How Do Users Interact with a Pet-Robot and a Humanoid?

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Abstract
In this paper, we compare users' interaction with the humanoid robot ASIMO and the dog-shaped robot AIBO. We conducted a user study in which the participants had to teach object names and simple commands and give feedback to either AIBO or ASIMO. We did not find significant differences in the users' evaluation of both robots and 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 AIBO 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 ASIMO, users did not use touch as a reward and rather used personal expressions like "thank you" to give positive feedback to the robot.

Keywords
Robots, User Studies, Human-Robot Interaction, ASIMO, AIBO

ACM Classification Keywords
H5.m. Information interfaces and presentation: Miscellaneous.

General Terms
Human Factors

Introduction

When humans interact with each other or with their pets they tend to adapt their way of speaking and interacting to their interaction partner: People talk to adults in a more elaborated way than to small children, and they pet their dog as a reward while they would rather just say "thank you" when praising a colleague. We assume that similar mechanisms also affect how people interact with robots. Especially the appearance of a robot and its resemblance to familiar creatures or objects can be an important factor which helps a human to anticipate the capabilities of a robot and decide how to interact with it. The results from our research can help inform the design choices that roboticists make when considering what type of interaction they want with their robots.

In recent years, there have been various studies [3] [4] [5] [6] investigating on the effect of a robot's appearance on the interaction with a user. However, most studies concerning the appearance of robots rather deal with the uncanny valley effect [2] and users' impression of robots than with the effect of a robot's appearance on its user's communicative behavior. Kanda et al. conducted a study with two different humanoid robots – ASIMO and Robovie - and showed that [4] 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. Goetz et al [5] investigated on users' attribution of capabilities depending on the appearance of a robot. They found that people systematically preferred robots for jobs when the robot's human-likeness matched the sociability required in those jobs. Similar results were obtained by Hegel et al. [3] who found that the appearance of robots affected users' attribution of possible applications.

As a part of our work on learning commands and feedback for human-robot interaction [1], we conducted a user study on how participants give commands and feedback to the robots AIBO and ASIMO. AIBO is a dog-shaped robot, made by Sony, which has roughly the size of a cat or a small dog. ASIMO is a 1,30m tall humanoid robot created by Honda.

Outline of the Study

The goal of our study is to find differences and similarities in user behavior when the participants give commands and feedback to ASIMO or AIBO. The users interacted with either ASIMO or AIBO and instructed the robot perform different household tasks like bringing a coffee, switching on the light or the TV, tidying up etc. and gave feedback to the robot for correct or incorrect performance. In order to avoid

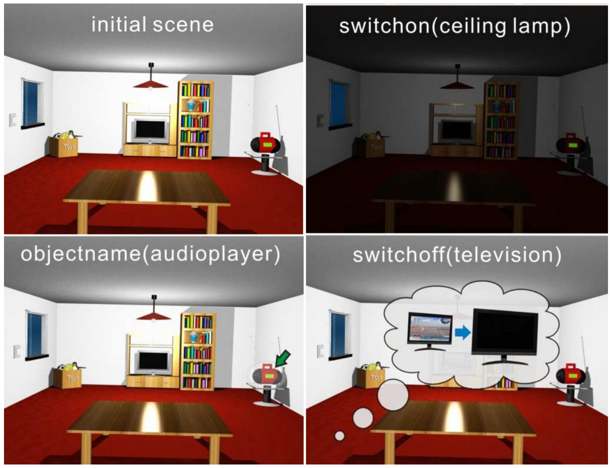

Figure 1: Visualization of the tasks

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". The tasks are visualized on a screen in such a way that the user can understand from the scene, what command to give to the robot. We use a graphical representation of the scene without any text, in order to avoid influencing the participants' wording when giving commands to the robot.

The robot performs in front of the screen using motion and speech. The robot's actions are visualized on the screen with a hand or paw icon, so that the user can easily understand the relation between the robot's motions and the changes happening in the scene. A picture of the virtual living room scene is shown in Fig. 1. More 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.

Assumptions

Based on the schema theory [7] in psychology, which suggests that people use schemas of familiar objects and situations to understand and handle unfamiliar situations, we assumed, that users are likely to interact with a pet-robot like AIBO in a similar way as with a real dog, while interaction with a humanoid like ASIMO was expected to resemble more to the interaction with a human.

Moreover, we assumed that the participants are likely to conclude that ASIMO is more intelligent than AIBO, based on its humanlike appearance. This might lead to higher expectations and to a more elaborated speaking style, when interacting with ASIMO. Details are given in the results section.

Experimental Setting

We have conducted a user study with 16 participants aged from 22 to 52. Ten participants (7 males, 3 females) interacted with ASIMO and six participants (4 males, 2 females) interacted with AIBO for roughly 45 minutes. The language used in the experiments was Japanese. All participants were employees of the Honda Research Institute Japan. Fig. 2 shows the experimental setting. The participants were told to teach the robot in two phases. In the first phase, they were asked to name the objects that the robot was pointing at. In the second phase, they were instructed to give commands to the robot and give positive feedback if the robot reacted correctly and negative feedback if the robot reacted incorrectly. They were instructed to give commands and feedback in the way they like by speech, gesture and touch.

Figure 2: Experimental Setting with AIBO and ASIMO

Results

In our user study, we obtained two different kinds of results: We asked the participants to answer a questionnaire about their subjective impression of the interaction and we annotated the data, which was recorded during the interaction to find objective similarities and differences in the participants' behavior. We used the T-Test to determine the statistical significance of the observed differences.

Questionnaire results

From the results of the questionnaire, we can see a slight tendency towards more positive ratings for the interaction with AIBO. However, none of the differences is statistically significant.

Question ***(5: fully agree – 1: do not agree)***	**ASIMO** ***mean (stdev)***	**AIBO** ***mean (stdev)***
I enjoyed teaching the robot through the given task	3.5 (0.8)	4 (0.8)
The robot understood my feedback	3.6 (0.9)	4.3 (1.1)
The robot learned through my feedback	3.2 (1.3)	4.3 (0.5)
The robot adapted to my way of teaching	3.2 (1.1)	3.8 (1.3)
I was able to instruct the robot in a natural way	3.6 (1.1)	3.5 (1.5)
The robot took too much time to learn	3.6 (1.4)	2.7 (0.9)
The robot is intelligent	2.7 (1.3)	2.8 (1.5)
The robot behaves autonomously	2.7 (1.4)	2.8 (0.9)
The robot behaves cooperatively	3.7 (0.8)	3.3 (0.7)

Table 1: Users' evaluation of the training task

User behavior

We analyzed different aspects of the user's 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 ASIMO was 3.75 (sd=0.42) words long, while an average command for AIBO was 3.72 (sd=0.71) words long. The speaking speed was also similar for AIBO with 0.45 (sd=0.09) seconds per word, and ASIMO with 0.42 (sd=0.07) seconds per word. This is in line with the participants' subjective evaluation of the robots' intelligence, shown in Table 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 ASIMO but for five out of the six participants who interacted with AIBO. As touch is frequently used with real dogs, we assume that users considered touch to be appropriate for giving feedback to AIBO because of its dog-like appearance.

VERBAL COMMANDS

We analyzed how many commands had explanations or polite expressions and how many commands were phrased as a question. We estimated 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	**ASIMO**	**AIBO**
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: Types of commands used in the interaction with ASIMO and AIBO *(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.

VERBAL POSITIVE AND NEGATIVE FEEDBACK

We distinguished three different types of feedback: Personal rewards like "Thank you", which emphasize, that the robot has done something for the user, 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	**ASIMO**	**AIBO**
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: Types of feedback used in the interaction with ASIMO and AIBO *(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 AIBO, they used more personal rewards like "Thank you (arigatou)" for ASIMO, especially for positive reward. While the participants gave more explanations when talking to ASIMO, especially for negative rewards, the difference between both robots was not significant.

Discussion and Conclusion

In our experiments, we observed less than expected differences in users' behavior toward AIBO and ASIMO. Our initial t-test shows some interesting differences between the feedbacks that were statistically significant. However, we need to study more people including participants from outside Honda Research Institute to confirm this trend scientifically. 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 AIBO, while touch was almost not used for ASIMO. Moreover, we found, that users tended to give personal feedback like "Thank you" to ASIMO, while they rather commented on the performance for giving feedback AIBO. These findings suggest that people actually use their experience with real dogs as a guideline when giving feedback to AIBO.

The users' subjective evaluation did not reveal significant differences between ASIMO and AIBO. As both robots were programmed to behave in the same way on the same task, we assume that the users' impression of the robot's behavior on the given task depends rather on its actual performance than on its appearance.

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 AIBO had communicated with the user in a more dog-like non-verbal way. As there was no significant difference in users' evaluation of both robots' intelligence, users may have considered similar types of commands acceptable for both robots.

In our future work, we are planning to further analyze the variability and robot-dependence of given commands and feedback. The results will be applied to improve our method for learning to understand commands and feedback through a training task.

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