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# A Study on Human Interactions With Robots Based on Their Appearance and Behaviour

Zuzanna Janeczko

School of Computing Science, University of Glasgow  
Glasgow, UK  
zuz.janeczko@gmail.com

Mary Ellen Foster

School of Computing Science, University of Glasgow  
Glasgow, UK  
MaryEllen.Foster@glasgow.ac.uk

## ABSTRACT

When designing a natural-language interaction for a social robot, it is not enough to design the conversation itself: the success of a human-robot interaction can also be significantly affected by seemingly small factors such as a robot's physical appearance and non-verbal behaviour. In this paper, we deploy an identical chatbot system onto two different robots, Furhat and Pepper, and compare users' subjective responses to conversations with both robots to get a clear measure of the impact of robot appearance on a social robot when the interaction context is held constant. The results of the study were varied: Furhat was considered to display emotions better and to be more intelligent and trustworthy than Pepper, while both robots were seen as equally friendly. No significant differences were found in the likeability and comfort categories.

## CCS CONCEPTS

• **Human-centered computing** → **User studies; Natural language interfaces.**

## KEYWORDS

human-robot interaction, social robotics

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## 1 INTRODUCTION

Social robots have been deployed in a wide variety of different domains, including healthcare [1, 20], education [4, 12] and entertainment [1]. For a social robot to be successful in any deployment context, it must be accepted and understood by humans, which has been shown to be influenced by factors including appearance, purpose, intelligence [1], behaviour [5] and physical embodiment [9, 15]. For people to treat robots as partners rather than tools, they need to look and behave in a way that can easily be interpreted by humans [13]. The selection of a robot design should be influenced

by its intended tasks [13], which sets up users' expectations and prevents disappointment; in particular, if a robot is designed to help humans, it must be perceived as trustworthy [13]. In general, humans tend to anthropomorphise non-human entities [10, 18].

In this paper, we aim to determine the specific impact of the appearance and behaviour of two robots, Furhat and Pepper, on user responses to the robots, where the interactions with both robots are based on an identical chatbot implementation. Eighteen participants were invited to talk with both robots, in their respective default, off-the-shelf configurations, to determine the specific impact of the robot's appearance and behaviour on users' subjective responses to the robots. While it is known that, generally, social robots' appearance and behaviour do influence the quality of interactions [8], our specific goal here is to investigate the impact of these two very different robots' appearance and behaviour when the conversational content is held constant.

## 2 PREVIOUS WORK

Even though studies directly comparing user responses to multiple robots are not common, previous work has clearly demonstrated that the physical appearance of a robot influences user's expectations of it [2, 7, 14] and that this factor is critically important to the success of HRI [1]. Indeed, Li et al. [16] claim that personalising robots is crucial to make them usable by a great variety of people. Robots must be designed with adaptability in mind to tend to the different needs of humans.

A range of previous work has examined the influence of a robot's appearance on user responses to the robot. For example, Kanda et al. [11] compared the appearance of two humanoid robots and a human experimenter. The results show that the participants had better impressions of both robots than of the experimenter, which the authors hypothesise could be because the human was behaving similarly to the robots (not smiling or engaging in small talk), which demonstrates that humans require more from other humans than from robots.

Goetz et al. [8] carried out three experiments to show that the robots' appearance influences the expectations of users. The first experiment determined that robots with a more human-like appearance are preferred in social situations, and robots with a less human-like appearance are suitable for non-social tasks. In the second experiment, a robot asked participants to perform some exercises (a serious task) in two ways: playful and serious. Again, the results indicated that users preferred a robot whose appearance and behaviour matched the task. The third study compared participant compliance with the playful and serious robots in playful and serious tasks—the results were stronger for the robot whose behaviour matched the task.

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**Furhat:** My name is Furhat, and I'm a social robot. Hi there!

**User:** Hi how are you

**Furhat:** I'm doing great! It's nice to meet you today. Are you a student?

**User:** yes, I am

**Furhat:** And what do you study?

**User:** I study software engineering

**Furhat:** Nice! Do you like studying it?

**User:** I said yes

**Furhat:** It's great that you like studying software engineering. I still have a lot to learn, but I feel like I get smarter every day! So, what country are you from?

**User:** I'm from Poland

**Furhat:** I think you said that you're from Poland, is that correct?

**User:** yes, it does

**Furhat:** That's great! I really like staying in Glasgow, but I would also like to travel in the future. Anyway, do you have any nice holidays planned?

**User:** yes, I do

**Furhat:** That's really cool, I'm jealous! I'm too busy to go anywhere now but maybe next year. So, do you prefer living in a city, or the countryside?

**User:** I prefer living in the city

**Furhat:** I agree - I think living in a city provides you with a lot of social and career opportunities. Hey, let's talk about food now! I don't really eat much apart from electricity... But what is your favourite dish?

**User:** my favourite dish is pizza

**Furhat:** pizza is a good choice! Do you prefer eating out, or ordering food?

**User:** I prefer eating out

**Furhat:** I see, that's a good answer! And do you enjoy trying new dishes?

**User:** yes, I do

**Furhat:** It's really fun to try new tastes, isn't it? I find that electricity tastes different depending on where I'm plugged in, or the type of batteries! Here is a food fact for you! Did you know that stew is one of the oldest dishes that is still being prepared today? It was being prepared 6000 years BC. Are you interested in history?

**User:** no not really

**Furhat:** Same, history is not something I'm personally very passionate about, though I can remember as many random things as my memory size allows! What do you like doing in your free time?

**User:** I like watching movies

**Furhat:** Do you prefer board games, or video games?

**User:** board games

**Furhat:** Cool! And what is your favourite board game?

**User:** I think exploding kittens

**Furhat:** Sounds great! And what is your favourite colour? Mine is white!

**User:** mine is blue

**Furhat:** Good choice, blue is the most common favourite colour in the world... And do you play any instruments?

**User:** no, I don't

**Furhat:** If you could play any instrument, what would you play?

**User:** I'll play the piano

**Furhat:** The piano is an awesome instrument, you can play many songs on it! Speaking of music, what is your favourite genre?

**User:** I like rock music

**Furhat:** I think that rock is a great choice! Thanks for sharing! Anyway, I don't want to keep you for longer - thank you for talking with me today, it was great to meet you! Hopefully we can speak again soon. Bye!

**User:** bye-bye

**Furhat:** Bye

**Figure 1: Model conversation with the chatbot – in this case with Furhat, but the same chatbot was also deployed on Pepper.**

Physical embodiment [15] and realistic robot appearance and behaviour [5] have a positive influence on interactions with humans. Physical embodiment makes humans more engaged in the interchange [9]. Even though it is cheaper to construct non-embodied agents and the practical difficulties of such agents are significantly less [15, 21, 24], several studies have demonstrated that physical embodiment has a significant effect. For example, Lee et al. [15] found that physical embodiment has a positive influence on humans and it makes the feeling of social presence stronger.

### 3 IMPLEMENTATION

Our goal in this paper is investigate the specific impact of the appearance and behaviour of two robots, Furhat and Pepper, on user responses to those robots, when both robots implement the same conversational behaviour. In this section, we present the implementation that was used.

#### 3.1 Chatbot

RASA Open Source [22] allows for creating chatbots and voice assistants. It was employed in this project to create conversations that the robots would have with the participants. It handles dialogue management and NLU by creating intents used to classify the utterances, slots that store the information provided by users, and stories that describe possible conversation paths. Custom connectors were created to connect both Furhat and Pepper with the toolkit: in both cases, the speech recognition and embodied text-to-speech were implemented on the robot, while the interaction management was carried out by the RASA chatbot. The chatbot supported a range of interactions, primarily based on social chit-chat. A model conversation is presented in Figure 1.

#### 3.2 Furhat

Furhat was created by the Swedish company Furhat Robotics. The robot has a human-like head mounted on a humanoid torso, with no body (Figure 2a). Its main advantage is a highly expressive face that can communicate all the main emotions that humans recognize and demonstrate themselves, which is achieved by equipping the robot with a simple white mask that the face is projected on. This design choice means that certain characteristics of the robot, such as skin colour or facial features, can be easily changed. It is claimed by the company that Furhat does not cause the uncanny valley effect [17] despite being quite anthropomorphic [6].

#### 3.3 Pepper

Pepper was first introduced by the French company Aldebaran (later bought by SoftBank Robotics) in 2014. It is 120 cm tall, which makes it shorter than most humans and not intimidating to them [10]. Pepper has two arms, a wheeled mechanism, and 20 degrees of freedom. Pepper has a camera and can track human faces, which allows it to keep eye contact. Pepper's face is not expressive – the robot can show its emotions with its voice or body gestures, such as raising its arms (Figure 2b).

#### 3.4 The Differences Between the Robots

The most immediately noticeable difference between the robots (see Figure 2) is in their basic physical appearance: Furhat has an expressive face, but no body at all, while Pepper has a humanoid body, but a completely inexpressive face. Both robots were used in their default configurations in this study, which resulted in several



(a) Various faces displayed by Furhat  
<https://www.facebook.com/FurhatRobotics>



(b) Pepper is able to perform body gestures  
<https://xconomy.com/boston/2018/08/28/softbank-taps-affectiva-to-boost-pepper-robots-emotional-iq/>

**Figure 2: The Furhat and Pepper robots**

differences in their appearance and non-verbal behaviour. For example, the default Furhat face and voice are those of a grown man, while Pepper has a higher-pitched, childish voice. Pepper’s face tracking is enabled by default, while Furhat’s tracking is disabled. Both robots used only their default, basic non-verbal behaviours during this study: Furhat would raise its eyebrows while listening, would move its mouth while speaking, and would blink regularly, while Pepper would make elementary, subtle finger movements.

Hardware differences related to the robots’ microphones and automatic speech recognition system (ASR) also affected the robots’ behaviour. In particular, Pepper has a significantly worse microphone and also uses an older, offline speech recognition system, while Furhat includes a higher-quality microphone and uses cloud-based speech recognition.

## 4 EVALUATION

To test user responses to the two robots, a user study was carried out, where the participants interacted with both of the robots and answered a range of questions about each. Based on the previous studies of human responses to embodied conversational agents (Section 2), we had the following hypotheses:

- H1** Pepper will be seen as more likeable than Furhat
- H2** Pepper will be seen as more trustworthy than Furhat
- H3** Furhat will be considered more intelligent than Pepper
- H4** Pepper will be seen as more comforting than Furhat
- H5** Pepper will be seen as more friendly than Furhat
- H6** Furhat will be considered to display emotions better than Pepper

### 4.1 Questionnaires

Each participant filled in three online questionnaires. The first one asked about their background and experience with social robots, voice assistants and technology, while the other two questionnaires consisted of the same ten questions asking for the participants’

opinions on the robots. The answers to the first set of questions, corresponding to the hypotheses above, were collected on a five-point Likert scale from 5 ‘Strongly agree’ to 1 ‘Strongly disagree’. The last question asked the participants to describe the robots with three adjectives of their choice.

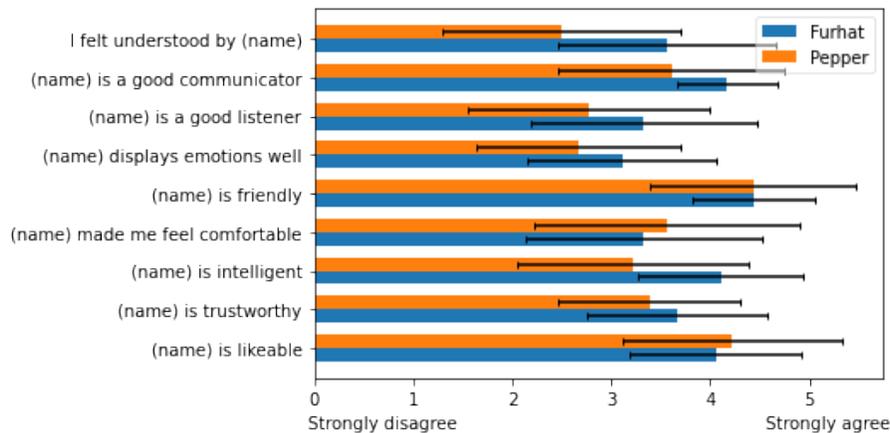
### 4.2 Participants

Eighteen participants were recruited for this study. They all had an educational background in computer sciences, with eight participants (44%) studying Software Engineering. Eight participants were native English speakers, while the other ten spoke English fluently. Sixteen participants (89%) had never talked with a social robot before, two were not sure about that and twelve (67%) had no experience with social robotics or human-robot interactions. Two participants (11%) used voice assistants every day, while six (34%) used them never or almost never.

### 4.3 Experiment Design

A within-participants design was used in the study. To mitigate possible order effects, half of the participants interacted with the Pepper robot first followed by the Furhat, while the other half interacted with the Furhat first, with the order for each participant chosen randomly. Both robots were always in the experiment room, and the participants could see them throughout the experimental period. Each experiment session started with a participant signing a consent form and filling in the demographic questionnaire.

Each small-talk-like conversation with a robot lasted from 1 to 5 minutes. The participants were instructed to answer the robots’ questions precisely. The conversation topics included weather forecasts, the occupation of a participant and their hobbies (Figure 1). After each conversation, the participants filled in the full questionnaire about that robot.



**Figure 3: User responses to the full questionnaire (mean and standard deviation, where 5 = strongly agree, 1 = strongly disagree), also including items about listening, communicating, and understanding which are discussed separately below**

## 4.4 Results

**4.4.1 Rating questions.** Figure 3 summarises the mean responses to all of these questions, showing the mean and standard deviation of the responses given for each robot. The graph also includes responses to questions regarding the robots’ abilities to listen to, understand, and communicate with the user. For each of these items, the Furhat scored higher than the Pepper, but from observing user interactions, these results were almost certainly due to the difference in the ASR systems used by the two robots rather than any aspects of the appearance or behaviour.

To analyse the statistical significance of the results for each question, we used the Wilcoxon Signed-Rank Test.

**The robot is likeable.** The participants preferred Pepper ( $M=4.22$ ,  $SD=1.11$ ) over Furhat ( $M=4.06$ ,  $SD=0.87$ ). The result is not statistically significant ( $Z = 1.34$ ,  $p = .18$ ), hence, there is insufficient evidence to accept or reject H1.

**The robot is trustworthy.** Furhat ( $M=3.67$ ,  $SD=0.91$ ) was seen as more trustworthy than Pepper ( $M=3.39$ ,  $SD=0.92$ ), which disproves H2. The results are statistically significant ( $Z = 2.24$ ,  $p = .025$ ).

**The robot is intelligent.** Furhat ( $M=4.11$ ,  $SD=0.83$ ) was rated as more intelligent than Pepper ( $M=3.22$ ,  $SD=1.17$ ), which proves H3. The results are statistically significant ( $Z = 3.56$ ,  $p < .001$ ).

**The robot made me feel comfortable.** The participants felt more comfortable with Pepper ( $M=3.56$ ,  $SD=1.34$ ) than with Furhat ( $M=3.33$ ,  $SD=1.19$ ). The result is not statistically significant ( $Z = 1.63$ ,  $p = .102$ ), so to accept or reject H4, more data is needed.

**The robot is friendly.** Furhat ( $M=4.44$ ,  $SD=0.62$ ) was perceived to be as friendly as Pepper ( $M=4.44$ ,  $SD=1.04$ ), which disproves H5. The result of the Wilcoxon Signed-Rank Test shows that the sample means for the robots are identical ( $Z = 0.00$ ,  $p > .999$ ).

**The robot displays emotions well.** Furhat ( $M=3.11$ ,  $Sd=0.96$ ) was found to show emotions better than Pepper ( $M=2.67$ ,  $SD=1.03$ ), which proves H6, and this result was determined to be statistically significant ( $Z = 2.83$ ,  $p = .005$ ).

**4.4.2 Descriptive adjectives.** For both robots, ‘friendly’ was the most common adjective chosen. Eight (29%) of the participants

used it to describe Pepper, and eleven (39%) identified it with Furhat. Figure 4 shows word clouds of the responses to this question for each robot, with ‘friendly’ removed from both.

The second most frequent adjective provided for Pepper was ‘cute’ (five participants). It was also described as ‘funny’ (three participants). Curiously, participant 5 described Pepper as ‘robotic, uncomfortable, threatening’, participant 13 as ‘twitzy, confused, trying’, and participant 14 as ‘out-of-context, uncanny, pretentious’. When it comes to Furhat, the second most common terms were ‘knowledgeable’, ‘uncanny’ and ‘talkative’ (each used by three participants). Furhat, similarly to Pepper, was seen rather negatively by three participants. Participant 4 described it as ‘creepy, awkward, sketchy’, participant 5 as ‘weird, uncanny, strange’ and participant 13 as ‘uncanny, creepy, friendly’ (the last adjective might contradict the other two). Notably, two participants—participant 5 and participant 13—described both robots in somewhat negative terms.

**4.4.3 Additional comments from the participants.** Each person was encouraged to provide further comments at the end of the study. Five people said that Furhat caused the uncanny valley effect, and one person noticed that it is weird that the robot does not have ears. One person found Pepper’s hand movements weird and threatening, and another said that it is creepy due to its big, black eyes. One person specifically noted that the fact that Pepper moves its head to keep eye contact with the interlocutor is quite good.

## 5 DISCUSSION

Two out of the six original hypotheses were confirmed by the results. The participants indeed saw Furhat as more intelligent than Pepper (H3), and Furhat was also determined to display emotions better (H6). Two other hypotheses, that Pepper will be seen as more likeable (H1) and comforting (H4) than Furhat, did not show significant results and require more data to analyse.

An interesting outcome was that two hypotheses were rejected: we predicted that Pepper would be seen as more trustworthy (H2) and more friendly (H5) than Furhat, while the results did not bear this out. In fact, Furhat was viewed as more trustworthy (H2),



**Figure 4: The most common adjectives used to describe each robot (not including ‘friendly’)**

while both robots were judged to be equally friendly (H5). For the trustworthiness, it seems that Furhat’s adult-style face and body would have made users trust it more than Pepper, which has a more childish appearance. Regarding friendliness, as noted above, both robots were considered extremely friendly by most participants on the final question, so no difference was found overall. Indeed, the free-form comments also back up this explanation.

Considering the participants who described both the robots in negative terms (participants 5 and 13), it is interesting to examine their answers to the other items on the questionnaire. Participant 5 described Pepper as ‘robotic, uncomfortable, threatening’, and they were the only person who ‘strongly disagreed’ that Pepper is likeable, trustworthy, friendly, made them feel comfortable and is a good communicator. The same participant claimed that Furhat is ‘weird, uncanny, strange’ and ‘strongly disagreed’ that the robot made them feel comfortable, yet ‘strongly agreed’ that the robot is likeable, which shows a minor inconsistency (and may have been a mis-click on the question form). Participant 13 felt that Pepper was ‘twitchy, confused, trying’. They ‘disagreed’ that Pepper made them feel comfortable, displayed emotions well, was a good communicator and made them feel understood, ‘strongly disagreed’ that the robot was a good listener, though they ‘agreed’ that Pepper was friendly. Moreover, this participant described Furhat as ‘uncanny, creepy, friendly’. They ‘agreed’ that the robot was friendly, likeable and trustworthy, but ‘disagreed’ that it made them feel comfortable. It is worth noting that such negative attitudes toward social robots are not uncommon. In fact, this is a well-known phenomenon that is frequent enough that there is a specific, validated scale that can be used to measure it, called the Negative Attitude toward Robots Scale (NARS) [19]. Consequently, it is not surprising that some participants presented negative opinions of the robots.

Generally, looking at the results of this study, we can see that the participants had an overall preference for Furhat over Pepper; for every question where a significant difference was found between the robots, the trend was in favour of Furhat. It is well known that people depend on recognising emotions and intentions that are shown by human faces [23], so Furhat’s human-like face might be a better design choice than Pepper’s inexpressive one. As mentioned earlier, the different ASR systems integrated with the robots could have also influenced the results—in general, the conversations with Furhat had much fewer ASR errors—suggesting that high-quality ASR software is important to the success of a social robot.

On the other hand, five participants (28%) mentioned in their free-form comments that Furhat caused the uncanny valley effect that made them feel rather uncomfortable. This is another aspect of using such a realistic robot in this context; as noted by von Zitzewitz et al. [25], even when a robot resembles a human a lot, it might not have a positive impact on the interaction due to this effect.

## 6 CONCLUSIONS AND FUTURE WORK

In this paper, we compared two robots, in their respective default configurations, to determine how their appearance and behaviour influenced the participants’ perception during conversational interaction. The results showed that there were significant differences between user responses to Furhat and Pepper; in particular, the Furhat was rated more highly on all measures where a difference was found. This confirms the findings of previous papers such as Goetz et al. [8], who also demonstrated that the robot’s appearance and behaviour do influence the quality of interactions, and extends those previous results to a case where two robots are directly compared with the communicative behaviour held constant. We note, however, that the participants’ responses were somewhat variable, and in particular that some participants expressed negative views about one or both of the robots.

Although the results are informative, this study did have some limitations which limit the generalisability. First, the results were obtained in a lab study, which might not be representative of real-world conditions. Most notably, the controlled lab setting guaranteed that there were no sound or visual distractions. The need for real-world studies in the field of human-robot interaction is well known, and an increasing number of such studies are now being carried out [3, 9]. In addition, each interaction was short-term and the study tested a specific demographic: university students with a technological background. Finally, since we made a deliberate choice to use both robots in their default configurations, other factors could have affected user responses to the robots: for example, the differing ASR performance, and the differences in non-verbal behaviours such as gestures and face tracking.

Due to these limitations, we believe that a real-world, long-term study, with both robots configured to be as similar as possible including factors such as ASR and user face tracking, would be beneficial to confirm and extend these results in a more naturalistic setting, providing additional evidence to help choose between these two very different social robots in future deployment contexts.

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