

The interpretation of complex spatial relations by integrating frames of reference*

Carola Eschenbach, Christopher Habel & Annette Leßmöllmann
University of Hamburg, Germany
{eschenbach, habel, lessmoellmann}@informatik.uni-hamburg.de

Abstract

This paper presents an analysis of German expressions such as ‘links unterm Schrank’ (*left below the cupboard*). In this structure, two projective terms (an adverb and a preposition) are combined to give a complex description of a spatial constellation. We argue that there are mainly two strategies for interpreting these combinations, usually resulting in different models. One of them relates both terms to the same frame of reference. The other strategy involves the integration of two independently determinable frames of reference. Therefore, both selection and integration of frames of reference have to be taken into account.

1. Introduction

Expressions such as *over*, *under*, *in front of*, *behind*, *to the left of*, *to the right of* are used to describe spatial constellations between two objects. Although the expressions mentioned are comparable with respect to their usage, they need not be of a uniform syntactic category. Therefore we will use ‘projective term’ to refer to such expressions, focusing on their function and conceptual background rather than their syntactic category. To differentiate between the roles of the two related objects we use the term ‘reference object’ for the role filled by the cupboard in (1) and the terms ‘target’, ‘located object’ or ‘localized object’ for the role of the mosquito in (1) (cf. Miller & Johnson-Laird, 1976; Talmy, 1983; Habel, 1990).

(1) The mosquito is under the cupboard.

As is well known, projective terms relate the reference object and the target relative to a system of directions, axes or regions, i.e., a ‘spatial frame of reference’. The frame of reference is a structure induced on space that allows to identify a direction and locates the target in that direction relative to the reference object. Although frames of reference are discussed in Linguistics, Artificial Intelligence and Cognitive Science and there are intensive debates about classes of frames and frame selection, the question what the constituents and the properties of a frame of reference are is less prominent in the actual discussion.¹

* The research reported in this paper was supported by the Deutsche Forschungsgemeinschaft (DFG) in the project ‘Axiomatik räumlicher Konzepte’ (Ha 1237/7). We would like to thank Lars Kulik, Emile van der Zee and two anonymous reviewers for their helpful comments. Authors’ address: FB Informatik (AB WSV) and Graduiertenkolleg *Kognitionswissenschaft*, Universität Hamburg, Vogt-Kölln-Str. 30, D-22527 Hamburg.

¹ See, e.g., the papers in part I (‘Frames of reference’) in Eilan, McCarthy and Brewer (1993) and Levinson’s critical discussion (1996, p. 126). An overview of various sources of reference is given by Retz-Schmidt (1988). There are also different terms used (e.g., ‘reference system’). But up to now it is not clear to what extent such terminological differences reflect theoretical differences.

The main function of a frame of reference is to introduce a structure in a spatial constellation, for instance via a system of regions or of axes, its origin coinciding with the reference object, such that the target is localized with respect to an axis or in a corresponding region (Franklin & Tversky, 1990; Herskovits, 1986; Tversky, 1996). Usually the bias to axes leads to a view which identifies ‘frames of reference’ with ‘systems of co-ordinates’ (cf. Levinson (1996), who emphasizes the importance of co-ordinate systems). In contrast to this, Eschenbach and Kulik (1997) present an axiomatic approach to the analysis of the projective terms in the plane that is based on ordered geometry, i.e., that is not committed to co-ordinates. Assuming that frames of reference can be specified in spatial structures that are weaker than geometries with co-ordinates, e.g. topology or ordered geometry,² allows to integrate other types of spatial expressions, for instance topological prepositions, in the framework of frames of reference.

In the present paper we start without being committed to a specific concept of frame of reference, i.e., what it is and how it should be formalised. E.g., we will employ both axes and regions in our explanation without assuming one of them to be simpler than the other. Rather, axes and regions correspond to each other, since regions can be defined on the basis of axes.³

Describing and explaining the way projective terms are used in natural language, it is necessary to determine which frame of reference is used in the interpretation of a speaker or hearer. The frame of reference can be introduced by the reference object itself (intrinsic use) or by an additional perspective or origo (deictic use), which – in turn – can be given by different contextual factors like the speaker, the hearer or an (imaginary) observer (Bühler, 1934; Jarvella & Klein, 1982; Vandeloise, 1991; Levelt, 1996). Furthermore, the environment may introduce an ‘extrinsic’ or ‘environment-centered frame’ (Carlson-Radvansky & Irwin, 1993), and speaker and hearer often take distinct perspectives that induce two different deictic frames (Schober, 1993).

The discussion of different classes of frames mainly focuses on the question how a frame of reference is established and how a speaker/hearer selects one from a set of alternatives. Bryant, Tversky and Franklin (1992) and Franklin, Tversky and Coon (1992) discuss how the choice between alternative frames is determined. They propose ‘spatial frameworks’ for describing and explaining the choice of perspective in understanding narrative texts.

The choice between the different classes of frames discussed above will play only a minor role in the following. One of the aims of the present paper is rather to study how combinations of projective terms relate to frames of reference.

Studies on the conceptual function of projective terms usually concentrate on the question which constellation is expressed by a simple expression such as (1). In this paper we will tackle the question of how projective terms combine to express more complex or more specific spatial constellations between objects. We will discuss some consequences, leading to the requirement of an integration of frames of reference.

The syntactic means of combining projective terms to form complex expressions are different across languages. English uses, among other constructions, co-ordination with *and* (2.a). In German, corresponding constructions are syntactically well formed, but there is no clear intuition as to which spatial constellation is expressed in a case like (2.b). In contrast to this, (2.c) leads to the interpretation that some mice are to the left of the cupboard while others are behind it.

² Levinson (1996, p. 135) excludes topological prepositions from his discussion of frames of reference; his description of their “complex relation to frames of reference” (p. 161, footnote 29) is due to his commitment to co-ordinates. To see Topology as a member in the family of Geometries is in agreement with the historical development of this branch of mathematics. Topology started as ‘geometria situs’ and is nowadays characterized as ‘rubber sheet geometry’.

³ It should be noted that also the terms ‘axis’ and ‘region’ can be formally specified in different ways.

In contrast to English, German allows a combination of projective terms as shown in (3).

- (2) a. The mouse was sitting behind and on the left of the cupboard.
 b. ??Die Maus saß links von und hinter dem Schrank.
*the mouse was sitting left of and behind the cupboard*⁴
 c. Die Mäuse saßen links von und hinter dem Schrank.
the mice were sitting left of and behind the cupboard

- (3) Die Maus saß links hinterm Schrank.⁵
the mouse was sitting left behind the cupboard

English expressions combining projective terms are analysed by Herskovits (1986, chap. 10.2).⁶ She argues that, e.g., *in front and on the left of* specifies the intersection of the LEFT-region and the FRONT-region (see Fig. 1). Concerning German expressions like (3), a similar analysis has been carried out by Maaß (1996) with respect to sections in route descriptions and by Gapp (1996) with respect to regions.

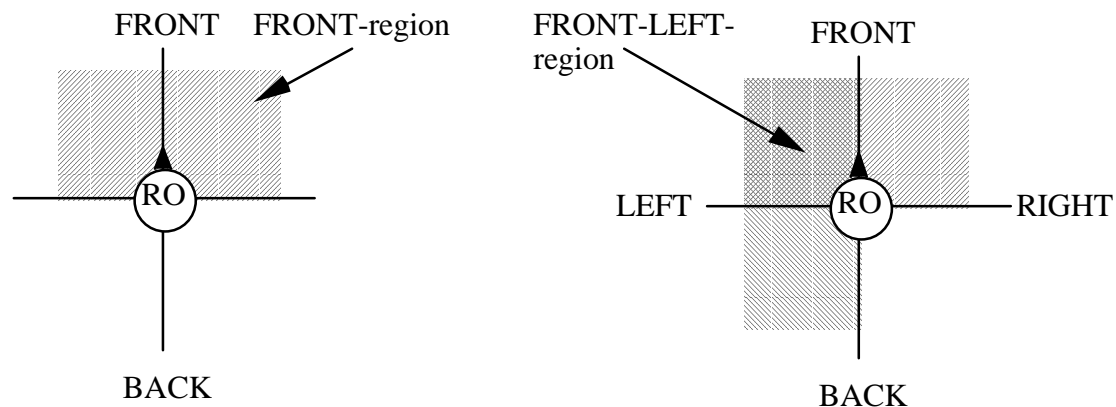


Fig. 1: Combination of projective terms (*in front and on the left of*) according to the analysis of Herskovits (1986), RO = reference object.

In this paper we will argue that analyses like Herskovits' (1986) do not apply to complex expressions in German. Firstly, the relations expressed in (3) do not always denote the same regions as those expressed by the co-ordinate English expressions. Therefore, a direct translation is not possible. Secondly, we will show that some of the complex expressions of German are ambiguous. They have an alternative reading whose extension can only be determined by the integration of multiple frames of reference.

In order to determine the location of the target based on these complex expressions, two strategies are available for natural language users: Either two regions are established with respect to one frame of reference, and the intersection of these regions yields the possible location of the target. Or, as we will show in sections 2 and 3, two reference frames are

⁴ The English counterparts given in italics serve to illustrate the German examples. They are not meant to be proper translations.

⁵ 'Hinterm' is a contracted form of the preposition 'hinter' (*behind*) and the definite article 'dem' (gender: masculine and case: dative). The regularities with respect to the use of the contracted vs. uncontracted form ('hinter dem Schrank') are complex but not related to the subject matter of this paper. Therefore we will ignore any difference and use both forms interchangeably.

⁶ As one of the referees pointed out to us, beyond the co-ordination with *and* discussed by Herskovits it is possible to combine projective terms in English as in the following expressions 'behind the cupboard to the left' and 'behind the cupboard on the left'. While the differences in interpretation seem to correspond to our findings concerning the German data, an additional study of these expressions needs to be carried out.

established and integrated and regions with respect to these reference frames are used for the location of the target. In this paper we focus on these strategies rather than on a detailed analysis of the location and form of the denoted regions.

The German data show that the multiplicity of frames of reference does not only lead to the problem of selecting one but, at least for complex expressions as considered here, also to the problem of integrating different frames of reference.

2. Projective Terms and Their Combinations

2.1 Projective Prepositions and Projective Adverbs

Projective terms are usually analysed as relations that localize the target relative to the reference object with respect to a frame of reference. Projective prepositions like ‘über’ (*over*), ‘unter’ (*under*), ‘vor’ (*in front of/before*), ‘hinter’ (*in back of/behind*), ‘links von’ (*at/on/to/by the left of*), and ‘rechts von’ (*at/on/to/by the right of*)⁷, can be said to be external, i.e., the region the target is localized in is external to the reference object.

- (4)
- a. Der Schrank steht links/rechts vom Bett.
the cupboard is standing on the left /on the right of the bed
 - b. Die Mücke fliegt über/unter dem Schrank.
the mosquito is flying over/under the cupboard
 - c. Die Katze liegt vor/hinter dem Ofen.
the cat is lying in front of/behind the stove

In German – as in many other languages – there is an additional class of spatial adverbs⁸: ‘oben’ (*above*), ‘unten’ (*below*), ‘vorne’ (*in front*), ‘hinten’ (*at the back*), ‘rechts’ (*on the right*), ‘links’ (*on the left*). These projective terms are related to the prepositions morphologically as well as by their specification of axes. Thus, ‘vorne’ just as ‘vor’ specify axes which we call here the FRONT-axes.

These projective adverbs seem to depend on frames of reference in much the same way as the projective prepositions do. However, they differ in two respects. Firstly, an explicit specification of a reference object is not necessary (Wunderlich & Herweg, 1991), as can be seen in (5). Here, the reference object is derived contextually. But as shown in (6), an overt expression is possible.

Secondly, the regions specified by these adverbs are in many cases not external to the reference object.

- (5)
- a. Der Schrank steht rechts/links.
the cupboard is standing on the right/on the left
 - b. Die Mücke ist oben/unten.
the mosquito is above/below
 - c. Das Auto steht vorne/hinten.
the car is standing in front/at the back

⁷ ‘links von’/‘rechts von’ are syntactically more complex prepositions than ‘über’/‘unter’/‘vor’/‘hinter’ and therefore – in principle – a more fine-grained discussion would be appropriate. Since this topic is not relevant for our present analysis, we do not go into details here.

⁸ We use the term ‘adverb’ in traditional manner, referring to expressions from a certain class of words (or word forms), but not referring to a specific syntactic position relative to the verb. We apologize for the possibility of confusion but it seems that proper alternatives are not available.

- (6) Die Teller stehen oben/hinten/rechts im Schrank.
the plates are standing above/behind/right in the cupboard

In (5.a) ‘rechts’/‘links’ denote the RIGHT-region and the LEFT-region, respectively, of the inner part of a room. In the case of (5.c), the reference object supplied by the context might be a driveway, a parking lot, or a street. Here, the FRONT-region or BACK-region is denoted with respect to the position of the observer and particular object properties, which we will not investigate in detail here.

Strictly speaking, these spatial adverbs do not induce a reference object but regions (we call them ‘reference regions’).⁹ This corresponds to the fact that spatial prepositional phrases (denoting regions) rather than noun phrases (denoting objects) can be added to specify such a reference region explicitly. In example (6), a projective adverb is combined with a non-projective spatial prepositional phrase, i.e. ‘im Schrank’. In this case we could analyse the combination as follows: The projective relation (based on an axial system) specifies a region that is part of the region specified by the non-projective preposition, see Fig. 2.

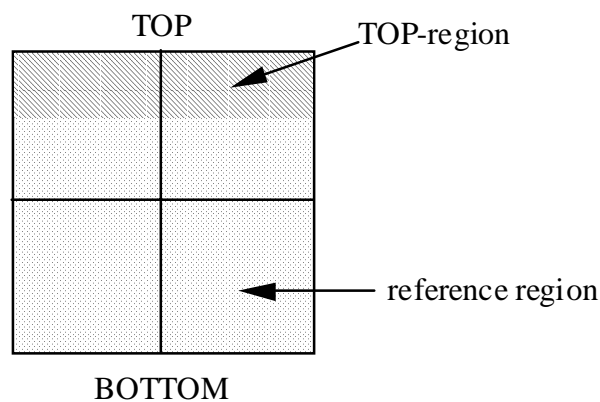


Fig. 2: Restriction of the reference region (in this case the denotation of ‘im Schrank’) by a projective adverb (‘oben’) to the TOP-region

Although simple syntactic tests suggest that expressions such as ‘oben im Schrank’ can be constituents, their internal structure is not clear and can be analysed in at least three different ways.¹⁰ The first analysis is to assume the prepositional phrase (‘im Schrank’) to be an optional complement of the adverb (‘oben’). In this case, the adverbs can be classified as prepositions as well: Semantically, they are as relational as prepositions are. Ignoring this, we will call them ‘projective adverbs’ in the following in order to avoid confusion with the notion of projective preposition.

Wunderlich and Herweg (1991) point out two alternative syntactic analyses. In one analysis, the adverb modifies the prepositional phrase (7.a) (i.e., ‘im’ is head of the phrase), in the second version, the prepositional phrase modifies the adverb (7.b) (i.e., ‘oben’ is head of the phrase).

- (7) a. [PP oben [PP im Schrank]]
above in the cupboard
 b. [PP[PP oben] im Schrank]
above in the cupboard

⁹ The concept ‘internal reference region’ requires the topological aspects of reference frames.

¹⁰ A fourth syntactic analysis of sentences like (6) is to consider both adverbs and prepositional phrases as modifiers of the verb. In this case, they do not form a constituent.

Wunderlich and Herweg (1991) relate this syntactic ambiguity to a semantic ambiguity. Although both readings – in this case – yield the same model, the interpretation works differently based on the syntactic ambiguity. In (7.a), an IN-region is specified, and ‘oben’ restricts the extension of this region. The interpretation is roughly this: *In the cupboard, to be specific, above*. In (7.b) ‘im Schrank’ restricts the extension of ‘oben’; the interpretation in this case is: *Above, to be specific, in the cupboard*.

Although the approach of Wunderlich and Herweg (1991) to associate syntactic ambiguity with different procedures of interpretation is quite attractive for the data we will present in the next section, we will not follow it. To justify the correlation between syntactic structures and procedures of interpretation, we feel the need of independent evidence for assigning a specific syntactic structure to the expression under consideration.

2.2 Combinations of Projective Terms

Comparing examples (6) and (3) as well as systematic variations of them in (8), we find that the combinations of projective terms we are interested in can be syntactically analysed in the same ways as stated for (6). In addition, the adverbs can combine with each other, which can be seen in (9). As shown in (10), these constructions allow for overt reference objects the same way a single adverb does, cf. (6). In contrast to the adverbs, direct combinations of the prepositions in question are not possible, see (11). The lexical items ‘links’ and ‘rechts’ differ from the other terms under consideration, since they can appear both as adverbs and as prepositions.¹¹

- (8) a. Die Mücke ist oben vorm Schrank.¹²
the mosquito is above in front of the cupboard
 b. Die Mücke ist hinten unterm Schrank.
the mosquito is behind under the cupboard
 c. Die Mücke ist links unterm Schrank.
the mosquito is to the left under the cupboard
 d. Die Mücke ist unten links vom Schrank.
the mosquito is below (to the) left of the cupboard
- (9) a. Der Schal liegt oben vorne.
the scarf is lying above in front
 b. Der Schal liegt links oben.
the scarf is lying (to the) left above
 c. Der Schal liegt vorne links.
the scarf is lying in front (to the) left
- (10) Der Schal liegt oben vorne im Schrank.
the scarf is lying above in front in the cupboard
- (11) *Die Mücke ist über vor dem Schrank.
the mosquito is over in front of the cupboard

¹¹ The exclusion of examples like (11) can be related to syntax, since the prepositions discussed seem to subcategorize noun phrases and assign (dative) case. The syntactic status of ‘rechts’ and ‘links’ differs from the other terms considered here and is – generally – unclear.

¹² ‘vorm’ is contracted from ‘vor’ (*in front of*) and the definite article. Be cautious to avoid the confusion for ‘vom’ the contraction of ‘von’ (*of*) and the definite article.

The systematic variation leads to a classification of the combinations according to acceptability and interpretation of prosodically unmarked combinations. Fig. 3 specifies labels for the classes of examples we discuss in the following and shows an evaluation of different constructions in terms of acceptability judgements. The judgements are based on our own intuitions and on those of several other native speakers. They apply to cases where the textual and non-textual context is rich enough to provide reference regions and frames of reference as needed.

	rechts von	links von	über	unter	vor	hinter
rechts	* [1]	*	+ [2]	+	+ [3]	+
links	*	*	+	+	+	+
oben	(+) [4]	(+)	+ [5]	+	(+) [6]	(+)
unten	(+)	(+)	+	+	(+)	(+)
vorne	(+) [7]	(+)	(+) [8]	(+)	+ [9]	+
hinten	(+)	(+)	(+)	(+)	+	+

Fig. 3: Acceptability of combinations of projective terms

‘*’: not acceptable without prosodic hints; ‘+’: acceptable, ‘(+): restricted acceptability

The clearest judgements of acceptability are with respect to combinations of the adverbs ‘rechts’ and ‘links’ with any projective preposition, i.e., the classes [1], [2] and [3]. Examples from class [1] are generally not accepted (cf. example (12)), unless additional prosodic hints – such as a pause between the two projective terms – is given.¹³

- (12) a. *Die Mücke ist rechts rechts vom Schrank.
the mosquito is (to the) right to the right of the cupboard
 b. *Die Mücke ist links rechts vom Schrank.
the mosquito is (to the) left to the right of the cupboard

In contrast to this, examples from class [2] and class [3], such as (13), are most easily accepted and understood. The interpretation of (13.a) corresponds to the one given for example (6) above and depicted in Fig. 4: The prepositional phrase ‘vorn Schrank’ specifies a region based on the vertical axis of the reference frame and ‘links’ selects a part of this region according to the left-right horizontal axes of the reference frame. We call this interpretation the ‘sub-region interpretation’.

- (13) a. Die Mücke ist links vor dem Schrank.
the mosquito is (to the) left in front of the cupboard
 b. Die Mücke ist rechts hinterm Schrank.
the mosquito is (to the) right behind the cupboard

¹³ In the case of explicit prosodic hints the multiple frame strategy (see below) is chosen.

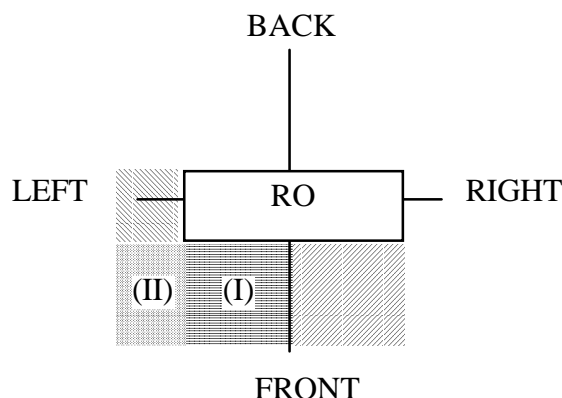


Fig. 4: 'links vorm Schrank'

As a result, the preferred interpretation of (13.a) is illustrated in Fig. 4 as region (I). The analysis in Herskovits (1986) of the English construction *to the left and in front of* assumes region (II) to be the preferred interpretation. Gapp (1996, Chap. 3.3.4) discusses four methods to compute 'grades of applicability' for combined projective relations. This leads to the computation of the internally structured region (II). Our data show that German speakers predominantly use the even more complex expression 'schräg links vor' (*diagonally to the left in front of / at an angle to the left in front of*) to identify region (II).

For the remaining classes, combinations of terms specify the same kind of axes. I.e., expressions from classes [5] and [9] are acceptable (cf. (14)) but – in contrast to what might have been expected comparing them with class [1] – do neither derive pleonastic nor contradictory interpretations.

- (14) a. Die Mücke ist oben über der Tür.
the mosquito is above over the door
 b. Die Ratte ist unten unter dem Fußboden.
the rat is below under the floor
 c. Die Mücke ist oben unter der Lampe.
the mosquito is above under the lamp
 d. Die Mücke ist unten über dem Teppich.
the mosquito is below over the carpet

The preferred interpretation of (14.a) can be paraphrased as: The mosquito is in the TOP-region of the room and above the door. Fig. 5 depicts the corresponding situation. In this case, 'über der Tür' specifies the (external) TOP-region relative to the door (and the vertical axis) and 'oben' specifies the (internal) top part of a contextually provided reference region such as the inner region of the room.

We call such interpretations 'detached'.¹⁴ They can best be understood as localising the target in the intersection of two regions that are provided independently of each other. The same observation applies to (14.d). It can be paraphrased as: The mosquito is in the BOTTOM-region of the room and in the region over the carpet.

¹⁴ We do not claim that in these cases only detached readings are available. Thus, a reading that results in a conceptual interpretation analogous to the one shown in Fig. 4 is possible. This 'pleonastic' reading seems to be the preferred one in cases such as (1'), where only one frame of reference is available.

(1') Das Auto steht vorne vorm Haus. *the car is standing in front in front of the house*

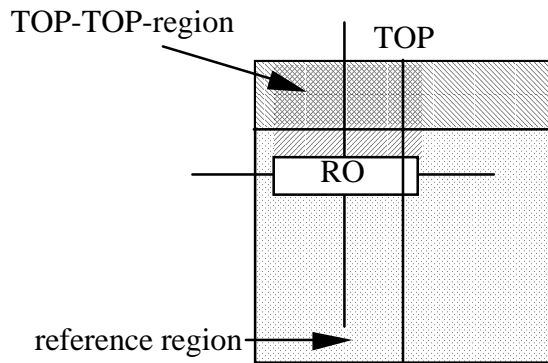


Fig. 5: Detached interpretation of 'oben über RO'

Combinations of prepositional 'rechts / links von' with adverbs specifying different axes, i.e., examples from classes [4] and [7], are predominantly not accepted at first presentation (cf. (15)). But – as often observable in linguistic tests – little training with examples from class [5] or [9] leads the informants to get detached interpretations for examples of these classes as well. As to be expected, (15.a,b) are not understood to be just the inverse constructions of (13.a,b). The detached interpretations of 'rechts vom Schrank' (the RIGHT-region relative to the cupboard) and of the adverbs 'unten' and 'hinten' (interpreted relative to a contextually specified reference region) are derived. Thus, (15.a) can be paraphrased as: The mosquito is in the BOTTOM-region of the room and to the right of the cupboard.

- (15) a. (?)Die Mücke ist unten rechts vom Schrank.
the mosquito is below to the right of the cupboard
 b. (?)Die Mücke ist hinten rechts vom Schrank.
the mosquito is behind to the right of the cupboard

The fact that (15) is less acceptable than the examples of classes [2], [3], [5] and [9] does not concern us here, as an interpretation is possible in principle.

Reconsidering the examples in (13) (i.e., classes [2] and [3]), it becomes obvious that they allow detached interpretations as well. But in contrast to the examples (14) and (15), an intonational support – like a short pause – is needed to force the detached interpretation.

In contrast to the cases already discussed, the intuitions about the classes [6] and [8] are less clear and more dependent on functional aspects of the reference object specified. Take, e.g., the contrast of (16.b) and (16.c): In (16.c), 'vorne unter' yields the region under the front part of the car. In (16.b), with the cupboard as reference object, no clear intuition is available.

- (16) a. Die Mücke ist oben vorm Schrank.
the mosquito is above in front of the cupboard
 b. ?Die Mücke ist vorne unterm Schrank.
the mosquito is in front under the cupboard
 c. Der Ball ist vorne unterm Auto.
the mosquito is in front under of the car
 d. ?Die Mücke ist vorne überm Schrank.
the mosquito is in front over the cupboard

This again gives evidence for the assumption that projective adverbs and projective preposition have to be analysed in a different way.

In Fig. 6 we summarise the empirical findings with respect to preferences of interpretations for combined projective terms.

	rechts / links von	über / unter	vor / hinter
rechts links	[1] no interpretation	[2] sub-region or detached	[3] sub-region or detached
oben unten	[4] detached	[5] detached	[6] unclear
vorne hinten	[7] detached	[8] unclear	[9] detached

Fig. 6: Preferred interpretations for combined projective terms

3. Multiple Frames of Reference

Projective terms in German form two distinguishable classes that can be combined yielding complex and specific spatial descriptions. In contrast to English, German uses combinations of adverbs with adverbs as well as combinations of adverbs followed by prepositional phrases in order to join projective terms. In this paper, we have concentrated on the latter case.

Although the general pattern of these combinations seems fairly uniform at the surface, acceptability judgements and the preferred conceptual interpretations of the combined terms show a more complex pattern. The data discussed in section 2 demonstrate that there is more than one method of deriving an interpretation for combined projective terms. The method preferred is determined by diverse factors such as the terms combined, contextual aspects and intonational patterns. To study all the factors that influence the preferred interpretations of these terms is not the aim of the paper. We rather want to point out, firstly, that there is more than one option available and, secondly, that in some cases more than one reference frame is involved.

The strategy suggested by the analysis of Herskovits (1986) for English expressions such as (17) locates the target (i.e., the mouse) in a region that does not fall within the typical regions denoted by ‘to the left of’ and ‘behind’. According to our intuitions and those of our informants, this interpretation is not used for the German expressions under consideration here, cf. (18), but rather for the more complex form shown in (19).

(17) The mouse is to the left of and behind the cupboard.

(18) Die Maus saß links hinterm Schrank.
the mouse was sitting left behind the cupboard

(19) Die Maus ist schräg links hinterm Schrank.
the mouse is diagonally left behind the cupboard

The alternative strategy we propose for this case establishes one region corresponding to the prepositional phrase (‘hinterm Schrank’) and selects a sub-region according to the adverb. Thus, ‘hinterm Schrank’ denotes the BACK-region of the cupboard and ‘links’ is taken to specify the left part of it. This interpretation justifies the conclusion that the mouse is behind the cupboard. But it does not justify the conclusion that it is to the left of the cupboard. In addition, no conclusion about the location of the cupboard (e.g., in a room) will be derived.

The reading that we called detached is most obvious in examples such as (20). We called this reading detached, because in contrast to the modificational readings, ‘oben’ keeps its

original denotation. It results from a strategy which establishes two regions with respect to two frames of reference and locates the target within both of them.

- (20) Die Fliege ist oben über der Tür.
the fly is above over the door

This interpretation justifies both the conclusion that the fly is in the TOP-region of the room and that it is above the door. In this case the adverbs keep their capacity of referring to a contextually provided region. In most of our examples, the adverb refers to the inner region of a room, i.e., the adverb induces a reference region according to which the target is located. The projective preposition establishes a region according to the object denoted by its complement. This region, of course, is not the same as the reference region induced by the adverb.

Thus, in order to interpret the expression ‘oben über der Tür’, both projective terms introduce a frame of reference. Thereby, the frame introduced by the projective preposition ‘über’ is located within the frame introduced by the projective adverb ‘oben’. Therefore, the region denoted by the prepositional phrase ‘über der Tür’ intersects the TOP-region of the room, and the target is located within this intersection.

The ambiguity of (21) should be clear now. Only in the detached reading, the inference (22) is valid.

- (21) Die Fliege ist rechts über der Tür.
the fly is right over the door
- (22) Die Fliege ist rechts.
the fly is to the right

Considering additional examples, we find that by uttering (23) the speaker suggests that the glass is in the TOP-region as well as the cup. This can be explained if the regions constituted by ‘hinter’, ‘über’ etc. are bounded (e.g., according to the edges of a circumscribing cuboid as depicted in Fig. 4 and 5, cf. van der Zee 1996) rather than infinitely extending (as depicted in Fig. 1): In any model that locates the cups in the TOP-region (of, e.g., a contextually provided cupboard) and in the BACK-region of the glass, these regions intersect. If the BACK-region is bounded as suggested, then at least a part of it has to be at the same height as the cup, i.e., in the TOP-region of the cupboard.

- (23) Die Tasse ist oben hinter dem Glas.
the cup is above behind the glass

4. Conclusion

The study of combinations of projective terms in German has led us to the following results: The complex descriptions under consideration are in general more specific than simpler ones, i.e., they specify sub-regions of those specified by simpler expressions. Their interpretations can be described as resulting from two different strategies. Preferences regarding the selection of one strategy available differ, based on the projective term involved and to properties of the objects related. One of these strategies integrates multiple frames of reference. The resulting interpretations tend to include information about the relative position of the origins of the reference frames involved.

The differences in acceptability reported with Fig. 6 are not based on linguistic (i.e., syntactic or semantic) properties of the items but are mainly due to conceptual or pragmatic factors. Expressions are accepted, if they make sense, i.e., if an interpretation strategy is accessible which yields a consistent model. Finer differences of acceptability can be explained based on the difficulties of finding such an interpretation. Up to now these hypotheses are based on purely linguistic evidence, namely acceptability ratings given by the authors and some informants. Finer and much more precise methods of psycho-linguistics are needed to test and develop our approach.

The need for finding a consistent interpretation to understand and accept a complex description and the difficulties observed thereby suggest in addition that the regions designated by projective terms are not to be described as graded, unbounded structures (e.g., according to prototypes or fuzzy sets) but as having boundaries and shape.

References

- Bryant, D., Tversky, B. & Franklin, N. (1992). Internal and external spatial frameworks for representing described scenes. *Journal of Memory and Language*, 31, 74–98.
- Bühler, K. (1934): Sprachtheorie. Die Darstellungsfunktion der Sprache. Fischer: Stuttgart. [partly reprinted in English as: The deictic field of language and deictic words. In R.J. Jarvella & W. Klein (eds.) (1982) *Speech, place, and action*. (pp. 9–30). Chichester: Wiley.]
- Carlson-Radvansky, L. A. & Irwin, D. E. (1993). Frames of reference and vision in language: where is above? *Cognition*, 46, 223–244.
- Eilan, N., McCarthy, R. & Brewer, B. (eds.) (1993). *Spatial representations*. Oxford: Blackwell.
- Eschenbach, C. & Kulik, L. (1997). An axiomatic approach to the spatial relations underlying *left-right* and *in front of-behind*. (Manuscript submitted to publication). Hamburg: University of Hamburg, Comp. Science Dept.
- Franklin, N. & Tversky, B. (1990). Searching imagined environments. *Journal of Experimental Psychology*, 119, 63–76.
- Franklin, N., Tversky, B. & Coon, V. (1992). Switching points of view in spatial mental models. *Memory and Cognition*, 20, 507–518.
- Gapp, K.-P. (1996). Ein Objektlokalisierungssystem zur sprachlichen Raumbeschreibung in dreidimensionalen Umgebungen. (Doctoral dissertation, Universität des Saarlandes, Saarbrücken, Germany).
- Habel, Ch. (1990). Propositional and depictorial representations of spatial knowledge: The case of *path* concepts. In R. Studer (ed.): *Natural language and logic*. (pp. 94–117). Lecture Notes in Artificial Intelligence. Berlin: Springer.
- Herskovits, A. (1986). *Language and spatial cognition*. Cambridge: Cambridge University Press.
- Jarvella, R.J. & Klein, W. (eds.) (1982) *Speech, place, and action*. Chichester: Wiley.
- Levelt, W. J. M. (1996). Perspective taking and ellipsis in spatial description. In P. Bloom; M.A. Peterson; L. Nadel; & M.F. Garrett (eds.), *Language and Space* (pp. 77–107). Cambridge, MA: The MIT Press.
- Levinson, S.C. (1996). Frames of reference and Molyneux's question: Crosslinguistic evidence. In P. Bloom; M.A. Peterson; L. Nadel; & M.F. Garrett (eds.) *Language and space*. (pp. 109–169). Cambridge, MA: MIT-Press.

- Maaß, W. (1996). Von visuellen Daten zu inkrementellen Wegbeschreibungen in dreidimensionalen Umgebungen: Das Modell eines kognitiven Agenten. (Doctoral dissertation, Universität des Saarlandes, Saarbrücken, Germany).
- Miller, G. & Johnson-Laird, P.N. (1976). *Language and perception*. Cambridge: Cambridge Univ. Press.
- Retz-Schmidt, G. (1988). Various views on spatial prepositions. *AI Magazine*, 9, 95–105.
- Schober, Michael F. (1993). Spatial perspective-taking in conversation. *Cognition*, 42, 1–24.
- Talmy, L. (1983). How language structures space. In H. Pick & L. Acredolo (eds.). *Spatial orientation*. (pp. 225–282) New York: Plenum.
- Tversky, B. (1996). Spatial perspective in descriptions. In P. Bloom; M.A. Peterson; L. Nadel; & M.F. Garrett (eds.) *Language and space*. (pp. 463–491). Cambridge, MA: MIT-Press.
- Vandeloise, C. (1991). *Spatial Prepositions: A case study from french*. Chicago: University of Chicago Press.
- van der Zee, E. (1996). *Spatial knowledge and spatial language*. Ph.D. Dissertation. Rijksuniversiteit Utrecht.
- Wunderlich, D. & Herweg, M. (1991). Lokale und Direktionale. In A. v. Stechow & D. Wunderlich (Hrsg.): *Semantik. Ein internationales Handbuch der zeitgenössischen Forschung*. (pp. 758–785). Berlin/New York: de Gruyter.