Discourse Conditions for Spatial Perspective Taking

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Abstract

This paper addresses which reference systems speakers employ in verbal human-robot interaction, under which conditions they employ them, and to what extent speakers stick to one system once they have started to use it. The method is to compare human-robot dialogues that differ only with respect to a single variable, namely the robot's linguistic output. The conversation analytic and corpus analyses of our data show that speakers take path-based descriptions from the partner's perspective to be useful because they are fail-safe, yet they involve constant attention of the speaker; object-naming strategies from the partner's perspective are taken to be most efficient; external relations, such as 'go north', may be used because the artificial communication partner, the robot, seems to be particularly good at it, even though the speaker herself may not be; and egocentric descriptions are easy for the speaker but are believed to be too difficult for the robot.

1. Introduction

The interpretation of spatial descriptions depends to a large extent on the perspective taken by the speaker. Especially in situations in which one of the communication partners moves around, due to his or her changing origo, perspective taking is non-trivial. As Hermann and Grabowski (1994: 138) argue, taking the other's perspective requires longer processing times and thus involves a higher cognitive load than speaking from one's own point of view.

For the interpretation of spatial instructions in human-robot interaction, it is crucial to understand the choices speakers make with respect to the frame of reference they are basing their instructions on. It is essential that the computational system knows the reference system employed by the human user. Three questions are relevant here: which systems speakers employ at all, under which conditions they are employed, and to what extent speakers stick to one system once they have started to use it.

Previous studies on spatial perspective taking in discourse have produced inconclusive results regarding speakers' perspective taking strategies, in particular those related to the communication partner. In Schober (1993), speakers mostly used their own perspective for producing spatial instructions when they had a real communication partner who was allowed to give feedback. In contrast, if speakers had to imagine a

communication partner, they exclusively relied on the partner's perspective. Schober (1998) attributes the difference to speakers' knowledge about the success of their instructions due to feedback. If their communication partners signal to them that understanding is successful, speakers may stick to the mode of instruction which needs the least collaborative effort (Clark & Wilkes-Gibbs, 1986). In the case they do not know whether the communication partner understands them, they adjust to the partner's perspective in order to guarantee understanding in the absence of feedback.

Similarly, von Stutterheim and Kohlmann (1998) found that speakers stick to their own perspective even if the spatial position of the addressee changes. They therefore propose a model of text planning in which partner hypotheses play a role at different stages. In particular, they argue that global choices, such as perspective taking, are set at an early stage of text planning and are therefore fairly resistant to modification. In contrast, changes on the level of specificity can be made easily and locally on the basis of hearer intervention.

In Schober's (1995) study, however, speakers often take the perspective of their communication partner. Moreover, after exchanging roles as instructor and instructee, speakers try to be egalitarian. That is, they try to take the other's perspective as often as these have taken theirs. Finally, speakers' use of spatial instructions independent of particular viewpoints increases in these dialogues. Schober (1998) therefore argues that speakers are generally orienting towards the principle of ease in communication as a collaborative effort.

Also Tversky et al. (1999) argue for an orientation at the principle of ease. They find that in spite of higher processing costs speakers may change the perspective in text production if the switch pays off in some way or other.

What these studies on the usage conditions of different perspectives leave open is firstly which role the partner model, the speaker's hypotheses about her communication partner, plays. In this paper I will therefore show that the choice of reference system crucially depends on the concept of the communication partner. That is, perspective is chosen as part of the speakers' recipient design. Secondly, the studies mentioned above leave open what the precise role of interaction consists of. Consequently, I am going to shed more light on which interactional processes are relevant and in which ways. Thirdly, I shall try to further our understanding of the reasons for changing perspective within an interaction, presenting certain discourse conditions for the spatial strategies chosen.

2. Methods

The first choice of methods concerns the type of dialogues investigated. A crucial part of the hypothesis investigated here concerns the mental model of the communication partner the speaker has in mind when she is choosing a particular reference system for her addressee. Now, in the case of human-to-human communication,

the speaker's mental model of her communication partner may be difficult to identify. Investigation is easiest if the communication partners differ in measurable ways, for instance, children versus adults, experts versus novices, strangers versus acquaintances or native versus non-native speakers (Schober & Brennan 2001: 130). One reason may be that particular features of addressees that may play a role in speakers' linguistic choices are difficult to investigate under scientific conditions. In contrast, human-robot interaction allows the identification of many different parameters that speakers take into account when choosing their language for their particular communication partner (Fischer, 2003). Besides these methodological reasons, there is also a practical side to the choice of human-robot interaction. While it is of theoretical relevance which factors influence the perspective taking decisions speakers take in spatial tasks, for human-robot interaction a thorough understanding of the processes involved is crucial if communication is to be successful. To conclude, in the following I am going to analyse human-robot interaction dialogues.

Since we are interested in the discourse conditions for particular linguistic choices in human-robot interaction, we need to investigate free interactions between humans and robots. Free interactions however impose a number of methodological problems. In particular, different dialogues in the same setting cannot be compared and thus the influence of situational variables does not become apparent if each interaction constitutes a unique interactional achievement. Thus, in order to identify the influence of particular situational variables, all other factors must be kept constant. In the methodology employed here (Fischer, 2003), the comparability and control of the situation is achieved by keeping the robot behaviour constant. That is, the robot's behavioural and verbal output is based on a fixed schema which is the same for all dialogues and across corpora. In this way, not only are all speakers confronted with exactly the same situation. The methodology also allows us to investigate speakers' concepts of their (artificial) communication partner. Because of the fixed schema that is causally unrelated to the speakers' actual behaviour, the speakers' sense-making efforts cannot be attributed to particular features or misbehaviours of a particular robot, but they have to be understood as arising from the speakers' own mental models of the situation, including their communication partner. For example, if the speaker after a miscommunication (which is of course frequent if the robot does not really react to the speakers' utterances) uses a different descriptive term for the goal object, she displays that she holds the problem to be due to the robot's limited lexicon. If she switches to another reference system, she displays to us that she believes the reference system to be possibly inappropriate in this situation. Thus, the design allows the identification of the explanatory models speakers build up to make sense out of the human-robot situation.

Finally, the frequent impression of miscommunication encourages speakers to employ more than one linguistic strategy. If speakers are immediately successful, they have been found to stick to this strategy (Moratz et al., 2001, Fischer, submitted). This would however yield very uninteresting data to us because the speakers'

reformulations are particularly revealing concerning the participants' concepts of the communication partner and their understanding of the situation.

3. Experimental Design

We compare human-robot dialogues that differ only with respect to a single variable, namely the robot's linguistic output. The robot used here is Sony's Aibo, a small dog-like pet robot.

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, which took up about two thirds of the time per dialogue, the experimenter told each speaker that she was allowed to refer to the objects directly. The robot was steered by student employees behind a screen according to a fixed schema of robot behaviours. 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:

- 13 German human-robot dialogues
- Task: to instruct the robot verbally to move to particular goal objects
- Robot behaviour: according to fixed schema of behaviours, independent of the speakers' utterances ('wizard-of-Oz' scenario)
- after two tasks, speakers are 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 Fraser & Gilbert 1991). The robot utterances were pre-synthesized and were played in a fixed order. The utterances were so designed as to give no clue as to what may have gone wrong in order to avoid prompting particular error resolution strategies from the users. However, in these utterances, three design features were used which previous studies (Moratz et al., 2001, Fischer, 2003, submitted) had revealed to be quite rare in human-robot interaction if the robot does not give feedback: First, we made the robot ask for and propose spatial references using object naming strategies and deictic perspective taking the point of view of the robot. Second, we made the robot use an extrinsic reference system. Third, as an indicator of high linguistic capabilities, the robot made extensive use of relative clauses.

The robot's utterances are, for instance, the following:

Ja Guten Tag, wie geht es Ihnen? (*yeah hello, how do you do?*)	Soll ich das blaue Objekt ansteuern? (*do you want me to aim at the blue object?*)

Was kann ich für Sie tun? (*what can I do for you?*)	Welches Objekt soll ich ansteuern? (*which object should I aim at?*)
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? (do *you mean the object that is 30 degrees west of the box?*)
Ich habe Sie nicht verstanden. (*I did not understand*.)	Soll ich mich zum Glas begeben? (*do you want me to move to the jar?*)
Meinen Sie das Objekt, das sich süd-süd-östlich der Dose befindet? (*do you mean the object which is south south east of the box?*)	Entschuldigung, welches der Objekte wurde von Ihnen benannt? (*excuse me, which object was named by you?*)
Eine Drehung um 360 Grad ist nicht sinnvoll. (*a 360 degree turn is not useful*.)	Ich kann nicht schneller. (*I can't go faster*.)

Condition 2 can be summed up as follows:

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

4. Analysis

The analysis comprises the qualitative study of the types of reference systems employed, as well as a quantitative analysis of their distributions with respect to the two corpora. The point is that differences in the distribution of the reference systems used indicate either differences in the speakers' mental models of their artificial communication partner, or effects due to the contents of the robot's utterances.

Condition 1	Example
path-based descriptions	rechts (*right*)
object-based[1]	zur blauen Schale (*to the blue bowl*)
	rechte Schale (*right bowl*)
	zur hinteren Schale (*to the rear bowl*)
	nimm die zweite Schale rechts von Dir (*take the second bowl to your right*)
	rechts zum Behälter (*right to the container*)
group-based	zum Topf in der Mitte (*to the pot in the middle*)

In the first condition, that is, with the robot displaying only non-verbal behaviour, we find an almost consistent use of path-based instructions. That is, speakers steer the robot around as with a verbal remote control. In

[1] I coded all those descriptions as object-based that made use of an object name, unless it was also based on the spatial position of alike objects, in which case it was marked as group-based.

particular, 11 of the 13 speakers only use path description. One speaker employs target object descriptions, such as the blue bowl to your right, one speaker switches back and forth between a target object-based description and a path-based instruction. All instances of spatial instructions in these dialogues are based on the communication partner's perspective. That is, speakers consistently use the robot's point of view for their spatial instructions.

After being prompted by the experimenter that they may directly refer to the objects, all speakers make use of this strategy. A single speaker switches back after a sequence that he seems to interpret as a misunderstanding.

Also in the second condition, in which the robot also produced verbal utterances, most speakers take their partner's perspective; however, there are notable exceptions. Although the types of spatial instructions found in the two conditions are similar such that those used in the first condition constitute a subset of those employed in the second condition, there are considerable differences regarding the quantitative distribution of the strategies used and with respect to the variation of spatial strategies employed, for example:

	Condition 2
path-based	45 Grad nach links (45 degrees to the left)
object-based	Tasse auf der linken Seite (*cup on the left side*)
	dritte Tasse von links (third cup from left)
	zur Schale die rechts unten vor dir steht (*to the bowl which is right below in front of you*)
	zu drittem Objekt vorne (*to the third object in front*)
cardinal points-based	die Tasse ähm ja zur südlichen Seite (*the cup um yes to the south side*)
group-based	zu dem mittleren Objekt (*to the middle object*)
	die linke der beiden weißen Dosen (*the left of the two tins*)
category-based	das andere blaue (*the other blue one*)
dialogue history-based	den gleichen von eben (*the same as before*)
landmark-based	Plastikdöschen das rechts von dem Glas steht (*plastic tin which is right of the jar*)

In the second condition, none of the dialogues are consistently path-based. Path-based instructions are usually only used for situations of 'fine-tuning' or after incidents of perceived communicative failure. The following is an

example for a mix between object-based and path-based instructions, where the path-based instructions serve to 'fine-tune' the robot to the right object:[2]

A010 geh zu dem blauen Objekt ganz außen - nach links - jetzt geradeaus - zu dem blauen Objekt links außen (*go to the blue object far on the ouside – to the left – now straight – to the blue object left on the outside*)

Seven of the 17 speakers employ object descriptions only, including reference to previous events from the joint dialogue history, reference to groups of objects (some explicitly mention *Ansammlung* (*collection*) or *Gruppe* (*group*)), and reference to objects of the same category, such as 'the other bowl'. Five speakers take up the external reference system proposed by the robot, based on the cardinal points of the compass, for example (see also Fischer and Wilde, 2005):

A003: (10) ähm, (4) zu der -- Tasse, -- ähm, (3) circa -- m, 80 Grad -- nach links. – (*um to the cup um about um 80 degrees to the left*)

R: in Ordnung (*okay*)

A003: (18) etwas nach rechts, (1) (*a bit to the right*)

R: Welches Objekt soll ich ansteuern? (*which object should I aim at?*)

A003: (5) die Tasse, zur (5) ja ähm (7) südlich ähm, -- ja - zur südlichen Seite, (2) (*the cup, to well um south um yes to the south side*)

R: In Ordnung. (*okay*)

A003: (5) (laughter)

R: In Ordnung. (*okay*)

A003: (2) zu der Tasse, nord-östlich. (2) (*to the cup north-east*)

R: Soll ich mich zu dem Objekt begeben, das vorne liegt? (*do you want me to go to the object which is in front?*)

A003: (4) nord-west. (laughter) mein Fehler. (laughter) (3) nein einmal drehen und zu der Tasse dann - jetzt m, (7) (hnoise) eine halbe Drehung? – (*north-west. my mistake. no turn around and to the cup then – now um half a turn?*)

[2] It is interesting to note that speakers react to the robot linguistic and non-linguistic actions in the same way as found for conversation between humans by Clark & Krych (2004).

A010: das Objekt, das sich süd-süd-ost der Dose befindet (*the object that is south-south-east of the tin*)

In a previous experiment (Moratz et al., 2001), we found that speakers may suspect robots to work on the basis of external relationships, especially the four cardinal points of the compass. This hypothesis is supported by the fact that in spite of its unintelligibility in the current situation, as many as five speakers made use of this type of spatial instructions. The following examples illustrate how speakers negotiate the meaning of the cardinal system in the current spatial setting:

A005 (2) dann äh -- ja dann mu+ -- m+ müssen wir uns erst mal eichen, -- und äh - ich würde dich bitten mir zu sagen wo Norden für dich is. -- in welche Richtung. lauf mal n Stück nach Norden. -- direkt nach Norden. -- circa - zehn Zentimeter das sollte reichen. - damit ich bescheid weiß. (*then uh yes then we have to tune ourselves and uh I would ask you to tell me where is north for you. In which direction. Walk a bit north. Directly north. About 10 centimeters should be enough. So that I know.*)

A099: ähm also äh Norden ist da genau geradeaus jetzt also da wo die (...) is daneben (...) Norden dann is alles ganz einfach neunzig Grad ja das reicht schon ne? (*um well uh north is exactly straight ahead now well where the* (not understandable) *is besides (*not understandable*) north then everything is just 90 degrees yes that's enough isn't it?*)

Furthermore, five speakers use egocentric instructions, for instance:

A010 jetzt begib dich zu dem Glas links von mir (*now move to the jar left of me*)

A013 -- das blaue Objekt rechts von mir – (*the blue object right of me*)

A099 dahin ähm ja ja du sollst jetzt ähm zu der dem zweiten blauen Schälchen gehen und zwar das zweite von mir aus (3) (*there um yes yes you have to go um to the second blue bowl, that is, the second from my point of view*)

A004 (1) nein ich meine das Objekt das rechts von mir steht (*no I mean the object which is right of me*)

As a first result we can conclude that speakers in the second condition may change their perspective very easily. Contrary to von Stutterheim and Kohlmann (1998) who suggest that perspective taking is set at a very high level of text planning and is therefore not adapted within the course of the dialogues, in our dialogues we find a broad range of different strategies, based on different reference systems, between which the speakers switch back and forth.

The following example shows how a speaker switches between his egocentric perspective, the robot's perspective, based on its virtual path, and a landmark-based description, enriched by an egocentric description:

A005 (4) m, jetzt fähr+ krieg ich Schwierigkeiten hier. (3) also, -- von mir aus gesehen, -- von meinem Standpunkt aus. (4) 30, -- Grad, - nach rechts. - oder f+ sagen wir mal sogar f+ äh 45 Grad nach rechts. -- da steht ein - weißer Becher mit einem roten Deckel. -- direkt dahinter steht ein Glas von mir aus gesehen auch wieder. (2) das steuer mal bitte an. (4) links. - von dir. also, - gemessen an - der Richtung die wir eben gefahren sind. (2) oh, genau. komm erstmal zurück. (2) (laughter) (2) stopp - mal, stopp stopp stopp, (2) ein Stück zurück (3) (hnoise) die linke der beiden Dosen. -- na ja okay. von mir aus gesehen die hintere der beiden Dosen. (5) (*m now I'm getting problems here. Well from my point of view, from my perspective 30 degrees to the right. Or let's say even 45 degrees to the right. There is a white mug with a red lid. Directly behind that is a glass from my point of view again. That aim at please. Left – of you, well, measured by the direction which we drove before. Oh, exactly, come back first. Stop please, stop stop stop, a bit back, the left of the two tins. Well okay from my point of view the rear one of the two tins.*)

5. Discussion

The analysis shows that the linguistically 'interactive' robot triggers much more varied spatial descriptions than the robot with the same behaviour but without speech output. What causes these differences? I want to argue that the mode of instruction and thus the reference system chosen depends crucially on what the speakers believe the robot to be able to do. A linguistically skilful robot obviously creates a different, more complicated image than a robot who does not display any linguistic knowledge. This corresponds to Schober's findings that speakers choose the perspective for high- and low-ability speakers differently (this volume). The effect observed cannot be due to interactional features, such that the speakers would feel better understood, since the robot behaviour is identical in both situations, and its linguistic output does not convey successful understanding. That is, there is no more feedback signalling understanding in the second condition than there is in the first.

This interpretation is supported by further indicators of a more sophisticated concept of the artificial communication partner in the second condition. While the partner-centred reference system corresponds to the primitive instruction mode using path-descriptions, in the second condition speakers employ their own perspective. They furthermore use a whole range of ways of referring to the spatial position of the target object. They also take up the frequent use of relative clauses, which, as previous studies (Fischer, 2003, submitted) have shown, speakers normally regard as quite problematic in interaction with artificial communication partners.

The speakers' choice of perspective in our dialogues therefore seems to depend essentially on their partner model. Without feedback, speakers choose the safest (from the point of view of the hearer) strategy available, that is, the strategy that is easiest for their communication partner. Both Schober's (1993) and our results support this. The linguistic feedback from the partner then plays at least two roles: on the one hand speakers get evidence whether their partner is understanding them (Clark & Krych, 2004), on the other the partner's utterances reveal information about him, her or it, which speakers make use of when building up their partner models. Thus, in our dialogues, the robot does not give feedback in terms of understanding; in fact, it behaves independently of what the speakers say. Nevertheless the robot's verbal output has a great effect on the instructional strategies taken. Speakers obviously regard the robot in the second condition to be much more skilful than in the first condition.

However, also in our dialogues the type of information disclosed by the communication partner plays an important role, besides its function in the establishing of the partner model. We have found that in the first condition all speakers employed target object-based descriptions after they were informed by the experimenter that they were allowed to do so. All but one stuck to object-based instructions afterwards, thus displaying that they regard them to be more useful for the current task than the previous path-based instructions.

We can therefore conclude about the different strategies used that:

- path-based descriptions from the partner's perspective are useful because they are fail-safe, yet they involve constant attention of the speaker;
- object-naming strategies from the partner's perspective are more economical since all speakers stick to them after having been told that such instructions are possible. That is, if speakers know that they can use them because the robot understands them, they prefer those;
- partner-based descriptions using external relations, such as 'go north', may be used because the artificial communication partner, the robot, seems to be particularly good at it, even though the speaker herself is not (cf. Fischer and Wilde, 2005);
- egocentric descriptions are easy for the speaker but are believed to be too difficult for the robot.

A third function of interaction, besides providing feedback on the speaker's success and as evidence for the partner model, is thus the interactive alignment to the partner's utterances (see Pickering & Garrod, 2004). We have seen this in many respects: the consistent use of object-based descriptions in the second condition in which the robot asks object-based questions; the consistent switching to object-based descriptions after the experimenter's prompt in the first condition; the uptake of the external reference system in condition two by at least some speakers; and the frequent use of relative clauses in the second condition, following the robot's example.

How can von Stutterheim's and Kohlmann's (1998) results be accounted for? I propose that their findings that speakers take their own views and do not adapt to their communication partners is due to the fact that an understanding had already been established by the time the hearer changed his (an obviously male confederate) spatial position. Furthermore, the hearer, even in the new spatial position, had been working some time from the previous position. Thus, switching perspectives could have been assumed by the speakers to be easier for him than for the speaker herself. And finally, as in Schober's (1993) experiment, the hearer was always able to give feedback, and thus displays of understanding were always present for the speaker.

6. Conclusions

In this paper it was shown that speakers may switch perspective frequently in interaction and that the choice of the perspective taken, as well as the spatial strategy used in general, largely depends on the speakers' judgements about their communication partner's capabilities. In absence of such evidence, speakers use those strategies that are easiest to understand for their communication partners. Otherwise they use those strategies that are most useful in the current situation, that is, those that are most economical (as the target-object-based descriptions in the first condition show after the prompt by the experimenter and in the egocentric perspective taking in the second condition), those that are easiest to comprehend due to the nature of the task (cf. Tversky et al., 1999), or those that show a particular degree of politeness (cf. Schober, 1995). In sum, speakers switch between perspectives quickly and without interactional efforts in interaction depending on their partner model and other requirements of the situation.

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