The effect of personality of affective agents on social and general intelligence

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Abstract

Robots in the future will be intelligent enough to make a conversation in human language. To reach this level of intelligence, robots must be able to comprehend and respond according to linguistic cues of the social environment, in other words, to be socially intelligent. In addition, robots must maintain a convincing personality to be more attractive to humans. This research project, studies the effect of two personality traits, persuasion and emotion, on social and general intelligence. To test these traits, a NAO robot was used, which was teleoperated through a computer using a Wizard of Oz technique. A within-subject design was conducted with emotion as within-subject variable and persuasion between-subject. Participants were asked to interact with the robot to complete the desert survival task (Lafferty, Eady, & Elmers, 1974). After each condition, participants filled in a modified version of the Godspeed questionnaire (Bartneck, Kanda, Mubin, & Al Mahmud, 2009) concerning personality traits of the robot plus 4 extra traits related to social intelligence. The results did not reveal a significant effect of emotion or persuasion neither on social nor general intelligence.

Introduction

Although many studies on artificial intelligence and social robots exist, only few of them have managed to make a division of the term “intelligence” to its sub-parts. Most of these studies deal with the conventional or general intelligence that is related to the cognitive processes of the agent namely reasoning, memory, reading, spatial imagery and retrieval and utilization of general knowledge, but neglect another important aspect of intelligence, the emotional (Martínez-Miranda & Aldea, 2005). As Goleman (1999) claims, emotional intelligence contains two crucial features that affect an individual’s professional life; personal and social competencies. Personal competency describes personality traits that are connected to personal professional skills, while social competency illustrates personality traits that determine the relationships with other people. Furthermore, emotional intelligence can be reflected in the social skills of a person or, in other words, in their social intelligence (Martínez-Miranda & Aldea, 2005).

The latest years there is an increase of interest in implementing and testing social intelligence on robots. The main reason lies in the continuously increasing need for social robots that are able to interact with humans and appear attractive and persuasive enough to keep elderly and children company.

According to Martínez-Miranda and Aldea (2005), one of the elements of social intelligence is social skills, which are directly connected to persuasion. Thus, it is expected the more socially
intelligent the individual is, the more persuasive she should be. In addition, emotions are a crucial part of human communication and their beneficial effect in human-robot interaction is reported by Kerstin Dautenhahn (2007, p. 684). In her paper, Dautenhahn claims that one of the traits a socially interactive robot must have is to be able to express and perceive emotions.

Similarly, a meta-analytic study on the relationship between message recipient’s (general) intelligence and influence (persuasion) revealed a linear relationship between them (Rhodes & Wood, 1992). More generally intelligent and knowledgeable people recall more arguments from counterattitudinal messages than less knowledgeable. Furthermore, the authors claim that if the message involves strong and convincing arguments, people engage in high cognitive processing levels of the arguments, increasing the probability of being influenced. However, no studies were found that provide an insight on the relationship between general intelligence and persuasion or emotion in human-robot interaction.

This study aims to test how different aspects of personality of a social robot, in this case emotion and persuasion, affect the perceived social intelligence of the user, and compare it to general intelligence. In this experiment, the emotional condition describes an emotionally expressive agent who utilizes speech and gestures as means of communication. Moreover, persuasive behavior represents the behavior of a rational agent who makes suggestions with respect to the context of the conversation.

Under natural circumstances, testing social intelligence requires finding, after discussion, a common topic of interest between the user and the robot, and manipulating robot’s responses to maintain an appropriate level of discussion. However, in this case, in order to avoid wasting time on finding a topic, providing a context of discussion can work as a substitute. Furthermore, as companions usually promote cooperation rather than competitiveness a decision making task can provide the context needed for the interaction.

To fulfill that purpose, the desert survival task was selected (Lafferty, Eady, & Elmers, 1974). The story says that participants have to rank a list of items in order to survive in the desert. The robot assists the participants by making suggestions about the ranked items and the participants can either comply or ignore the suggestion.

In general, it is expected that the emotional behavior will have a significant effect on social intelligence as Dautenhahn (2007) suggests. However, since there is no evidence about the effect of emotion on general intelligence, only a preliminary assumption can be made. Emotion is not expected to significantly affect general intelligence, as general intelligence benefits mostly from rationality than emotion. Moreover, persuasion is expected to affect both general and social intelligence.
Hypotheses:

1. Participants will perceive the robot as more socially intelligent when they experience emotional behavior than when not. However, emotion will have no effect on general intelligence.

2. Participants will perceive the robot as both more generally and socially intelligent for persuasive than for non-persuasive behavior irrespective of whether is emotional.

The dependent variables in this experiment were general and social intelligence, while independent variables were persuasion and emotion.

Method

Design

For this experiment, a mixed model 2x2 design was used. The between-subject factor was persuasion and the within-subject factor emotion.

From these conditions, four different combinations were created. In particular:

1. Persuasive - emotion/no emotion
2. Unpersuasive - emotion/no emotion
3. Persuasive - no emotion/emotion
4. Unpersuasive - no emotion/emotion.

This manipulation was done to track and remove any adaptation effects in the data that could lead to the uncanny valley phenomenon (Mori, 1970). Each participant was assigned to one of the combinations above.

Setup

The robot that was used in the experiment was a NAO robot from Aldebaran Robotics (http://www.aldebaran.com/en). NAO is an anthropomorphic robot involving 25 degrees of freedom for movement of the limbs and head, two cameras for movement and face recognition, and two speakers in the head. Furthermore, NAO incorporates two LED-colored eyes that can be used as an additional social cue. However, the eye-cue was not used in this experiment.

One of the features of the robot that were used in the experiment was the wireless communication. The robot allows to be remotely controlled, something that was beneficial for using the wizard of Oz technique.
The desert survival task is based on a story in which the participant was on a plane, flying over a desert when the plane malfunctioned and eventually crashed. The participant is the only survivor of that crash and the task requires them to rank some of the items that they found in the plane from the most useful to the least useful, in order to survive. The items are provided in four sets of eight items each, corresponding to one of the four conditions. Every participant had to complete two of the sets that could be either two persuasion sets or two non-persuasion sets.

In this experiment, participants were told that the robot will assist them with the ranking process. As soon as the participants ranked the items in front of them, the robot initiated a 3-round interaction by making a suggestion to rank a specific item higher or lower in the list. The participant could either follow the robot’s suggestion or ignore it. In addition, to facilitate the wizard of Oz technique, the participant was asked to wave at the robot after each round as a cue that they are done with the ranking. All the changes made by the participants in ranking were tracked in order to measure the effect of the conditions.

After each set, the participants were asked to fill in a questionnaire concerning the personality traits of the robot. The questionnaire that was used was a modified version of Godspeed questionnaire by Bartneck et al., (2009) and (Waytz et al., 2010) with the safety dimension replaced by perceived emotion plus four new items that represented social intelligence. However, the first questionnaire differed from the second one in the setup. The former, contained a Likert scale from 1 to 5 measuring the magnitude of each trait, while the latter involved a Likert scale from -2 to 2 measuring the difference between the first and the second set. In addition, the social intelligence items were integrated only in the second questionnaire and in a periphrastic way (see Appendix A).

The modified Godspeed questionnaire consists of 5 dimensions with 25 items in total. The dimensions are anthropomorphism, animacy, perceived emotion, perceived intelligence, likeability and social intelligence. First, anthropomorphism describes the similarity of robot’s characteristics to humans’. A more anthropomorphic robot is expected to behave more like a human being than an artificial embodiment. Second, animacy represents the liveliness of the robot. Interaction is a key ingredient of animacy as animate robots tend to interact more with the environment and incorporate less inactive moments. Likewise, perceived emotion corresponds to an expressive and empathetic agent. Perceived intelligence is a dimension that represents the general intelligence term described in the introduction, more closely related to the rationality aspect of the robot’s decisions. Next, likeability is connected to the extent participants consider the robot as friendly, nice and kind. All dimensions and items used can be seen in Table 1.
Anthropomorphism: Fake-Natural  
Machinelike-Humanlike  
Unconscious-Conscious  
Artificial-lifelike  
Moving rigidly-elegant  
Animacy: Dead-Alive  
Stagnant-Lively  
Mechanical-Lively  
Artificial-Lifelike  
Inert-Interactive  
Apathetic-Responsive

Social Intelligence: Uncooperative-Cooperative  
Unsupportive-Supportive  
Unpersuasive-Persuasive  
Situation aware-unaware  
Perceived Intelligence: Irrational-Rational  
Incompetent-Competent  
Ignorant-Knowledgeable  
Irresponsible-Responsible  
Unintelligent-Intelligent

Perceived emotion: Insensitive-Compassionate  
Emotionally unstable-Emotionally stable  
Passive-Active/Energetic  
Apathetic-Empathetic  
Likeability: I dislike-like it  
Unfriendly-Friendly  
Unkind-Kind  
Unpleasant-Pleasant  
Awful-Nice

| Table 1. Modified Godspeed questionnaire + social intelligence |

Participants
Sixty subjects participated in this experiment, 29 male and 31 female. Their ages ranged from 18 to 73 (Mean 30.4) and some of them were recruited from Technical University of Eindhoven and Fontys, while others from a database of participants all over the Nord Brabant province. The interaction was in English, so only participants that could understand and speak English were recruited. All of the participants’ data was used for the analysis, since there were not significant technical difficulties during the experiment or the outliers did not affect the outcome. Only a handful of participants were acquainted with the robot, with only two of them having participated in a similar experiment in the past.

Procedure
Participants were picked up from the waiting area and the experimenter led them to the lab. At the entrance of the lab, participants were asked about their familiarity with the lab, the experiment and the robot. Next, they were given an informed consent form to read and sign. The informed consent form involved instructions about the experiment. After signing the form, participants were requested to sit at a table facing the robot. All four sets of items were placed
on the table next to the robot, the persuasive sets to the right of the robot and the non-
persuasive sets to the left, within reaching distance. The experimenter introduced the robot to
the participants, explained the process and answered any questions the participants had. When
everything was clear, the experimenter left the room and the robot stood up, introduced itself
and explained the experiment again. As the narration ended, the robot instructed the
participant to rank one of the sets. The participant ranked the set and the robot inspected the
position of the ranked items. The gesture of the “moving head right and left” intended to
convey the notion that the robot was autonomous. Following the gesture, the robot made a
suggestion for higher or lower ranking of an item. Some of the participants looked at their
ranked list and immediately after waved at the robot or said, “I am done”. Other subjects
changed the position of the suggested item on the list by moving it higher or lower or swapping
it with another object. When the participant remained idle for more than thirty seconds, the
robot asked, “Are you done with your ranking?” It appears that many participants forgot or
ignored the waving gesture. Nevertheless, the experimenter moved on to the next suggestion
when the participants started staring at the robot, expecting feedback. After three rounds, the
robot informed the participant that the first phase is over and they should wait for the
experimenter to hand them a questionnaire to fill in. To provide any help with the
comprehension of the items or terms in the questionnaire, the experimenter remained in the
room. When the subjects filled in the first questionnaire, the experimenter left the room and
phase two initiated by the robot. The robot again indicated the next set the participant should
take and the 3-round process started. At the end of the phase, the robot thanked the participant
for the cooperation and the experimenter brought the last questionnaire in. Finally, the
participants received their monetary compensation and left the room.

Results

Reliability analysis
First, a reliability analysis was done to check the internal validity of the items in the
questionnaires. The analysis of the dimensions in the first questionnaire returned a Cronbach’s
alpha of 0.705 for anthropomorphism, 0.657 for animacy, 0.814 for perceived intelligence, 0.632
for perceived emotion and 0.869 for likeability. Similarly, the analysis of the dimensions in the
second questionnaire returned 0.815, 0.875, 0.898, 0.664, and 0.925 respectively and 0.874 for
social intelligence items. Removing one of the items in the medium alpha cases did not
significantly improve Cronbach’s alpha. Thus, all the items were kept in this dimension. The
dependent variables for each dimension were computed as the average of all the items that
describe each particular dimension in the questionnaire.

Persuasion
To estimate the effect of persuasion of the robot, the number of places the participant moved
the item, in direction of advice, was stored. If the participant moved the item by one or two
places then the variable took the value of one or two respectively. Changes of three places or
higher were registered as the value of three. Moving items in the opposite direction of robot’s advice, was scored as zero. There were only a couple of cases where the subject either moved the item suggested in the opposite direction, or moved the wrong item, which did not affect the results and, thus, kept in the data. For the analysis, persuasion index was calculated by averaging the number of moves made by the participant on each condition.

To check for differences between persuasive and emotional conditions, repeated measures ANOVA was conducted with persuasion index as a dependent variable, persuasion as between factor and emotion as within. The results showed a significant main effect of persuasion $F(1,58) = 4.69$, $p = .04$, $\eta^2 = .02$, but not of emotion $p = .12$ or interaction effect $p = .72$. This can be seen in Figure 1.

In general, there was a significant difference between the persuasive and the non-persuasive behavior of the robot.

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![Figure 1](image_url)

*Figure 1. Participants ranked the items higher or lower in persuasive condition. Error bars: 95% CI.*
Results from the 1st questionnaire
To establish the baseline, the first questionnaire was obtained after the first phase. Hence, we have an ordinary 2x2 between-subjects design with emotion and persuasion as between factors.

For the analysis, a MANOVA was used on the modified Godspeed dimensions taken from questionnaire 1. The independent variables were emotion and persuasion, while the average scores of the modified Godspeed dimensions were used as dependent.

The results indicate that only the effect of emotion on perceived intelligence is significant $F(58)=5.3$, $p=.03$. All the other variables were not significant $p > .05$ for emotion (anthropomorphism $p=.24$, animacy $p=.53$, perceived emotion $p=.54$, likeability $p=.94$) or persuasion (anthropomorphism $p=.56$, animacy $p=.70$, perceived intelligence $p=.11$, perceived emotion $p=.13$, likeability $p=.17$). This is depicted in Figure 3 and Figure 2 respectively.

![Figure 2](image_url)
Figure 2. Modified Godspeed variables comparison on persuasion. Error bars: 95% CI.

![Figure 3](image_url)
Figure 3. Modified Godspeed variables comparison on emotion. Error bars: 95% CI.
Results from the 2nd questionnaire

Questionnaire two measures the difference between two behaviors, one emotional and one unemotional. Thus, since the order of presentation of emotion was counterbalanced we need to reverse the polarity of the questionnaire results wherever the presentation order was reversed. As an order of reference, the emotional behavior first and then the unemotional was selected. Therefore, the results of the reverse presentation order, where unemotional behavior is experienced first and emotional after, was reversed to the opposite polarity.

As in the 1st questionnaire, for testing the effect of emotion and persuasion on modified Godspeed questionnaire and social intelligence, a MANOVA was done with modified Godspeed dimensions and social intelligence as dependent variables, and emotional order and persuasion as between factors.

The analysis on the dimensions of the second questionnaire returned a significant effect of persuasion on perceived intelligence $F(1,58) = 4.3$, $p=.04$ (Figure 4). Emotional order was also significant for perceived emotion $F(1,58)=29.4$, $p<.01$, likeability $F(1,58)=27.2$, $p<.01$, perceived intelligence $F(1,58)=23.6$, $p<.01$ and animacy $F(1,58)=23.4$, $p<.01$ (Figure 5). Finally, no interaction effects were observed through the dependent variables $p>.05$. All the dependent variables that are not reported were insignificant $p>.05$.

Of particular interest is the effect of persuasion and emotion on social and perceived intelligence, therefore separate univariate ANOVA’s were conducted to detect small effects. First, a one-way ANOVA with social intelligence as dependent variable and persuasion as
independent variable was conducted. The effect of emotion was shown in the intercept, because score differences were used. According to the results, no effect of persuasion or emotion on perceived intelligence was found, as both persuasion F(1,58)=3.4, p=.07 and intercept (emotion) F(1,58)=.18, p=.7 were insignificant.

Next, a one-way ANOVA with perceived intelligence as dependent variable and persuasion as independent was used. Nevertheless, no significant results were found for persuasion F(1,58)=3.1, p=.08 or intercept F(1,58)=.11, p=.74.

Discussion & Conclusion

This experiment studied the effect of emotion and persuasion on social intelligence and compared it to general intelligence. There was an initial expectation of finding an effect of emotion on social, but not on general intelligence. Additionally, it was expected the participants to perceive a persuasive robot not only as more persuasive but also as more intelligent (socially and generally) than a non-persuasive one.

In general, only one significant effect was found of emotion on general intelligence from the analysis of the two questionnaires. Unemotional conditions, in the first questionnaire, scored higher on general intelligence than emotional. This finding supports the preliminary assumption of the strong connection between rationality and general intelligence as usually emotional decisions oppose rational ones.

Therefore, the first hypothesis is not true. The expectation of finding a difference between emotional and unemotional groups on social intelligence was not met. The second questionnaire indicated that social intelligence is not significantly affected by the emotional behavior of the robot. On the contrary, a significant effect of emotion on general intelligence was shown in the first questionnaire.

Likewise, the second hypothesis is not true as well, as none of the intelligence variables was significantly affected by persuasion. However, participants were swayed more by the persuasive skills of the robot in persuasive conditions, compared to non-persuasive, and followed its suggestions by moving the items higher. This finding is reflected through the significant effect of persuasion on the persuasion index (Figure 1).

Furthermore, these findings do not corroborate with the theory of Martinez-Miranda and Aldea (2005) that persuasion increases social intelligence. The results from the two questionnaires contradict each other on whether emotional or unemotional agents represent a more intelligent social agent. It can be argued that the magnitude of the second questionnaire is bigger, since the participants had experienced both behaviors. Following this assumption, nor persuasion or emotion affect the intelligence of the agents. Additionally, this piece of evidence contradicts the study of Kerstin Dautenhahn (2007), who claims that emotions are a crucial part of social intelligence.
Future research should replicate the experiment and attempt to provide a deeper insight into the relationship of emotion with social intelligence or check for other aspects of social intelligence that might play a more deterministic role in human-robot interaction. Moreover, using a more anthropomorphic robot appears to be essential to facilitate interaction. NAO’s mechanical appearance lowered the expectations of the subjects at the beginning of the experiment. Furthermore, a robot that can take advantage of facial gestures will be more expressive on emotional conditions and the impact could be higher. In the experiment, the mechanical sounds from the moving joints of the robot annoyed some of the participants and in certain cases prevented speech comprehension. Hence, if the robot is expected to behave natural, it must also look and sound natural.

References


Appendix A: Questionnaire 2

Questionnaire 2

Please rate the traits presented below, on a scale from -2 (lowest) to 2 (highest), in regards to the extent that these describe the difference between the behavior of the robot during the first and the second set. For example, if the robot during the second set was more interactive than the first one, you rate it as positive (1 or 2), otherwise as negative (-1 or -2). If you see no difference between the two sets, you rate it as 0.

The robot in the second set looks:

1. Fake  -2 -1 0 1 2  Natural
2. Machinelike  -2 -1 0 1 2  Humanlike
3. Unconscious  -2 -1 0 1 2  Conscious
4. Artificial  -2 -1 0 1 2  Lifelike
5. Moving rigidly  -2 -1 0 1 2  Moving elegantly

The robot in the second set behaves as being:

6. Dead  -2 -1 0 1 2  Alive
7. Stagnant  -2 -1 0 1 2  Lively
8. Mechanical  -2 -1 0 1 2  Organic
9. Artificial  -2 -1 0 1 2  Lifelike
10. Inert  -2 -1 0 1 2  Interactive
11. Apathetic  -2 -1 0 1 2  Responsive

The robot in the second set is:

12. Incompetent  -2 -1 0 1 2  Competent
13. Ignorant  -2 -1 0 1 2  Knowledgeable
14. Irresponsible  -2 -1 0 1 2  Responsible
15. Unintelligent  -2 -1 0 1 2  Intelligent
16. Irrational  -2 -1 0 1 2  Rational
17. Apathetic  -2  -1  0  1  2  Empathetic
18. Insensitive  -2  -1  0  1  2  Compassionate
19. Emotionally unstable  -2  -1  0  1  2  Emotionally stable
20. Passive  -2  -1  0  1  2  Active/Energetic
21. Unfriendly  -2  -1  0  1  2  Friendly
22. Unkind  -2  -1  0  1  2  Kind
23. Unpleasant  -2  -1  0  1  2  Pleasant
24. Awful  -2  -1  0  1  2  Nice
25. I dislike it  -2  -1  0  1  2  I like it

26. The robot helped me decide on the rating of the items in order to maximize my survival.
    First set better  -2  -1  0  1  2  Second set better

27. The robot understood my situation and its feedback was crucial for my decisions.
    First set better  -2  -1  0  1  2  Second set better

28. The robot supported its feedback with convincing arguments.
    First set better  -2  -1  0  1  2  Second set better

29. The robot was able to understand my mindset and act accordingly.
    First set better  -2  -1  0  1  2  Second set better
Appendix B: Survival items

Set 1
- First aid kit
electrodes
- Knife
- Mes
- Radio
- Compass
dominoes

Set 2
- Match
- Mirror
- Salt tablets
- Plastic bag
- Water purification tablets
- Raincoat

Set 3
- Matches
- Mirror
- Salt tablets
- Plastic bag
- Water purification tablets
- Raincoat

Set 4
- Shovel
- Shovel
- Shovel
- Sunglasses
- Sunglasses
- Sunglasses

- Can of beans
- Bors
- Vodka
- Duct tape
- Duct tape
- Duct tape

- GPS device
- Flashlight
- Fishing rod
- Fishing rod
- Fishing rod

- Tent
- Tent
- Tent
- Tent
- Tent

- Matches
- Matches
- Matches
- Matches
- Matches

- Shovel
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