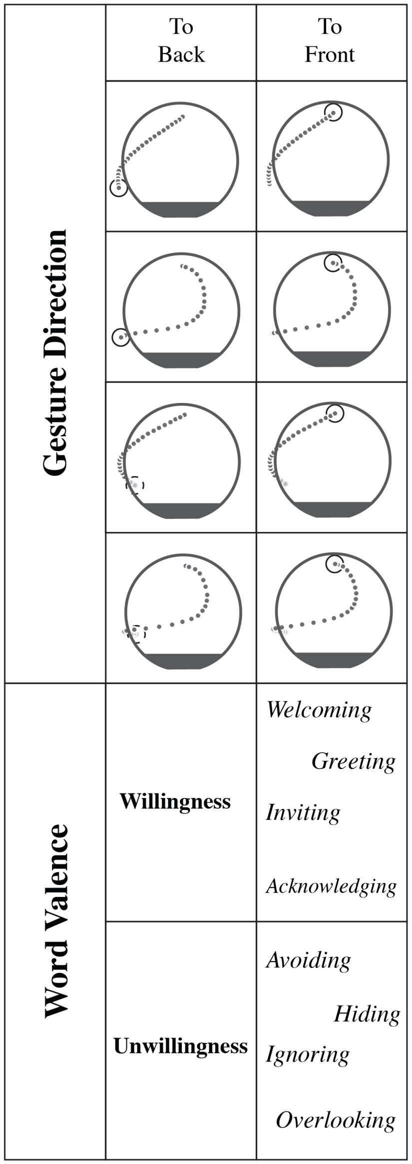

Figure 2: Gestures classified according to direction; Words classified according to social valence.

The seminal 1944 animation study by Heider and Simmel showed that participants consistently interpret the movement of animated geometric shapes as social interaction [6]. The participants associated intention, emotions, and even personas to the animated abstract geometrical shapes.

Studies evaluating movement of everyday objects including a trash-barrel and automatic doors, showed that people perceive the movement as social cues, indicating willingness or unwillingness for interaction [7, 12]. In prior work [1], we showed that people assign social interpretation to the gestures of an abstract robot (used in the current study). The non-humanoid robot performed minimal movements of a ball rolling on a dome. Participants consistently perceived the movements as either positive or negative interaction, and described the interaction using socially-related terminology [1].

While previous studies focused on designing movement that will be interpreted as social cues, in this study, we test if this social interpretation is an automatic process that cannot be avoided.

METHOD

A within-participants experimental design was used to evaluate if the robot's gestures are automatically interpreted as social cues. Participants performed an adaptation of the Implicit Association Test (IAT) [9], designed to measure reaction-times for identifying automatic implicit associations between the robot's gestures and their social interpretation. The test involved word and gesture classification tasks. Participants were asked to perform the tasks as accurately and as quickly as possible. The gesture classification task required classification of videos presenting the robot's gestures according to the movement direction (the small ball moving to the front of the dome vs. to the back of the dome). Video methodology allowed to randomize the gestures as is required in the IAT. The word classification task required classification of words according to their social valence (Willingness vs. Unwillingness for social interaction). Notably, the gestures were presented as physical movements to specific directions and participants had no motivation to attribute social interpretation to the robot's gestures.

Participants

24 undergraduate students (Mean age=22, SD=2.37; 16 female, 8 male) participated in the study. Participants were native English speakers and were granted 2 bonus points for their participation.

The robot's gestures

The abstract robot used in the study was designed as a dome with a smaller ball rolling on its surface (see Figure 1) [1]. Two gesture classes were used: "to-front" and "to-back", previously shown to be associated with positive and negative social cues, respectively. Each class included four movement variances (see Figure 2). The different gestures in each category allowed to evaluate two movement categories instead of two specific movements.

Congruency \ Response key	A	L
Congruent	“To Front” Willingness	“To Back” Unwillingness
Incongruent	“To Back” Willingness	“To Front” Unwillingness

Figure 3: Associations of words’ valence and gestures’ social interpretation.

Blocks order	Block description	Response keys’ assignment
1	Gestures classification training block	[A] TO FRONT TO BACK [L]
2	Words classification training block	WILLINGNESS [L] [A] UNWILLINGNESS
3	Incongruent classification block	[A] TO FRONT WILLINGNESS [L] TO BACK [L] [A] UNWILLINGNESS
4	Switched gestures classification training block	TO FRONT [L] [A] TO BACK
5	Congruent classification block	TO FRONT [L] WILLINGNESS [L] [A] TO BACK [A] UNWILLINGNESS

Figure 4: The 5 blocks of the IAT.

The IAT paradigm

The IAT paradigm was used with two classification tasks (see Figure 2): Robot gesture direction (the two direction classes) and word social valence (Willingness and Unwillingness for interaction). Within the IAT paradigm, participants were asked to classify stimuli from both tasks using two response keys. Thus the same response keys were used for classifying words valence and gestures direction. As a result, words and gestures share the same response keys (The response keys were ’A’ and ’L’, counterbalanced between participants; see Figure 3).

Gestures-Words conflict: If social interpretation of robotic gestures is not an automatic process, the association of words and gestures to mutual response keys will not lead to a conflict in the classification tasks, as there is no overlap between classifying the gestures direction and the social valence of the word. However, if it is an automatic process, it may lead to a conflict between word classification and gesture classification depending on the association to the shared response keys. The association can be incongruent or congruent based on the social cue the word and gestures represent.

(1) Congruent association: "to-front" movements (shown to be associated with positive social interaction) share the same response key as words representing willingness for interaction; "to-back" movements (shown to be associated with negative social interaction) share the same response key as words representing unwillingness for interaction.
(2) Incongruent association: "to-back" movements (shown to be associated with negative social interaction) share the same response key as words representing willingness for interaction; "to-front" movements (shown to be associated with positive social interaction) share the same response key as words representing unwillingness for interaction.

Indication for Automaticity: A conflict between the classification tasks will be indicated by longer reaction times. We, therefore, expect longer reaction times in the incongruent condition compared to the congruent condition if participants cannot avoid the social interpretation of the robot gestures.

The 5 blocks of the IAT: The paradigm included five blocks (see Figure 4): (1) Gesture classification training block: classification of gesture direction (24 randomized trials). (2) Word classification training block: classification of the words’ social valence (24 randomized trials). (3) Incongruent classification block: classification of both tasks. "To-front" movements shared a response key with unwillingness for interaction words and "to-back" movements shared a response key with willingness for interaction words (48 randomized trials). (4) Gesture classification training block: The response keys for the gesture classification were switched, e.g. the response key previously assigned to "to-front" movements was now assigned to "to-back" movements (24 randomized trials). (5) A socially congruent classification block: classification of both tasks. "to-front" movements shared a response key with willingness for interaction words and "to-back" movements shared a response key with unwillingness for interaction words (48 trials randomized trials). Blocks 3 and 5 were counterbalanced between participants.

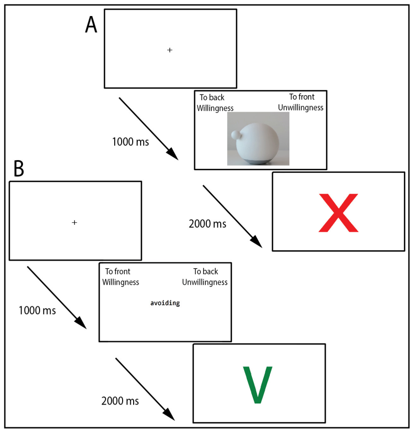

Figure 5: A. Gesture Classification Task; B. Word Classification Task.

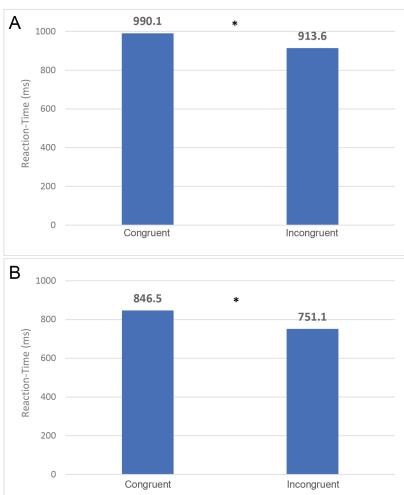

Figure 6: Congruency effects. A. Gesture classification reaction times; B. Word classification reaction times.

At the beginning of each block, participants received instructions concerning the task. Each trial began with a fixation point presented for 1000ms (a cross in the center of the screen), followed by the stimulus: a word or a video of a gesture for 2000ms. A feedback was than presented for 1000ms. If the participant failed to respond within the 2000ms, an inaccurate feedback was presented (see Figure 5).

Procedure

Participants signed a consent form, and were instructed to perform the task as fast and as accurate as possible. To motivate high performance in the classification tasks, high performance was granted a reward of 100 US dollars. Participants were tested in a quiet room and performed the five blocks of the IAT with short breaks between blocks.

FINDINGS

A two-way ANOVA analysis was performed for reaction times in both gesture and word classification tasks. As there were very few errors it was not possible to perform the same analysis for accuracy

The two-way ANOVA for gesture direction ("to-front" vs. "to-back") and congruency (congruent vs incongruent), revealed a significant main effect for congruency (see Figure 6A). Reaction times for direction classification were slower in the incongruent condition compared to the congruent condition. Hence, when the social interpretation of the gesture was incongruent with the social meaning of the words, participants needed more time for classifying the gestures according to their direction, $F(1,23) = 10.36$, $p < 0.004$. All other effects were not significant.

A similar effect was found for word classification (see Figure 6B). The two-way ANOVA for word classification (willingness vs. unwillingness) and congruencey, revealed a significant main effect for congruency. Reaction times for word classification were slower in the incongruent condition compared to the congruent condition. Hence, when the word's valence and the social interpretation of the gesture were incongruent, participants needed more time for classifying words according to their valence, $F(1,23) = 17.12$, $p < 0.001$. All other effects were not significant.

DISCUSSION

In this study, we reveal that the social interpretation of an abstract robot's gestures is an automatic cognitive process. This social interpretation is activated even when it conflicts with the participant's intentional task (words and gestures classification tasks). The reward for high performance did not eliminate this effect, suggesting that motivation and control do not mediate this automatic process.

One possible explanation for this finding is related to Theory of Mind (ToM) [4]. ToM is defined as the human ability to attribute a mental state to others in order to explain and anticipate their behavior. ToM is considered to be an automatic process that is essential for understanding and functioning in the social world [4]. With social understanding being a key function of human behavior [11], it is possible that people automatically apply ToM to the gestures of a robot. This phenomenon should be further studied in order to map movement features that are automatically interpreted as social cues.

Our findings are limited to a specific robot design, specific gestures, and video presentation of the gestures. Future studies should evaluate this phenomena in a real life interaction with various robots.

CONCLUSION

Robots have a growing potential to impact human society. Physical movement is a key element relevant for the robot's function and communication. Our findings reveal that people cannot avoid attributing a social interpretation to robot movement, indicating that it is an automatic process. Future research should explore how this automatic process influences the perception of non-social robots, for example, would a factory employee automatically perceive the movement of a robotic-arm as a social cue? We conclude that interaction designers should consider the possibility that people automatically interpret robot movements as social cues, even if the robot is not designed for social interaction.

ACKNOWLEDGMENTS

We would like to thank Iddo Wald, Andrey Grishko, Benny Megidish, and Netta Offer for their great contribution to the project.

REFERENCES

[1] Lucy Anderson-Bashan, Benny Megidish, Hadas Erel, Iddo Wald, Andrey Grishko, Guy Hoffman, and Oren Zuckerman. 2018. The Greeting Machine: An Abstract Robotic Object for Opening Encounters. In *Robot and Human Interactive Communication (RO-MAN), 2018 27th IEEE International Symposium on*. IEEE.

[2] Joanna J Bryson. 2010. Robots should be slaves. *Close Engagements with Artificial Companions: Key social, psychological, ethical and design issues* (2010), 63–74.

[3] Brian R Duffy. 2003. Anthropomorphism and the social robot. *Robotics and autonomous systems* 42, 3 (2003), 177–190.

[4] Helen L Gallagher and Christopher D Frith. 2003. Functional imaging of theory of mind. *Trends in cognitive sciences* 7, 2 (2003), 77–83.

[5] Valeria Gazzola, Giacomo Rizzolatti, Bruno Wicker, and Christian Keysers. 2007. The anthropomorphic brain: the mirror neuron system responds to human and robotic actions. *Neuroimage* 35, 4 (2007), 1674–1684.

[6] Fritz Heider and Marianne Simmel. 1944. An experimental study of apparent behavior. *The American journal of psychology* 57, 2 (1944), 243–259.

[7] Wendy Ju and Leila Takayama. 2009. Approachability: How people interpret automatic door movement as gesture. *International Journal of Design* 3, 2 (2009), 1–10.

[8] Michal Luria, Guy Hoffman, and Oren Zuckerman. 2017. Comparing social robot, screen and voice interfaces for smart-home control. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. ACM, 580–628.

[9] Brian A Nosek, Anthony G Greenwald, and Mahzarin R Banaji. 2005. Understanding and using the Implicit Association Test: II. Method variables and construct validity. *Personality and Social Psychology Bulletin* 31, 2 (2005), 166–180.

[10] Fumihide Tanaka and Madhumita Ghosh. 2011. The implementation of care-receiving robot at an English learning school for children. In *Proceedings of the 6th international conference on Human-robot interaction*. ACM, 265–266.

[11] Robert H Wortham, Andreas Theodorou, and Joanna J Bryson. 2016. What does the robot think? Transparency as a fundamental design requirement for intelligent systems. (2016).

[12] Stephen Yang, Brian Ka-Jun Mok, David Sirkin, Hillary Page Ive, Rohan Maheshwari, Kerstin Fischer, and Wendy Ju. 2015. Experiences developing socially acceptable interactions for a robotic trash barrel. In *Robot and Human Interactive Communication (RO-MAN), 2015 24th IEEE International Symposium on*. IEEE, 277–284.