Interpersonal Variation in Understanding Robots as Social Actors

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ABSTRACT

In this paper, I investigate interpersonal variation in verbal HRI with respect to the computers-as-social-actors hypothesis. The analysis of a corpus of verbal human-robot interactions shows that only a subgroup of the users treat the robot as a social actor. Thus, taking interpersonal variation into account reveals that not all users transfer social behaviors from human interactions into HRI. This casts doubts on the suggestion that the social responses to computers and robots reported on previously are due to mindlessness. At the same time, participants' understanding of robots as social or non-social actors can be shown to have a considerable influence on their linguistic behavior throughout the dialogs.

Categories and Subject Descriptors

J.4 [**Computer Applications**]: Social and Behavioral Sciences

General Terms

Human Factors

Keywords

Computers-as-Social-Actors paradigm, linguistic variation, verbal human-robot interaction, mindless transfer

1. INTRODUCTION

In numerous studies, Nass and colleagues [e.g. 7,20,21] have shown that people may treat artificial communicators in ways similar to other humans; for a broad range of human behaviors, which had previously been identified in social psychological research, they found participants to exhibit similar behaviors when confronted with a computer; i.e. participants equated artificial systems with humans [27]. Nass and collaborators therefore suggest that the results may be best described as involuntary, i.e. automatic, mindless transfer from human interaction to the interaction with artificial communication partners. This idea has been developed into the computer-as-social-actor paradigm, which asserts that people treat computers as social actors just like other humans [27, 21, 20].

However, while the mindless transfer effect could be shown on a broad range of phenomena, some studies focusing on interpersonal variation report gender differences in the amount of anthropomorphism of artificial agents [17], and other studies have found that anthropomorphism may differ for different situations [10]. The current study adds to this research by showing that there is considerable interpersonal variation with respect to whether or not artificial communication partners are treated as social actors. Interpersonal variation however plays a crucial role in the explanation of the nature of the effects observed. That is, if all users exhibit a bias to treat computers or robots as social actors, this effect is more likely to be due to biological or psychological characteristics of human interactants than when only some participants exhibit the behavior in question. At the same time, if studies on user behavior disregard interpersonal variation, taking only average measures into account, a computer-as-social-actor effect may be observable that may be caused by a small group of participants. If however different user groups emerge, other explanatory models besides evolutionary psychology or even biology have to be taken into account.

In this investigation I aim to show that participants' understanding of human-robot interaction as social crucially depends on their preconceptions, leading to interpersonal variation. This will lead us to the conclusion that either people can be more or less mindless, weakening the role of automaticity, or alternative explanations for participants' behavior need to be sought.

2. RELATED WORK

Related work concerns findings on mindless transfer, i.e. studies on how participants in the interaction with artificial systems make use of social behaviors they are acquainted with from the interaction among humans, but also findings on human-computer and human-robot interaction that suggest interpersonal differences. Thirdly, relevant previous research concerns the role of preconceptions in interactions with artificial communication partners since preconceptions about the communication partner have been found to influence participants' behavior considerably.

2.1 Mindless Transfer

The computers-as-social-actors hypothesis rests on the concept of mindless transfer [21]; that is, although speakers are aware that they are talking to a computer, not to another human, they are taken to mindlessly employ those behaviors that they are used to

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employing in interactions among humans. The reason for treating computers just like people lies in, according to Nass [19], evolutionary psychology, since “identifying other humans constitutes a significant evolutionary advantage” (Nass 2004:37). Mindless transfer constitutes an error, a kind of overgeneralization which is automatic and involuntary as well as revealing regarding human nature – favorably so in this case: "polite responses to computers represent the best impulse of people, the impulse to err on the side of kindness and humanity" (Nass 2004: 37).

Nass and colleagues have investigated a broad range of such social behaviors; for example, people were found to react similarly to the flattery from a computer as they react to human flattery [7], or to transfer human characteristics to the agents, such as intentionality [14], ethnicity [26] or gender, where, for instance, a synthesized female voice will trigger the attribution of female characteristics to the computer persona [20].

However, some studies suggest that mindless transfer may provide only a partial explanation of the behaviors observed. Johnson et al., for instance, find that the flattery effect described by Nass and colleagues ([7] and [27]) only holds for some speakers and also only under certain conditions [11]. If transfer is mediated, however, it cannot be claimed to be mindless any more.

2.2. Interpersonal Variation

Interpersonal variation with respect to social responses in human-computer (or human-robot) interaction has been reported on in several studies. For instance, some studies address previous findings [7] on flattery and find that whether flattery is effective when coming from a computer depends on whether the information is presented verbally or textually [17], whether it is presented to men or women [11] (men are not affected by flattery if the computer is female, and even the opposite effect has been observed), or whether it is presented by a male or female agent image [17]. Thus, if transfer is involved, it seems to be mediated by a set of factors.

Finally, Nass [19] himself suggests a broad range of factors to influence the likelihood of ‘etiquette responses’ to computers; that is, he suggests language use, voice, face, emotion, manifestation, interactivity, engagement with and attention to user autonomy, unpredictability, and the filling of traditional roles to ‘trigger’ mindless transfer. However, if various factors may influence the amount of social behaviors to computers and robots, treating computers and robots as social actors seems rather to be a matter of degree, casting doubt on the amount of mindlessness involved.

2.3. The Role of Conceptualization

Several authors report differences between human-human and human-computer and human-robot interaction that should not occur if people transferred from natural interactions mindlessly to interactions with artificial agents. Amalberti et al. [1] find considerable differences between human-human and human-computer interaction, even though the wizard behaved identically in both situations; the conceptualization of the communication partner as human or as computer thus seems to play an important role. Similarly, Okita et al. [22] find that the mere conceptualization of the communication partner as human versus machine has a considerable impact on participants' learning behavior. Also the results by Kanda et al. [15] on human-robot interaction indicate differences between human-human and human-robot interaction especially regarding social behavior.

Further problems regarding transfer have been encountered specifically with respect to linguistic interaction. In particular, Shechtman and Horowitz [28] find human-human and human-computer communication to differ especially along various social dimensions. Thus, understanding the communication partner as another human or as a computer does make a difference; participants' preconceptions about their partner consequently have a considerable impact on their subsequent behaviors.

In addition to the role of the belief to be talking to an artificial communication partner, also preconceptions about the nature of the artificial communication partner seem to play a role. For instance, an effect of preconceptions concerning the robot’s capabilities was reported by Paepke and Takayama [23]. They find that if participants' expectations were high, for instance, because they were exposed to advertising material praising the social capabilities of the robot, they were all the more disappointed if the robot did not meet these expectations, and they evaluated the robot more negatively than participants whose expectations had been low from the beginning. Similarly, Pearson et al. [24] find significantly more alignment with a 'basic' computer than with an 'advanced' computer, all other things being equal. In their case, they manipulated the start-up screen participants got to see before the experiment began.

Finally, preconceptions may also play a role in the understanding of the interaction as social or non-social directly. That is, participants may be more or less inclined to treat computers and robots as social actors. Turkle [31] approaches human-robot interaction from a psychoanalytical perspective. She reports on analyses of interview data she elicited in nursery homes and elementary schools from elderly and children who had kept a pet robot for several weeks. The interviews show that both children and elderly people vary considerable regarding their relationships with these 'relational artifacts'. She thus suggests human-robot relationships to be highly individual and similar to a Rorschach test projection of the self.

If the mere thought to be talking to a computer or robot has such an impact, and if differences in the understanding of the artificial communication partner may also influence the interaction, preconceptions may be a useful starting point for alternative explanations.

The current study addresses the question in how far there are interpersonal differences in understanding robots as social actors and what influence these beliefs have on participants’ communicative behavior.

3. METHODOLOGY

The research focus on natural language interaction in the current study necessitates the use of relatively unconstrained interactions in which participants are free to choose social or non-social behaviors. However, the research question raised, how participants differ with respect to their understanding of robots as social actors, furthermore implies that all participants are exposed to comparable situations. The data elicitation methods developed are intended to account for these two requirements.

3.1 Data Elicitation Methodology

For the elicitation of the data the so-called Wizard-of-Oz methodology was used, which has been developed as a means to pretest the design of automatic dialog systems [9]. In such a scenario, subjects believe to be communicating with a real computer or robot while the supposed system's behavior is actually manipulated by a human ‘wizard’. At the same time, human users are not prompted to display a particular linguistic behavior, but are free to behave naturally, that is, in a way that is similar to the way they would behave in real situations with real computers or robots.

The data elicitation scenario is a home-tour scenario in a room furnished as a flat for handicapped people. The participants’ task was to teach an electric wheelchair, the Bremen autonomous wheelchair Rolland [6], useful locations by steering it around to familiarize it with the environment. Participants were told that the robotic wheelchair would learn the labels for these locations and would be able to take the respective participant to the locations in question after the training phase.

The comparability and control of the situation is achieved by keeping the robot behavior constant. That is, the robot's verbal output is based on a script which is the same for all dialogs. The robot's utterances were played according to a fixed schema by the human wizard behind the scene. In a pre-study, typical locations, labels and strategies employed by users had been identified, on the basis of which the schema of robot utterances for the elicitation of the data used here was designed for each possible location. The wizard's task was to check to which location the user had moved the wheelchair and to play the pre-synthesized utterances specified for this location in a pre-specified order. Although this procedure seems quite unnatural, the resulting dialogs are in fact quite smooth, and it is important to understand that for the participants themselves, the situations are highly interactional; the perspective that the robot is not 'really' interacting is therefore an etic view taken from the outside, i.e. not from the participants’ own perspective. The fact that all participants are exposed to the same utterances in the same sequence allows us to compare the dialogs across participants. A questionnaire study involving pre- and post-questionnaires [2] revealed furthermore that a) participants had indeed believed to be talking to an automatic speech-processing system, b) they found the interactions pleasant, and c) their attitude towards robots in general improved significantly during the interactions.

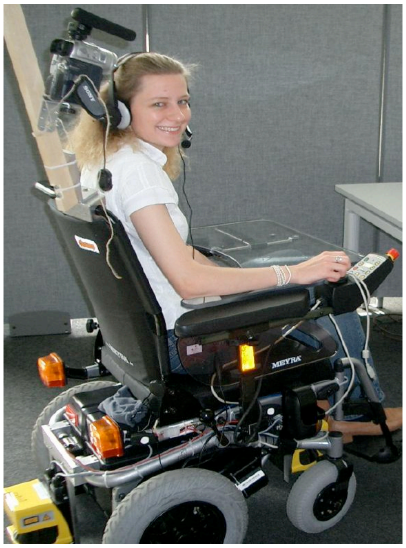

Figure 1. The autonomous wheelchair *Rolland*

3.2 Data Collection

Participants in this study were fifteen students at the University of Bremen, none of whom had participated in a human-robot interaction experiment before. The corpus consists of 15 dialogs between 15 native speakers of German, nine female and six male, and the robotic wheelchair Rolland. Interactions took about 30-45 minutes.

In these dialogs, participants were asked to train a robotic wheelchair regarding particular spatial locations in a flat furnished for a handicapped person. Participants had to carry out four different tasks:

- The first task consisted in familiarizing the robot with useful locations in the flat, such as *the living room* or *the dinner table*, but also *in front of the TV*. Which locations participants pointed out and the order in which they did was entirely up to them.
- The second task was to summarize the locations taught to the robot from a static position and then to listen to the robot's summary of what it had learned.
- The third task was to familiarize the robot with particular locations in the building, such as *the student administration room, the staircase*, or *the lift*.
- The final task was to instruct the robot verbally to take the user to one of the locations in the building the robot had been familiarized with previously.

The robot's linguistic utterances in the dialogs with Rolland were explicitly designed to ensure natural dialogs and to guide the user subtly and implicitly into a useful understanding of the task.

The different tasks involve activities of different degrees of interactivity; while the first task is interactional such that the robot basically elaborates on every utterance the participant produces, indicating a high level of understanding, aiming at fluent dialog and involving the user in the grounding process, the second task is asymmetrical such that first the speaker has the turn while summarizing the locations in the room and then the robot summarizes what it supposedly has been taught. This phase, while not interactional, is useful to study in how far speakers are inclined to provide the robot with feedback.

The third task is similar to the first, but the robot does not produce any linguistic output (which it announces at the beginning of that phase). This phase is interesting here with respect to the amount of discourse structuring carried out for the robot. Finally, the last task consists in instructing the robot to move to a location it had been familiarized with in Task 3.

During the teaching and instructing situations, participants had to steer the Rolland like a normal electric wheelchair. Only at the end of the last task the robot was meant to move by itself. Yet, since the autonomous, speech-driven version of Rolland was not available at the time of the experiments, Rolland would claim that its batteries would have to be recharged first, after which the experimenter ended the interaction. The pretense was nevertheless necessary to establish a convincing teaching scenario.

3.3. Data Analysis

The data were analyzed in two ways: On the one hand, as a measure of participants’ understanding of the situation as social or non-social, a dialog opening was designed that allows the operationalization of the degree with which participants treat the robot as a social actor [cf. 5]. In particular, the robot volunteers a social greeting to the participants: *Yes, hello, how do you do?*

Participants may now ignore the social message in this utterance and simply begin instructing the robot. Alternatively, participants may react minimally, either reciprocating the greeting by saying *hello*, or by answering the questions, for instance, with *fine*. Participants may also do both. Furthermore, participants may react to the social content of the utterance, replying *thanks* or *thank you*. Finally, they may even reciprocate the question by asking, for instance, *and how do you do?* (In this connection it is worth mentioning that while the counter-question constitutes a conventional response in English, in German such a question is rather taken literally.) Depending on how many of these reactions participants produced, dialogs were coded on a scale from 0 to 3.

On the other hand, as measures describing participants' linguistic behavior, the dialogs in all tasks were analyzed semi-automatically for several linguistic properties; the presence or absence of these properties provides evidence for particular kinds of understandings of the communication partner and the human-robot relationship. Most features below were automatically extracted for each dialog using standard corpus-linguistic methods, checked manually for accuracy and divided by the number of turns; in addition, a constraint-based dependency parser was used to identify indicators of linguistic complexity, such as relative clauses or subclauses [8]:

- number of structuring cues: Structuring cues comprise implicit (for instance, *jetzt* (*now*), *okay* or *also* (*so*)) and explicit (for instance, *als erstes* (*first of all*)) structuring cues; the individual tokens were counted for each speaker. The amount of structuring provides indirect evidence on the cognitive capabilities speakers suspect the robot to have; for instance, 'first of all' projects a longer and complex task in which the current action is only the first step. Interactants using such a structuring cue thus presuppose such a complex shared background, while interactants who do not use such cues expect the robot to handle only one isolated event at a time;
- number of politeness formulas: Politeness formulas, i.e. *bitte* (*please*) and *danke* (*thank you*), were counted for each speaker and divided by the number of turns of each speaker; these cues directly inform us about how much interactants attend to social behavior in the dialogs;
- amount of speaking: For each participant the number of turns produced during the task under consideration was determined; the number of turns tells us about speakers' linguistic effort spent on the instruction and serves as the basis for the calculations of the other measures; in addition, the number of finite verbs was counted as evidence for full, grammatical sentences directed towards the robot;
- number of feedback signals: As an indicator for speakers' interactivity with their artificial communication partner, their use of feedback was analyzed, comprising the feedback signals *ja* (*yes*), *okay, gut* (*good*) and *mhm* (*uh-huh*);
- abstract language: As an indicator of suspected competence, instances of abstract terms, such as *Objekt* (*object*) or *Hindernis* (*obstacle*), were counted;
- alignment: Alignment [25] with the linguistic material presented by the robot on the lexical and constructional level was measured in absolute occurrences of linguistic structures previously used by the robot, here in particular the spatial preposition *davor* (*in front of*) and the phrase *wir fahren* (*we are going to)*. Alignment is relevant because it indicates the amount with which speakers are willing, or see the necessity [3], to share linguistic expressions with their communication partner and can thus be understood as evidence for cooperativeness;
- personal pronouns: Pronouns like *you* and *I* are indicators of the interactants' understanding of the situation; for instance, they may construe the situation as joint action (*we are going...*), as personal action (*I am going...*), or as impersonal action (*to the cupboard*);
- linguistic complexity: Measures for the level of linguistic complexity assumed for the robot are relative clauses, which have been shown in previous studies to be related to suspected high cognitive competence [5] on the one hand, and the amount of subclauses on the other. In other situations, for example, when talking to children, people have been found to reduce the complexity of their utterances if they suspect the linguistic and cognitive capabilities of their communication partners to be low [6]. These features were identified automatically on the parsed corpus [8].

4. RESULTS

4.1 Interpersonal Variation

We can observe considerable interpersonal variation both in the way participants react to the social greeting of the robot and concerning the linguistic properties of their utterances.

Table 1 shows the number of aspects of the robot's social greeting attended to by each of the fifteen participants.

Table 1: Interpersonal Variation in Dialog Openings

properties of the robot's greeting attended to	**0**	**1**	**2**	**3**
example	'okay, backwards'	'fine'	'fine, thanks'	'fine, thanks, how are you?'
number of dialogs	2	7	4	2

The dialog excerpts below illustrate some of the differences in participants' understanding of the identical human-robot interaction situation:

(1) Rolland: Ja, guten Tag, wie geht es Ihnen? (*yes, hello, how do you do?*)

R005: (noise) - okay, (breathing) -- rückwärts, (1) und nach rechts? - und gerade (laughter) aus? Gott, (breathing) (1) (*okay, - backwards, and to the right? and straight ahead? God,*)

Rolland: wohin fahren wir? (*where are we going to*?)

R005:- nach links. (2) geradeaus? - an den Tisch? (1) und, rückwärts? - (*to the left. straight, and to the table? and backwards?*)

Rolland: entschuldigung, was für ein Tisch? (*excuse me, which kind of table*?)

R005: (3) hä? (laughter) (2) und nach rechts. (2) (*huh? and to the right.*)

Rolland: entschuldigung, was für ein Tisch? (*excuse me, which kind of table*?)

R005: - (1) äh, ein Esstisch. -- mit Geschirr drauf. (*uh, a dining table – with plates*)

Rolland: der was? (*the what?)*

R005: (2) hä? (3) ja. wie auch immer. nach rechts vielleicht? (laughter) (2) (*huh? well, however. to the right maybe?)*

The participant in example (1) ignores the robot's social utterances completely, as well as other robot utterances he does not readily understand, commenting this move with 'however'. At the same time, he uses very low-level descriptions of his own navigation procedures.

The participant in example (2) reacts minimally to the robot's greeting and provides an answer to the robot's question. However, this reply is morphologically and syntactically not aligned with the robot's utterance:

(2) Rolland: ja guten Tag, wie geht es Ihnen? (*yes, hello, how do you do*?)

R002: (1) gut. - (fine)

Rolland: Sie können uns nun zu einem Ort fahren, den Sie benennen möchten. (*you can take us now to a place you want to name*.)

R002: (noise) gelber Schrank. (*yellow cupboard*.)

In contrast, in examples (3), (4) and (5) the participants all react to the social, pragmatic aspects of the robot's first utterance, and all three examples exhibit well-aligned, fluent dialogs with the robot:

(3) Rolland: Ja, guten Tag, wie geht es Ihnen? (*yes, hello, how do you do?*)

R009: (breathing) ja gut (laughter) danke (2) (*yeah fine thanks*)

Rolland: Sie können uns jetzt zu einem Ort fahren, den Sie benennen möchten. (*you can take us now to a place you want to name*.)

R009: (1) okay ich fahre uns zum Kühlschrank. – (*okay I'm taking us to the refridgerator*)

(4) Rolland: Ja, guten Tag, wie geht es Ihnen? (*yes, hello, how do you do*?)

R008: (1) (hnoise) mir geht es gut und Dir? (1) (*I'm fine and how are you*?)[1]

Rolland: Sie können uns jetzt zu einem Ort fahren, den Sie benennen möchten. (*you can take us now to a place you want to name*.)

R008: (1) gut. (1) oje oje, (2) (*good. oh oh*)

Rolland: wohin fahren wir? (*where are we going*?)

R008:(1) wir fahr'n zu einer - palmenartigen Pflanze. – (*we are going to a palm-like plant*)

(5) Rolland: Ja, guten Tag, wie geht es Ihnen? (*yes, hello, how do you do?*)

R011: oh, (1) gut (laughter) und selber, -- (*oh, good, and how about yourself*?)

Rolland: Sie können uns jetzt zu einem Ort fahren, den Sie benennen möchten. (*you can take us now to a place you want to name*.)

R011: (2) okay ich benenn den jetzt mal zum Fernseher, (9) (*okay I name it now to the TV*)

Rolland: wohin fahren wir? (*where are we going?*)

R011: (1) äh zum Fernseher, (*uh to the TV*)

The examples do not only illustrate different dialog openings and different amounts of orientation to the social content of the robot's utterances, but also different degrees of cooperation and alignment in the turns following the dialog openings. In particular, participants who react more to the social content of the robot's utterance cooperate more in the following exchanges. This impression is supported by the quantitative analysis.

4.2 Effect of Understanding the Interaction as Social or Non-social

The statistical correlation analysis used here reveals the degree with which the occurrences of two features are in a linear relationship of the type 'the more x, the more/less y'. In the case under consideration, the relationship we are interested in is whether a speaker who attends to the social features of the robot's initial utterance will use more or less of a particular other linguistic feature. The (Pearson's Product-Moment) correlation coefficient ***r*** ranges from -1 to +1, where the two endpoints describe perfect negative or positive correlations. The results of the analysis of the current data reveal statistical correlations between dialog openings and the linguistic features encoded as shown in Table 1.

There is also a gender effect for the use of the personal pronoun "*I*" (r=.65), technical language (r=.61) and questions (r=.67), which are more common for male than for female interactants. In order to calculate the relationship between gender and linguistic behavior, female speakers were encoded as 1 and males as 2; these values were then subjected to a correlation analysis. The higher the values, the more they are associated with male speakers.

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[1] The fact that the robot does not respond to the participants' social utterance is due to the scripted dialog used for methodological reasons, i.e. the comparability of the dialogs, yet this lack of response might of course dampen the amount of social behavior from the speaker in the course of the dialog.

*Table 2: Correlations between linguistic choice and dialog opening; N=15, * = p< .05*

r	**Dialog opening**
Task 1	
structuring cues	.22
discourse markers	.37
feedback	.70*
amount of speaking	.33
abstract language	.49
alignment	
- lexical	.45
- constructional	.59*
politeness formulas	.27
Task 2	
structuring cues	.43
discourse markers	.51
feedback	.36
Task 3	
structuring cues	.43
personal pronoun "ich" ('*I*')	.57*
finite verbs	.35
Task 4	
structuring cues	.27
feedback	.30
relative clauses	.63*
subclauses	.49
politeness formulas	.22

The results show that participants who greet the robot and thus attend to a social relationship use more structuring cues, more feedback, align more and suspect higher linguistic and cognitive competence of their communication partner as evidenced by the higher amounts of abstract language and sub- and relative clauses. Moreover, participants who react more to the social aspects of the robot's greeting tend to speak more, are more interactional, as apparent from the amounts of feedback signals and politeness formulas, and align more with the robot's utterances. Speakers' very first reactions to the robot's greeting are thus not accidental, but are related to other linguistic choices that treat the robot more like a partner than as a tool.

The fact that significant correlations between the very first utterance and speakers' linguistic behavior in this last task can be established, even though about half an hour of interaction has occurred in between, demonstrates that speakers' conceptualization of the communicative situation and the communication partner as apparent from the dialog opening is indeed a strong predictor for linguistic behavior.

The cluster analysis shows the grouping of participants on the basis of their linguistic behavior. Thus, compared to the correlation analysis, it takes the opposite perspective by taking participants' linguistic behavior on a broad range of linguistic levels as a starting point.

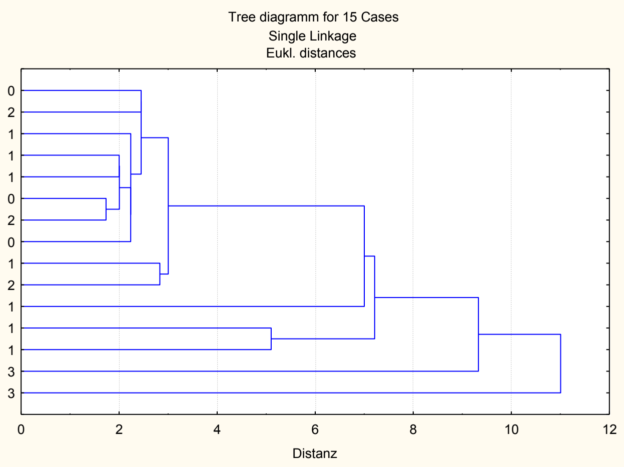

Figure 2: Cluster analysis for the 15 dialogs on the basis of interactants' linguistic behavior; y-axis = dialog openings

5. DISCUSSION

The qualitative and quantitative analysis has revealed considerable variation concerning participants' reaction to the robot's greeting; since the robot's greeting comprises a broad spectrum of aspects to which participants may attend, their choice is revealing regarding the level of social relationship the participant is willing to establish for the purpose of the interaction. While participants may ignore the robot's social utterance completely, react minimally to its channel establishing function, respond to its function to elicit reports on one's own well-being, or reply to the social aspects of the interaction, the verbal choices made by the participants can be taken as indicators of their understanding of the human-robot interaction situation as social or as non-social.

Since participants in these dialogs are all confronted with identical robot behaviors, interpersonal differences can be attributed to their differing preconceptions about robots, human-robot interactions and their interactional goals. That their choice is not mindless is supported by the fact that their initial greeting behaviors correlate with a set of other linguistic features that assign more competence to the robot, involve attention to social relationships and are more cooperative, as for instance in terms of interactivity and alignment. Furthermore, the conclusion that reacting to the robot's greeting is not mindless behavior but part of a more elaborate mental model of the robot is supported by the fact that participants who reciprocate the robot's greeting on all levels usually laugh before producing their social responses (see examples (3) and (5)).[2] That is, they acknowledge that there is something unusual and even funny about pretending to carry out a social interaction with the robot. It may therefore be considered whether the reason for the understanding of the robot as social actor not better be described as a kind of joint pretense, as Clark [4] suggests.

Finally, participants' preconceptions turned out to be a useful predictor of their linguistic behavior throughout the dialogs.

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[2] Unfortunately, laughter is too multifunctional to lend itself to a quantitative analysis.

While few of the correlations reported reach significance, the correlations observed are consistently positive and concern linguistic behavior on all levels of linguistic analysis.

6. CONCLUSIONS

The investigation has revealed considerable interpersonal variation concerning participants' understanding of the human-robot interaction situation as social or as non-social.

One possible conclusion could be that people differ with respect to their inclination to be mindless; however, in this case, the reason for the mindlessness would not lie in evolutionary psychology or biology any more, but in individual psychological predisposition (or possibly in the psychological predisposition of certain groups, as the gender effects found (see also [11]) suggest). Moreover, the fact that social treatment of an artificial interactant is mediated by individual, cultural or other factors casts doubt on the role of automaticity.

Another problem for automaticity is that the amount with which participants treat the robot as a social interactant in their very first utterance was found to correspond systematically to certain linguistic behaviors, even over longer periods of time and on a broad range of linguistic features and functions. These behaviors are not random but correspond to more elaborate and more cooperative understandings of the artificial communication partner. This suggests that participants, instead of reacting involuntarily and mindlessly, understand the situation to require particular behaviors, according to which they interact with the robot. Depending on their interactional goals, they choose their linguistic features in accordance with what they understand as the requirements of the current situation. In this interpretation, verbal human-robot interaction is in line with communication in other situations, for instance in communication with foreigners, where also speakers' interactional goals were found to determine whether they treat their interaction partner as an individual, adapting to his or her responses, or whether they rather orient at a particular stereotype (see [29] or [33]).

That participants' behaviors are not simply involuntary, automatic responses is also supported by the fact that many participants laugh before treating the robot as a social actor. This suggests that they are aware of their choice. Nevertheless, the claim here is of course not that participants make a conscious choice to treat the robot as a social actor – linguistic behavior in general is not conscious – yet usually it is functionally fully appropriate for the situation as understood by the participants [6]. The suggestion here is therefore that participants' behavior reflects their understanding of the situation, which in turn can be inferred from the linguistic choices they make.

Another possibility is to distinguish between different types of anthropomorphism. As Takayama suggests [30], acceptance 'in the moment' needs to be distinguished from a general attitude towards robots; this distinction is supported by different degrees of anthropomorphism revealed by different methods of analysis [10]. In his study, more anthropomorphism was found when people described the robot's behavior verbally than when they answered questions in a questionnaire. In this interpretation, there are subconscious, involuntary, mindless responses 'in the moment', which however can be mediated by more conscious beliefs about the communication partner. This may be very useful to account both for findings in interactional situations like the one investigated here and for the involuntary, automatic responses when people react to non-interactive artifacts like images [27] in social ways.

The current investigation cannot distinguish between these two different hypotheses, and certainly more research is needed to identify the causes for treating artificial interactants as social actors in all kinds of situations. However, as system designers we create products which suggest participants to treat them as social actors; under this perspective I'd rather risk to 'err on the side of kindness and humanity' and suspect that my participants do not go about mindlessly.

7. DESIGN IMPLICATIONS

Given the two different user groups emerging, those that understand the interaction as social and those who do not, user-adapted dialog design may be at issue. In particular, if one group of users does not conceptualize the interaction with a robot as a social endeavor anyway, possibly much more efficient dialogs can be envisaged that disregard all 'etiquette' issues, especially since these participants prove to be somewhat resistant to all attempts at shaping [32] their utterances in a particular way as is apparent from the low amounts of alignment exhibited in their utterances. Yet which kinds of robot utterances are most suitable for which user group is eventually an empirical question to be left for future research.

However, the current investigation has shown that the particular understanding of the situation as social or non-social can be measured by participants' reactions to the robot's first utterance, and that these reactions serve to predict users' linguistic behavior in the course of the dialogs [cf. also 5]. These correlations can and should be considered in order to facilitate automatic speech processing and dialog design.

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