KEEPING HUMANS ENGAGED WITH HUMANOID ROBOTS BASED ON PERSONALITY TRAITS

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1 Introduction

Humanoid robots are quietly undergoing a revolution in our society. They are becoming more prominent, leaving research laboratories and making their way into our everyday lives [1]. This means that robots have to adapt to the way humans communicate to be able to establish meaningful connections and maintain engagement with humans. Research in the field of artificial intelligence has placed a lot of emphasis on language understanding and output instead of concentrating on the fundamental issues of creating and maintaining connections (i.e. engagement) [2]. When communicating with a robot, it is important that the interaction between the robot and the human runs smoothly and that humans stay engaged during the interaction. Research shows that when a humanoid robot interacts with a human, the interactions in only a few cases last more than 30 seconds, and even though many studies are looking at the social connection between humans and robots, ongoing long-term engagement is still mostly unexplored [3].

Therefore, the interaction problem we aimed to solve is maintaining long-term engagement between a human and a humanoid robot. C.L. Sidner and C. Lee define engagement as "Engagement is the process by which two (or more) participants establish, maintain and end their perceived connection during interactions they jointly undertake. Engagement is supported by the use of conversation (that is, spoken linguistic behavior), ability to collaborate on a task (that is, collaborative behavior), and gestural behavior that conveys the connection between the participants" [4]. We will adopt this definition but focus only on maintaining perceived connection during interactions. Establishing the perceived connection is out of our scope and has already been researched [5].

1.1 Related work

Human-robot interaction has been an ongoing discussion in literature and is currently still being explored. Focusing on robot gestures in [6], it was found that people become more engaged with a robot and found engagement more appropriate when engagement gestures are present than when they are not. Another research explored how social a robot needs to be for people to engage with it, and concluded that a robot with social cues led to more engagement

[7]. Looking specifically at the extroversion-introversion personality trait in a restaurant information request setting, [8] proved that participants preferably engage with a robot when it has a personality that is similar to their own. A result also found by and [9]. Similarly, [10] reported that when a robot's personality is tailored to reflect human personality traits, they are seen as being friendlier.

1.2 Research question

As mentioned above, research has already been done on gestures and social cues in establishing a long-term engagement between humans and robots, but we are adding on top of this research how personality adaptation can add to establishing long-term engagement. Our project aims to investigate whether introverted and extroverted people are more engaged in conversation with a robot when that robot matches its personality type. We will accomplish this by programming a robot that is capable of having a conversation with a human. This conversation will eventually lead to an interaction where the robot and human will play games with each other. We will create two characters for the robot, an introverted and an extroverted character. The robot was created to be simple to interact with and not require any special skills or training, as well as compelling enough to encourage engagement for a longer time period. Anyone can interact with this robot.

1.3 Evaluation

To evaluate if humans interacting with their own personality type are more engaged with the robot, we measure the duration of the interaction in minutes. We assume that if the interaction takes longer, there is more and longer engagement with the robot. However, sometimes the robot repeats itself because it can't hear the human properly or doesn't understand the answer. When the robot has to repeat itself, often the duration of the interaction will be longer, but not because there is more engagement between the robot and the human. Therefore, we also count the times the robot has to repeat questions. Additionally, we measure the number of games played. If the user enjoys the interaction, he/she will play more games, and therefore, there will be more engagement. Furthermore, we also included subjective measures because how the human feels about the interaction is also important when determining if there was more engagement. We asked the user to rate their satisfaction with the interaction on a scale of 1 to 10. We also asked if they knew whether the robot they interacted with was an introverted or extroverted robot to see if the user noticed the character trait.

2 Interaction design

The general idea of the interaction is that a human will partake in a conversation with the robot, after which they will play a game. The conversation starts with a general question about how the human feels, and the human can ask any type of question back to the robot. If the human does not have any more questions, the robot will propose to play a game with the human, which the human can accept or deny. In case the human chooses to play a game, they will play rock-paper-scissors. After the game is finished, the robot will ask whether the user wants to play another game or not. The human can then choose to continue or quit the interaction.

As mentioned in the introduction, the goal of our research is to investigate whether the personality matching of a robot and a human will help the engagement of the human in the interaction with the robot. Therefore, we created two different versions of the robot, namely, an introverted and an extroverted robot. The interaction with these different robots is very similar. The differences between the interactions with the introverted or extroverted robot are in the exact sentences being said, the voice, and the movements.

In this section, we will discuss the full interaction according to the interaction diagram. The interaction modalities that we took into account are speech and movement. We will also discuss how we implemented these different interaction modalities for introverted and extroverted robots.

2.1 Conversational Interaction

As mentioned above, the interaction starts with a conversation, which is initiated by the robot. A small introduction is made after which the robot asks how the human is doing. Then, the robot will ask whether the human wants to ask a question, which can be any type of (general knowledge) question. If the human does not have any questions, the robot will propose to play a game of rock-paper-scissors. It can explain the rules of the game if the human does not know these. Then, the robot initiates the game, after which it tells the human which move he chose and asks the human which move they chose. Based on this, the robot determines who won the game. After congratulating or comforting the human, it will ask whether the human wants to play another game. If the human agrees, the robot will initiate another game of rock-paper-scissors. If the human denies it, the interaction will end.

The interaction diagram for interaction with the extroverted robot is shown in figure 1, and the interaction diagram for the introverted robot is shown in figure 2. The interaction diagrams are very similar for extroverted and introverted robots. The differences are in what is being said.

For example, extroverted people tend to talk more than introverted people. They are more likely to give what they say a background story. We implemented this by making the extroverted robot say, "I played rock-paper-scissors with my robot dad, this was really fun", whereas the introverted robot will only ask the human to play a game.

Extroverted people also tend to be more confident, thus avoiding words like 'maybe' or 'perhaps'. Extroverted people are also more likely to propose something in the form of a statement, whereas an introverted person would ask a, possibly hesitant, question. An example of where we made this distinction is

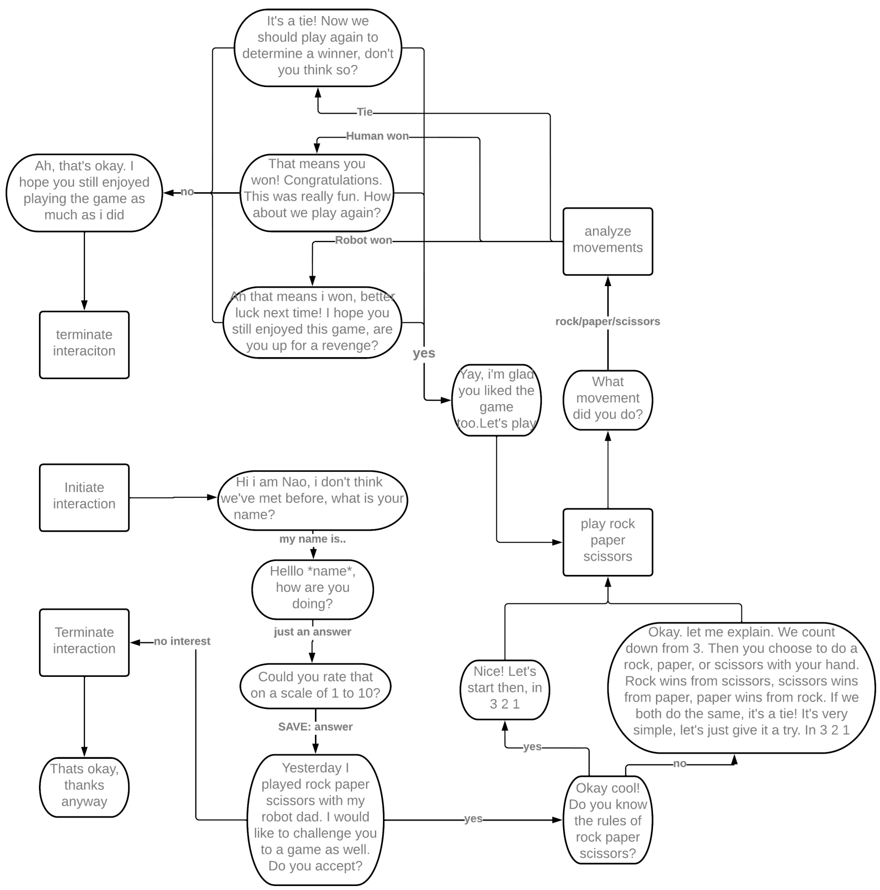


Fig. 1: Interaction Diagram Extroverted Robot

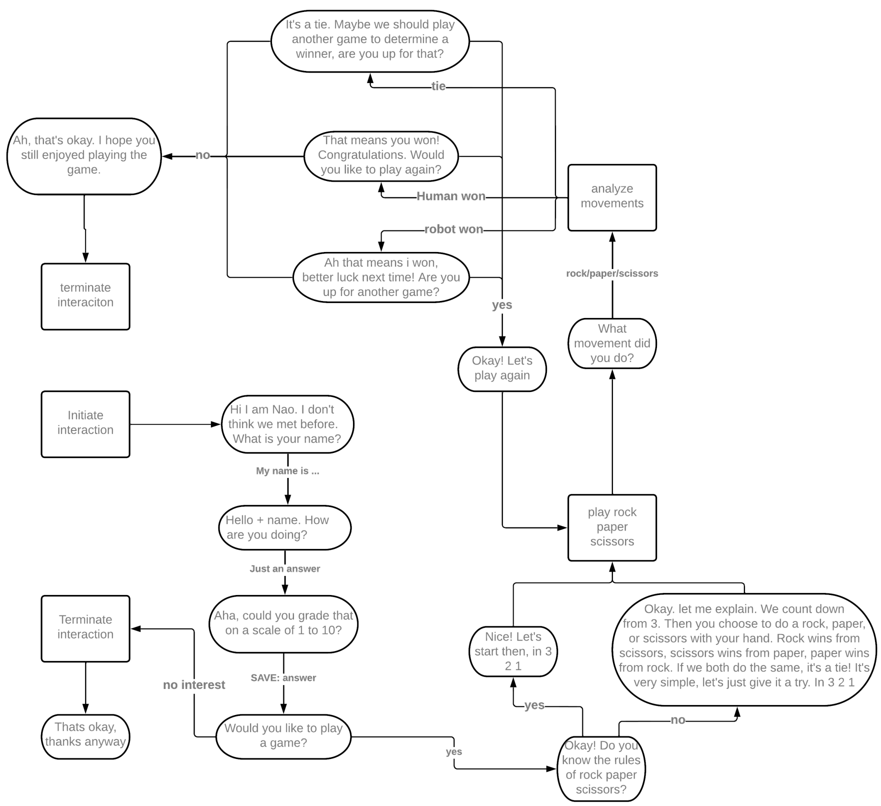


Fig. 2: Interaction Diagram Introverted Robot

when the robot first proposes to play a game. The introverted robot will ask "do you want to play a game?", whereas the extroverted robot will say "I want to challenge you to a game".

2.2 Speech

The conversation with the robot will be in English. To make the distinction between introverted and extroverted robots clear, we adjusted the speech. The extroverted robot will have louder, faster speech, making the robot a bit more notable and in-your-face. The introverted robot will have a more quiet, slower voice, giving it a more reserved appearance.

2.3 Gestures

We created custom movements to make the robot less static and further improve the distinction between introverted and extroverted robots. The extroverted robot has bigger, more extreme movements. More specifically, the extroverted robot waves when first introducing itself; it happily cheers after it wins a game and very sadly sighs after losing. For the introverted robot we implemented similar gestures; we also implemented a wave, cheer, and sad sigh. However, these gestures are smaller and slower, creating a less 'in your face' appearance than the extroverted robot.

3 Evaluation

In this research, we aimed to answer the question of whether personality adaptation (being introverted or extroverted) will lead to humans having a longer engagement with the robot.

3.1 Setup

The goal of the project is to investigate whether people are more engaged in a conversation with a robot if the robot matches their personality type. To test this, we created four different research groups, as displayed in table 1. Each research group represents a combination of a human and a robot personality. In order to know which robot personality to match to the human, we needed to know if the human identifies more with an introvert or extrovert personality. Therefore, we asked the participants to fill in a few questions before the interaction with the robot starts, see appendix A. The answer options in 2, 3, and 4 are phrased in such a way that one option aligns best with an introverted personality and the other option aligns best with an extroverted personality. In this way, the answer option that is chosen most often will be linked to the participant, and the corresponding robot can be chosen for the experiment.

In total, we had 12 participants, which we divided into the research groups. All participants had an interaction with the robot. To prevent a biased response, the participants did not know that the experiment was about the personality of the robot. After the interaction, the participants filled in a questionnaire where we asked them about their experience with the robot. The questionnaire can be seen in Appendix B.

	Human Personality	
Robot Personality	Introvert	Extrovert
Introvert	Group II	Group IE
Extrovert	Group EI	Group EE

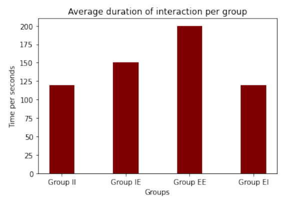
Table 1: Experiment Groups

3.2 Results

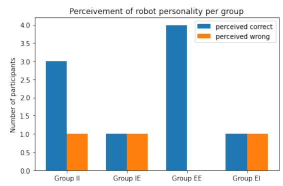
The experimental results show that all groups had a positive experience and an increase in their overall enjoyment of the robot. Group II had 4 participants and spent 120 seconds with the robot, playing 1 game and asking 1 question on average. Their scale of enjoyment pre-interaction was 7, which increased to 8 post-interaction. Group IE had 2 participants and spent 150 seconds with the robot, playing 1 game and asking an average of 1 question. Their scale of enjoyment pre-interaction was 8, which increased to 8.5 post-interaction. Group EE had 4 participants and spent 200 seconds with the robot, playing 1 game and asking 2 questions on average. Their scale of enjoyment pre-interaction was 8.25, which increased to 9.25 post-interaction. Finally, Group EI had 2 participants and spent 120 seconds with the robot, playing 1 game and asking 1 question. Their scale of enjoyment pre-interaction was 8, which increased to 9.5 post-interaction.

After analysis of the results, we found the following. The extrovert version of the robot achieved higher interaction time. Group IE and Group EE achieve an average increase in the interaction time of 25% and 67%, respectively, when compared to the introvert version. However, the interaction with the introvert robot achieved higher measurements in the post-interaction mood scale independently of the personality of the user. The increase achieved was 0.5 higher on average.

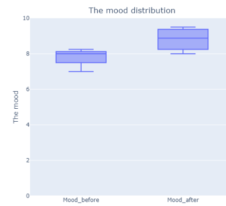
Regarding the correct identification of the personality trait associated with the robots. The study showed that the participants in "Group II" had a 75% accuracy rate, with 3 correct responses and 1 incorrect response. "Group IE" had a 50% accuracy rate, with 1 correct response and 1 incorrect response. "Group EE" had a 100% accuracy rate, with 4 correct responses and 0 incorrect responses. "Group EI" had a 50% accuracy rate, with 1 correct response and 1 incorrect response. Figure 3b



(a) Average time interaction



(b) Perceivement of robot personality per group



(c) The mood distribution

Groups	Participants	Time (s)	Games played	Questions	Scale*	Scale†
Group II	4	120	1	1	7	8
Group IE	2	150	1	1	8	8.5
Group EE	4	200	1	2	8.25	9.25
Group EI	2	120	1	1	8	9.5

Table 2: Experimental Results.
* Scale pre-interaction with the robot.
† Scale post-interaction with the robot.

4 Discussion

The purpose of our study was to investigate the influence of robot personality on human interaction duration and enjoyment. While our results showed that the extrovert robot increased interaction time in all groups, it is important to consider the limitations of our study.

Firstly, the small sample size of our study means that it is difficult to draw definitive conclusions. It is possible that the results we obtained may not be representative of the general population. Additionally, the fact that our participants had previously worked with the robot may have biased their responses, as they may have already formed certain expectations or attitudes towards the robot.

Despite these limitations, our findings suggest a relationship between robot personality and human interaction duration and enjoyment. However, we cannot definitively say that the extrovert robot caused the increased interaction time, as there may be other factors at play. In order to more fully understand this relationship, future research could focus on identifying which elements or combinations of elements contribute to the increased interaction time.

Additionally, our results showed that introverted participants rated their enjoyment lower on average compared to extroverted participants. This warrants further investigation to understand the cause and potential ways to improve the enjoyment of introverted individuals during interactions with robots.

Nevertheless, our data indicate that interactions with the introverted robot, regardless of human personality, result in more enjoyable than with the extroverted one. Again, the actual cause of this has to be researched further before we can truly attribute this to the robot's personality type.

Finally, we found no differences in the number of games played between the groups, which could be worth investigating further. It is possible that the results may differ for other games or activities, and future research could explore this possibility.

5 Conclusion

This study aimed to investigate the effectiveness of personality matching in social robotics by comparing the interaction experience of four groups of participants with a Nao robot. The results showed that all groups had a positive experience and an increase in their overall enjoyment of the robot, but personality match does not have strong evidence to be considered an important factor in the interaction.

However, the personality the robot displayed had a clear effect on the duration and enjoyment of the interaction. Extrovert robots increase the interaction time, while introvert robots achieve a more enjoyable interaction for the human user.

It is worth noting that these results should be interpreted with caution, as the study's sample size was small, and the duration of the interactions was relatively short. Further research is needed to confirm and extend these findings, using larger and more diverse samples and longer interaction times. Additionally, it would be interesting to explore other factors that may influence the effectiveness of personality matching in social robotics, such as the type of activity, the user's age and cultural background, and the level of social support.

This study provides initial evidence that personality matching is not an important factor in the success of social robots, and suggests that further research in this area could be directed to the influence of the robot personality on other aspects of the interaction. By leveraging the potential of modifying the robot's personality, it may be possible to create more engaging and effective social robotics applications that can benefit a wide range of users and contexts.

6 Appendices

6.1 Appendix A: Questionnaire pre-interaction

QUESTIONNAIRE

Please fill in this questionnaire **before** interacting with the NAO robot.

QUESTIONS PRE-INTERACTION

1. Please rate your feelings towards interacting with a robot on a scale from 1 to 10. Circle your answer.

1 2 3 4 5 6 7 8 9 10

2. Chose the statement that suits you best: Meeting new people is...

☐ Interesting and exciting

☐ Tiring and scary

3. Which option would you typically go for when planning a night out?

☐ Dinner with a good friend and sharing what's on your mind

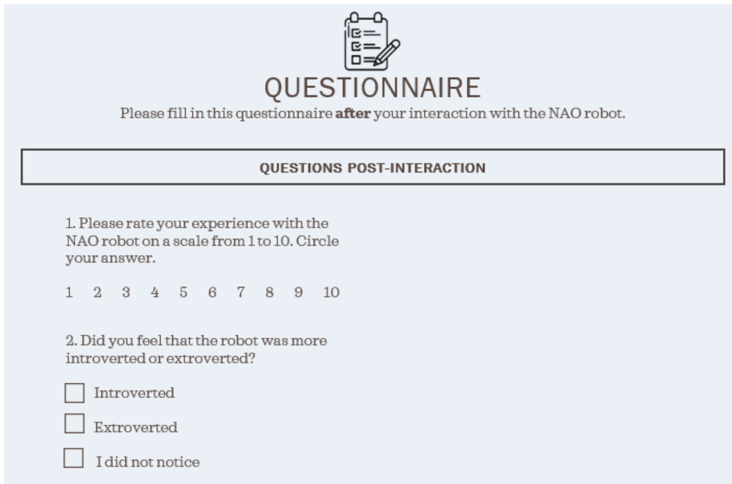
☐ Going out with a group of friends. More people gives you more energy.

4. If you have to chose one, which statement would you pick?

☐ A weekend full of social activities

☐ A weekend with zero social activities

6.2 Appendix B: Questionnaire post-interaction



QUESTIONNAIRE

Please fill in this questionnaire **after** your interaction with the NAO robot.

QUESTIONS POST-INTERACTION

1. Please rate your experience with the NAO robot on a scale from 1 to 10. Circle your answer.

1 2 3 4 5 6 7 8 9 10

2. Did you feel that the robot was more introverted or extroverted?

☐ Introverted

☐ Extroverted

☐ I did not notice

6.3 Appendix C: Individual contribution summary

Here the group members will explain individually what they have worked on during this project.

Fauve Wevers
I started working with Chantal on the introduction of the paper. Once that was finished, I did some literature research on the characteristics of introverts and extroverts. Victor and I have created all (custom) movements and we created one python project where all our code could be combined. Finally, Chantal and I created the poster for the presentation.

Chantal Vogles
After discussing with the whole group what our interaction problem should be about, I started doing literature research on our problem. With this, I could write the introduction and related work sections of this report. Afterwards, I switched to the speech part of the robot, where I tried to make sure that the robot speaks in a logical order for every possible path. When other group mates continued on this, I wrote the pre- and post-questionnaire that was needed to evaluate part of our experiment. Lastly, I created the poster together with Fauve to present it at the final presentation.

Demi Peek
I started with working on the speech together with Quinn, where I mainly tried

to figure out how to connect Dialogflow and get a basic code example for speech running. I made the flowcharts for the dialogue of the interaction. When this was finished, I figured out how to adjust the speech (volume, speed) for the robot. For the report, I wrote the Interaction Design section.

Quinn Scot
After coordinating the general direction of our project with the whole group, I started by developing a basic interaction flowchart, which was later improved by Demi. Demi and I also started together on the speech implementation and Dialogflow integration and were later joined by Mohammed and Chantal. Regarding the report, I wrote the discussion.

Victor Retamal
I help with the installation and technical support in the first weeks of the course. After that, Mohammed and I were working on the computer vision part of the project. Face recognition and tracking. Once this was done, I worked alongside Fauve to create the movements and gesture set to bring our robot to life. After the gestures were finished, I wrote the main framework we used to coordinate the submodules (vision, speech, and movement) to control the robot. Also, I initialized the main experiment script following the interaction flow presented in this paper. Quinn helped abstract some of the base functions. I performed the experiments together with Mohammed. In this report, I took care of the results and conclusion, analyzing and extracting insights from the data gathered.

Mohammed Majeed
I initially attempted to understand the installation setup and subsequently collaborated with Victor on the face and people detection. Additionally, I worked with Demi, Quinn, and Chantal on integrating speech recognition with the chatbot Dialogflow and the robot. I also integrated GPT3 with both the robot and Dialogflow in order to optimize performance. As for the report, I contributed to the analysis, results, and plots.

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