The effects of a robot´s nonverbal behavior on users´ mimicry and evaluation

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Abstract. In an attempt to replicate earlier research on intelligent agents for robots, we analysed the effects of the presence and absence of a robot´s nonverbal behavior on users´ nonverbal behavior and evaluation with a between subjects experimental study (N = 90). Results demonstrated that when the robot shows nonverbal behavior (head movement and deictic, illustrative and rhythmic gesture) participants evaluated it more positively. Against expectations, however, participants displayed more nonverbal behavior when the robot only used speech.

Keywords: robot, nonverbal behavior, mimicry, experimental study

1 Theoretical background and research questions

As can be expected from human-human interaction, numerous studies in human-robot interaction show that nonverbal communication is beneficial. For example, Sidner, Lee, Kidd, Lesh and Rich [1] demonstrate that a robot who displays nonverbal behavior is evaluated more positively. Similarly, Salem et al. [2] show that a robot is rated as more positive when it uses hand and arm movements – independent of whether these were semantically congruent or incongruent to the verbal utterances.

While the effects of robots´ nonverbal behavior on people´s evaluation of the robot are consistent, there is not much research on the effect of a robot´s nonverbal behavior on users´ nonverbal behavior. Within human-human interaction it has been demonstrated that people tend to adapt the nonverbal movements of their interaction partners such as self-touching behavior [3]. Interestingly, this mimicry behavior has already been shown for human-agent-interaction [4]. An agent who smiled more frequently lead the user to smile more – although the agent was not evaluated more positively. Based on studies giving evidence that – depending on the task – the effects of robots and agents are similar [5] it can be concluded that these mimicry effects can also be expected within human-robot interaction. However, Salem et al. [6] caution against the simple conclusion that human-agent and human-robot-interaction might yield similar effects. Therefore, the present research should clarify whether effects found in human-agent interaction can be replicated in human-robot interaction. Based on previous research [1, 2, 4] we expect that a robot showing nonverbal behavior a) is evaluated more positively and that b) leads to more nonverbal behavior on the part of the user.

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2 Method

2.1 Experimental design, participants and procedure

In order to analyse the effects of a robot´s nonverbal behavior we employed a between-subjects design with the conditions "only speech" and "speech and nonverbal behavior" as independent variables. While in the "only speech" condition the Nao robot merely talked to the participants (N = 44) and did not move, it accompanied its utterances with various gestures in the "speech and nonverbal behavior" condition. The nonverbal behavior included head movements, deictic, iconic and rhythmic gestures [7].

Ninety volunteers (59 female, 31 male) aged between 17 and 48 years (*M*=21.90; *SD*=4.47) participated in this study. The NAO robot was sitting on a desk and was steered by a Wizard of Oz (the wizard started predefined dialogue parts and nonverbal behavior).

First, participants were instructed by the robot to conduct a five-minute procedural task (change position of objects on a table). In a subsequent communication task (mean duration: 13 min 19 sec), the robot took the role of a tutor and presented facts on the diseases Alzheimer and diabetes. After each explanation he posed a related question. Afterwards, participants were asked to fill in the questionnaires. Finally, they were debriefed and thanked for participation. The study was approved by the local ethics committee.

2.2 Dependent variables

Self-report: Perception of the robot. For the person perception of the robot, we used a semantic differential with 37 bi-polar items which are rated on a 5-point scale [4]. A factor analysis yielded six subscales: (1) Likeability (29.2% explanation of variance; $\alpha = .91$), (2) Sociabilty (7.9 % explanation of variance; $\alpha = .73$), (3) Competence (6.7 %; $\alpha = .76$), (4) Relaxation (5.24 %; $\alpha = .70$), (5) Involvement (4.2 %; $\alpha = .70$), (6) Agreeableness (4.0 %; $\alpha = .70$).

Self-report: Social Presence. We assessed participants' sense of co-presence with the Nowak and Biocca Presence Scale [8], which contains 12 items on the concept of "perceived other's co-presence" (Cronbach's $\alpha = .78$, when only 11 items were included) and 6 items on "self-related co-presence" (Cronbach's $\alpha = .72$, when only 4 items were included), both rated on a 5-point Likert scale.

Self-report: General evaluation of the interaction. The general evaluation of the interaction was assessed by five items that asked for the participants' interest in the interaction, the enjoyment of the interaction, and whether participants like to use a system like this for other tasks (rated on a 5-point Likert scale; Cronbach's $\alpha = .84$).

Nonverbal behavior of the participant. The nonverbal behavior of the participants during the communication task was videorecorded by two cameras and coded using ELAN. In order to broadly assess nonverbal behavior, it was coded as either illustrative gestures (IL), torso movements (TM) or self-touching (ST). Interrater reliability was good for all categories (IL: ICC(3,2) = .89, $p = .029$, TM: ICC(3,2) = .88, $p = .032$, ST: ICC(3,2) = .85, $p = .029$).

3 Results

3.1 Participants' self-reported experiences

Robot evaluation: An ANOVA revealed that the robot´s behavior affected the evaluation as likeable ($F(1,84) = 5.19$, $p = .025$, $\eta^2p = .058$). The robot was perceived as more likeable when it showed nonverbal behavior ($M = 35.57$; $SD = 0.78$) compared to the speech only condition ($M = 32.92$; $SD = 0.84$). Also, there was an effect on relaxation ($F(1,84) = 6.88$, $p = .010$, $\eta^2p = .076$). Here, however, participants evaluated the robot as more relaxed in the condition without nonverbal behavior ($M = 12.43$; $SD = 0.33$) than with nonverbal behavior ($M = 11.24$; $SD = 0.30$).

Social presence: There was a marginal effect of the robot´s nonverbal behavior on perceived others´ co-presence ($F(1,86) = 3.31$, $p = .072$, $\eta^2p = .037$). Participants perceive higher co-presence when the robot shows nonverbal behavior ($M = 32.91$; SD=6.01) compared to when not ($M = 30.20$; SD=7.33). There was no effect on the subscale self-related co-presence.

General evaluation of interaction: There was a marginal effect of the robot´s nonverbal behavior on evaluation of the interaction ($F(1,84) = 2.76$, $p = .100$, $\eta^2p = .032$). Participants´ ratings are more positive when the robot showed nonverbal behavior ($M = 19.53$, $SE = 0.53$) than when it did not ($M = 18.21$, $SE = 5.72$).

3.2 Participants' nonverbal behavior

The presence of nonverbal behavior affected the illustrative gestures of participants marginally ($F(1,84) = 3.55$, $p = 0.63$, $\eta^2p = .041$). Against expectations, however, participants used fewer gestures when the robot showed nonverbal behavior (see table 1). This is even more pronounced for self-touching ($F(1,84) = 3.97$, $p = .050$, $\eta^2p = .045$). When the robot only uses speech, participants display more self-touching behavior (table 1). For torso movement there is no difference between conditions.

Table 1. Means and standard deviations of percent of time nonverbal behavior is shown

	Speech only		Speech & nonverbal	
	M	*SD*	*M*	*SD*
Illustrative gestures	1.43	0.16	1.01	0.15
Torso movements	3.12	0.32	3.17	0.30
Self-touching	22.28	2.29	15.93	2.13

4 Discussion

As expected, results showed that a robot´s nonverbal behavior is beneficial in the sense that it leads to more positive evaluations. Results also indicate, somewhat sur-

prisingly, that more relaxation is attributed when the robot shows no nonverbal behavior. This becomes plausible, however, when considering that the subscale also includes adjectives such as calm. There was only a marginal effect on social presence but additional analyses show that social presence serves as covariate when measuring the effects of a robot´s nonverbal behavior on its evaluation and therefore plays an important role.

The results on the users´ behavioral reactions are even more interesting: With regard to two of the three categories of the users´ nonverbal behavior we found that there was no mimicry but on the contrary that the users showed less nonverbal behavior when the robot showed nonverbal behavior. This might be taken as indication that users try to compensate for the robot´s behavior. However, we also have to consider that the results might be due to several limitations of the present work. For example, the categories used are merely preliminary and can be refined in future analyses. We can therefore not preclude that effects, for example, for some more specific type of illustrative gesture might not have been detected. Additionally, the robot´s nonverbal behavior was limited and, for instance, did not include self-touching behaviors. Also, the robot is not as expressive (e.g., with regard to facial expressions) which limits comparability with earlier research on virtual agents. In sum, our study indicated that mimicry might not always be observable as the result of a robot´s behavior. Future research must analyse whether this is persistent and what the underlying mechanisms are.

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