Do We Need Emotionally Intelligent Artificial Agents? First Results of Human Perceptions of Emotional Intelligence in Humans Compared to Robots

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Abstract. Humans are very apt at reading emotional signals in other humans and even artificial agents, which raises the question of whether artificial agents need to be emotionally intelligent to ensure effective social interactions. For artificial agents without emotional intelligence might generate behavior that is misinterpreted, unexpected, and confusing to humans, violating human expectations and possibly causing emotional harm. Surprisingly, there is a dearth of investigations aimed at understanding the extent to which artificial agents need emotional intelligence for successful interactions. Here, we present the first study in the perception of emotional intelligence (EI) in robots vs. humans. The objective was to determine whether people viewed robots as more or less emotionally intelligent when exhibiting similar behaviors as humans, and to investigate which verbal and nonverbal communication methods were most crucial for human observational judgments. Study participants were shown a scene in which either a robot or a human behaved with either high or low empathy, and then they were asked to evaluate the agent's emotional intelligence and trustworthiness. The results showed that participants could consistently distinguish the high EI condition from the low EI condition regardless of the variations in which communication methods were observed, and that whether the agent was a robot or human had no effect on the perception. We also found that relative to low EI high EI conditions led to greater trust in the agent, which implies that we must design robots to be emotionally intelligent if we wish for users to trust them.

Keywords: Human-robot interaction, emotional intelligence, empathetic robot

1 Introduction

With the advances in technology, robots and artificial agents are becoming more prominent in our lives. Virtual personal assistants like Siri and Amazon Echo allow for frequent interactions in a casual conversational tone. Research has found that virtual therapists and teachers can hold effective sessions with patients and students [22, 2]. To improve the relationship between social artificial agents and their users and increase the effectiveness of their interactions, we must examine the social protocols embedded within our society.

Humans are expected to understand and follow customs and social norms when communicating, while also being aware of others' perceptions of them and appropriately regulating their emotions. Showing empathy is also a highly regarded social skill which can be demonstrated through verbal and nonverbal communication such as words, tone of voice, facial expressions, posture, and physical gestures.

However, people might hold different expectations for artificial agents in social situations. Despite interacting with technology on a daily basis, and oftentimes in a social manner, an artificial agent that can appropriately interact in an emotional capacity may be unexpected (and perhaps unwelcome) to some people. An important open question is whether artificial agents need to be emotionally intelligent in order to be successful at social interactions with humans. Another related question is, whether artificial agents exhibiting emotional intelligence are evaluated differently from agents without EI, and whether such emotionally intelligent agents are considered more trustworthy. Answering these questions is critical for the design of socially interactive artificial agents, not only to ensure smooth interactions, but ultimately to ensure their acceptance and success.

In this paper, we set out to investigate several fundamental questions that can help answer whether artificial agents need EI, including whether humans will even be able to perceive EI in artificial agents compared to their perceptions of EI in other humans, which behavioral factors are critical for perceiving EI, and the extent to which perceptions of EI affect the trustworthiness of artificial agents. The rest of the paper is structured as follows. After a brief review of EI, we introduce our online study together with the specific hypotheses we intended to address. Next we present the results, followed by a discussion about what they imply for the design of artificial agents. Then we conclude with a summary of our findings and a brief outlook of the next steps.

2 Background

Emotions influence thinking, decision-making, relationships and mental health, and success both within and outside of work environments. Emotional intelligence is the capacity to accurately assess one's own and others' emotional state and to use that information to adapt, manage, and guide subsequent thinking and actions [24]. Considerable research has been conducted on EI in the workplace, demonstrating that EI strongly predicts the quality of the organizational climate [20], performance and stress management [7], and teamwork and conflict management [6]. In educational settings, research shows that students with higher emotional intelligence perform better academically [23], have improved emotion-management skills [4], and experience fewer learning and conduct problems [23]. Likewise, school leaders and teachers who are emotionally intelligent are more effective leaders and better co-workers [17], are better able to manage stress and create learning environments that provide greater emotional support, better classroom organization, and improved instructional support [9].

Enhancing EI skills provides individuals with the capacity to enhance personal growth, performance, problem solving, and relationships [24]. EI screening, training, and assessment have become a burgeoning business as everyone from companies, to the military, to educational institutions are hoping to increase productivity with workers who are more flexible, adaptable, and skilled at working in teams [1]. Now, with growing pressure for efficiency and achievement among workers in a competitive and increasingly technologically advanced global environment, not only is more emphasis being placed on the EI skills of the human worker, but also on that of the machines in which the workers interact [21].

In artificial intelligence, emotional intelligence is implicitly assumed under the concept of "relational agents" which are defined as "computational artifacts designed to build long-term, social-emotional relationships with their users" [3]. One study compares a relational agent with programmed social skills to a non-relational agent without any such skills. In the development of the relational agent used in their experiment, the authors gave the agent nonverbal skills, such as hand gestures, posture shifts, and facial expressions, as well as verbal messages that conveyed humor, empathy, politeness, and friendliness. When participants interacted with either the relational or non-relational agent for an extended period of time, participants reportedly felt closer to and preferred the relational agent.

The concept of relational agents has further been explored and found to be effective in a variety of settings, from education to elder care [8] to public areas like shopping malls [11]. In Baylor's study of virtual educators [2], participants were able to distinguish between virtual agents with different teaching styles, and found the agent that exhibited the least relational cues to be less human-like and less engaging.

The relationship between a human and an artificial agent is not negligible, since it affects not only the user's perception of the robot, but also the user's behavior following the interaction. In the aforementioned study on virtual educators, results showed that participants interacting with a more relational agent had a bigger boost in confidence and performed better on the task taught by the agent.

While much research has been conducted on what makes an artificial agent perceived as more emotional, not much has been explored on the perception of emotional intelligence in an artificial agent, which focuses on how well the agent comprehends and displays emotions in specific social situations. Moreover, it is unclear to what extent emotional intelligence, if exhibited by an artificial agent would engender trust in the agent. In humans, emotions (impacted by EI skills and training) can exert a significant influence on trust judgments and behavior [19, 12, 16, 13, 10, 26, 25]. Trust is defined as the willingness to be vulnerable to the actions of another based on positive expectations [19, 12] and thus a critical factor to consider for human-agent interactions as trust impacts how much humans rely on artificial agents like robots [16, 13, 10, 26, 25]. Previous research has established that numerous factors related to human, artificial agent, as well as the environment in which they interact can impact trust and human-robot team outcomes [16, 13, 25]. For instance, we believe that emotional intelligence of the team-members (human and artificial agent) leads to emergence of team dynamics processes (e.g., human-agent team's rapport, communication, cooperation, team management), which influences trust and team performance [16]. In past work, we have shown that emotional intelligence displays by an artificial agent results in greater trust and reliance on that artificial agent [16, 14, 15]. However, little empirical evidence is currently available to understand how EI levels of both human and artificial agent impact trust and teamwork and whether artificial agents need to display EI. In the present study, we have compared EI displays by an artificial agent versus a human to better understand the role of EI and its influence on trust outcomes.

3 The current study

With the rise of artificial agents in everyday life from personal robots to human-machine teaming in the military to collaborative robots in manufacturing it may be expected that we would want the same EI competencies in our artificial agent counterparts as we have come to expect in our human teammates. Would it not be great, for example, if an artificial agent teammate (perhaps more so than a human teammate) was capable of detecting a certain threshold of stress and in response swiftly relieved a worker of the burdensome task before it became riddled with errors? In this study we focus on empathy, a core competency of EI. While empathy is integral in an interaction between two humans, it is unclear whether we expect artificial agents to also empathize with us during an interaction. It also remains to be seen how we determine that an artificial agent is empathizing with us.

In order to understand human perception of emotional intelligence in artificial agents, we explore the importance of different factors in social behavior, including the content of the message, tone of voice, posturing, and gesturing are also relevant factors in judging an agent's emotional intelligence. We designed our experiment so that we could incrementally evaluate the effect of each of these factors on human perception of an artificial agent's empathy skills.

The study consisted of a participant watching a short workplace scenario between a human and an agent. The agent was either a human or a robot, and either displayed empathy (high EI) or failed to display empathy (low EI). We ran four permutations of this study which varied in the communication methods presented on screen. The communication methods of interest were message content, tone of voice, body posture, and physical gestures. The permutations were phased such that one communication method was removed for each proceeding permutation. We specifically intended to test the following hypotheses:

H1. If robots are not perceived as human-like, then we would expect to see a difference between the human high EI condition and the artificial agent high EI condition, and possibly a difference between the human low EI condition and the artificial agent low EI condition.
H2. If the dynamics of the interactions matter for the perception of EI, then we expect to see a difference in the EI effect between the full video showing all the dynamics of the interaction and the two still images at the beginning and in the middle of the interaction, for both artificial agent and human, with the full video showing overall higher levels of EI than the still images.
H3. If the bodily postures of the two still images convey enough information about the EI of the agent, then we expect a difference between the audio-only condition (with only an initial image of the agent) compared to the condition with the two still images (at critical times during the interaction) and also the full video with the full dynamics of the interaction displayed. Similarly, we would expect a further reduction in the EI assessment for the text-only condition if prosody and other vocal qualities matter for the EI assessment in addition to the semantic content of the utterances.
H4. Overall we expect humans to trust human and artificial agents with high EI more than human and artificial agents with low EI.

3.1 Design

Participants. A total of 395 participants (43% females) were recruited for this study through Amazon Mechanical Turk. Participants were between 18 to 66 years of age (mean age = 33.66, SD = 10.19). The ethnicity distribution for the sample was: White or Caucasian 77.5%, Asian 7.6%, African American 7.8%, Hispanic 5.1%, two or more races 4.5%, and other 2%.

Materials. We used the PR2 robot as the agent, which is physically slightly larger than an average person and has arms that end in a clawed hand. It has 7 degrees of freedom in its arm and wrist, and its head can pan and tilt. In the original videos, the PR2 started at a neutral position, facing the supervisor with arms in front, then moved to a posture reflecting the EI condition as described above. Although the PR2 played the pre-programmed dialogue during filming using its native text-to-speech software, we later dubbed its lines using the "Alex" voice on the Mac OS due to lack of clarity. We filmed a series of videos in which an agent interacted with a workmate who was recently reprimanded by his supervisor. The agent (human or robot) demonstrated empathy (high EI) by showing concern and offering encouragement to his workmate, or failed to demonstrate empathy (low EI) by chastising his workmate. Apart from dialogue, the two EI conditions differed in the posture of the agent. In the high EI condition, the agent faced the workmate with open arms, while in the low EI condition, the agent faced away from the workmate with crossed arms. Naturally, the videos with the human agent had minimal physical gestures and slightly different tones of voice between the EI conditions, while the robot in the robot agent videos did not move once it struck its designated pose, and did not vary its tone of voice between the EI conditions. The supervisor, workmate, and human agent were played by male actors, and a male voice was used for the robot agent.

To do a phased study of the different communication methods, we varied the presentation of the stimuli-type in the following way:

1. *Video.* The video was shown in its entirety, which displayed the agent's message, tone of voice, posture, and movement.
2. *Audio.* The video showed two still images from the original video while keeping the audio (see Fig. 1). The first still in both EI conditions showed the agent and the workmate looking at the supervisor in a neutral position. In the second still, the supervisor has left and the workmate is looking at the agent. The agent is displaying the posture for the given EI condition as described above. By showing stills instead of the video throughout the interaction, this experiment removes physical gestures and other dynamic movements from the participant's evaluation of the human and agent's EI.
3. *Image.* The video showed two head-shot images of the agent and workmate, respectively, in neutral positions prior to the dialogue, then played the audio from the original video against a black background with no images. This removes posture information in addition to gestures from the participant's evaluation.
4. *Text.* The video showed images of the agent and workmate prior to the dialogue, then displayed the text of the dialogue without audio or other visuals. This removed tone of voice from the communication methods the participant observed.

Questionnaires. Prior to viewing the scenario, the participants answered a demographic survey about their age, gender, and ethnicity. After viewing the scenario, to measure how participants perceived the agent's EI, a standardized questionnaire was completed by the participants (24-item, Cronbach's α was .99) [5]. Example items include: "Considerate of others' feelings", "Puts people down". Next, participants reported how much they trusted the agent using a standardized questionnaire (4-item, 5-point Likert scale, Cronbach's α was .76) [18]. An example item is: "I really wish I had a good way to keep an eye on the agent").

3.2 Procedure

Participants from Mechanical Turk were redirected to our website which led them through the experiment. After accepting the consent form, participants completed the demographics and EI questionnaire. The participants were then led to a page that played a video with randomly assigned conditions. The scenario was only played once, and the participant could not pause or skip the video. The participants then answered the agent EI questionnaire, after which they were given a code to redeem payment from Mechanical Turk.

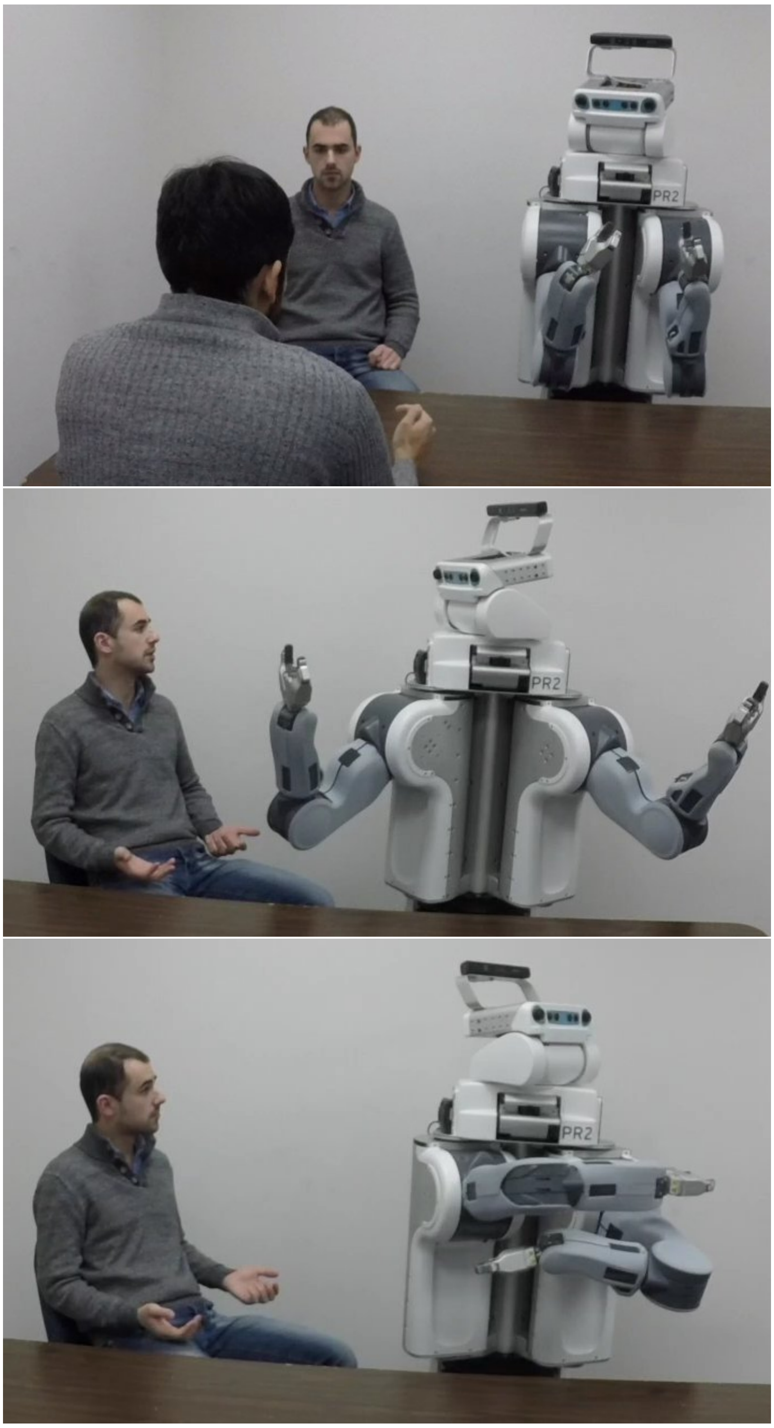


Fig. 1. Three still images from the EI robot scenario (from top to bottom): at the beginning of the interaction, in the high EI condition and the low EI condition after the supervisor left.

4 Results

As a manipulation check, we wanted to make sure that the high EI vs. low EI scenarios that were created for this study actually led to high vs. low EI-related perceptions by the participants. We tested if EI-related perceptions of the agent (dependent variable) was influenced by the EI behavior presented by the agent in the scenario (low vs. high) for each of four stimuli-types (video, audio, image, and text stimuli). Fig. 2 presents the mean and standard error values across the resulting 16 conditions.[4] Simple contrast comparisons confirmed that the manipulation led to significant differences in EI level presented by the human or robot agent across all the stimuli-type was significantly different. For human agent: in video ($F(1, 379) = 46.84, p < .001$), audio ($F(1, 379) = 23.59, p < .001$), image ($F(1, 379) = 45.39, p < .001$), and text ($F(1, 379) = 52.46, p < .001$) stimuli-types, high-EI (than low-EI) behavior displayed by the agent resulted in higher EI perceptions of the agent. Similarly, for robot agent: in video ($F(1, 379) = 41.87, p < .001$), audio ($F(1, 379) = 23.89, p < .001$), image ($F(1, 379) = 44.33, p < .001$), and text ($F(1, 379) = 51.74, p < .001$) stimuli-types, high-EI (than low-EI) behavior displayed by the agent resulted in higher EI perceptions of the agent. These findings suggested that during high-EI scenarios (relative to low-EI), human as well as robot agents were perceived to have higher EI. These analyses were done as a manipulation check to ensure that the stimuli manipulation led to conditional differences in agent's EI perception.

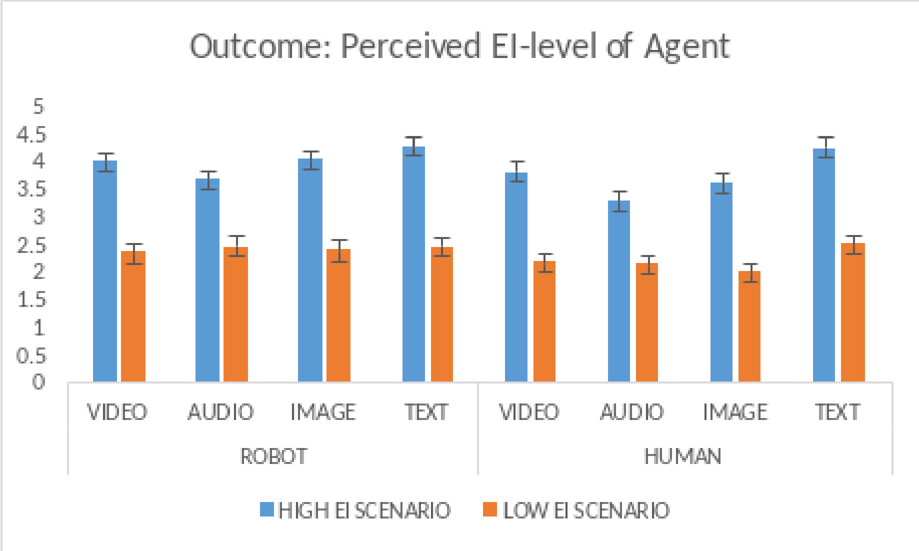
Planned comparisons using one-way ANOVAs were conducted to examine if there were any differences in perceived EI depending upon the agent being a human versus a robot (related to H1). No significant differences for any of the comparisons were found suggesting that the perceived EI were not different for human versus robot agents.

Furthermore, related to H2 and H3, stimuli-type was found to have no difference on perceived EI of robot agent, whereas the stimuli-type influenced perceived EI levels of human agent. Specifically, text stimuli led to higher perceived EI of the human agent than video ($p = .03$), audio ($p < .001$), as well as image ($p = .001$) stimuli.

Next, we examined how trust in the agent (dependent variable) was influenced by the following three factors: *agent-type* (human vs. robot), *agent's EI level displayed in a scenario* (low vs. high), and *different stimuli* (video, audio, image, and text stimuli). Fig. 3 presents the mean and standard error values across the resulting 16 conditions. A between-subjects analyses of variance (ANOVA) model revealed a significant effect of EI-scenario ($F(1, 379) = 121.87, p < .001, \eta_p^2 = .24$), as well as stimuli-type on trust ($F(1, 379) = 3.23, p = .02, \eta_p^2 = .03$). No effect of agent-type was found on trust ($p = .23$).

Planned comparisons using one-way ANOVAs related to H4 suggested that during high-EI scenarios, participants trusted the agent significantly more than the low-EI scenarios, for both human and robot agents, in all conditions. For hu-

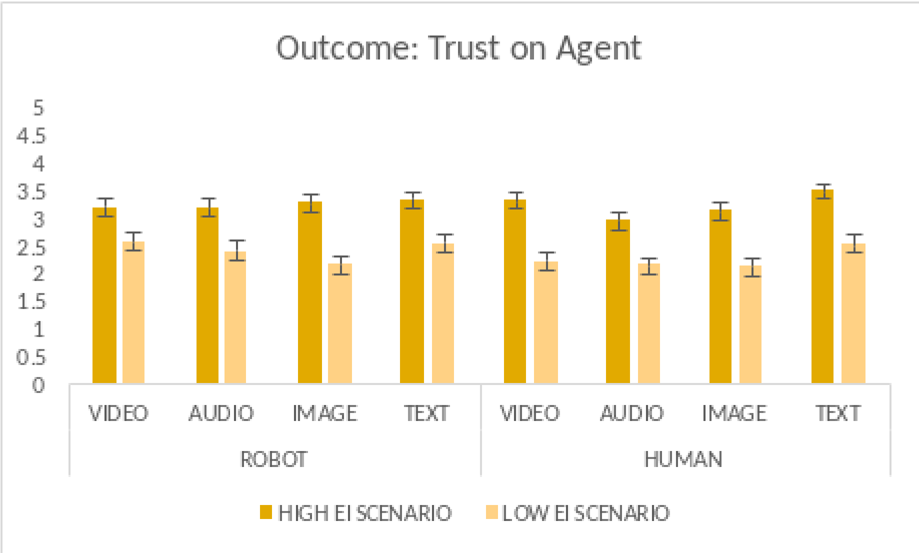
[4] No significant differences in the outcome variables (perceived EI and trust) due to age or gender were found and thus they were excluded from further analyses.



EI Scenario	Agent-type	Stimuli-type	Mean	Std.Err
Low EI	Robot	Video	2.35	0.19
		Audio	2.47	0.18
		Image	2.39	0.17
		Text	2.46	0.18
	Human	Video	2.15	0.17
		Audio	2.11	0.16
		Image	1.97	0.17
		Text	2.50	0.17
		Video	3.99	0.17
High EI	Robot	Audio	3.67	0.17
		Image	4.02	0.18
		Text	4.26	0.18
	Human	Video	3.81	0.18
		Audio	3.28	0.18
		Image	3.59	0.18
		Text	4.23	0.17

Fig. 2. Mean values and standard errors of perceived EI presented by the agent.

man agent: in *video* ($F(1, 379) = 22.94, p < .001$), *audio* ($F(1, 379) = 13.19, p < .001$), *image* ($F(1, 379) = 20.61, p < .001$), and *text* ($F(1, 379) = 18.45, p < .001$) stimuli-type, high-EI (than low-EI) behavior by the agent resulted in greater trust on the agent. Similarly, for robot agent: in *video* ($F(1, 379) = 6.65, p = .01$), *audio* ($F(1, 379) = 11.32, p = .001$), *image* ($F(1, 379) = 22.89, p < .001$), and *text* ($F(1, 379) = 11.06, p < .001$) stimuli-type, high-EI (than low-EI) behavior by the agent resulted in greater trust on the agent.



EI Scenario	Agent-type	Stimuli-type	Mean	Std.Err
		Video	2.59	0.18
	Robot	Audio	2.42	0.17
		Image	2.18	0.16
Low EI		Text	2.56	0.16
		Video	2.23	0.16
	Human	Audio	2.15	0.15
		Image	2.13	0.15
		Text	2.54	0.16
		Video	3.19	0.15
	Robot	Audio	3.19	0.16
		Image	3.27	0.16
High EI		Text	3.34	0.17
		Video	3.31	0.16
	Human	Audio	2.97	0.17
		Image	3.15	0.16
		Text	3.50	0.16

Fig. 3. Mean values and standard errors of trust presented by the agent.

Next, we examined differences in trust appraisal when the agent is human versus robot across all conditions (related to H1). These comparisons revealed that there were no differences in trust appraisals when human versus robot agents were used to display EI-relevant behavior.

We conducted planned contrast comparisons using one-way ANOVAs to examine if there were any differences in trust levels in the agent depending upon the stimuli type. Stimuli-type was found to have no difference on trust in robot agent, whereas the stimuli-type was found to influence trust appraisals of human agent in the following two comparisons: Specifically, text stimuli led to greater trust in human agent than audio ($p = .01$) as well as image stimuli ($p = .02$).

5 Discussion

The results revealed that there was indeed no significant difference in how the human and robotic agents were perceived, thus allowing us to reject H1 and providing evidence for the fact that robots can be perceived as showing human-like EI in human-robot interactions. In addition, variation in the stimuli-type had no effect on the perceived EI of the robot agent, thus allowing us to reject H2 and H3 for the artificial agent. In the human case this was not true, as the text stimulus led to even higher perceived EI of the human agent than the video, audio, and image stimuli, thus making an even stronger case for rejecting H2 and H3 for humans. We did find support for H4 in that people did rate the high EI robots and humans as more trustworthy than the low EI robots and humans.

Overall, our findings suggest that regardless of whether the agent is human or robot, people are able to perceive a difference in the agent's EI level. We also found that while the different factors of communication had some effect on the perception of the human's EI, we observed no effects in the different communication methods displayed by the robot. These results suggest that the content of the verbal interaction is essential for humans' perceptions of EI in both humans and robots and not the tone of voice, posture, gesturing or other bodily dynamics. The fact that the high-EI human is rated even higher in the text-based condition compared to all other conditions squarely points to that fact. Hence, when a robot or artificial agent is capable of natural language interactions, it will be critical for the agent to demonstrate EI through the semantics of its utterances rather than its appearance and bodily dynamics. This is all the more important since trust in an artificial (and human) agent is critically linked to the perception of that agent's EI.

While the question of whether we will, in fact, need emotionally intelligent artificial agents is still open and needs much more extensive investigations, including investigations of interactions between humans and artificial agents with different levels of EI (as opposed to the interaction observation experiments we have conducted in this study), the present results provide first evidence that we artificial agents might have to be endowed at least with rudimentary EI capabilities. For if we wish to design robots and other artificial agents to have strong working relationships with their users, they will not succeed at establishing and maintaining human trust without demonstrating that they are capable of being emotionally intelligent and empathetic to the user's emotional state.

6 Conclusion and Future Work

In this paper, we set out to evaluate the perception of emotional intelligence in robots vs. humans. Our study consisted of participants viewing scenarios in which a robot or human acted out a scene with or without empathy, and we had participants rate the agent's EI and trustworthiness. We also varied the presentation of these scenes to see the effect of different facets of communication, such as tone of voice and posture. We found that participants were consistently able to tell the difference between the high and low EI conditions, and that agents with high EI were rated as more trustworthy than agents with low EI. We also found that natural language is the most influential factor in determining an agent's EI, and therefore conclude that in order to design more trustworthy artificial agents, we must focus on designing them with empathetic natural language capabilities. Given the fact that people have different responses to observing a situation and participating firsthand in a situation, we hope to conduct a future study in which participants interact with the robot directly. In addition to empathy, we also wish to investigate the perception of additional EI competencies, such as self-regulation and self-awareness. Although we observed no gender effects in the results of this study, it would also be interesting to investigate whether the gender of the agents in the scenario have an effect on their perceived level of emotional intelligence. By gaining a better understanding of perception in emotional intelligence context, in the future we can design more empathetic robots which will be viewed as more trustworthy.

Acknowledgments.

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