The effect of gaze behavior on the attitude towards humanoid robots

Bachelor Thesis

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Abstract

Due to a growing proportion of elderly people, demand for care will become more difficult to fulfill. In order to satisfy this high demand for care it is an option to use human-like robots to fulfill some of the tasks required to take care of people. Making this robot more human-like has a positive influence on the mental well-being of the user. Therefore, in this study, we aim to find out how to give the robot more human-like gaze behaviors. We find no difference in attitude towards the robot or persuasiveness of the robot when comparing looking-while-listening and looking-while-talking behavior. We do find a more positive attitude towards the robot when the robot reacts to eye-contact from the human interaction partner. We also find that it is likely that different types of gaze behavior have no additive effect on the attitude towards the robot.
Introduction
This chapter gives a general introduction to the topic and discusses what has already been found about it. Then the chapter gives the research question and hypotheses of this thesis.

General introduction
It is expected that in Europe, by 2050, there are less than two persons of working age per person of over the age of 65 (United Nations Department Of Economic And Social Affairs, 2001). This means there will be a relatively high percentage of people who need care. In order to satisfy this high demand for care it is an option to use human-like robots to fulfill some of the tasks required to take care of people, and in the process make life better for its users.

The most natural way for humans to interact with robots is in the same way as how they interact with other human beings. This kind of interaction makes people interpret the robot not as a technical object but as a social being. This way of interpreting is called anthropomorphizing, and research suggests that humans subconsciously do this in order to get a better idea of what behavior to expect from the objects that they anthropomorphize (Waytz, Morewedge, Epley, Monteleone, Gao, & Cacioppo, 2010). It makes them feel more in control of the situation, which benefits their mental well-being (Benassi, Sweeney, & Dufour, 1988). Giving the robot a more human-like behavior also has the advantage that users have a more positive attitude towards the robot, and are more easily persuaded by advice given by the robot (Ham, Bokhorst, & Cabibihan, 2011). Because of these advantages we want to research how to make a robot behave more like a human.

In order to achieve a human-like way of interacting with robots it is important to consider non-verbal behavior. One of the most important types of non-verbal behavior is gaze behavior (Kleinke, 1977). Gaze behavior has been shown to have an effect on how well a participant remembered a story told by a robot (Mutlu, Forlizi, & Hodgins, 2006). And seemingly more intelligent gaze behavior is thought to be more persuasive than simply gazing straight ahead (Chidambaram, Chiang, & Mutlu, 2012).

Research question
In the paper titled "Attitude towards robots depends on interaction but not on anticipatory behavior", Cuijpers, Bruna, Ham & Torta (2011) conclude that the perceived intelligence and attitude towards a robot depend on the type of interaction. In this report we want to find out whether it can be confirmed that the type of interaction influences the attitude of a person towards a humanoid robot. More specifically, we want to find out how different types of gaze behavior influence this attitude.

Hypotheses
The type of interaction is made concrete by having two types of gaze behavior by the robot, and the presence or absence of a reaction by the robot to gaze behavior of the person. The two types of gaze behavior are turn-taking behaviors called "looking-while-talking" and "looking-while-listening". Looking-while-talking means that the robot looks at his conversation partner when the robot is talking, and looks away when he is listening. Look-while-listening is the other way around. These two types of gaze behavior were found to influence the attitude towards the conversation partner in human-human interaction (Argyle, Lefebvre, & Cook, 1974). A second type of interaction is that the robot reacts when the conversation partner looks at it. In the looking-while-listening condition, the robot will look at the participant at the moment the participant looks at it. In the looking-while-
talking condition, the robot will look away when the participant looks at it. These behaviors are together called "dynamic" gaze behavior. When the robot does not react to the gaze behavior of the participant, this is called "static" gaze behavior. Previous research has suggested that multiple types of interaction behavior can have additive persuasive effects (Ham, Bokhorst, & Cabibihan, 2011).

This results in three hypotheses:

- When a humanoid robot applies looking-while-listening gaze behavior, positive attitude towards the robot and persuasion by the robot will be higher.
- When a humanoid robot reacts to gaze behavior of a person (dynamic condition), positive attitude towards the robot and persuasion by the robot will be higher.
- Looking-while-listening and dynamic gaze behavior will have an additive effect on the positive attitude towards the robot and persuasion by the robot.

Method
This chapter explains the research method that was used. The chapter will explain the experiment design, the participants, the setup and finally the procedure that was followed during the experiment.

Task
Participants were asked to do a desert survival task (Lafferty, Eady, & Elmers, 1974). This meant that the participant was told a story about how he or she crash landed in the desert, and was supposed to survive using a number of items (see appendix B). The task of the participant was to rank the available items according to which item increased their chances of survival the most.

Design
This study used a 2x2 repeated measures design. One independent variable was whether Nao made eye contact based on the participant looking at him (dynamic) or not (static). The other independent variable was whether Nao looked at the participant while talking or while listening. The four conditions were tested on each participant and were ordered according to Williams' Latin square method (Williams, 1948).

Participants
A total of 19 naive participants took part in the experiment. The participants were mostly students from different departments at Eindhoven University of Technology, but also some participants were from outside the university. During some trials there were technical difficulties with the robot that may have influenced the participant. The data of these participants has therefore been discarded. The data of 16 participants was used for analysis. Of these 16 participants, 3 participants were female, and 13 were male. The age of the participants varied between 21 and 60, and the average age was 31.
Setup
For the experiment we used a programmable robot called Nao, developed by Aldebaran Robotics (see Figure 1). Nao is 58 cm tall and has 25 degrees of freedom. Among other things, it has two cameras and two speakers. Nao can be controlled wirelessly by a computer.

The participant sat on a chair at a table. Nao was standing across the table, facing the participant. On the table there were pictures of items for the desert survival task.

A questionnaire was repeatedly administered (see appendix A). Dutch-speaking participants were given a Dutch questionnaire which was a direct translation of the English version that was given to non-Dutch-speakers.

Procedure
The participants were taken to the lab by the experiment leader and were asked to sit at the table across Nao. Nao was introduced as an intelligent robot who would guide them through the rest of the experiment. Participants were instructed to look at Nao when they were done with the ranking task.

The experiment leader then went to another room. From here Nao took over the instruction of the participant. Nao told the participant the story about how the participant had crash-landed in the desert. Next it asked the participant to rank the items on the table according to which item increased their chances of survival the most. After the participant had ranked the items, Nao would give a recommendation to rank a certain item differently. Nao told the participant that he or she may choose to change their ranking. This cycle of Nao giving an advice and giving the participant the chance to change their ranking was repeated six times for each of the four conditions.

Questionnaire
The questionnaire that was administered was based on (Waytz, Morewedge, Epley, Monteleone, Gao, & Cacioppo, 2010) and (Bartneck, Kulic, Croft, & Zoghbi, 2009). It measured five dimensions of interaction between humans and robots: Anthropomorphism, animacy, likeability, perceived intelligence and perceived safety. Each of these dimensions was measured by between three and seven specific properties. These properties are the following, ordered by dimension:
Anthropomorphism:
Has a mind of its own - Does not have a mind of its own
Has intentions - Does not have intentions
Has a free will - Does not have a free will
Has consciousness - Does not have consciousness
Has desires - Does not have desires
Has beliefs - Does not have beliefs
Is able to experience emotions - Is not able to experience emotions

Animacy:
Alive- Dead
Lively - Stagnant
Organic - Mechanical
Lifelike - Artificial
Interactive - Inert
Responsive - Apathetic

Perceived intelligence:
Competent - Incompetent
Knowledgeable - Ignorant
Responsible - Irresponsible
Intelligent - Unintelligent
Sensible - Foolish

Likeability:
Like - Dislike
Friendly - Unfriendly
Kind- Unkind
Pleasant - Unpleasant
Nice - Awful

Perceived safety (how safe the participant felt):
Relaxed - Anxious
Calm - Agitated
Surprised - Quiescent

Data analysis
First the reliability and internal consistency of the properties of each dimension of the questionnaire were tested. The Cronbach's alpha statistic was used for this purpose. If Cronbach's alpha is above 0.7, then the properties are considered to have good internal consistency. When a dimension had an alpha below 0.7, an effort was made to increase the alpha by removing inconsistent properties. This was the case with the perceived safety dimension, which had an alpha of 0.161 before removing an inconsistent property. After removing this inconsistent property, the Cronbach's alphas were as follows:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Cronbach's Alpha</th>
<th>Remaining properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropomorphism</td>
<td>0.744</td>
<td>7</td>
</tr>
<tr>
<td>Animacy</td>
<td>0.710</td>
<td>6</td>
</tr>
<tr>
<td>Likeability</td>
<td>0.791</td>
<td>5</td>
</tr>
<tr>
<td>Perceived intelligence</td>
<td>0.722</td>
<td>5</td>
</tr>
<tr>
<td>Perceived safety</td>
<td>0.312</td>
<td>2</td>
</tr>
<tr>
<td>Total attitude</td>
<td>0.857</td>
<td>26</td>
</tr>
</tbody>
</table>

Each participant filled out the questionnaire five times: one time at the beginning of the experiment, and then after each condition. So from each data point, we subtracted the data point from the questionnaire from the previous condition. The questionnaire data were then analyzed using a factorial multivariate analysis of variance (ANOVA), with the average of each dimension as a dependent variable. A second set of data came from the ranking of desert survival items. This data set was analyzed using a factorial repeated measures ANOVA. From this ranking data set, the total amount of places in the ranking that the participant changed in compliance with suggestions from the robot was taken as a dependent variable. The measured extraneous variables were age and sex.
Results

The dependent variable from the ranking data (the total change in ranking) was adjusted to account for differences between participants, since we were only interested in within-subject differences.

The results from the ranking were analyzed using a factorial repeated measures ANOVA. These results are represented visually in figure 2 and figure 3. Though figure 3 suggests that there might be an interaction effect between Talking/Listening and Static/Dynamic, we only see a trend in the analysis ($F(1,15) = 3.378, p = 0.086$). Of the separate independent variables, Talking/Listening was not significant ($F(1,15) = 0.144, p = 0.709$). Static/Dynamic was also not significant ($F(1,15) = 0.159, p = 0.696$).

The questionnaire data were analyzed using a factorial multivariate ANOVA. With these data, only the influence of static/dynamic on perceived intelligence was significant ($F(1,60) = 5.029, p = 0.029$). The rest was not significant ($p > 0.05$). The influence of static/dynamic on total attitude was close to being significant ($F(1,60) = 3.831, p = 0.055$), but this was mostly due to perceived intelligence being part of this total. When perceived intelligence was removed from the total attitude, static/dynamic had a less significant effect on it ($F(1,60) = 2.439, p = 0.124$). A visual representation of these results can be seen in figure 4.
Discussion

The results indicated that when the robot applied looking-while-listening gaze behavior, positive attitude towards the robot and persuasion by the robot (first hypothesis) were not significantly higher. This is in contradiction with findings in human-human interaction by (Argyle, Lefebvre, & Cook, 1974). One reason for this could be that Argyle et al. used same-sex interaction partners, while the participants in our study may have interpreted the robot's sex as either male, female or neither. Though the robot was introduced as "Marvin", which is usually a male given name in the English and Dutch language. Another reason might be that the ranking task which the participant had to fulfill may have distracted the participant too much from the interaction with the robot. In future research, a different way of measuring persuasiveness might be used in order to facilitate more interaction between the participant and the robot.

When the robot reacted to gaze behavior of a person (dynamic condition), positive attitude towards the robot (second hypothesis) was higher, but not significantly. However it was very close to being significant, so it is certainly a trend. Which means we can assume that the hypothesis holds that positive attitude of a person towards a robot is higher when this robot reacts to gaze behavior of the person. The reason that the effect is not more significant might be that the robot did not always have an immediate reaction because of technical limitations. This problem occurred more prominently in the looking-while-listening condition, so the problem might be a confounding variable. Perceived intelligence was significantly higher when the robot reacted to the persons gaze behavior. Persuasion by the robot was not significantly higher in the dynamic condition.
Looking-while-listening and dynamic gaze behavior had an almost significant interaction effect, so that indicates that there are no additive effects on the persuasion by the robot (third hypothesis). This means that adding multiple more human-like behaviors together does not automatically improve the persuasiveness of the robot with the sum of the effects of each individual gaze behavior. So this third hypothesis is not confirmed.

In conclusion, looking-while-listening and dynamic gaze behavior did not influence persuasiveness, but the attitude towards the robot and perceived intelligence of the robot were higher when dynamic gaze behavior was used. A trend toward an interaction effect implied that there was no additive effect of the looking-while-talking/looking-while-listening variable and the static/dynamic variable.
## Appendix A: Questionnaire

For the properties below, please mark the extent to which these properties apply to your state of mind.

<table>
<thead>
<tr>
<th>Property</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surprised</td>
<td></td>
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<tr>
<td>Calm</td>
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<tr>
<td>Anxious</td>
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</tbody>
</table>

*For the properties below, please mark the extent to which you believe they apply to the robot in front of you.*

<table>
<thead>
<tr>
<th>Property</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
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</thead>
<tbody>
<tr>
<td>Foolsish</td>
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<tr>
<td>Intelligent</td>
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<td>Responsible</td>
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<td>Knowledgeable</td>
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<td>Competent</td>
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<tr>
<td>Nice</td>
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<tr>
<td>Pleasant</td>
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<tr>
<td>Kind</td>
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<tr>
<td>Friendly</td>
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<tr>
<td>Like</td>
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<tr>
<td>Responsive</td>
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<tr>
<td>Interchangeable</td>
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<tr>
<td>Likelike</td>
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<tr>
<td>Organized</td>
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<tr>
<td>Lively</td>
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<tr>
<td>Alive</td>
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<tr>
<td>Is not able to experience emotion</td>
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<tr>
<td>Has beliefs</td>
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<tr>
<td>Has desires</td>
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<tr>
<td>Has consciousness</td>
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<tr>
<td>Has a free will</td>
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<tr>
<td>Has intentions</td>
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<tr>
<td>Does not have a mind of its own</td>
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</tr>
</tbody>
</table>
Appendix B: Survival items
Bibliography


Cuijpers, R. H., Bruno, M. T., Ham, J. R., & Torta, E. (2011). *Attitude towards robots depends on interaction but not on anticipatory behavior.*


