Object Orientation in Dialogue: A Case Study of Spatial Inference Processes

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Abstract. Most research on spatial communication focuses either on route instructions or on object reference, detailing how places and objects are referred to and where they are located. In this paper, we address object *orientation* in a spatial dialogue situation involving the placement of dollhouse furniture, and explore the role of canonical orientation for the amount of details provided and success of communication. Our results show that speakers are extremely creative when referring to and inferring object orientation information. They achieve communicative success in spite of leaving decisive aspects implicit, drawing on common sense. Where objects are oriented in a non-canonical way, references become more explicit, allowing for a similar level of success.

1 Introduction

Imagine you are moving house, and a friend is helping you place furniture into the various rooms. Because you can't be everywhere at once, you describe to her how chairs and tables should be placed. You might say things like *This one goes into the living room, on the wall to your left as you walk in* or *Put the chairs around the dining room table*. But would you also explain how the furniture items should be oriented? Would you add *All chairs must face the table*? Most likely, you would take this aspect of the object placement for granted - you have good reason to assume that your friend knows very well how chairs are normally oriented, relative to a table. Perhaps you would mention it if the chairs should be oriented in a *different*, unexpected way. Or if you didn't, the result might not be as desired.

In this paper, we address this kind of scenario by drawing on a dialogue corpus collected to explore spatial object reference in a referential communication task, where a *Director* explains to a *Matcher* how objects should be placed in order to match a given dollhouse configuration. We investigate the role of canonical orientation in such a situation. If objects are not oriented in the way they

S. Creem-Regehr et al. (Eds.): Spatial Cognition 2018, LNAI 11034, pp. 92–106, 2018.
https://doi.org/10.1007/978-3-319-96385-3_7

functionally relate to each other, will Directors become more explicit in their instructions, so as to compensate where common sense fails - or will communicative success be hampered?

For illustration, consider the following examples (adapted from our data, described below). Example 1 contains no orientation information, whereas the Director in Example 2 makes several attempts to clarify how the object's back side relates to the addressee's current position. Both objects were oriented correctly by the addressee, using common sense along with explicit information.

1. Put the couch at some distance to the longer side of the table, namely to the left.
2. In the front, there is a double armchair. Put it with its backside towards you so to speak with its back to you. So that the backside points to you.

To see more generally how dialogue partners manage to understand each other in the face of incomplete information (as in Example 1), we first take a look at communicative principles and then turn to spatial descriptions in particular.

2 Communicative Principles

One main goal underlying all conversation is to establish and expand common ground [4]. This is defined as the knowledge, beliefs, and suppositions that dialogue partners believe to be shared between them. Within a given dialogue, further common ground is accumulated based on the verbal exchange as well as contextual and non-verbal information (e.g. gestures and facial expressions).

Whenever dialogue partners do not share some information, the speaker expects the addressee to point this out [5], or to draw inferences from common ground. Conversational success, therefore, depends on the coordinated actions between the speaker and the addressee [6]. According to the *principle of least collaborative effort* [7], both dialogue partners try to minimize the conversational effort both for themselves and for their partner. While this can involve the risk of miscommunication [2], repairing failures typically involves less effort than anticipating information needs by the addressee, or spelling everything out in meticulous detail. In effect, this means that a larger portion of everyday discourse relies on inferences. In our initial example, your friend will probably assume that all chairs should be facing the table even if you don't tell her so. Neither of you may be aware of the fact that the given information is incomplete – that alternatives are possible. Since chairs in our everyday experience normally face tables, the inference is natural that they should do so in this case also.

Levinson [16] distinguishes between three types of heuristics or implicatures that license inferences. The Q-heuristic 'What isn't said, isn't' [16, p. 31] relates to the *Maxim of Quantity* according to Grice [11], which states that speakers normally aim to be as informative as required in the dialogue context. As a result, whatever information a speaker does not express is not evoked by the discourse. Using an example by Levinson [16], if the speaker refers to a *pyramid*, he or she is not talking about a *cone* although the forms are similar.

The M-heuristic 'What's said in an abnormal way, isn't normal; or Marked message indicates marked situation' [16, p. 33] relates to Grice's *Maxim of Manner* [11], which state that speakers normally aim to represent situations in a clear and orderly way. The M-heuristic takes this idea further by stating that abnormal situations are typically represented in language in some way. Thus, when referring to an object as a *cuboid block*, the addressee may infer that the object is not a stereotypical *cube* but similar to one [16].

The I-heuristic 'What is simply described is stereotypically exemplified' [16, p. 32] draws on a different aspect of Grice's *Maxim of Quantity* [11]. It states that a contribution is normally not more informative than is required in a context, because minimal descriptions may already evoke fairly rich interpretations of the situation, based on everyday knowledge. The I-heuristic therefore allows for very efficient communication. If the speaker refers to a pyramid simply as a *pyramid*, the addressee may draw the conclusion that it is a stereotypical one.

Although dialogue partners aim to achieve maximal understanding using principles such as these, they will never reach identical mental states [10]. Mostly this is unproblematic; speakers will be happy with a mutual belief that they have understood each other 'well enough for current purposes' [4, p. 221]. A dialogue involving specific goals, such as a referential communication task, allows for assessing if this belief is correct. If a Director believes to have understood the Matcher's instructions, they will act accordingly, and the result can be evaluated for accuracy. Spatial reference is a particularly well suited domain in this respect, since communicative success can be derived from clearly specifiable aspects. We will now briefly summarize some main findings in this domain.

3 Reference to Objects in Space

Placing objects in a referential communication task involves three main aspects [22]: the identification, the localization, and the orientation of the object in question. Each of these aspects makes different features of the spatial scene relevant. While identifying an object can be achieved either by reference to the object's features as such or by contrasting it with other candidate objects, location and orientation information always involve some kind of reference to spatial entities in the context. In the following we use the terms *locatum* and *relatum* to refer to two entities that are relevant for descriptions of spatial relations.

Locatum: The locatum is the object in question, which is to be located or oriented.[1]

Relatum: The relatum is an entity that serves to specify the locatum's position or orientation.[2] The relatum may remain linguistically implicit even if conceptually present [24].

While the identification and localization of objects in space have been extensively debated in the relevant literature, the orientation of objects in space has

[1] Talmy [20] refers to this entity as *Figure*, and Langacker [14] as *trajector*.

[2] Synonyms for relatum are *reference object*, *Ground* [20], and *landmark* [14].

been mostly taken for granted (again indicating the intuitive nature of everyday inferences when placing objects). It is therefore one of the goals of this paper to specify in more detail what it means to verbalize object orientation in an unambiguous way. This will involve a clear distinction of explicit information (given by a speaker) as opposed to inferences made on the basis of common ground or world knowledge. To establish a firm basis for this specification, we will now take a closer look at the two better explored aspects - object identification and object localization.

3.1 Object Identification

The identification of a particular object to be placed, the locatum, may be as simple as calling it by its conventional name, e.g. *the vase*. However, if there is more than one object available that looks like a vase, further information is necessary. Speakers then either refer to salient object features such as size, colour, shape etc., or to their spatial location (if available). Recognizing suitable discriminating features and using them to identify objects is not hard; speakers do it all the time, and they adapt flexibly to changes in the situation that require them to switch to a different reference strategy [12]. References to the locatum are often over-specified, i.e. they involve more features of the locatum than necessary for identification [9]. This redundancy facilitates ruling out competing objects quickly. In contrast, *underspecification* occurs mainly when the object has already been identified in the current context and is still accessible in the dialogue partners' common ground [18].

3.2 Object Localization

Reference to the location of an object involves a spatial term that describes the relationship of the locatum to a *relatum*. Depending on the type of spatial term, the location description may be based on an underlying *perspective*.

Relatum Choice. Relata are often larger and more stationary compared to locata [20]. Normally, the sentence *The vase is on the table* would therefore be preferred to its converse *The table is under the vase* [19]. If the table's location is to be described, speakers would choose another similar-sized object as relatum, or a room area as in *The table is in the middle of the room*. Furthermore, according to the *Spatial Term First Hypothesis* [3], speakers prefer relata with a simple spatial relation to the locatum. If the spatial scene does not offer simple relations between the locatum and other entities in the surrounding, speakers might have a weak preference to choose relata due to their salient features. Here are some examples of frequent choices of relata in an object placement task [24].

3. The table is at the back wall. (environment)
4. The chair is behind the table. (object)
5. The table is in front of me. (observer)
6. The couch is to the left. (implicit)

Environmental relata as in Example 3 are very common [3]. References to the speaker's position as in Example 5 are similar to references to the addressee's position (*in front of you*) (hence *observer*). Speakers may also describe objects relative to more than one relatum, or they leave the relatum implicit as in Example 6, where the relatum is available conceptually (e.g. to *my* left) but not expressed in language [24]. In extended descriptions of spatial arrays, it is common to describe sequences of objects in an orderly manner [1,25].

Spatial Terms. Coventry and Garrod [8] distinguish between locative and directional prepositions, where directional prepositions are related to movement (*across, through, along,* etc.), whereas locative prepositions are static. Static prepositions include projective terms (*to the left/right of, in front of, behind, above, below,* etc.) and topological terms (*in, on, at,* etc., involving coincidence, contact, containment, contiguity, or proximity [17]), plus a few others such as *between* and *opposite* that express further types of spatial relationships [21]. Topological terms in particular are known to be sensitive to functional object relationships: for instance, a flower is *in the vase* not because it's geometrically enclosed but because the vase exerts location control [8]. Related effects can also be found for other kinds of spatial prepositions used to describe spatial location.

Projective terms depend on an underlying perspective, based on an *origin* that may be made explicit or remain implicit in the context. The terms *above* and *below* are usually implicitly interpreted relative to the earth's gravity [15], whereas terms such as *left, right, front, behind* normally relate to people or objects in the context: e.g., *my* left or *your* left, using either the speaker's or the addressee's perspective if nothing else is clear from the context.

Based on cross-cultural studies, Levinson [17] found that languages mainly use three types of spatial reference frames. *Absolute* reference frames use environmental information such as cardinal directions (*north, west, south, east* etc.). With an *intrinsic* frame, the relatum must have some kind of asymmetry so that its intrinsic sides can serve as origin (e.g., *to your left* or *in front of the car*). *Relative* frames, in contrast, require another entity that provides a perspective on the scene (e.g., *to the left of the chair from my/your/her point of view*).

3.3 Reference to Object Orientation

According to the Oxford English dictionary, to *orient* an object means specifying it relative to cardinal directions or other positions identified in the context. Consider Examples 7 to 10, where various kinds of directional information specify how the chair's back is oriented.

7. The chair's back points north.
8. The chair's back points to the right.
9. The chair's back is along the left wall.
10. The chair's back is towards the table.

The examples highlight some observations concerning orientation descriptions. Example 7 suggests that the notion of an absolute reference frame is readily

applicable to orientation descriptions, with the compass providing an available system for directionality. Example 8 illustrates the use of projective terms for orientation descriptions. In contrast to location descriptions, an intrinsic reference frame does not seem to be available, and a relatum is not required. All that is needed to make sense of the description in Example 8 is a perspective, based on an *origin*, for instance the speaker looking at the scene. In contrast, Examples 9 and 10 demonstrate that some directions encoded by spatial terms (such as *along* and *towards*) do require a relatum (*left wall* and *table*, respectively). Finally, to align the locatum with a particular direction, it is necessary to specify at least one of its axes (such as the chair's *back*). We will now take a closer look at some of these issues.

Features of the Locatum. An object's orientation is based on its geometric properties like axes or parts. Landau and Jackendoff [13] distinguish between three different axes and two forms, based on the human body. The principal axis is the vertical one that due to the earth's gravity is usually considered a directed axis (i.e. top-bottom). The secondary axes are orthogonal to the principal axis, and may either be directed (e.g. differentiating between *front* and *back*), or regarded as symmetric (e.g., not differentiating in a directional sense between *left* and *right*). Whether an object has directed or symmetric axes depends on its features and the way humans use it. For instance, speakers may project the differentiation of *left* and *right* onto objects like chairs and wardrobes, whereas other objects have no directed axis at all (e.g., dinner tables).

Direction via Spatial Term and Relatum. In contrast to the common sequential order of object location descriptions where previously located objects serve as relata for the following ones, *orientation* descriptions do not seem to follow this principle [24]. Instead, speakers seem to prefer relata depending on where the locatum *points towards*, among the available objects and entities. Paralleling the Spatial Term First Hypothesis for object location described above [3], a potential relatum for object orientation might, therefore, be chosen for its simple relation to one of the locatum's axes - disregarding any other factors that have been found to influence the choice of relatum in *location* descriptions, such as size, movability, sequential order, and so on.

Parameters for Object Orientation. Following the observations so far, we can conclude that being explicit about object orientation differs from object location in some respects. Locating an object requires the parameters of *locatum, relatum, spatial term*, and (with projective terms) a *reference frame* based on an *origin*. Orienting an object by an explicit spatial description requires specifying the *locatum* and its *axis* (which can be *directed* or not), and a *direction parameter* that encodes how this axis is oriented. The direction parameter may be filled by a *directional term* (e.g., *to, towards, along*) together with a *relatum*, or via an *absolute frame of reference* (e.g., compass direction terms like *north, south*). Alternatively, the direction may be expressed by a projective term (*left, right*), whose directionality is determined by an available perspective (based on an *origin*). Spatial terms differ with respect to whether they presuppose a directed

axis or not. While the common expression *points to* presupposes a directed axis, a directional term like *along* does not.

In [23], we observed that functional object relationships affected whether speakers provided orientation information, but the relationship to task success remained inconclusive. Here we take this line of research further by examining the extent to which parameters are specified for object orientation, whether further strategies for orienting objects can be identified, and under what circumstances addressees may fail to interpret orientation descriptions correctly.

4 Empirical Study

Our study uses data from a dialogue corpus previously published in [23], in which participants negotiated spatial configurations in a dollhouse.

29 pieces of dollhouse furniture were placed in one of two identical dollhouses (two-storied, measuring $71 \times 38 \times 53$ cm, and comprising four same-sized rooms). One participant (henceforth called *Director*) was placed in front of it, and was asked to describe for a dialogue partner (henceforth called *Matcher*) how to furnish their version of the dollhouse, which was empty, with an identical set of 29 furniture items placed aside. No further information was provided (e.g., as to how precisely the objects should be placed). A screen separated the participants, so that they could not see each other nor the interior of their partner's dollhouse.

There were two within-participants conditions, designed to explore the effects of everyday knowledge on spatial dialogue. In the *functional* condition (henceforth abbreviated as F), the furniture items were arranged conventionally so that the rooms could be identified as kitchen, living-room, bedroom, and bathroom. In the *non-functional* condition (henceforth abbreviated as NF), the furniture arrangement did not correspond to any specific room functions (see Fig. 1). All participants did both conditions, in balanced order and with switched *Director* and *Matcher* roles. Here, we focus on the first run for each dyad only (resulting in a between-participants design for the current analysis).

The study was conducted in German (our examples in this paper are translated from the original). Before beginning, the participants were allowed to have a look at the furniture which was loosely set aside of the unfurnished house, but they were not allowed to talk to each other. The study was audio and video recorded and the Matcher's finished dollhouse was photographed.

Participants were 34 females (16 F-NF; 18 NF-F) and 14 males (10 F-NF; 4 NF-F) with an age range of 16–26 (mean age: 20 years). Participants were assigned in pairs of same gender and similar age; none of them was familiar with the background of the study. 13 pairs started with the functional condition, and 11 pairs started with the non-functional condition.

Objects were coded as oriented wrongly when their orientation differed from the model at 45° or more. Error scores were coded for object location and orientation by two independent raters who agreed in 96.77% of the cases.[3] A third coder resolved coding disagreements.

[3] The number is based on the annotation for the entire study reported in [23].

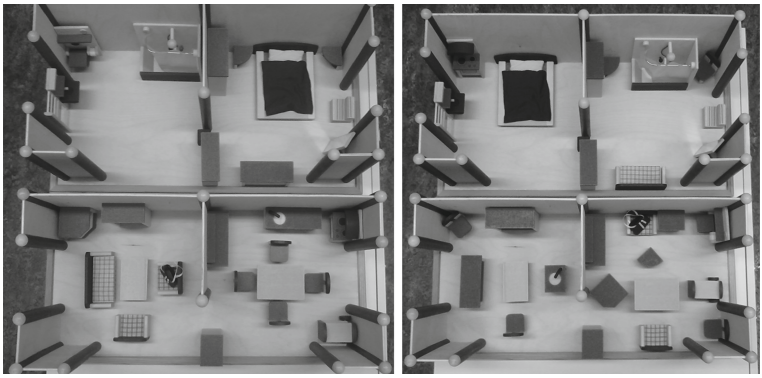

Fig. 1. The model houses of the functional (F) (left) and the non-functional (NF) condition (right).

The utterances were analysed with respect to completeness of object orientation information, based on the parameters outlined in Sect. 3.3. This included reference to the locatum's (directed) axes (*yes, no, undirected*), relata, and spatial terms; projective terms were specified as such (*yes, no, projective*). If objects were positioned diagonally, this would have to be mentioned in complete orientation descriptions (*yes, no*); however, if objects were parallel to the walls, this parameter was coded as *not applicable*.

Based on this annotation, references to object orientation were coded as *complete, incomplete*, or *missing* (see Table 1). A description of object orientation was regarded as *complete* if it involved an explicit reference to (i) one of its

Table 1. Examples of annotated orientation descriptions in the functional and non-functional condition.

Cond.	Speaker	Orientation Description	Locatum	Locatum's Axes	Direction	Diagonal	Extent Explicitness
F	Director	uh the toilet is uh parallel to the shower practically placed at the back wall	A02	undirected	yes	n.a.	incomplete
F	Director	and the opening points toward the bed, yes	B08	yes	yes	n.a.	complete
F	Director	yes, well, diagonally opposite the wardrobe so beside the armchair there in the corner	B07	no	yes	yes	incomplete
NF	Director	with the blue thing at the wall, right	B05	yes	yes	n.a.	complete
NF	Matcher	so uhm with the back towards me with the	B01	no	yes	n.a.	incomplete
NF	Director	n+ n+ no with the side towards you, and the side towards you	B01	undirected	yes	n.a.	incomplete

axes and the axes' directedness if applicable, and (ii) a fully specified direction. Direction was regarded as incomplete if one of the required parameters was missing, such as the underlying perspective for a projective term. The orientation of diagonal objects was considered as completely described only when (iii) diagonality was made explicit. If object orientation was not communicated at all the description was annotated as *missing*. Where speakers used alternative ways of communicating object orientation, decisions about completeness were made on a case by case basis. We will discuss some of these cases in Sect. 5.2.

5 Results

Figure 2 (left) summarizes the extent to which orientation information was made explicit during successful object placement (the breakdown for failed placements is shown on the right). While error scores did not diverge much between conditions, the amount of information given by Directors did:[4] In the functional condition (F), nearly half of the descriptions were *missing* (i.e., orientation was taken for granted), whereas in the non-functional condition (NF), nearly half of the descriptions were *complete*, i.e. fully specified. About 1/4 of descriptions in F and 1/3 in NF included incomplete orientation (i.e., descriptions with a missing parameter, or alternative descriptions as discussed in Sect. 5.2 below).

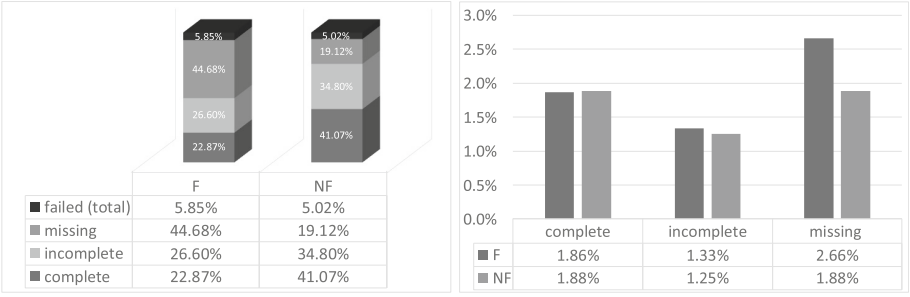

Fig. 2. Left: orientation information given in the functional (F) and non-functional (NF) condition. Right: breakdown of information given in cases of failed orientation.

The error rate for object orientation was generally low: 5.85% (22 out of 377 objects) in F, and 5.02% (16 out of 319 objects) in NF. Figure 2 (right) reveals that objects were sometimes wrongly oriented even with full information provided. We will now take a closer look at orientation failures (Sect. 5.1) and at alternative ways of conveying orientation information (Sect. 5.2).

[4] In [23] we noted inclusion of object orientation in any given utterance. Here we provide a far more detailed breakdown based on our operationalization of orientation parameters presented in Sect. 3.3.

5.1 Exploring Error Cases

7 errors occurred with complete orientation information in F, and 6 in NF. Sometimes the Matcher simply ignored relevant information, as in Example 11:

11. Director: So, first the upper floor in the left half, there is uh the shower. The shower is placed at the middle wall.
Matcher: Yes wait a minute, uhm middle wall right or left?
Director: uhm yes well uh
Matcher: oh I see at the middle
Director: the left side at the middle wall
Matcher: ah okay yes alright.

The video recording for this dialogue extract reveals that the Matcher places the shower with its back axis pointing to the middle wall, ignoring the reference to the object's left side. This corresponds to the conventional practice of placing objects with their back towards a wall that is indicated during the location process (*at wall x*). This kind of location information does not include orientation information, but it seems very natural to infer in such cases that the back axis should point to the wall in question. The general acceptance of this inferential preference appears to have led to the error in Example 11.

In F, errors with *complete* information reveal some problems of understanding either the orientation information in general, or references to a specific directed axis in particular. In NF, errors in this category occur mainly with a specific object type, a triangular bedside table which repeatedly caused problems for orientation description. Speakers would often refer to its orientation as follows:

12. The round side points to the shower, triangle points to the wardrobe.

Although complete, the orientation information provided in this example can easily misunderstood, as illustrated in Fig. 3.

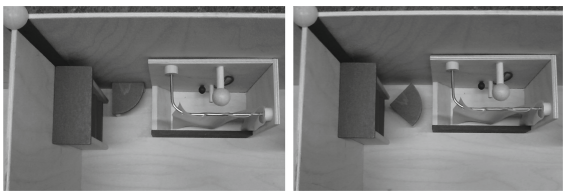

Fig. 3. The orientation of the bedside table in the model dollhouse (left) and as a possible interpretation of Example 12 (right).

In F, errors related to *incomplete* orientation information (5 cases) were due to problems caused by the bedside table, a failure to refer to the locatum's directed axis, and by incorrect orientation information. The 4 errors in NF in this category were caused by miscommunication, ignoring the information that

had been given, and by different interpretations of the term *längs* (*along*) in two cases where the locatum was symmetric and the relatum was the room.

Errors based on *missing* orientation information occur most often in F (10 cases, 2.66%; 6 in NF, 1.88%). These errors occurred mainly with objects for which no stereotypical orientation was available, and for diagonally oriented objects. However, even in the complete absence of any orientation information, the error rate is strikingly low. It seems that in most of these cases orientation was inferable from the identification and location process. For instance, the location description *at wall x* allows for reasonable inferences about orientation.

5.2 Alternative Ways of Communicating Object Orientation

Even though alternative ways of communicating object orientation were rarely unambiguous and therefore coded as *incomplete*, they typically allowed for object orientation to be inferred correctly. One frequent method (across both conditions) was to mention the object's function as in Example 13:

13. The wardrobe is at the back wall (...) so that one can use it, of course.

By indicating the usage of the wardrobe, the Director hints at its frontal axis, the only object side with a usage function. In addition to this information, orientation is further constrained by placing it at a wall, supporting the common *at wall x* inference. The marker *of course* reveals how obvious this is felt to be.

Secondly, the objects' front or back axis was frequently hinted at (but not mentioned explicitly) using verbs such as *gucken* (*look*) and *zeigen* (*show*) or nouns such as *Blick* (*view*), *Gesicht* (*face*), and *Rücken* (*back*). Here the direction of an axis is projected onto the locatum via analogy to the human body. This kind of projection was never questioned by the dialogue partners.

Thirdly, axes could be projected onto the locatum by establishing symmetry between the locatum and the relatum. If the relatum was another object, this would usually be expressed by spatial terms such as *(so) wie (the same as), andersrum (the other way round), parallel (parallel), symmetrisch (symmetrical), spiegelverkehrt/gespiegelt (mirror-inverted), im rechten Winkel (perpendicular), waagerecht (level)*, and *senkrecht (vertical)*. This description type is risky if no additional orientation information is given, as in Example 14. The descriptions are incomplete because a reference to the locatum's directed axis is missing.

14. Director: uhm now in the other slanted corner there is the toilet placed at the back wall as well
    Matcher: uh again
    Director: uh the toilet is uh parallel to the shower practically placed at the back wall. Can you imagine?
    Matcher: Parallel to the shower
    Director: Well it is at the roof of the house pra+ well at the roof yes. The shower is at the middle wall and the toilet is at the roof.

In this example, the toilet's orientation is described as parallel to the shower's, which had been placed incorrectly (cf. our Example 11 above). The present description specifies that the toilet is placed at the back wall but it does not involve a reference to the toilet's directed axis. Therefore, the Matcher is unable to disambiguate the description, and subsequently orients the toilet incorrectly but symmetrically to the shower.

If the relatum was the room (or a part of it), symmetry was mainly indicated by spatial terms such as *längs (alongside), quer (crosswise), seitlich (sideways), waagerecht (level), vertikal (vertical), im rechten Winkel (perpendicular)*, and *parallel (parallel)*. This type of symmetry was mainly used for objects with undirected axes (like tables). Since the dollhouse rooms were actually square, references to the symmetry of the room as a whole (e.g. *the table is alongside the room*) are not quite precise, leading to a need for further negotiation by reference to other available relata.

6 Discussion

In the present study, we asked how speakers negotiate object orientation information and to what extent this leads to success in orienting objects correctly, based on a corpus involving object placements in functional and non-functional dollhouse furniture arrangements. Results reveal that dialogue partners achieved a similarly high success rate across the different spatial configurations, but the extent to which explicit information was given differed widely between the conditions. We started our analysis of orientation information by identifying explicit spatial descriptions of a similar type as object location descriptions, based on a set of parameters derived from the literature and available examples. In our corpus, it turned out that this type of explicit spatial orientation information was not provided or incomplete in the majority of cases. Instead, speakers were creative in suggesting object orientation in a number of other ways, or they assumed that the addressee would be able to draw relevant inferences based on world knowledge. Although this was risky, the low error rate for object orientation suggests that this strategy of minimal or inference-based information was overall successful.

In general, it can be assumed that people within a society share knowledge about how furniture items are typically arranged in a house. This allows dialogue partners to draw on Levinson's I-heuristic 'What is simply described is stereotypically exemplified' [16, p. 32]: if minimal descriptions (such as the location description *at wall x*) already evoke rich interpretations of the situation, no further specific information is required. In our data, it appears that the Directors and Matchers mostly relied on the I-heuristic for objects where the spatial array was stereotypical (in our *functional* condition). Clearly, functional arrangements in general support and simplify communication, adding to previous findings on effects of functional relationships [8]. When objects relate to each other in a functional way or are arranged ready to be used based on their function, the I-heuristic is licensed and the potential interpretations are limited

to the functionally adequate orientation of the locatum. Monologue studies show that typical arrangements may license stereotypical interpretations irrespective of further contextual information [1,24].

In atypical spatial configurations, addressees are still able to draw inferences based on cultural knowledge to a limited extent. Our data show that dialogue partners far less often relied on this kind of common ground, and instead negotiated object orientation explicitly. This happened even in cases where the locatum was, in fact, oriented in a typical way. In this way, the use of the I-heuristic appeared to be mediated by the typicality of the object arrangement. With a non-typical arrangement, the need for object orientation information was enhanced, leading to less *simple* descriptions (in Levinson's terms [16]) and, accordingly, less stereotypical interpretations. By being more informative than might arguably be required concerning *typical* spatial aspects, speakers accounted for the *atypicality* of the entire spatial array.

This also supports Clark's [5] suggestion that information is frequently communicated when perceived as necessary. However, this perception is not always valid – incorrect inferences are possible. In the functional condition, the higher error score within the category of *missing* orientation information suggests that speakers sometimes take a high risk when relying on the *principle of least collaborative effort*, rather than avoiding underspecification and ambiguity. The nature of the risk was, of course, negligible in our scenario as there was no penalty for incorrect object placements; dialogue partners were simply motivated by the playful challenge of the situation itself.

Our data clearly demonstrate that both dialogue partners were sensitive to the availability of cultural knowledge. Directors (and sometimes Matchers[5], in their creative contributions to the joint effort) adjusted their descriptions of orientation information to context-specific conditions, and Matchers reacted by regularly making correct inferences based on incomplete or missing orientation information, using their cultural knowledge to fill in the gaps. While dialogue partners tended to negotiate orientation information explicitly for atypical spatial arrangements, with typical object arrangements they tended to rely on inferences drawn from cultural knowledge. Based on this adaptation to the availability of cultural knowledge, errors occurred rarely and to a similar extent in both conditions - irrespective of the typicality of the spatial situation.

Cultural background knowledge was invoked, for instance, when axes were projected onto the locatum via analogy to the human body. These strategies to imply object orientation were successful as long as the verbal information was in line with general inference preferences (such as placing objects with their back to the wall). When the locatum was described based on symmetry to another available entity, the axes of the two entities involved needed to be compared to each other and adjusted accordingly. This task often appeared difficult to resolve, and was often accompanied by further negotiation of orientation.

[5] In [22] we found that although Matchers in our dialogue corpus often provided suggestions to specify object location (adding to the Director's instructions), they did so less often concerning orientation.

In contrast, leaving the perspective on the scene implicit when using projective terms did not cause problems for interpretation, as all of the Matchers simply used their own perspective, matching the Director's in this scenario. It remains to be investigated how dialogue partners treat diverging perspectives when talking about object orientation, and whether any further spatial frames of reference may be available, paralleling the complexity of references to object location.

7 Conclusion

In dialogue, speakers pursue different strategies to refer to object orientation. They provide explicit and implicit information about how the object in focus is directed towards a particular reference entity, partially requiring the addressee to draw inferences based on knowledge about typical furniture arrangements and the projection of the human body's axes, or they refer to how the object can be used, licensing inferences of typical object utilization. The way information was negotiated by our participants, along with their conversational success, suggests a high degree of sensitivity for specific contextual needs, relative to the functionality of the array. We conclude that speakers heavily rely on common ground when determining the extent to which explicit information is required to enable successful communication. This same source is also the main basis for inferring or interpreting information about object orientation across situation contexts.

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