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Users' Interaction with a Pet-Robot and a Humanoid

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In this paper, we compare users' interaction with a humanoid robot and a dog-shaped pet robot. We conducted a user study in which the participants had to teach object names and simple commands and give feedback to either the pet-robot or the humanoid. We did not find significant differences in the way commands were given to the two different robots. However, the way of giving positive and negative feedback differed significantly: We found that for the pet-robot users tend to give reward in a similar way as giving reward to a real dog by touching it and commenting on its performance by uttering feedback like "well done" or "that was right". For the humanoid, users did not use touch as a reward and rather used personal expressions like "thank you" to give positive feedback to the robot.

1. Introduction

Different factors influence how people interact with robots. Studies such as [2][3][4][5] showed, that the appearance of the robot plays an important role for the behavior as well as the impression of users when interacting with robots.

As a part of our work on learning commands and feedback for human-robot interaction, we conducted a user study on how participants give commands and feedback to a pet-robot and a humanoid. In the study we compared the commands and feedback given by the participants to a dog-shaped pet-robot, which has roughly the size of a cat, and a 1,30m tall humanoid robot.

2. Related Work

In recent years, there have been various studies [2][4][5] investigating the effect of a robot's appearance on the interaction with a user. However, most studies concerning the appearance of robots rather deal with users' impression of robots than with the effect of a robot's appearance on its user's communicative behavior.

Kanda et al. [3] conducted a study with two different humanoid robots and showed that different appearances of the robots did not affect the participants' verbal behavior but did affect their non-verbal behavior such as distance and delay of response. They explain the observed differences by impressions, such as novelty, safety, familiarity and activity as well as attributions, such as whether the robot is respected as a conversation partner.

Kriz et al. [5] investigated users' conceptualizations of robots by analyzing the way the users talked to the robot. They compared features of robot-directed speech to how humans talk to infants or adult non-native speakers. They found that the participants spoke more loudly, raised their pitch, and hyperarticulated when they spoke to the robot. This behavior is typical when the conversation partner is assumed to have low linguistic competence. However, they did not speak in easier sentences, which suggests, that they believed that the robot has almost humanlike cognitive capabilities.

Goetz et al. [4] investigated users' attribution of capabilities depending on the appearance of a robot. They created images of more or less human-like looking robots and had participants judge their suitability for different tasks. They found that people systematically preferred robots for jobs when the robot's human-likeness matched the sociability required in those jobs. They also found that playful or serious demeanor of the robot affected the compliance of the participants. The participants performed a playful task longer, when the instructing robot showed a playful demeanor while the participants performed a serious task longer, when the robot behaved more seriously.

Similar results were obtained by Hegel et al. [2] who found that the appearance of robots affected users' attribution of possible applications. They conducted a user study in which the participants were asked to match videos of robots to different categories of applications. Especially the perceived human-likeness or animal-likeness of the robots affected which tasks the participants considered suitable for them. While the participants considered human-like robots for fields like healthcare, personal assistance, security and business, they considered animal-like robots as companions, entertainers, toys, and robotic pets.\\

3. Outline of the study

The goal of our study was to find differences and similarities in user behavior for giving commands and feedback to a humanoid and a pet-robot. The users interacted with either the humanoid or the pet-robot and instructed the robot to perform different household tasks like bringing a coffee, switching on the light or the TV, tidying up objects etc. and gave feedback to the robot for correct or incorrect performance.

In order to avoid time-consuming and error-prone task execution and because of the different physical capabilities of the two different robots, we decided to use "virtual training tasks" for our experiments. The tasks, which the participants should ask the robot to perform, were visualized on a screen, and the robot acted in front of the screen using gestures and speech. On the screen, the robot's actions were visualized with a hand or paw icon, so that the user could easily understand the connection between the robot's motions and the changes, happening in the

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scene. Details on the training tasks can be found in [1]. While the robots differed in shape and size, we kept all other parameters as similar as possible, using the same synthesized speech utterances, similar gestures, same simulated learning rate etc.

We have conducted experiments with 16 participants. Ten participants (7 male, 3 female) interacted with the humanoid and six participants (4 male, 2 female) interacted with the pet-robot for roughly 45 minutes. The language used in the experiments was Japanese. All participants were employees of the Honda Research Institute Japan. Fig. 1 shows the experimental setting.

4. Results

We annotated the data, which was recorded during the experiments, to find objective similarities and differences in the participants' behavior. We used the T-Test to determine the statistical significance of the observed differences. We analyzed different aspects of the users' commands and feedback that we assumed to be related to the perceived intelligence and human-likeness of the robot. We compared the speaking speed (in seconds per word) and the number of words per command/feedback, as we assumed that people talk slower and in simpler sentences, when they consider the robot less intelligent. However, we found, that the length of commands was almost the same for both robots. An average command for the humanoid was 3.75 (sd=0.42) words long, while an average command for the pet-robot was 3.72 (sd=0.71) words long. The speaking speeds were also similar for the pet-robot with 0.45 (sd=0.09) seconds per word, and for the humanoid with 0.42 (sd=0.07) seconds per word. This is in line with the participants' subjective evaluation of the robots' intelligence as shown in Table 1.

4.1 Multimodality

During the interaction with both robots, we did not observe pointing gestures from any of the users. A possible explanation is that all objects were very easy to distinguish verbally, so that pointing gestures would have been redundant.

We observed touch-based rewards for only one out of ten participants for the humanoid but for five out of six participants, who interacted with the pet-robot. As touch is frequently used with real dogs, we assume that users considered touch to be appropriate for giving feedback to the pet-robot because of its dog-like appearance.

Figure 1. Experimental Setting

(1) Verbal commands

We analyzed, how many commands had explanations or polite expressions and how many commands were put as a question. We assumed that users might be more polite, explain more and use more questions when talking to a humanoid robot, while they rather give plain commands to a dog-like robot. We considered commands that contain words like "…kudasai", "…kureru?", "…moraeru?" etc., which are similar to the English word "please" as polite commands. We also analyzed, how many commands were implicit ones like saying "it is too dark here" to make the robot switch the light on, and in how many commands some expected parameters were left out like in "put away the toy car" instead of "put *the toy car* into *the box*", because we assumed, that this kind of verbal behavior might be related to the perceived intelligence of the robot. The results can be found in table 2. The values do not add up to 100% because not all types of commands are mutually exclusive (e.g. a polite command can have parameters left out):

Type	Humanoid	Pet-Robot
Plain commands	75.01 (14.00)	60.83 (41.04)
Polite commands	9.86 (10.88)	26.23 (41.99)
Questions in commands	10.23 (3.51)	8.34 (6.73)
Implicit commands	3.40 (4.82)	4.10 (7.23)
Parameters left out	6.78 (2.25)	4.13 (4.77)
Explanations in commands	1.81 (3.90)	0.95 (2.32)

Table 2: Command types: All values in percent, value in brackets is the standard deviation

While we observed quite different utterances for different users, the differences seemed to be rather caused by personal preferences, than by the appearance of the robots. This assumption is supported by the high standard deviations between users. None of the observed differences was statistically significant.

4.2 Verbal positive and negative feedback

We distinguished three different types of feedback: Personal rewards like "Thank you", feedback which directly comments on the performance of the robot, like "Well done." or "That was wrong." and explanations used as rewards like "That is not a toy car, it is a ball." or "That is a toy car".

Type	Humanoid	Pet-Robot
Personal	52.78 (17.99)	24.83 (27.41)
Performance evaluation	38.39 (18.28)	70.02 (28.16)
Explanations	11.10 (14.29)	3.56 (3.90)

Table 3: Feedback types: All values in percent, value in brackets is the standard deviation

We found statistically significant differences for the usage of personal rewards (df=14, t=2.480, p=0.026) and rewards, which comment on the robots' performance (df=14, t=2.745, p=0.016). While the users usually gave feedback like "well done (yoku dekimashita)" or "good (ii yo)" to the pet-robot, they used personal rewards like "Thank you (arigatou)" for the humanoid, especially for positive reward. While the participants gave more explanations when talking to the humanoid, especially for negative rewards, the difference between both robots was not significant.

4.3 Behavior Changes over Time

We also investigated the change in user behavior over time by comparing the commands and feedback, the participants gave in the first five minutes of the command learning phase to the commands to the feedback given throughout the whole experiment and to the last five minutes of the experiment.

We did not find any significant change in commands given to both robots and feedback given to the pet-robot over time. We observed two marginally significant changes in the feedback given to the humanoid: The amount of explanations for negative feedback was marginally significantly lower (p=0.071, t=2.06, df=9) at the beginning of the experiments than it was throughout the whole experiment. We also observed a marginally significant increase (p=0.091, t=1.90, df=9) in personal feedback given to the humanoid comparing the first five minutes of the command learning to the whole command learning phase. There were similar but non-significant trends toward more personal feedback and more explanations for negative rewards for the pet-robot.

Type	Humanoid	Pet-Robot
Explanations for negative Feedback (overall)	34.57(35.87)	21.78 (23.58)
Explanations for negative Feedback (first five minutes)	26.98 (32.32)	18.06 (30.92)
Personal feedback (overall)	52.78 (17.99)	24.83 (27.41)
Personal feedback (first five minutes)	34.85 (22.62)	18.67 (23.19)

Table 3: Changes in Feedback: All values in percent, value in brackets is the standard deviation

5. Discussion

In our experiments, we observed less than expected differences in users' behavior towards the humanoid and the pet-robot. While especially the way of uttering commands seems to depend rather on the personal preferences of the user, than on the appearance of the robot, we found robot-dependent differences in the feedback, given by the participants. The most obvious one was the frequent use of touch for giving feedback to the pet-robot, while touch was almost not used for the humanoid. Moreover, we found, that users tended to give personal feedback like "Thank you" to the humanoid, while they rather commented on the performance for giving feedback to the pet-robot. These findings suggest that people actually use their experience with real dogs as a guideline when giving feedback to a pet-robot.

When interacting longer with the humanoid, people started to give more explanations when the robot performed incorrectly and also gave more personal reward. While the results are only marginally significant and hard to interpret, one explanation may be, that the perception of the humanoid robot as an intelligent interaction partner increases when the robot shows learning capabilities and improves its performance during the experiment. Similar tendencies could be observed with the pet-robot, however they were not significant.

There are different possible explanations, why no significant differences were observed for giving commands. One of them is that both robots used speech to communicate with the user. As speech is a typical human modality of interacting, differences might have been stronger, if the pet-robot had communicated with the user in a more dog-like non-verbal way.

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