Shaping Naive Users' Models of Robots' Situation Awareness

Kerstin Fischer & Manja Lohse
Southern University of Denmark & University of Bielefeld

Kerstin FISCHER, Institute of Business Communication and Information Science, Grundtvigs Allé 150, DK-6400 Sønderborg, Denmark, e-mail: kerstin@sitkom.sdu.dk
Manja LOHSE, Technische Fakultät, Bibliotheksstraße 1, D-33501 Bielefeld, Germany,
e-mail: mlohse@techfak.uni-bielefeld.de

***Abstract*—This paper addresses a so far neglected area of human-robot interaction by approaching situation awareness from the point of view of naïve users. In particular, we present an investigation into which naïve models of robots' capabilities users carry into the interaction, how these models influence the interaction, and which means can be taken to guide users into more realistic models and behaviours if necessary. Quantitative and qualitative investigations reveal not only considerable uncertainty about robots' situation awareness, but also significant differences in dealing with this uncertainty. Three different types of users can be distinguished on the basis of the strategies they take. Finally, we describe experiments with two means of shaping the users' models into more realistic accounts of robots' capabilities. The results suggest that verbal robot output is a powerful means for guiding users subtly, unobtrusively and online into an understanding of robots' capabilities that is more realistic and adequate than users' naïve models of robots' situation awareness.**

I.Introduction

Situation awareness is not only a central precondition for the interaction with the environment in general; it is essential in communication where users have to estimate their common grounds with their interaction partners in order to determine which knowledge they can rely on and which information they need to provide.

In human-robot interaction, the problem does not arise to the same degree for computer experts and naïve users (see also Schultz et al. 2004); experts may be much more able to estimate the perceptive capabilities of the respective robot than users who are unfamiliar with the interaction with artificial communication partners. Extending Drury et al.'s design guidelines for improved human-robot interaction [1], it is thus also necessary for the humans to understand the capabilities of the robot they interact with, particularly if the interface is based on natural dialogue [2].

The first question arising for speech- or language-driven human-robot interaction is then, what do naïve users hypothesize about their artificial interlocutor's situation awareness, what do they presuppose and how much attention do they pay to establishing common ground, i.e. a joint perception of the current situation. Secondly, it would be useful to know how homogeneous prospective users are in their beliefs and behaviours concerning robots' situation awareness. In particular, we need to determine whether distinct user groups emerge and finally which measures might be taken to meet the users' expectations.

Following Endsley [3], we understand situation awareness as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." For current purposes, we shall distinguish users' hypotheses about robots' capabilities with respect to:

- situation awareness level one:
  - object perception
  - self-perception/spatial orientation
  - perception of the human instructor
  - perception of cardinal directions
- situation awareness level two:
  - understanding of meaningful categories of objects
  - understanding of context-dependent interpretation of spatial regions
  - understanding of the current task
- situation awareness level three:
  - prediction of upcoming tasks
  - prediction of human behaviour

Previous studies addressing humans' mental representations of robots have focussed on matters of acceptancy; for instance, many studies have investigated the influence of particular non-linguistic behaviours, such as mimics (e.g. [4]), gaze and attentativity [5], proxemics (e.g. [6]), the use of personal information and apologies [7,8] or the role of robot appearance [9]. Some of these studies focus on particular user groups, such as autistic children (e.g. [5]) or elderly people [10], while other intend to measure the effect of particular functionalities. However, few studies are concerned with the contents of humans' mental models of robots and the effect these have on human-robot interaction.

Previous work regarding users' perceptions of robots' reasoning and linguistic capabilities in general reveal great uncertainties by the users about what to expect from their artificial communication partner [11,12]. What is necessary is thus to identify in detail which hypotheses about robots' situation awareness users hold, how homogeneous users are in their beliefs and whether these beliefs determine the users' linguistic behaviour. Moreover, it will be most useful to determine how such behaviour can be shaped by robot output if necessary.

II.Methods and Data

In order to address the questions outlined, three different approaches were taken. First, we carried out a questionnaire study. The questionnaire was designed to reveal users' *a priori* conceptualizations about robots' situation awareness. Since questionnaires are restricted to conscious aspects of behaviour and thus are subject to conscious control by the participant, the results from the questionnaire study were supplemented by further analyses of users' behaviour in human-robot interaction.

The second approach employed is therefore the qualitative analysis of users' utterances based on ethnomethodological conversation analysis (CA, [13,14]). In particular, we use three different methods [for details, see 12]: Following Schegloff [15], we investigate clarification questions that are designed to initiate insertion sequences. These reveal what users consider as necessary information for producing their spatial instructions. '*Aibo, do you see the bowl?*' is an example for a clarification question, displaying the speaker's worry whether the robot perceives the object it is supposed to head towards. The second method for qualitative analysis relies on the investigation of off-talk, speech directed towards the experimenter or to the speaker her- or himself. Users commonly display their hypotheses about their artificial communication partner and about what may have caused a perceived misunderstanding in off-stage statements. An example is '*does he have antennae?*'. The third CA-inspired method is the analysis of reformulations. In the dialogues elicited for this study, the robot either produces only non-verbal behaviour or linguistic output carefully designed not to reveal clues to the users what might have caused a communication problem. Thus, since the aim of this study is to identify naïve users' models of robots' situation awareness, we avoid influencing the the users' own hypotheses. The proposal a user makes in the turn following a misunderstanding constitutes therefore an attempt to simplify communication on the basis of the user's model of the artificial communication partner. An example of this use of reformulations as displays of users' mental models of the robot is the following:

User: *go left*
Robot: *error*
User: *go north*

Here, the user proposes cardinal points to solve the communication problem, which in this case is taken to be due to the robot's inability to process "left". Note that this is not the real cause for this communication problem (see [16]), but based on the user's hypothesis about what robots are good and bad at. Further studies reveal that users systematically try out cardinal directions in human-robot interaction and that thus robots are generally expected to use the cardinal points of the compass for orientation (see [12]).

Finally, statistical methods are used for a quantitative study of the influence of particular variables in robot output design. The corpora used have all been designed to allow the comparison with respect to a single feature. Since one of the central questions of this study concerns the conditioning factors of users' hypotheses about robots' situation awareness and possibilities for shaping such beliefs, the effect of different robot output will be analysed both qualitatively and quantitatively.


Fig. 1: Aibo

The corpora used in the current study are part of a set of comparable corpora of verbal human-robot interaction which have been elicited over a period of four years in the framework of the collaborative research area 'Spatial Cognition' at the University of Bremen. In the first set of corpora employed here we used Sony's Aibo, a small dog-like pet robot (see Fig. 1).

In the first part of the experiment, we recorded 13 German speakers instructing Aibo to move to particular goal objects, pointed at by the experimenter. Pointing was used in order to avoid prompting the participant with particular spatial descriptions. Most tasks involved a single goal object, one task involved a sequence of several objects to which the robot had to go. After two tasks, that is, after approximately 15min, the experimenter told each user that it was possible to refer to the objects directly. The robot was steered by student employees behind a screen. In order to ensure comparability of the interactions in this corpus and with the data elicited in the other condition, the robot was steered according to a fixed schema of robot behaviours. Note however that the users perceive the robot's behaviour as interactive. From the participants' perspective, i.e. from an emic point of view, these interactions are dialogical since users interpret the robot's behaviour as reaction to their instructions. After the recording, speakers were asked whether they had believed that they were talking to a real robot, which all of them acknowledged. Condition 1 can thus be summarised as follows:

- Participants: 13 German university students and Aibo
- Task: to instruct the robot verbally to move to particular goal objects
- Robot behaviour: according to fixed schema of behaviours ('Wizard-of-Oz' scenario)
- after two tasks, speakers were prompted that they can use object-based descriptions

The second part of this study (17 dialogues with native speakers of German) was carried out in the same way and with the same robot behaviours, which were then augmented by verbal robot output. Again, the robot behaviour was manipulated by a human 'wizard' (see [17]). The robot utterances were pre-synthesized and were played in a fixed order. The utterances were created according to four principles: First, we made the robot ask for and propose spatial references using object naming strategies. Second, we made the robot use an extrinsic reference system, using cardinal directions. Third, as an indicator of high linguistic capabilities, the robot made extensive use of relative clauses. Fourth, the utterances were so designed as to be felicitously applicable in various contexts, thus yielding natural dialogues. The robot's utterances are, for instance, the following:

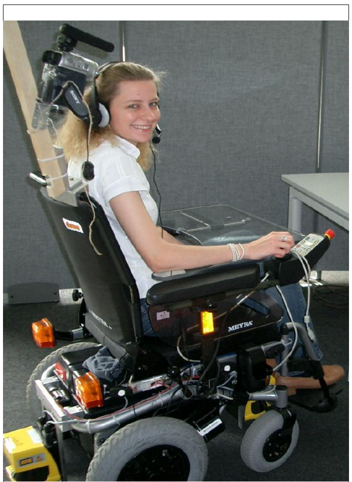

Fig. 2: Rolland

✘Ja Guten Tag, wie geht es Ihnen?
(*yeah hello, how do you do?*)
✘Soll ich mich zu dem Objekt begeben, das vorne liegt?
(*do you want me to move to the object which lies in front?*)
✘Meinen Sie das Objekt, das 30 Grad westlich der Dose liegt? (d*o you mean the object that is 30 degrees west of the box?*)

Condition 2 can be summed up as follows:

- 17 German human-robot dialogues
- conditions as in Condition 1, just that the fixed schema of robot behaviours is paired with a fixed schema of robot utterances.

Also after elicitation of the dialogues in Condition 2, all participants noted in the questionnaire that they had believed to be interacting with a real robot.

The second set of corpora was elicited using Rolland (see Fig. 2), a robotic wheelchair [18]. In these experiments, the users' task was to steer the robot around in a flat for handicapped people and to teach it the relevant locations, such as the kitchen, the living room, the TV, and so on. A 'wizard' provided suitable robot output, designed to guide the users into an appropriate model of the robot and the task. These data are comparable with both a non-verbal condition, and a condition in which robot output comprises the same dialogue moves, however, where the utterances did not provide direct cues to the robot's situation awareness.

III. Naïve Models of Robots' Situation Awareness

In order to determine potential users' mental models of robots' first and second level of situation awareness, a questionnaire was designed, addressing by way of example a particular robot functionality.

Questionnaire Study

The questions regarding to level one situational awareness concerned:

- the perception of objects such as *cups, bowls,* etc.
- the identification of the user's spatial position
- the identification of the user's gaze direction
- the ability
  - to orientate itself
  - to determine the cardinal points of the compass

As indicators of level two capabilities, there were questions concerning meaningful categorization of objects and events, such as:

- the understanding of relational terms, such as *left, right, front, back*
- the understanding of group terms, such as *group, line, collection*
- as indicators of task understanding,
  - the processability of verbs for spatial instruction such as *go, move, turn*

Some further questions concerned stereotypical human versus stereotypical mechanical behaviours:

- as an indicator for the understanding of argumentative contexts, the understanding of discourse and modal particles, such as *well, but, indeed*
- processability of hesitation markers, in particular, *uh* and *um*
- the ability to listen
- the ability to measure distances
- the ability to understand logical formulas

In the questionnaire study, 48 students, mostly undergraduates 19-22 years old, were asked to judge what robots would be good at on a scale from one to five (no additional information was provided). 12% of the participants noted that they have some experience with robots, the rest were unacquainted with artificial agents.

The results are shown in Fig. 3. The ability to measure distances was classified as relatively easy. Also verbal instruction by means of verbs of movement, to keep the orientation, identification of cardinal directions and the speaker's position, object perception and the processing of logical formulas are judged as relatively easy. Furthermore, participants judge robots to be generally competent in processing words like *left, right, front* and *back*. Note however that all these judgments are located around the middle of the scale. Thus, regarding the processing of logical formulas, for instance, robots are obviously not simply regarded as mobile computers.

Terms like *group, line* or *collection* are judged as generally difficult. This corresponds to earlier findings about metaphorical language use [12], which in case of miscommunication users were also found to identify as a potentially problematic aspect of language use in human-robot interaction. Furthermore, the identification of the user's gaze direction and particular features of spoken language use, particularly modal particles and hesitations, are judged as difficult to process for robots. That they are judged bad listeners shows that robots are not generally assigned human-like properties.

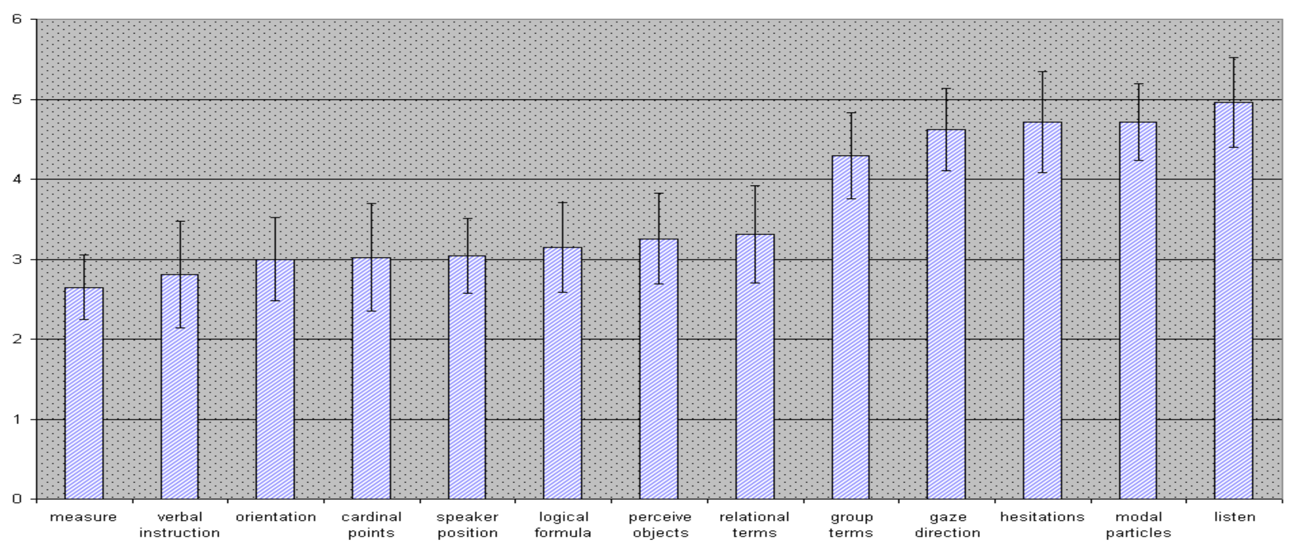

Fig. 3: Questionnaire Results

Noteworthy are in general the pessimistic judgements of even relatively common robot capabilities, such as the processing of verbs of spatial instruction, performing logical operations, distance measurement and orienting in space. Moreover, for most judgements, participants varied considerably in their answers.

The interpretation of the questionnaire results is not straightforward. Although typically human capabilities were judged consistently pessimistic, more probable robot functionalities were not rated consistently more likely. Instead, participants revealed considerable uncertainty about robot capabilities. This may be due to the fact that in decontextualized questionnaire studies participants have to imagine robots, and it it possible that they imagine different robots. Furthermore, it cannot be excluded that negative attitudes towards technical equipment in general also play a role; thus, the question, how good do you think robots could be at listening? might suggest that we should have robots as listeners, and there may be a strong attitude against that. Consequently, the questionnaire study was complemented with an analysis of users' subconscious displays of their mental models of a robot in human-robot interaction.

Analysis of Human-Robot Interaction

In general, the qualitative analysis of the two human-robot interaction corpora reveal the same uncertainties as in the questionnaire. In particular, users may worry about the robot's perceptive, linguistic and cognitive capabilities, its functionality and reasoning capabilities. With regard to the perception of the current situation, they are uncertain about the robot's level one situation awareness in the following respects:

Object perception

In Condition 1, 84.6% of the users do not refer to objects at all; instead, they employ lowest level instructions by providing descriptions of the path to follow, without reference to situational elements, such as landmarks. Only 15.3% of the users use object-based descriptions. That this is based on the implicit assumption that the robot does not perceive objects is shown from the fact that as soon as users are told that they can refer to objects directly, they consistently do so. Only one user switches back to path-based description afterwards after a perceived misunderstanding. Otherwise object descriptions are preferred, which is understandable since they demand much less attention from the human instructor.

Correspondingly, after the initial greeting of the robot in Condition 2, 88.2% use object descriptions. Thus, only a single utterance by the robot suffices to change the users' mental model of the robot and to elicit more elaborate behaviours. The mental model construed in this condition obviously comprises object perception and categorization. This is, on the one hand, consistent with the image construed in utterance design: Robot output indicates perception of objects. On the other hand, most speakers choose an object-based description strategy already after the robot's greeting. Thus, although the robot's utterances may have guided the users into object-based descriptions [19], they may have decided on this strategy on the basis of a more complex mental model of the robot due to its very first utterance. Still, clarification questions show that object perception is considered as potentially problematic for the robot:

A020: links von dir liegt eine Schüssel. -- links. links. links. noch 'n Stück, links, links, geradeaus, geradeaus, siehst du's? ja. (2) [*to your left is a bowl. left. left. left. a bit further, left, left, straight ahead, straight ahead, do you see it? yes.*]

Self-perception

In Condition 1, there are no instances of references to the robot's body; in contrast, in Condition 2 users commonly use the intrinsic orientation of the robot, for instance:

A001: als nächstes (3) gehen wir zu einer der Tassen die hinter dir liegen. (7) [*next we go to one of the cups that are behind you.*]

A025: (1) ja. hinter dir is' noch eine. - pass auf jetzt gehst du. zu der die schräg links vor dir is'. – [*behind you is another one. listen now you move to the one that is diagonally to your left*]

Another aspect of self-perception is self-localisation. In previous experiments we found that users frequently employ an extrinsic reference system using the cardinal points of the compass for orientation [16]. In Condition 1, none of the users employs this reference system; however, the robot uses it itself in clarification questions in Condition 2, and although the experiment took place indoors and thus the cardinal directions constituted a problem for the human users, as many as 29.4% of the users use extrinsic references in their instructions. The qualitative analysis reveals no doubts on the users' side that the robot can easily identify the cardinal points of the compass.

Perception of participants and their spatial position

In Condition 1, users never mention themselves, use egocentric references, or rely on the robot's perception of their own spatial position. In Condition 2, 29.4% of the users make use of their own spatial position, for instance:

A016: (2) zu dem Objekt was rechts von mir is'? [*to the object that is right of me?*]

A020: komm zu mir, okay, zu mir, zu mir, zu mir, gerade weiter [*come here to me, okay, to me, to me, to me, continue straight]*

A022: (1) von mir aus gesehen, - das nörd-westliche. (2) [*from my perspective the one north-west*]

A004: (1) nein ich meine das Objekt das rechts von mir steht [*no I mean the object that is to my right*]

Partner-oriented descriptions are also common in human-human interaction, depending on social factors [20] and on judgements about the communication partner's spatial abilities [21]. Since the users' linguistic choices in general suggest that users' mental models of their artificial communication partner are rather elementary, it is likely that the choice of partner-oriented instructions in Condition 1 and to a smaller degree in Condition 2 are related to negative judgements about the robot's situation awareness.

To summarize, in the condition with the speech processing but not speech producing robot, users doubt even a level one situation awareness of the robot. In Condition 2, in which the robot produces linguistic output, the capabilities users hypothesise the robot to have are more elaborate. We shall now investigate level two situation awareness, which concerns here the robot's understanding of the task at hand, its understanding of context-dependent spatial regions, as well as its meaningful categorization of objects.

Understanding of task/activity/action

In Condition 1, users do not presuppose knowledge about the task at all. The functionalities they rely on are equally restricted, and even those are not without doubt, as the following example illustrates:

A016: kann er sich auch drehen? (5) [*can he turn?*]

The clarification questions in Condition 2 concern similar behavioural and interactional aspects:

A001: -- ja, ich weiß nicht ob er jetzt weiter macht oder nich'? [*well, I don't know whether he will continue or not?*]
A013: hält der eigentlich von alleine an oder muß ich ihm irgendwann stopp sagen wenn er denn da is, [*does he stop on his own or do I have to say stop when he has arrived,*]
A016: -- muss ich immer warten bis er, bis er was sagt? [*do I have to wait until he says something?*]
A001:(hnoise) - kannst Du rückwärts fahren? (2) [*can you go backwards?*]

Moreover, users may interpret the robot's behaviour as intentional, for instance:

A028: jetzt is' er bockig (1) [*now he is playing hard to get*]
A020: wo willst du denn hin, (1) [*where do you want to go?*]

Such instances of anthropomorphization occur in both conditions.

Categorization of objects

Since users do hardly refer to objects in Condition 1 at all, they also do not presuppose object categorization. In contrast, in Condition 2, 41.2% of the users rely on object categories such as *collection, group*, or *line*, either explicitly by referring to such groups, or implicitly by referring to *the object in the middle*, meaning the object in the middle of a collection of objects.

To sum up, the users naïve models of a speech processing robot without linguistic output comprise not even situation awareness at level one. In contrast, the same robot with linguistic output creates a more sophisticated mental model and thus comprises both level one and two situation awareness to some degree. It can be concluded that the robot's linguistic output plays a crucial role in the mental model users develop of artificial communication partners.

IV. User Groups

While all users seem to build up similar mental models of the robot in the two conditions, the qualitative and quantitative analyses of users' strategies of dealing with their uncertainty about the robot's situation awareness reveal considerable interpersonal differences. Three different user groups emerged with respect to ways of dealing with the robot's situation awareness:

- first, there are those users who regard the robot as a mechanical tool; these users avoid issues of grounding completely and instead apply trial-and-error strategies;
- second, there are users who pay very much attention to grounding issues, asking clarification questions, proceeding consciously by trial and error in absence of other evidence, and providing extensive amounts of feedback to the robot. This group of users considers answers to these questions as vital for producing instructions to the robot. This results in much off-talk, clarification subdialogues, repair strategies etc. Thus, indicating the robot's situation awareness to these users seems an essential condition for successful human-robot interaction;
- third, there are users who treat the robot as a social actor and who transfer their grounding strategies from interactions among humans.

These results correspond to previous findings with respect to user behaviour in human-robot interaction; for various human-robot interaction corpora in different situations the same distinctions revealed themselves relevant regarding numerous aspects of linguistic behaviour, such as prosody, emotional expression, sentence mood, intensification, structuring cues, reformulations, clarification questions and reference to the robot [22]. These linguistic choices depend significantly on the degree to which users regard the human-robot interaction situation to be a social encounter. In all corpora, users who display no orientation to social aspects of communication employ low-level instructions on a trial-and-error basis, presupposing no situation awareness of the robot. In contrast, users oriented at social aspects may either transfer their linguistic behaviour from human-human interaction, including issues of politeness and emotional expression, or they may employ strategies from human-human communication, such as clarification questions, to identify the information they lack in their mental models.

V. Shaping Users' Models of Robots' Situation Awareness

The different assumptions about the robot's situation awareness and the differing strategies to deal with them exhibited by the three different user groups call for differential treatment in dialogue system design; the results of the previous study have shown that linguistic robot output plays a crucial role in shaping users' concepts of their artificial communication partner. In particular, the tool-group is problematic because they may underestimate the robot's capabilities and situation awareness. These users may produce descriptions that are so low-level that they may not be covered by the respective dialogue system [16]. Moreover, since the robot is not understood as a communication *partner*, users often ignore the robot's linguistic output completely and thus their behaviour is particularly difficult to influence. In a study involving the three corpora in the home-tour scenario with the robotic wheelchair, the following dialogue was elicited:

R: yes, hello, how do you do?
R031: (2) okay stop, - straight ahead, (3) not so fast, -straight ahead, (2) okay, -to the left, (1)...
R: Where are we going to?
R031: - (laughter) (2) straight ahead, (1) left, (4) left, (1)
R: Where are we going to?
R031: - right we're going to the table. (2) straight ahead. (2) back, (2) left, back,
R: I did not understand the word before table.
R031: (1) left, (2) turn around, (1) okay, - small table, we're going to the small, - table. straight ahead, (3) right, --we're going to the sofa, --straight ahead, (3) s+ left, s+
R: I understood sofa.

R031: uhuh straight ahead that's correct, -right,
R: is this part of the living room area?
R031: (3) straight ahead, (1) left, -
R: which name do you prefer, sofa or living room area?
R031: (2) straight ahead, (2) right. (2)

In this dialogue, the user ignores the robot's utterances systematically, and thus his attitude places severe limits to shaping users' mental models of artificial communication partners. In contrast, for the other two groups of users, which constitute by far the majority of users, the robot output design successfully guided them into very realistic concepts of the robot's situation awareness and consequently also into very natural dialogue, for instance:

R: yes, hello, how do you do?
R031: (1) fine, how are you. (breathing) -
R: you can take us now to a place you want to name. (2)
R: where are we going to?
R031: we are going over to the coffee table. (2)
R: did you say coffee table?
R031: - yes I did. (3)
R: am I in front of it?
R031: -- yes, (breathing) --
R: Oh okay, I see which object you mean.
R031: (2) now, -- let us go over to the television. (12)
R: Is this the place to watch TV or to switch it on or off?
R031: -- this is the place to, switch it on or off. -

Thus, for users who display some amount of orientation to social aspects even in human-robot interaction, dialogue can be used to guide users into realistic models of robot capabilities and into linguistic behaviour adequate for the respective system. Linguistic design criteria for the robot output were:

- requests for action that display task knowledge
- accounts like "oh, I see which object you mean" to inform the user about the robot's motivations for asking questions, which in turn serves to inform the user implicitly about the robot's perception
- clarification questions that display information about perceptional capabilities, such as "is it the object in the corner?"

As the example shows, the cues provided by the robot's utterances provided the user with sufficient information about its situation awareness.

VI. Conlusions

Users may be very insecure about the respective robot's situation awareness, and hey may take different strategies to cope with this insecurity. In particular, three groups of users were identified: users who regard the robot as a tool, users who transfer strategies from human-human interaction, and users who deal with their insecurity by eliciting the information they need by means of particular conversational strategies. Finally we have shown how the users' naïve models can be shaped by suitable linguistic robot output. Future work will need to provide more detailed recommendations and dialogue evaluation to provide human-robot interface designers with techniques for tailoring the users' concepts to the capabilities of the respective robots.

VII. References

[1]J.L.Drury, D. Hestand, H.A.Yanco and J.Schultz, "Design Guidelines for Improved Human-Robot Interaction," CHI 2004, April 2004.

[2]S.Li, B.Wrede and G.Sagerer, "A Dialogue System for Comparative User Studies on Robot Verbal Behaviour," in *Proceedings of the 15th International Symposium on Robot and Human Interaction Communication*, IEEE 2006, pp. 129-134.

[3]M.R.Endsley, "Design and Evaluation for Situation Awereness Enhancement", in Proceedings of the Human Factors Society 32nd Annual Meeting, Santa Monica, CA, Human Factors Society.

[4]M.P.Blow, K.Dautenhahn, A.Appleby, C.Nehaniv, D.Lee, "Perception of Robot Smiles and Dimensions for Human-Robot Interaction Design", *Proc. The 15th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN06)*, 2006.

[5]B.Robins, P.Dickerson, P.Stribling and K.Dautenhahn (2004) Robot-mediated joint attention in children with autism: A case study in robot-human interaction, Interaction Studies 5:2, pp. 161198.

[6]S. Woods, K. Dautenhahn, C. Kaouri, R. te Boekhorst, K. L. Koay (2005) Is this robot like me? Links between human and robot personality traits. Proc. IEEE-RAS International Conference on Humanoid Robots (Humanoids2005), December 5-7, 2005 Tsukuba International Congress Center, (EPOCHAL TSUKUBA),Tsukuba, Japan, pp.375-380

[7]Heerink, M., Kröse, B.J.A., Wielinga, B.J., Evers, V., "Human-Robot User Studies in Eldercare: Lessons Learned," Proceedings ICOST, Belfast, june 2006, pp. 31-38.

[8]B.Wrede, S.Buschkämper, C.Muhl and K.Rohlfing, "Feedback in HRI", *Proceedings of the Workshop on How People Talk to Computers, Robots, and other Artificial Communication Partners*, Bremen 2006, pp. 38-53.

[9]S.Woods, K.Dautenhahn, J.Schultz (2005) Child and adults' perspectives on robot appearance. Proc. AISB'05 Symposium Robot Companions: Hard Problems and Open Challenges in Robot-Human Interaction. Proc. AISB'05 Symposium on Robot Companions Hard Problems and Open Challenges in Human-Robot Interaction, 14-15 April 2005, University of Hertfordshire, UK, pp. 126-132.

[10]Heerink, M., Kröse, B.J.A., Wielinga, B.J., Evers, V., "The Influence of a Robot's Social Abilities on Acceptance by Elderly Users,"Proceedings RO-MAN 2006, pp. 521-526.

[11]E.Andonova, "Changing Mental Models of a Wheelchair Robot", *Proceedings of the Workshop on How People Talk to Computers, Robots, and other Artificial Communication Partners*, Bremen 2006, pp. 131-139.

[12]K.Fischer, *What Computer Talk Is and Isn't: Human-Computer Conversation as Intercultural Communication.* Saarbrücken: AQ 2006.

[13]H.Sacks, *Lectures on Conversation*, Oxford: Blackwell 1992.

[14]H.Sacks, E.Schegloff and G.Jefferson, "A Simplest Systematics for the Organization of Turn-taking for Conversation.," Language 50, 696-735, 1974.

[15]E.Schegloff, "Notes on a conversational practice: formulating place", Studies in Social Interaction, pp. 75-119, The Free Press, 1972.

[16]R.Moratz, K.Fischer and T.Tenbrink, "Cognitive modelling of spatial reference for human-robot interaction." International Journal on Artificial Intelligence Tools, 10(4):589-611, 2001.

[17]N.N.Fraser and G.N.Gilbert, "Effects of system voice quality on user utterances in speech dialogue systems", In EUROSPEECH-1991, 57-60.

[18]T. Röfer, A. Lankenau (2000). Architecture and Applications of the Bremen Autonomous Wheelchair. In P. Wang (Ed.), Information Sciences, 1-4 (126), pp. 1?20. Elsevier Science BV.

[19]M.Pickering and S.Garrod: "Toward a mechanistic psychology of dialogue." Behavioural and Brain Sciences 27, 2, 2004, 169-225.

[20]M.Schober, "Speakers, Addressees, and Frames of Reference: Whose Effort is Minimized in Conversations about Locations?" Discourse Processes 20, 1995: 219-247.

[21]M.Schober, "Spatial Dialogue between Partners with Mismatched Abilities", Proceedings of WoSLaD, 2005.

[22]K.Fischer, "The Role of Users' Preconceptions in Talking to Computers and Robots", *Proceedings of the Workshop on How People Talk to Computers, Robots, and other Artificial Communication Partners*, Bremen 2006, pp. 112-130.

VIII. Acknowledgement

This paper relies to a large extent on work carried out in the framework of the Collaborative Research Area SFB/TR8 'Spatial Cognition', funded by the German Research Council, at the University of Bremen.