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The role of structure and function in the conceptualization of direction

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6.1 Introduction

The specification of mental conceptualizations of spatial information is a lively topic in several disciplines (e.g. Coventry and Garrod 2004; Mark et al. 1995; Regier and Carlson 2001). In linguistics, for example, the specification of spatial relations as indicated by projective terms (e.g. *left*, *right*, *above*, *in front*) has led to research on how the conceptualization of a particular spatial relation is influenced by contextual parameters (e.g. Coventry and Garrod 2004; Herskovits 1986; Regier 1996) and how a resulting conceptualization is mapped onto a linguistic expression. One crucial aspect reflected, for example, in the notion of a spatial template (Carlson-Radvansky and Logan 1997), is the finding that projective terms can be applied best when referring to a position directly on a focal axis: they are typically combined with linguistic modifiers when they deviate from that axis (Zimmer et al. 1998). Besides the de facto geometric relation between two objects (called referent and relatum by Levinson 2003), several factors influence the choice of a specific reference system and the assignment of a linguistic category (and a corresponding linguistic expression) that specifies the spatial relation between them. Van der Zee and Eshuis (2003) list the following factors: (a) the function of the objects as, for example, detailed in the extra-geometric functional framework by Coventry and Garrod (2004); (b) force dynamic properties (e.g. Talmy 1988); (c) the part structure; and (d) orientation and movement. Most of these are also relevant for other spatial term categories, such as topological expressions (e.g. *in* and *on*). Van der Zee and Eshuis (2003) additionally specify features of the referent as such that influence the reference axis categorization: axis length, contour expansion, and curvature of the main plane of symmetry.

They combine these factors in their spatial feature categorization model to generate predictions on reference axis categorization derived from the spatial features of a referent for the purpose of intrinsic directional reference on both the horizontal and the vertical plane.

While Coventry and Garrod (2004), in their extra-geometric functional framework, focus on functional aspects that are external to the geometric features of a spatial relation, the model by van der Zee and Eshuis (2003) emphasizes the influence of the geometric features of the referent as such. In the area of route directions, the structure in which route-following actions take place is specifically crucial, as it influences the conceptualization of the movement. This idea will be addressed and elaborated in this chapter. We will develop a framework that allows for characterizing conceptualizations of actions (movement) at intersections by taking into account the angle of direction change but also the configuration of the intersection as such. Further aspects, such as the availability of additional environmental features (e.g. landmarks) are also decisive (e.g. Daniel and Denis 1998). Therefore, route directions may differ from other spatial localization tasks for which it is sufficient to choose a reference axis to guide the mapping of a linguistic expression, the direction in question, and deviations thereof, as presented and discussed in Chapter 5 in this book.

Route directions are widely studied, as they allow for investigating cognitive processes at the interface of language and space, language and graphics, and the conceptualization of motion events (Allen 1997; Daniel and Denis 1998; Habel 1988; Ligozat 2000; Tappe 1999; Tversky and Lee 1999). Due to their spatially restricted domain—routes are intrinsically linear and not multidimensional—route directions have the potential to reveal cognitive processes that otherwise are difficult to access. For example, the linearization problem in language (Levelt 1989) is alleviated by the fact that the order of a linear structure is regularly expressed verbally in route directions (Denis et al 1999).

Zwaan and Radvansky (1998) proposed to view language not primarily as information that is analysed syntactically and semantically and then stored in memory, but rather as a set of instructions on how to create a mental representation of a given situation. In this spirit, we aim to investigate how an appropriate situation model is instantiated that contains just the right amount of information at a decision point in a route instruction, yielding a set of cognitively ergonomic route directions (e.g. Daniel and Denis 1998; Lovelace et al. 1999). In the present chapter, we therefore focus on the question of what aspects of a spatial situation are verbalized at decision points in order to convey the information necessary to identify the intended direction to take, and how this influences the verbalization of the spatial relation itself. More precisely, how do people conceptualize and verbalize the actions to be performed at decision points in city street networks, depending on the general structure of a decision point (e.g. an intersection), the action itself (the change of direction, which is the functional aspect), and additional salient features (landmarks)?

6.2 Structure and function

A core element of wayfinding theory is the distinction between structure and function, which is essential for characterizing the conceptual level of route information (Klippel, Tappe et al. 2005). As the conceptual level is the basis for the externalization of knowledge in several modalities (e.g. Jackendoff 1997; Tversky and Lee 1999), the distinction between structure and function gains additional importance to account for the constraints induced by different representational media such as language or graphics. This approach has been inspired by work in spatial cognition (Montello 2005) in which a distinction is drawn between a behavioural pattern – a route – and the environment – a path. In contrast to laboratory studies on spatial relations that do not take place in a natural spatial context, our approach builds on the distinction between routes and paths, which we view as pertinent for conceptualization processes in interaction with spatial environments (see Figure 6.1).

In our approach, structure denotes the layout of elements physically present in the spatial environment that are relevant for route directions and wayfinding. This

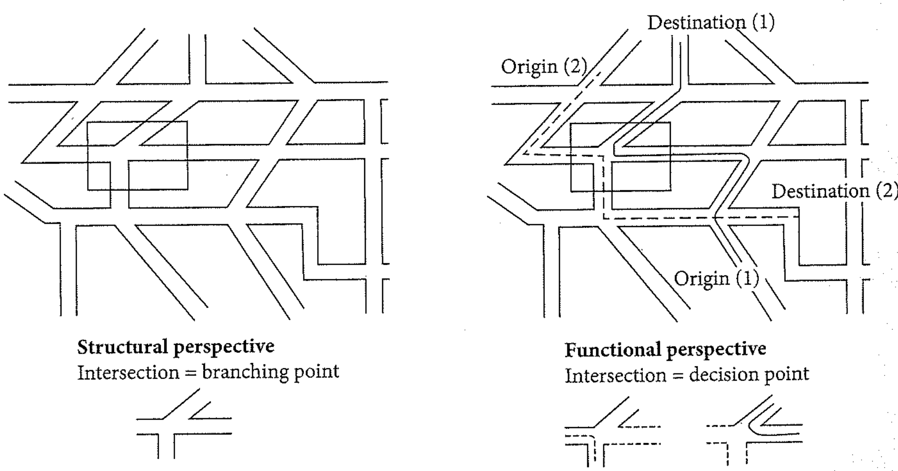


FIGURE 6.1 Distinguishing between structural and functional aspects of route information. Without any action taking place, an intersection is referred to as a branching point, i.e. the structural aspect (left part). In the course of route following, an intersection becomes a decision point and the action to take place demarcates functionally relevant parts (right part) (Klippel 2003). With kind permission from Springer Science & Business Media: Klippel, A. (2003). Wayfinding choremes. In W. Kuhn et al. (eds.): COSIT 2003, LNCS 2825.

comprises, for example, the number of branches at a street intersection and the angles between those branches. Function is related to the actions that take place in spatial environments. The functional characterization is contained within the structural characterization; that is, routes exist within those parts of path networks that are necessary for specifying the action to be performed.

6.3 Direction concepts at intersections

The general structure of a branching point is its spatial layout (the physical structure); that is, the size and number of branches, and angles between the branches. Examples for different general structures are T-intersections, circles, forks, different numbers of branches, highway exits, and so forth. The actions performed at an intersection can be roughly classified according to different direction models, for example, as left, right, and straight. Additionally, superimposed rule structures may come into play (which are not addressed in detail in this chapter), such as turning restrictions or the Australian hook turn. These rules are especially important for the design of navigation systems that provide the navigator with information to establish a suitable situation model.

The performed action itself, i.e. a turn with a specific angle of direction change, can be conceptualized with respect to the spatial structure in which it is embedded. For example, a half right turn may be conceptualized differently at a four-way intersection as compared to a fork in the road (see Figure 6.2). From our experiences

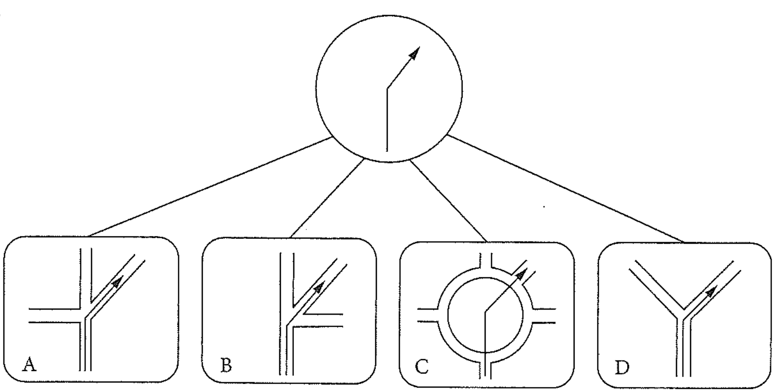


Figure 6.2 A change of a direction is associated with different meanings according to the intersection in which it takes place. The 'pure' change may be linguistically characterized as *veer right at the intersection* (A). At intersection (B), it might change to *the second right*; at roundabout (C), it changes to *the second exit*, and at (D), it becomes *fork right* (Klippel, Hansen et al. 2005).

with route direction corpora, we derived some first ideas on strategies speakers adopt to assign verbal labels to actions occurring in different structures. There are standard intersections, like a four-way intersection, and standard actions, like *left*, *right*, and *straight*. If standard actions occur at standard intersections, unmodified projective terms are used, for example, *turn right* (at the intersection). Additionally, people tend to adopt a direction model that comprises axes and sectors, expressed, for instance, by modifications of the projective terms if the angle of the intended direction departs from the prototypical axis. For example, *turn right* may change to *turn sharp right* and may be modified to *turn very sharp right*. While these directions allow some flexibility, i.e. they can be modelled as sectors, the concept for *straight* seems to be an axis and is applied only to this axis as far as simple intersections are concerned (Klippel et al. 2004). Otherwise, *straight* can also be interpreted in the sense of *follow the course of the street*, even if there are curves (Gryl et al. 2002).

The strategies participants adopt change if the action to be instructed takes place (a) at a complex intersection or (b) if competing branches require a disambiguation of the situation. For the identification of objects in a spatial configuration, Tenbrink (2005) provides results on how the contrast of competing objects can be enhanced by choosing a suitable reference system and spatial axis that allow for unambiguous reference, without necessitating a high level of precision. The exact spatial location is usually not specified if there are no competing objects close by, and projective terms are modified only if necessitated by the presence of competing objects on or near the same spatial axis within a reference system. An exception is the case of a position directly between two axes, in which case both projective terms are combined, in accord with the principle of redundant verbalization formulated by Herrmann and Deutsch (1976).

Klippel and Montello (2004) present some ideas on how contrastive reference can be achieved in route directions. Besides rendering the direction concept precise, for example, by providing detailed descriptions according to the direction model, and possibly relying on clock directions or an absolute reference system, speakers seem to adopt the following strategies: naming the structure in which the actions take place plus a coarse direction concept (e.g. *fork right*), a comparison of possibilities to take (e.g. *furthest right*), a conceptual change to ordering information plus a coarse direction concept (e.g. *the third to your left*), the description of competing directions not to take, or any combination of these strategies. The situation changes again if landmarks are present, as they can be used to anchor movement at an intersection and to identify the direction to take.

Although we use natural language expressions here to refer to mental concepts of route directions, it is important to note that the two are not identical. Verbalization is one possible way to externalize mental concepts (alternatives are graphics or gestures), and different verbalizations may be based on the same conceptualization. In our approach, we focus on the identification of systematic patterns in speakers' verbal descriptions that we believe point to underlying concepts.

To develop a systematic characterization of route directions and their underlying conceptualization, we present an analysis of a route direction corpus qualitatively at first, with respect to the underlying conceptualizations of direction change at intersections. We support the analysis by presenting quantitative data on strategies participants used to generate directional terms. In this way, we provide a framework for the characterization of motion and associated direction concepts in constrained spatial structures, and specifically add to research on defining criteria for good route directions and formalizing direction concepts (Dale et al. 2005; Klippel, Hansen et al. 2005; Ligozat 2000; Lovelace et al. 1999).

6.4 The route direction task

On the basis of the ideas and findings just discussed, we reanalysed the data collected in a route direction task (Klippel et al. 2003). This task was set up for participants as a simulated one-way dialogue. The scenario was to instruct, from a central office, an imagined bike messenger how to go through a town. Thus, the dialogue situation was 'on-line', but no feedback was provided by the bike messenger, i.e. it was a one-way dialogue. The stimulus map (see Figure 6.3) was built on topographical data of a street network of a medium-sized town in Germany; the landmarks were added afterwards to specific intersections. The route to describe was indicated by a solid black line; a green flag marked the starting point. The map was presented on a computer screen; the verbalizations were recorded with a tape recorder and afterwards transcribed. Twenty-two students of the University of California, Santa Barbara, participated in the experiment and received course credit for their participation. One participant had to be excluded due to technical problems. As the presentation of the map was timed to two minutes, the action at the last intersection was verbalized by nineteen instead of twenty-one participants, as two of the participants did not complete the task in time (for more details see Klippel et al. 2003).

6.4.1 Methods and analysis

The analysed corpus consists of twenty-one verbal route directions, in English, given for the route indicated in Figure 6.3. As discussed above, three aspects can characterize the conceptualization of a wayfinding action at an intersection: (a) the structure of the intersection; (b) the action itself (related to the functional aspect, or purpose, of route following); and (c) the availability of disambiguating features.

To capture these aspects systematically, we analysed verbalization data for five selected decision points, which differ with respect to the salience of their spatial

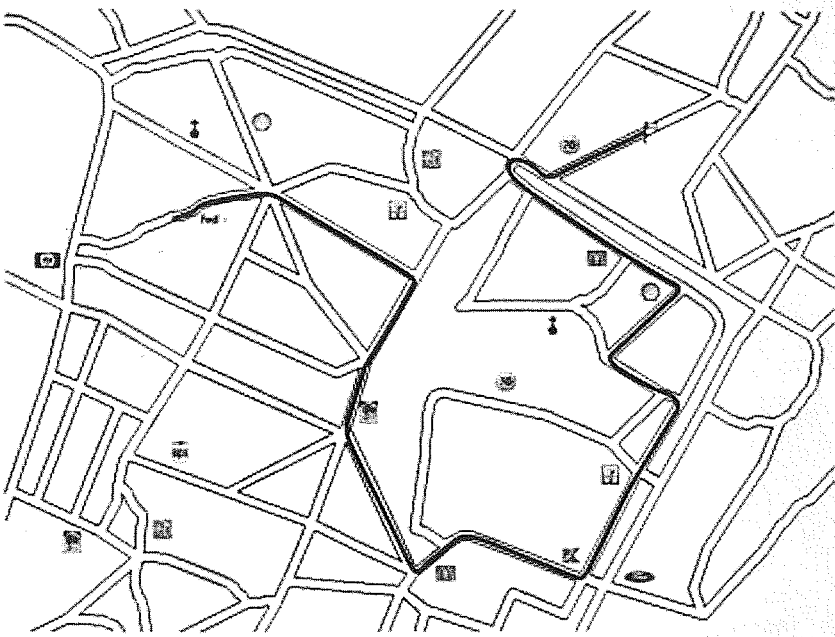


Figure 6.3 Map marked with route, shown to English-speaking participants (Klippel et al. 2003). With kind permission from Springer Science & Business Media: Klippel, A., Tappe, H., and Habel, C. (2003). Pictorial representation of routes: chunking route segments during comprehension. In C. Freska et al. (eds.): Spatial Cognition 2002, LNAI 2685.

structures, the presence of competing directions, and their deviation from a prototypical direction. The data were coded with respect to seven relevant conceptual categories. Two of the authors discussed the annotations until complete agreement was reached. Based on previous experience annotating natural language data for investigating concepts in spatial settings (Tenbrink 2009), a schema was developed that comprises the following categories, in order to provide deeper insight into the influence of the structural complexity of decision points on the conceptualization process:

I. Main direction concept. The main direction concept is the primary direction change indicated in an utterance. We viewed projective terms such as *left*, *right*, and *straight on* as the primary means to indicate a change of direction in a route instruction; these indicate direction via a location-based spatial axis. There are, however, alternatives, such as *make a U-turn*. We also distinguished unmodified projective terms from modified projective terms (such as *sharp right*) to identify the level of detail in the verbalization of the main direction concept, and checked for occurrences of more than one modification.

II. Use of verbs. In addition to spatial terms expressing the main direction concepts, verbs may also be used to characterize the change of direction in a meaningful way. Only one utterance in our data does not contain a verb at all. The variability in the verbs used points to the cognitive salience of expressing motion in suitable ways according to the situation. In order to capture direction changes that may be indicated by verbs rather than projective terms or other terms, we distinguish between (a) neutral verbs such as *go*, *move*, *turn*; (b) verbs that indicate that the route has a specific shape that needs to be followed, such as *follow*, *follow along*, *continue*; and (c) verbs that indicate a direction change, a 'drift', or small angle towards either right or left, such as *veer*. Such occurrences further highlight the range of options available to speakers for indicating the peculiarities of a spatial structure and making use of them to create route directions.

III. Redundancy. Although redundancy is not particularly indicative of the direction concept applied, it may offer a valuable means to draw conclusions about the complexity of an intersection and the cognitive effort that is required to conceptualize unambiguously a direction change in a spatial structure. Therefore, we took note of the presence of more than one spatial description in relation to a single decision point.

IV. Scene. Some utterances contain information about aspects of the spatial situation that is not directly relevant for the intended action—e.g. by describing the existence of competing alternative directions. Like redundancy, such information may serve as additional material indicating the conceived complexity of the situation if it is used systematically.

V. Reference to structure. In our data, the structure of the street network is referred to with varying levels of detail. On the one hand, a salient spatial structure such as an intersection may function as a landmark, as in *turn right at the second intersection*. On the other hand, the specification of a direction change may be achieved by reference to the structure in which the direction change occurs. In this case, the structure of an intersection is specified in some detail, as in *take the third to the left at the six-way intersection*. Occurrences of such a specification may be an indication of the complexity of the conceptualization necessary to verbalize the action to be performed. We distinguished between utterances in which spatial structures were mentioned at all versus those not containing reference to structure, and further identified if the spatial structure was specified in some way or simply mentioned.

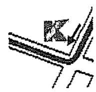
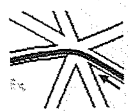
VI. Ordering concepts. Participants invoke rendering concepts as a means to distinguish the intended route segment at a decision point from competing branches. This occurs by using natural numbers, as in *second to the right*, or by referring to neighbouring directions, as in *next*.

VII. Landmark use. A landmark may be mentioned together with a direction change either to influence the identification of the correct future route, as in *turn right at the statue*, or to confirm that the correct route has been identified, as in *turn right and you will see a statue*. Such choices reflect the conceptualization of the scenario as complex with respect either to the identity of the location at which the direction change takes place or with respect to the identification of the future direction itself.

6.4.2 Results

Table 6.1 shows the results of our analysis broken down by the corresponding decision points. If not indicated otherwise, percentages in the table are based on the total number of utterances made with respect to a decision point (twenty-one utterances for Intersections 1–4, nineteen for Intersection 5). Our main goal concerns the interplay of structure and function in route directions, aiming to systematically specify the underlying conceptualizations of directions. We analyse our results in

TABLE 6.1. Frequency of occurrences of conceptual categories according to decision points

Intersection number	1	2	3	4	5
					
I. Main direction concept	95.2	95.2	95.2	85.7	89.5
a. unmodified projective terms	95.2	95.2	95.2	66.7	84.2
b. modified projective terms	0.0	0.0	0.0	19.0	5.3
II. Use of verbs	100.0	95.2	100.0	100.0	100.0
a. neutral verb	95.2	95.2	100.0	61.9	68.4
b. course of route	0.0	0.0	0.0	28.6	10.5
c. drift	4.8	0.0	0.0	9.5	21.1
III. Redundancy	9.5	4.8	4.8	4.8	31.6
IV. Scene	0.0	0.0	4.8	0.0	36.8
V. Reference to structure	19.0	52.4	14.3	66.7	68.4
a. specified structure	9.5	42.9	0.0	42.9	57.9
b. unspecified structure	9.5	9.5	14.3	23.8	10.5
VI. Ordering concepts	9.5	42.9	0.0	0.0	47.7
a. by numbers	9.5	28.6	0.0	0.0	47.7
b. by 'next'	0.0	14.3	0.0	0.0	0.0
VII. Landmark use	47.6	4.8	95.2	95.2	94.7
a. decision influencing landmarks	47.6	4.8	95.2	85.7	15.8
b. decision confirming landmarks	0.0	0.0	0.0	9.5	78.9

terms of the frequency patterns of our seven conceptual categories, separately for each spatial situation.

6.4.2.1 The main direction concept People apply several means to render direction concepts in route directions more precise. As shown in Table 6.1, most utterances contain projective terms (category I), which indicates that direction concepts are principally encoded by projective terms or at least entail them. As an alternative, a small number of utterances employ compass directions. Other exceptions, occurring at Intersections 4 and 5, were utterances like *go up*, *all the way past Taco Bell*, *keep going on the main road*, and *through an intersection*, all of which indicate their main direction concept by contextual information without using projective terms.

Our data contain no utterances with more than one modifier of a projective term, i.e. no occurrences of expressions like *very sharp right*. This means that our participants considered only one hedge term (cf. Lakoff 1973; Vorwerg 2003) sufficient to indicate a gradual membership in a specific direction category, such as *slightly right*. Additionally, as the results for categories Ia and Ib (Table 6.1) show, modifications generally occurred only very infrequently. It is especially striking that no modifications at all were given at Intersection 1; in spite of the fact that the direction change is between two major axes. Even in the case of the most complex intersections (4 and 5), the percentage of modifications is low. This is in contrast to the specification of spatial relations between objects in object localization tasks, as for example found by Vorwerg (2003), and results by Klippel and Montello (2004), where participants often expressed gradation effects by using combinations of hedge terms, such as *take a slight right*, for a direction change similar to the ones in our present analysis (e.g. Intersection 4). In a referential identification task where spatial reference primarily serves to achieve contrast, precise descriptions are also rare, although people do tend to combine two projective terms in the case of a position between two axes (Tenbrink 2005, 2009), and they do account for increased complexity in the scenario. Vorwerg and Tenbrink (2007) directly compared referential identification tasks and localization tasks, finding clearly that speakers' spatial descriptions are more detailed if the position between objects needs to be described, rather than just identifying an object's identity in answer to a 'which' question. In both cases, however, the presence of competing objects led to an increased use of modified projective terms. We do not observe this in our present data, where an increase in spatial complexity does not necessarily lead to increased description complexity, at least not as far as the usage and modification of projective terms is concerned. This is a striking result, since route description tasks are similar to 'which' questions in that the future direction needs to be identified out of a set of competing directions. Clearly, speakers systematically choose different methods of identifying the intended direction, other than modifying the projective term used for conveying the main direction concept.

How are direction concepts conveyed instead? One option, as indicated in section 6.4.1, is to encode directional information in the verb. While neutral verbs in combination with a projective term occur most frequently at standard intersections (such as Intersection 3 in Table 6.1) and when direction changes are close to the main lateral axis, i.e. approximately 90 degrees left or right (as at Intersections 2 and 3), verbs that inherently indicate a change of direction reflect direction concepts other than orthogonal left and right turns. Our analysis shows that verbs referring to the course of the route, such as *follow*, occur nearly exclusively at Intersection 4, which indicates that they require a special spatial configuration. Some possible candidates—all of them present in Intersection 4—are the absence of competing branches in a similar direction, no more than a moderate change in direction, and possibly the availability of a landmark immediately after the intersection in an unambiguous location. The use of such 'course of the route' verbs is often accompanied by a characterization of structure. Drift verbs such as *veer*, in contrast, most frequently occur at Intersection 5. Here, it seems specifically to be the presence of competing branches in a similar direction that induces speakers to use the verb to indicate that the direction deviates from the prototypical axis. However, since drift verbs also occur in other situations, they can be said to serve as a general alternative means to indicate such deviations, similar to modifications of the projective term. In the following subsections, we discuss other alternative means of conveying direction concepts.

6.4.2.2 Ordering concepts Ordering concepts may be applied in situations where more than one alternative for a specific direction change is available. Instead of relying on rendering the gradedness of a direction change more precise, it might be more reliable to coarsen the direction concept and combine it with ordering information as provided by the spatial structure. In specific spatial situations, the change of direction may be completely specified by ordering information, primarily by counting streets (category VIa, Table 6.1), e.g. *take your second left*. In the real world, such an expression may be used to identify an exit on a roundabout or highway exit.

Although ordering information is generally assumed to be robust (Schlieder 1995), ambiguity can be involved in its linguistic representation. Ordering can occur within or between intersections, which can typically be disambiguated by referring to the spatial situation itself. For example, at Intersections 1 and 2, all ordering concepts referred to the streets between intersections, while at Intersection 5, counting was done within the intersection itself. However, in the latter case there were further complications: an utterance like *take the third road on your left* can be interpreted in two ways, as counting may start either with the branch closest to the straight direction or with the one closest to the back direction. However, it is probably reasonable to assume that speakers typically count the branches as they encounter them along the route, that is, from the perspective of the mover. Since there is only one occurrence in our data in which this assumption does not match the spatial situation, we conclude that in spite of potential complications, ordering is a strong method to disambiguate directions at complex intersections.

6.4.2.3 Landmark use In our scenario, landmarks are very prominent, as they are the only environmental features we provided in the map (besides the street network and the route). This fact in itself explains the high frequency with which landmarks are mentioned (cf. category VII, Table 6.1) in situations where a landmark is available for reference, especially since mentioning landmarks is generally recognized to be a cognitively ergonomic means of providing route directions (e.g. Tom and Denis 2003). Mentioning landmarks simplifies the description of the action to be taken, because further explanations are often unnecessary if a landmark sufficiently distinguishes the intended action from alternative choices.

Some interesting conclusions can be drawn from analysing the frequency with which landmarks are mentioned together with the positions of the landmarks, as different landmark positions have different saliencies with respect to the action performed at an intersection (Klippel and Winter 2005). At Intersection 1, only about half of the participants combined their instruction to change direction at the decision point with the mention of a landmark. Others tended to conceptualize the landmark as belonging to the route segment before the intersection. This is illustrated by the following utterance (emphasis in intonation being transcribed here in capitals): *from the green flag walk straight... you'll pass a 76 gas station on the RIGHT... immediately after that, hang a right.* Here, the participant explicitly states that the relevant intersection occurs only after the landmark, thus using the landmark as an indicator in spite of its slightly remote position. Other participants mentioned the landmark but did not (grammatically) integrate this information with the decision point, as exemplified by: *past the 76 gas station... and then you turn RIGHT.* The distinction is subtle but nevertheless informative, since it reflects different conceptualizations of the situation. In the first example, the portion of the route is conceptualized as one part where the action to take is anchored by a landmark; in the second example, the action is split up into the two distinct parts of passing a landmark and making a right turn. Landmarks in the latter case are also referred to as *Wegemarken* (route marks) by Herrmann et al. (1998).

Intersections 3 and 4 differ from Intersection 1 in that the landmarks are positioned directly at the decision points. Here, the landmark was regularly used to anchor the action, as indicated by utterances like *turn right at the K-Mart*, where the direction change is directly associated with the landmark. At Intersection 5, on the other hand, the landmark is positioned only after the decision point. Not surprisingly, the function of the landmark shifted towards confirming the decision rather than anchoring it (category VIIb, Table 6.1). Since this intersection is particularly complex, most participants made use of this strategy. The following utterance illustrates the difficulty: *there is gonna be.. a.. c..centre, a corner where there is a convergence look like THREE streets.. and you're gonna gooo.. whoa.. that's gonna be a TOUGH one.. you're gonna have to.. take.. the THIRD street.. on your LEFT.. aaand.. if you take it, it's gonna be SOMEwhat of a LEFT bend.. and you SHOULD PASS a FEDEX.. if you don't pass the FedEx, then you've taken the wrong street and you're going the wrong way, ah*...

Additionally, intersections without any salient properties can function as landmarks due to their ordered occurrence within a specific part of the route. An example is found at Intersection 2, which is preceded by another intersection. Using the first intersection as a landmark results in utterances like *turn right after the first intersection*. Apart from these cases, the intersections themselves can be conceptualized as landmarks. The following section deals with this point.

6.4.2.4 Structure Our data reflect the fact that reference to spatial structure can fulfil several functions. An intersection can be used as a landmark (cf. Klippel, Richter, and Hansen, 2005), especially if it is distinguishable from the background information (Lynch 1960; Presson and Montello 1988). In the case of route directions, the background (i.e. the context) is set up by the route as such and the structural characteristics of the preceding intersections. In these cases, spatial structures in our data were simply mentioned as such, i.e. referred to as *corner*, *intersection*, *curve*, etc. (category Vb, Table 6.1). Typically, such references appear as basic-level terms that are generally assumed to be the most general and most cognitively efficient expressions (Mervis and Rosch 1981).

Alternatively, the naming of structural aspects can be part of establishing a proper situation model, to prepare for conceptualizing the action to be carried out at an intersection. As the example in the previous section shows, some intersections are viewed as extremely difficult, which is reflected in the complexity of the utterances. The labelling of an intersection by an informative term such as *six-way intersection* can be helpful in this case. Our data show that the intersection's structure is increasingly mentioned as the complexity of the intersection grows (category Va, Table 6.1), and also that the intersection's structure is specified more frequently in cases where the structure provides substantial additional information and is simple to refer to. For example, in Intersection 2 the decision point occurs at a *dead end*, which is easily recognized. Intersection 3, in contrast, is rather prototypical (Evans 1980; Moar and Bower 1983; Tversky and Lee 1999); the mental situation model initiated by referring to this intersection simply as *intersection* matches the encountered configuration sufficiently closely.

Interestingly, at Intersection 3, all references to intersection structure serve to describe the location of the landmark instead of the future direction of movement, as in *at the corner where the K-Mart is located*. This reflects the fact that, in this case, describing the (prototypical) intersection structure is insufficient, because there is another similar intersection and another corner nearby. The decision point needs to be identified unambiguously, which is achieved by mentioning the landmark.

Finally, another potential structural aspect which is not covered by our scenario but which is obviously salient to speakers is the distinction between main and minor roads. Our data contain several references to the *main road*. As all streets in our map have the same width, participants seemed to infer this information from some cue such as the course of the streets.

6.4.3 Discussion

Our analysis shows that speakers make use of a broad variety of strategies to instantiate a situation model that is suitable for identifying the intended future direction of movement at a decision point (i.e. an intersection). Apart from using hedge terms to render direction changes—specified by projective terms—more precise, as is done when describing spatial relationships between two objects, a number of further options is available in the domain of route directions. Clearly, spatial direction is only one of several salient aspects of the spatial situation that speakers make use of in order to convey the intended movement. Another prominent aspect, which has been dealt with frequently in the research literature, is reference to landmarks. Since landmarks serve different functions, their exact position with respect to decision points is pertinent for characterizing the action to be performed. The following general tendencies with respect to landmarks can be inferred from our analysis:

1. A landmark conceptualized at a position before a decision point may sometimes be used to identify the intended intersection, but it can also be mentioned separately in order to identify or confirm the route segment before the decision point.
2. A landmark conceptualized at a position at a decision point will (a) frequently be used to identify the intended intersection, especially if other intersections are nearby; and (b) frequently be used to anchor the direction change that has to be performed at the intersection in lieu of mentioning the intersection as such. Linguistically the anchoring is encoded as *turn* (*right*, *left*) (*before*, *after*, *at*) {landmark X}.
3. A landmark at a position after a decision point can be used to confirm that the correct direction has been identified. This will be done most frequently with particularly complex intersections.

Furthermore, speakers resort to other strategies that allow them to indicate future directions. To characterize these systematically, we propose the following general categories that reflect the conceptualization of turns at decision points and thereby correspond to different kinds of spatial knowledge. These categories reflect results of the data analyses we report in this chapter, as well as our general experience studying route directions.

1. Qualitative direction concepts expressed by projective terms, references to absolute directions, and direction-indicating verbs, e.g. *turn right, go west, veer right.*
2. Qualitative modifications (hedges) specifying direction, as in *slightly right.*
3. Quantitative measures of directions in degrees, e.g. *turn exactly 90 degrees.*
4. Clock directions, e.g. *turn to three o'clock.*
5. Reference to structure, e.g. *dead-end, fork.*
6. Ordering concepts, e.g. *the first exit.*
7. Reliance on landmarks to indicate direction, as in *where the statue is.*

These categories can typically be combined with each other, as in *veer slightly right 45 degrees at the first street on your right, where the statue is.* In our data, they occurred with different frequencies; some did not occur at all (e.g. reference to a clock direction), in spite of the fact that they do (infrequently) occur in other spatial contexts, as our own research has shown (e.g. Tenbrink 2006). Qualitative concepts occur almost throughout; but in contrast to other discourse tasks, they are seldom modified, indicating that speakers prefer other means of rendering their descriptions sufficiently precise. Our analysis of the results has, apart from a number of interesting details with regard to the distribution of options, shown that the complexity of a decision point—in terms of the combination of both structural and functional aspects—generally plays a major role in the choice of concepts. Thus, complex decision points lead to a number of systematic changes in speakers' utterances. Specifically, the more complex the intersection:

(a) the more verbose is the description, employing several of the above-mentioned options;
(b) the more varied are the verbalizations (e.g. strategies other than using projective terms are applied);
(c) the more references are made to intersection structure;
(d) the more alternative instructions are offered (redundant information) (see category III, Table 6.1); and
(e) the more references are made to competing directions (see category IV, Table 6.1).

The notion of complexity has, in the course of our analysis, proved to be crucial and yet difficult to specify. It concerns neither the structure alone (e.g. the number of branches) nor the change of direction as such; rather, it concerns a complex interplay among several factors. For example, although Intersections 2 and 3 are structurally very similar, the concepts expressed with respect to these locations during the course of the route description differed considerably (see Table 6.1). This is clearly motivated by the specific kind of direction change to be made at each of the intersections, and the ensuing range of competing or interfering directions that become relevant in each case. Intuitively, it should be possible to simply say *keep going straight at the intersection* even if the intersection in question is structurally complex. With a main direction concept such as 'straight', such a decision point does not imply a high degree of functional complexity. This observation is consistent with our results, although the data we report here do not explicitly include such a case. However, the remainder of this corpus of directions (see also Klippel et al. 2003) shows that, for instance, the intersection following Intersection 4 (see Figure 6.3 and Table 1) is hardly mentioned at all by participants. Typically, speakers combine their descriptions by spatially chunking subsequent individual decision points into higher-order route direction elements (HORDE), as in *when you get to the second intersection, you're going to make a left*. Similarly, the turn-off preceding Intersection 2 in our current data is typically only referred to by way of an ordering concept such as *your second right*, if at all.

Our analysis suggests that it is possible to derive cognitive measures of complexity, and that participants' strategies change along with the complexity of the intersections. The results therefore add to approaches at the interface of architecture and psychology that aim to derive measures for the legibility of buildings and built structures (e.g. Weisman 1987; O'Neill 1992). Generally, our results fit with earlier work in the area of route directions (e.g. Denis et al. 1999), spelling out the effects of route and path complexity in more detail than has been done before. In the context of a different setting, Bethell-Fox and Shepard (1988) suggested that dealing with complexity might be something that requires training but does not pose difficulties to a speaker. In the case of route directions, as personal experience attests, it is likely that complexity may specifically pose one major reason why spontaneous route directions given on the street are often unsuccessful (Habel 1988). It may also be the case that North Americans handle complexity less efficiently than Europeans due to the often more regular street grid structure (as conjectured by Davies and Pederson 2001). On the other hand, some studies indicate that there are no general differences in how route information is organized in the two continents; for example, landmarks are used in both languages to chunk route parts (Klippel et al. 2003).

Our analysis of route verbalizations shows how strategies change depending on the complexity of the interplay of structure and function. The tendencies we identify can provide a basis for a more systematic model of route directions, which is desirable for a number of reasons. For example, aspects of complexity and the ensuing changes in verbalization are not systematically implemented in current web-based navigation services (with the exception of ordering concepts at circles). Furthermore, the interaction of structural and functional aspects is not sufficiently accounted for in formal characterizations of spatial relations (as in many qualitative spatial reasoning models, e.g. Frank 1996).

6.5 Conclusion and outlook

In this chapter, we have systematically addressed verbalization data in a route description task by relating features of the descriptions to features of the decision points. We have identified patterns of speakers' choices that point to conceptualizations of complexity in relation to the given task (i.e. the functional rather than the structural aspect), and identified the range of means by which direction-givers identify future directions at complex decision points. Crucially, modifications of projective terms are not a primary means of describing direction change; rather, speakers use direction-indicating verbs, refer to landmarks and spatial structures, and offer additional information about the spatial situation.

Our research points to a number of desirable future research directions. Although the analysis in this chapter only concerned English-language data, the system we developed for the analysis (see section 6.4.1 and Table 6.1) allows comparison of route directions given in different languages. Our discussion of the complexity of decision points and the interplay of structure and function (with its impact on the conceptualization of actions) suggests avenues for exploring culturally influenced aspects of route directions. Therefore, a detailed analysis of the structuring of route knowledge in different languages and cultures—even a comparison between North American and European speakers—may shed light on differences based on language or on the environments to which speakers are accustomed. An interesting future endeavour would be to identify linguistically and culturally shared structuring principles for the organization of route knowledge, and to pinpoint systematic differences. Such research becomes especially important as companies offer navigation services that operate globally.

This leads us to the question of optimal or cognitively ergonomic route directions, especially with respect to automatic systems. It has been known for some time that a typical strategy of web-based route direction systems is cognitively inadequate, namely, to rely completely on street names as indications of direction change (cf. Tom and Denis 2003). Our approach is therefore to extract general principles for disambiguating direction changes at intersections, in order to specify how appropriate situation models can be instantiated with the use of verbal descriptions covering the conceptualization of the action to be performed with a minimum of information and a maximum of specificity (e.g. Grice 1989).

Our analysis of the verbalizations showed that the concept of 'at', at a decision point, is used in a spatially constrained sense. For anchoring an action at an intersection by a landmark, the landmark's position has to be directly at the meeting point of the branches. Further research is needed to detail the influences on conceptualizing landmark positions in cases where further objects are present. Additionally, there seem to be contextual factors as, for instance, introduced by the modality—such as *on foot*, *by bike*, or *by car*—of travel (Wahlster et al. 1998) that influence whether an object is used as an anchor for an action at a decision point or used to identify the route segment before the decision point. A detailed analysis of nearness concepts of landmarks and decision points is therefore one of our future goals, in accordance with approaches to the formal characterization of common-sense knowledge (Yao and Thill 2005). Generally, an important future aspect of our work will be to identify a method to formally characterize the interplay of structure and function on the conceptualization of motion in networks as part of route knowledge and directions.

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