

How Space Structures Language¹

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Abstract. As Talmy has observed, language schematizes space; language provides a systematic framework to describe space, by selecting certain aspects of a referent scene while neglecting the others. Here, we consider the ways that space and the things in it are schematized in perception and cognition, as well as in language. We propose the Schematization Similarity Conjecture: to the extent that space is schematized similarly in language and cognition, language will be successful in conveying space. We look at the evidence in both language and perception literature to support this view. Finally, we analyze schematizations of routes conveyed in sketch maps or directions, finding parallels in the kind of information omitted and retained in both.

1 Introduction

Language can be effective in conveying useful information about unknown things. If you are like many people, when you go to a new place, you may approach a stranger to ask directions. If your addressee in fact knows how to get to where you want to go, you are likely to receive coherent and accurate directions (cf. Denis, 1994; Taylor and Tversky, 1992a). Similarly, as any Hemingway reader knows, language can be effective at relating a simple scene of people, objects, and landmarks. In laboratory settings, narratives relating scenes like these are readily comprehended. In addition, the mental representations of such scenes are updated as new descriptive information is given (e. g., Glenberg, Meyer, and Lindem, 1987; Morrow, Bower and Greenspan, 1989). Finally, times to retrieve spatial information from mental representations induced by descriptions are in many cases indistinguishable from those established from actual experience (cf. Franklin and Tversky, 1990; Bryant, Tversky, and Lanca, 1998). Contrast these successful uses of language with another one. You've just returned from a large party of both acquaintances and strangers. You try to describe someone interesting whom you met to a friend because you believe the friend knows this person's name. Such descriptions are notoriously poor. In fact, in some situations, describing a face is the surest way to reduce memory for it (Schooler and Engstler-Schooler, 1991). Why is it that language is effective for conveying some sorts of spatial information but not others?

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The answer may lie in the way that language structures space. In 1983, Leonard Talmy published an article with that title which has rippled through cognitive psychology and linguistics like a stone skipped on water. In it, he proposed that language "schematizes" space, selecting "certain aspects of a referent scene...while disregarding the remaining aspects." (p. 225). For example, a term like "across" can apply to a set of spatial configurations that do not depend on exact metric properties such as shape, size, and distance. Use of "across" depends on the global properties and configuration of the thing doing the crossing and the thing crossed. Ideally, the thing doing the crossing is smaller than the thing being crossed, and it is crossing in a straight path perpendicular to the length of the thing being crossed. Thus schematization entails information reduction, encoding certain features of a scene while ignoring others. Talmy's analysis of schematization focused on the fine structure of language, in particular, closed-class terms, and less on the macroscopic level of sentences, paragraphs and discourse that uses a language's large set of open-class lexical items as elements. Closed-class grammatical forms include "grammatical elements and categories, closed-class particles and words, and the syntactic structures of phrases and clauses." (p. 227). Despite their syntactic status, they express meanings, but only limited ones, including space, time, and perspective, important to the current issues, and also attention, force, causation, knowledge state, and reality status. Because they appear across languages, they are assumed to reflect linguistic, hence cognitive, universals.

Not only language, but also perception and conception, which Talmy has collectively called '*ception*', schematize space and the things in it (Talmy, 1996). In the following pages, we first examine how '*ception*' schematizes. Then, we go on to examine how the schematization of '*ception*' maps onto language. There is no disputing that language is a powerful clue to '*ception*', that many of the distinctions important in '*ception*' are made in language, some in closed-class terms, others in lexical items. Yet, there are notable exceptions. As observed earlier, people are poor at describing faces, though excellent at recognizing them, a skill essential for social interaction. In contrast, routes and scenes are more readily conveyed by language despite the fact that, like faces, routes and scenes consist of elements and the spatial relations among them. Here, we propose a conjecture, the Schematization Similarity Conjecture: To the extent that language and '*ception*' schematize things similarly, language will be successful at communicating space.

To understand how '*ception*' schematizes space is to understand that perception is not just bottom-up, determined by the stimulus input alone, but is in addition top-down, conditioned by what is already in the mind, momentarily and longterm. Therefore, any generalizations based on schematizations of space necessarily lead to oversimplifications. One of these is ignoring context. It has long been clear, but is sometimes overlooked, that how people perceive of, conceive of, and describe a scene is deeply affected by a wealth of nonindependent factors, including what they are thinking, how they construe the scene, the goals at hand, past experience, and available knowledge structures.

Despite the fact that language and '*ception*' always occur in a context, there seem to be levels of schematization that hold over many contexts. People do not reinvent

vocabulary and syntax at every encounter. If they did, communication would not be possible. Schematization in language and in 'ception is always a compromise; it must be stable enough for the general and the venerable, yet flexible enough for the specific and the new. In the following sections, we will review the existing research on how both 'ception and language schematize space and objects in it, abstracting certain features and ignoring others. This review of schematization will be schematic itself. It will be an attempt to give the "bottom line," the general aspects of objects and space most critical to our understanding of them. The evidence comes from many studies using different techniques and measures, that is, different contexts. Some of this evidence rests on language in one way or another. Ideally, evidence based purely on perception could be separated from evidence resting on language in order to separate the schematization of perception alone from that influenced by language. But this is probably not possible. For one thing, using non-linguistic measures is no guarantee that language is not implicitly invoked. With these caveats in mind, let us proceed to characterize how the things in the world and the spatial relations among them are schematized.

2 Figures, Objects, Faces

When we look at the world around us, we don't see it as a pattern of hues and brightnesses. Rather, we perceive distinct figures and objects. For human perceivers, then, space is decomposed into figures and the spatial relations among them, viewed from a particular perspective. Similarly, figures can be decomposed into their parts and the spatial relations among them. Our experience of space, then, is not abstract, of empty space, but rather of the identity and the relative locations of the things in space.

2.1 Figures

There are two major questions in recognition of the things in space. First, how do we get from retinal stimulation to discernment of figures? This is the concern of the *Figures* section. Next, how do we get from a view-dependent representation to a view-independent representation? This is the concern of the *Objects* section. One of the earliest perceptual processes is discerning figures from background (e. g., Hochberg, 1978; Rock, 1983). Once figures are identified, they appear closer and brighter than their backgrounds. In contrast to grounds, figures tend to have closed contours and symmetry, so the Gestalt principles of figurality, including continuity, common fate, good form, and proximity, all serve as useful cues. Thus, the eye and the brain look for contours and cues to figurality in pursuit of isolating figures from grounds. Another way to put this is that figures are schematized as contours that are likely to be closed and likely to be symmetric.

Language for Figures. The distinctions that Talmy elucidates begin with figure and ground. Talmy borrows these terms from their use in perception and Gestalt psychology described above. Just as perception focuses on figures, so does language, according to Talmy. He argues that language selects one portion of a scene, the figure, as focal or primary, and describes it in relation to another portion, the ground, and sometimes in addition in relation to a third portion of the scene. We say, for example, "the horse is by the barn" or "the horse is near the trough in front of the barn." The figure is conceived of as geometrically simpler than the ground, often only as a point. It is also usually smaller, more salient, more movable, and more recent than the ground, which is more permanent and earlier. Although the ground is conceived of as geometrically more complex than the figure, the ground, too, is schematized, as indicated in English by prepositions, a closed-class form. For example, "at" schematizes the ground to a point, "on" and "across" to a two-dimensional surface, "into" and "through" to a three-dimensional volume.

A comparison between 'ception and language of figures shows a number of similarities and differences. Both divide the world into figures and ground, introducing asymmetries not present in the world per se. In 'ception, figures appear closer and brighter than grounds, becoming more salient. In language, figures are the primary objects currently salient in attention and discourse. Nevertheless, the object that is figural in perception may not be figural in language. An example comes from unpublished eye movement data collected by Griffin (Z. Griffin, 1998, personal communication). In scanning a picture of a truck about to hit a nurse, viewers fixate more on the truck, as the agent of the action. Yet, the nurse is the figure in viewers' descriptions of the scene. In addition, figures in 'ception are conceived of as shapes with closed contours and often symmetric, yet in language, they are often reduced to a point in space.

2.2 Objects

The human mind does not seem content with simply distinguishing figures from grounds; it also identifies figures as particular objects. But objects have many identities. What we typically sit on can be referred to as a desk chair, or a chair, or a piece of furniture. Despite the possibilities, people are biased to identify objects at what has been called the "basic" level (e.g., Brown, 1958; Murphy and Smith, 1982; Rosch, 1978). This is the level of chair, screwdriver, apple, and sock rather than the level of furniture, tool, fruit, and clothing, or the level of easy chair, Phillips-head screwdriver, delicious apple, and anklet. This is the level at which people seem to have the most information, indexed by attribute lists, relative to the number of alternative categories that must be kept in mind.

Many other cognitive operations also converge at the basic level. It is the level at which people are fastest to categorize instances (Rosch, 1975), the level fastest to identify (Murphy and Smith, 1982), the level people spontaneously choose to name, the highest level of abstraction for which an outline of overlapped shapes can be recognized, the highest level for which there is a common set of behaviors, and more (Rosch, 1978; Rosch, Mervis, Gray, Johnson, and Boyes-Braem, 1976). The basic level, then, has a special status in perception, in behavior, and in language (Tversky,

1985; Tversky and Hemenway, 1984). Rosch (1978) suggested that the natural breaks in labeling are based in the natural breaks in objects as we perceive them given our perceptual apparatus. Features of objects are not uniformly distributed across classes of objects. Instead, features of objects are correlated, that is, things that have feathers and beaks also lay eggs and fly.

The natural level for identifying objects, then, is the basic level. Arriving at view-independent representations of objects requires more than the visual input alone; it also requires some more general knowledge about the objects in question (e. g., Marr, 1982). As for figures, contour and symmetry characterize particular objects, but with greater specificity. Basic objects, such as couches and socks, can be recognized from a set of overlapping instances, standardized for size and viewpoint (Rosch, et al., 1976). Shapes of different kinds of socks are quite similar, but quite different from shapes of other objects even from the same category, such as shirts or ties. Furthermore, objects are most easily recognized when they are viewed from a canonical orientation, upright, and typically 3/4 view (Palmer, Rosch, and Chase, 1981). This view is one that presents the greatest number of features characteristic of the object. In many cases, those characteristic features are parts of the object (Biederman, 1987; Tversky and Hemenway, 1984); the greater the number of object parts detectable, the easier the identification of the object (Biederman, 1987). Parts have a dual status in cognition. On the one hand, they are perceptually salient as they are rooted in discontinuities of object shape (e. g., Biederman, 1987; Hoffman and Richards, 1984). On the other hand, different parts have different functions and serve different purposes to humans (Tversky and Hemenway, 1984). Parts are at once components of perception and components of function and facilitate inferences from appearance to behavior. Symmetry, too, is used to identify specific objects. Viewers interpret asymmetric nonsense figures as upright, off-center views of symmetric objects (McBeath, Schiano, and Tversky, 1997). Perception, then, schematizes specific figures, that is, objects, as shapes, composed of parts, and most likely upright and symmetric.

Language for Objects. Objects are typically named by open-class terms, thus not considered by Talmy. Perhaps individual objects are not an inherent part of the structure of language because there are so many of them and many of those are context specific. The place-holder for individual objects, nouns or subjects, is, of course, part of language structure as are various operations on them, such as pluralizing. Nevertheless, there are clues to way objects are conceived in the ways that names for objects are extended. Shape seems to be a primary basis for categorization as well as for extension of object terms, in both children's "errors" and adults' neologisms (Clark, 1973; Clark and Clark, 1979; Bowerman, 1978a, 1978b). There are old examples, like "stars" and "hearts" that are not really shaped like stars or hearts. And there are new examples, such as the body types loved by cardiologists--"pear-shaped"--and that disparaged by cardiologists--"apple-shaped,"--affectionately called simply "pears" and "apples."

2.3 Faces

Faces are a special kind of object in several ways. Recognition of faces is most typically at the level of the individual, not at the level of the class. For example, when we talk about identifying or recognizing a face, we mean recognizing that a specific face is the current president of the United States and not his brother. In contrast, when we talk about recognizing an object as a chair, we're usually not concerned with whose chair or even what type of chair. Of course, we need to identify some objects other than faces at the level of the individual. But identifying my house or car or jacket is facilitated by features such as locations or color or size, and such features may not facilitate identifying specific faces. Faces, in addition, are not integral objects in and of themselves, they are parts of other objects, human or otherwise. Recognizing faces is dependent on internal features, not just an outline shape. This is why we see faces not only in the moon, which has the proper outline, but also in cars, which do not. Furthermore, the features need to be in the proper configuration. Changing the overall configuration leads to something that is not a face, and even altering the relative distances among properly configured features diminishes resemblance substantially (cf. Bruce, 1988). For identifying individuals, in addition to configuration of features, the shapes of component features are also important, and those shapes are not regular. Similar to objects, 3/4 views are best recognized in faces (e. g., Hagen & Perkins, 1983; Shapiro & Penrod, 1986), perhaps because a 3/4 view gives better information about important component features, such as shape of nose, chin, and forehead. Even more than for objects, orientation is important in faces; upside down faces are considerably harder to recognize than right side up (e. g., Carey and Diamond, 1987; Yin, 1969). Turning objects upside down seems to be more disruptive to objects with irregular internal features such as faces than to objects with horizontal and vertical internal features like houses. Schematization of individual faces, then, is far more precise, entailing orientation as well as configuration and shapes of internal features.

Language for Faces. As noted earlier, faces are often perceived at the level of the individual. Similarly, they are referred to by open class terms, that is, names of individuals. In contrast to names for objects, when names of individuals are extended, it is typically personality traits or personal history that is extended, not shape as for objects, in fact, not appearance at all (cf. Clark and Clark, 1979). Identifying faces requires 'ception of subtle spatial relations among the parts (e. g., Bruce, 1988). Language, however, schematizes spatial relations in cruder categories, such as above, below, front, back, near, far, between, and among. Finer distinctions can be made but in the technical language of measurement. In addition, estimates of fine measurement are frequently unreliable (e. g., Leibowitz, Guzy, Peterson, and Blake, 1993). Thus, the puzzle that language is adequate for conveying routes but inadequate for describing faces is solved. The spatial relations usually needed for getting around are readily captured by language but the subtle spatial relations needed for identifying faces are not readily schematized by language.

2.4 Summary of Figures, Objects, and Faces.

For detecting figures, contour (especially closed contour) and symmetry are among the diagnostic features. For objects which are figures identified at the basic level, specific contours or shapes that are decomposable into parts are characteristic, along with orientation and symmetry. For faces which are parts of objects identified at the level of an individual, the internal configuration and shapes of features is critical, in addition to orientation and symmetry. Returning to language, note that figures and objects are named by open-class terms, as are grounds. These refer to classes of things, and, interestingly, are sometimes extended to refer to shapes (as in "pear-shaped"). Faces, by contrast, are called by names that refer to individuals, not classes, much like street addresses, and that have no perceptual interpretation other than reference to the individual. Names for objects and faces, though less schematized than closed-class terms, are nevertheless schematized. A table is a table regardless of point of view, of color, of material, of location, to a large extent of size. This is not to say that people cannot or do not remember individual objects with their specific features and locations, but that people generally think about and refer to objects more abstractly.

3 Spatial Relations

Thus far, we have discussed the elements in space and their schematization in 'ception and language. Knowledge and schematization of space also entail the spatial relations among elements. In fact, we observed that entities can be decomposed into parts and the spatial relations among them, and that as entities are identified at more specific levels, the spatial relations among the parts become more critical. In this section we turn to the schematization of spatial relations. In perceiving a scene, figures are not just discerned and identified, they are also located. Figures are not located in an absolute way, but rather relative to other reference figures and/or a frame of reference. We note, for example, that we left the car by a particular street sign or that we buried the family heirlooms in the middles of a circle of trees. Locating figures relatively makes sense if only because perception of a scene is necessarily dependent on a particular viewpoint, yet a view-independent representation of a scene is desirable in order to recognize a scene or object from other viewpoints. Reference objects and reference frames serve to schematize the locations of figures. Memory for orientations and locations of dots, lines, or figures is biased toward reference objects or frames (e. g., Howard, 1982; Huttenlocher, Hedges, and Duncan, 1991; Nelson and Chaiklin, 1980; Taylor, 1961; Tversky, 1981).

How are reference objects and frames selected? Proximity, salience, and permanence are influential factors (Tversky, 1981; Tversky, Taylor, and Mainwaring, 1997). Domain, semantic, and pragmatic factors, such as current goals and recent experience, can also affect choice. Reference objects are other figures in the same scene as the target object whereas reference frames tend to surround the scene, the set of figures, in some way.

Natural borders and axes often serve as reference frames, such as the sides of a room, the sides of a piece of paper, the land and the sky. Horizontal and vertical lines or planes are privileged as reference frames, whether actual or virtual, as in the sides of a page or map at odd orientations. Acuity is better for horizontal and vertical lines, as is memory, and both perception and memory are distorted toward them (see Howard, 1982 and Tversky, 1992 for reviews). Horizontal and vertical lines are relatively easy for children to copy, but diagonal lines cause difficulties and are drawn toward horizontal and vertical (Ibbotson and Bryant, 1976). The human body, especially one's own, also serves as a natural reference object. The projections of the natural horizontal and vertical axes of the body, head/feet, front/back, and left/right, are a privileged reference frame, with certain of the axes more accessible than others, depending on body posture and viewpoint (e. g., Bryant, Franklin and Tversky, 1992; Bryant, Tversky and Lanca, 1998; Franklin and Tversky, 1990). Regions defined by the axes also vary depending on viewpoint; for example, for self, front is larger than back, and both are larger than left, and right, but not for other.(Franklin, Henkel and Zangas, 1995).

3.1 Schematization and Language of Spatial Relations.

Spatial relations, then, are schematized toward reference objects and frames, especially horizontal and vertical planes. Spatial relations are frequently but not always referred to by closed-class terms, prepositions, such as "at," "on," and "in," or "in front of," "on top of," "across," "near," "between," and "parallel to." The schematization of closed-class elements is topological, according to Talmy. It abstracts away the metric properties of shape, size, angle, and distance, distinctions that are normally expressed in lexical elements. Talmy's analyses have been extended by others, especially in the direction of examining the topological constraints underlying prepositions, that is, the expression of spatial relations between a figure and a ground (e. g., Herskovits, 1986, Lakoff, 1986; Landau and Jackendoff, 1993; Vandeloise, 1986). Some languages, however, don't have prepositions. Even in English, which does, open class terms also describe spatial relations, as in "support," "hold," "lean," or "approach."

The scene alone does not determine how it is schematized to spatial relations, though it is often presupposed that the perceptual array is primary (e. g., Carlson-Radvansky and Irwin, 1993; Logan and Sadler, 1996; Hayward and Tarr, 1995). The speaker's perspective, intent, and goals, as well as cultural practices, are some of the influences on schematization. The interpretation of the scene in light of current goals and cultural practices are among the influences on selection of spatial relation terms. As Talmy (1983) noted, we can go "through" or "across" a park, and get "in" or "into" a car. Appropriateness of words like "near" or "approach" depend on the nature of the figure and the ground (Morrow and Clark, 1988). What's more, abstract uses of prepositions depend entirely on functional, not spatial relations, as in "on welfare" or "in a bad mood" (Garrod and Simon, 1989). Even spatial uses have a functional basis. One can say "the pear is in the bowl" where the expression is even though in fact the pear is outside the bowl on top of a pile of fruit. This is because the pear's location is controlled by the location of the bowl (Garrod and Simon, 1989). Although the quali-

ties of schematization of spatial relations in both language and perception are similar, the open-class terms that are used to refer to figures preserve far more detailed spatial information than the terms used to refer to spatial relations. Moreover, although memory for spatial location and orientation is biased toward reference frames and objects, it does not coincide with them. The schematization of the language of spatial relations may be in the same directions as the schematization of perception of spatial relations, but it is far more extreme.

4 Motion

Figures in space are not necessarily static, nor are viewers. Perceiving and conceiving of motion are needed from the beginning of life, and, in fact, motion in concert is another clue to figurality (e. g., Spelke, Breinlinger, Macomber, and Jacobson, 1992). Perceiving motion accurately is not a simple matter. For example, generations of paintings of horses galloping have portrayed their legs in impossible configurations. When motion is relatively simple, as in the path of a pendulum or a falling object, people are able to recognize correct and incorrect paths of motion. Yet, some people correctly recognizing paths of motion may nevertheless produce incorrect paths, indicating flawed conceptions of motion (Kaiser, Proffitt, Whelan, and Hecht, 1992). Although motion is continuous, people seem to conceive of it as sequences of natural chunks (Hegarty, 1992). And although motion is continuous, people tend to conceive of it hierarchically (e. g., Newton, Hairfield, Bloomingdale, and Cutino, 1987; Zacks and Tversky, 1997). As for objects, there seems to be a preferred or basic level, the level of going to a movie (Morris and Murphy, 1990; Rifkin, 1985). Although more can be said about actions and events, we focus here on schematization of motion in perception and language.

4.1 Schematization of Motion.

Many aspects of motion, such as frequency and causality, are carried by closed-class terms (Talmy, 1975, 1983, 1985, 1988), yet other aspects of motion are referred to by open-class terms, particularly verbs. Verbs vary notoriously within and across languages as to what features they code (e. g., Gentner, 1981; Huttenlocher and Lui, 1981; Talmy, 1975, 1985, 1988). For example, some languages like English regularly encode manner of motion in verbs, as in "swagger," "slink," "slide," and "sway," others primarily encode path in verbs, as in "enter," "exit," and "ascend" (Talmy, 1985). Choice of verb is open to construal. The same perceptual sequence, such as leaving a room may be described in many different ways (Gentner, 1981), such as "went," "raced," "stumbled," "cried," "got chased," "got pushed," or "escaped" out the door. Although activities, like objects, are conceived of hierarchically, descriptors of activities are not necessarily organized hierarchically. Huttenlocher and Lui (1981) have argued that verbs, in contrast to the nouns used to refer to objects, are organized more as matrices than as hierarchies.

Like figures, motion can be schematized at various levels of specificity. The simplest way of thinking about motion is the path of an entire figure, a point moving in space. Like objects, paths are perceived in terms of frames of reference and distorted toward them. Just as in locating objects, in perceiving paths of motion, horizontal and vertical coordinates often serve as a reference frame (e. g., Pani, William, and Shippey, 1995; Shiffrar and Shepard, 1991). A more complex level of schematization than a path of motion is a pattern of parts moving in relation to one another. This level is analogous to schematizing an object as a configuration of parts. It is the level of understanding of pulleys (Hegarty, 1992) or gears (Schwartz and Black, 1996) or of distinguishing walking from running, which people readily do from patch-light displays (e. g., Cutting, Proffitt, and Kozlowski, 1978; Johansson, 1975). Yet another level of schematization is manner of motion, as in distinguishing modes of walking, such as swaggering or slinking.

5 Route Directions and Maps

The simplest schematization of motion to a path or route is readily encoded in language (e. g., Denis, 1994; Levelt, 1982; Linde and Labov, 1975; Klein, 1982; Perrig and Kintsch, 1985; Talmy, 1975; Taylor and Tversky, 1992a, 1992b, 1996; Wunderlich and Reinhelt, 1982). Routes are schematized as a point changing direction along a line or a plane, or as a network of nodes and links. Though by no means identical with perceptual or conceptual schematization, route maps can be regarded as schematizations that are closer to externalizations of perceptions than descriptions. Depictions of routes use spatial relations on paper to represent spatial relations in the world. Moreover, they can use iconic representations of entities in the world to represent those entities. Routes, then, can be externally represented as descriptions or depictions. Like route directions, route maps are commonly used to convey how to get from A to B. Which is better seems to depend on the specifics of the navigation task (e. g., Streeter, Vitello, and Wonsiewicz, 1985; Taylor, Naylor, and Chechile, in press; Taylor and Tversky, 1992a). Both route directions and route maps, then, seem adequate to convey information sufficient for arriving at a destination. We were interested in whether descriptions and depictions of routes schematize them similarly.

To get at this question, we approached students outside a campus residence and asked them if they knew how to get to a popular off-campus fast-food restaurant. If they did, we handed them a piece of paper, and asked them to either write down the directions or sketch a map. We obtained a total of 29 maps and 21 directions. Sample descriptions appear in Table 1 and sample maps in Figures 1. Note that route maps differ from other kinds of sketch maps in that they contain only the paths and landmarks relevant to the specific route. Following Denis (1994), we broke down the depictions and descriptions into segments consisting of four elements each: start point, reorientation (direction), path/progression, and end point. As the paths are continuous, the start point for one segment served as the start point for the next. In this situation, the segments corresponded to changes of direction (action) in the route. It would be possible to have segments separated by, say, major intersections or land-

marks without changes in direction, but this did not happen in this corpus. Because the sketch maps, unlike street maps, contained very little information about the environment not directly related to the path, it was not difficult to segment the maps. As defined, each segment contains sufficient information to go from node to node. Together, these segments contain the information essential to reach the destination. Two coders coded the maps and descriptions for these categories of information and for categories of supplementary information. They first coded a subset of the protocols, and after reaching agreement on those, coded the rest separately.

Table 1. Examples of Route Directions

DW 9

From Roble parking lot
R onto Santa Theresa
L onto Lagunita (the first stop sign)
L onto Mayfield
L onto Campus drive East
R onto Bowdoin
L onto Stanford Ave.
R onto El Camino
go down few miles. it's on the right.

BD 10

Go down street toward main campus (where most of the buildings are as opposed to where the fields are) make a right on the first real street (not an entrance to a dorm or anything else). Then make a left on the 2nd street you come to. There should be some buildings on your right (Flo Mo) and a parking lot on your left. The street will make a sharp right. Stay on it. that puts you on Mayfield road. The first intersection after the turn will be at Campus drive. Turn left and stay on campus drive until you come to Galvez Street. Turn Right. go down until you get to El Camino. Turn right (south) and Taco Bell is a few miles down on the right.

BD 3

Go out St. Theresa
turn Rt.
Follow Campus Dr. way around to Galvez
turn left on Galvez.
turn right on El camino.
Go till you see Taco Bell on your Right

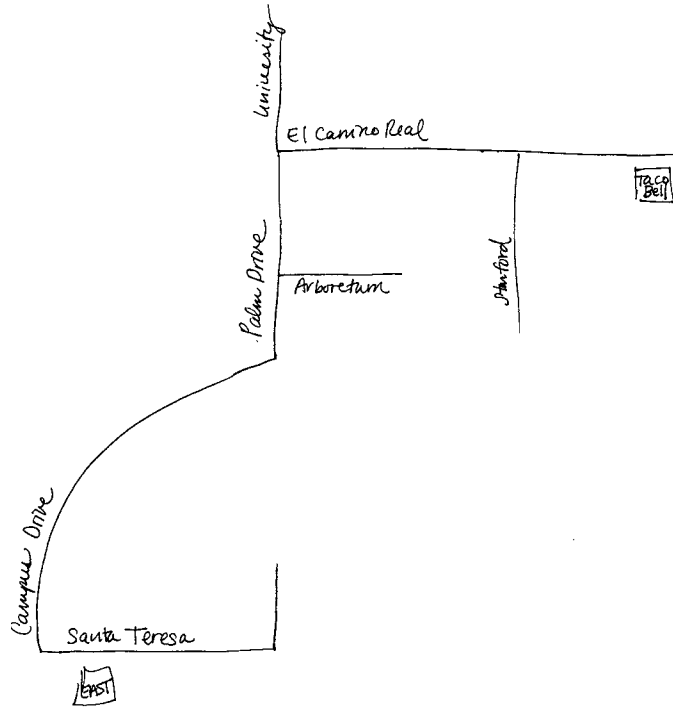
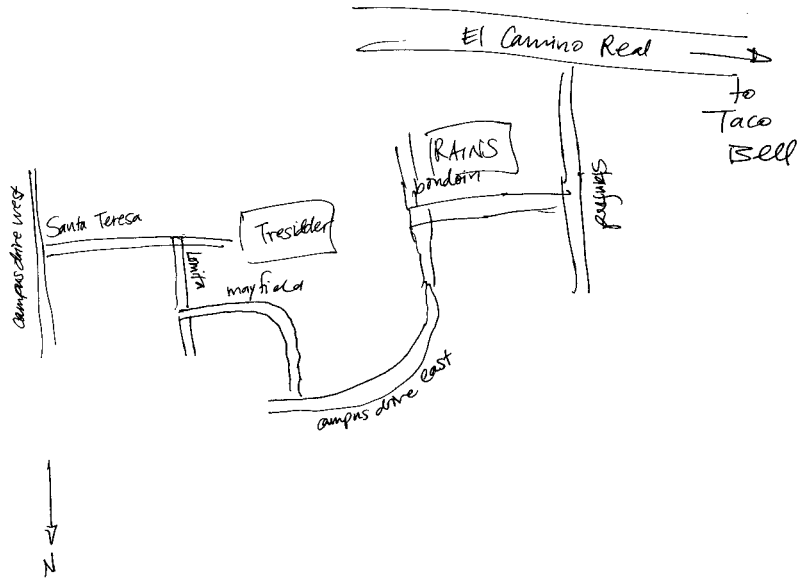


Figure 1. Examples of Route Maps

5.1 Essential Information in Descriptions and Depictions.

Not all of the information included in both maps and directions fit into the essential four categories. In fact, 91% of the people giving directions and 90% of the people sketching maps added some information in addition to the start and end points, reorientation and path/progression. The additional information for maps included cardinal directions, arrows, distances, and extra landmarks. That same kind of information was added to directions. In addition, some directions also contained detail describing the landmarks and paths. This information, while not essential, may be important for keeping the traveler confidently on track. It anticipates that travelers may become uneasy when there is a relatively long distance without a change of orientation or distinguishing feature or when there is uncertainty about the identity of a landmark. The descriptions obtained by Denis (1994) and by Gryl (1995) had the same character.

5.2 Schematizing in Descriptions and Depictions.

Not only did the same critical and supplementary information constitute the majority of content in route descriptions and depictions but also that information was represented in parallel ways. For both, start points and end points were landmarks, paths, buildings, fields, intersections, and the like. For maps, these were often presented as icons, typically schematized as rough geometric shapes, and often named, such as street or building names. Reorientations or turns were also schematized. In maps, they were typically portrayed as lines that were more or less perpendicular. About half the participants used arrows to explicitly indicate direction. Nearly half used double lines to indicate paths, though single lines predominated. There are at least two ways to interpret the use of double lines to indicate streets. The double lines could be iconic, as streets have width. Alternatively, they could indicate a perspective on the scene, conceiving of paths as planes rather than lines. In directions, there was a limited vocabulary and a limited structure, with slots for actions (verbs), directions, and paths. The common actions were the verbs "turn," "take a," "make a," and "go." The verb was omitted in some descriptions, especially those that were simply a list of the form: left on X, right on Y. Thus, in both maps and directions, changes of orientation were schematized as turns of unspecified angles. In maps, they were depicted as approximate right angles irrespective of their actual angle. Memory for intersections is also biased toward right angles (e. g., Byrne, 1979; Moar and Bower, 1983; Tversky, 1981). Progressions, too, were schematized. In maps, they appeared either as straight lines or as slightly curved ones, leaving out much of the detail in the real environment. The distinction between straight and curved paths was also made in language. By far, the two most frequent verbs for expressing progressions were "go" and "follow," and they were used differentially for straight and curved paths. "Go" was used 17 times for straight paths and only twice for curved (Chi-square = 9.0, $p < .005$),

whereas "follow" was used only 5 times for straight paths but 20 times for curved ones (Chi-square=11.8, $p < .001$). Thus, although the actual paths and intersections had many forms, a single category of intersection and two categories of path shape sufficed in schematization, whether verbal or pictorial.

5.3 Sufficiency in Descriptions and Depictions.

We found that both descriptions and depictions consist of the same critical and supplementary information schematized in similar ways. Was the information sufficient for conveying the route? That is, did each segment contain all the essential components: start and end points, path, and direction? For maps, the answer was a rousing yes. All of the maps contained all of the essential information. For descriptions, in contrast, the initial answer was no, much information was missing. In fact, 75% of the descriptions were missing a start or an end point and 45% of the descriptions were missing path/progression information. However, many communications contain missing information that can be inferred from context or medium (e. g., Clark and Clark, 1977). In the case of route directions, two simple rules of inference allow recovery of most of the missing information. The first is *continuity*. According to continuity, if a start point is omitted, it is assumed to be the same as the previous end point, or conversely, if an end point is missing, it is assumed to be the same as the subsequent start point. In fact, for depictions, where continuity is inherent in maps, start and end points are not well-defined or distinguishable. The second inference rule is *forward progression*. According to forward progression, the direction of motion is assumed to be forward. The first protocol in Table 1 lacks any end points, yet they can be easily inferred from the subsequent action. This protocol has only one explicit mention of forward progression, at the end ("go down few miles"); rather, the forward progression is implicit. After applying these two rules of inference, 86% of the directions were sufficient. In three of the descriptions, the direction of a turn was missing and could not be recovered.

Although maps and directions schematize routes in similar ways, maps are more complete than directions, which need to be supplemented with inference rules. Another way to put it is that directions are more schematized than maps. This difference, we believe, is inherent in the graphic medium, in the mapping of real space to representing space. Paths in real space are continuous and forward moving given particular start and end points; they are portrayed as such in representing space. Even though the mapping from real space to representing space is schematic rather than strictly iconic, it pragmatically presupposes the two inference rules, continuity and forward progression. The naturalness of the mapping of space to space is further evident in the greater variability of verbal expressions than pictorial expressions for the four elements.

6 Schematization of Space in Language and Cognition.

Clearly, there are parallels in the way that cognition and language schematize the spatial world. Language is revealing in this enterprise, not just closed-class terms, but open-class terms as well. Graphic communications, such as route maps, are also schematized, again with similarities to language and cognition. But both language and cognition are rich, and are able to express and encode more or less schematically, depending on the situation and how it is construed.

Figures, spatial relations among them, and paths between them seem to be schematized similarly in language and cognition. Language serves well to convey routes and environments, provided the routes and environments are well-known (e. g., Taylor and Tversky, 1992a, 1992b, 1996). In contrast, language seems to be inadequate at conveying faces, voices, and emotions. We can only speculate on the answer. It is likely that languages develop in small groups of people who know each other and who use language in direct social encounters. Faces and voices are present in those situations so they convey themselves--and emotions--directly, they do not have to be conveyed in words. They are tagged with proper names known to the community so that, if needed, they can be gossiped about in their absence. Proper names, in contrast to category names and closed-class terms, do not convey any spatial information in themselves. Like addresses or GPS coordinates, they point to individuals or locations without giving any other information about them. Routes are described by terms with more general spatial meanings. Unlike faces and voices, they may not be present in the social encounters in which they are discussed. Many cannot even be viewed in entirety from a single vantage point, much less the current one. What's more, individuals often set out alone to forage or hunt, so that developing ways to communicate route directions is useful in communal living. For faces, voices, and routes, then, the Schematization Similarity Conjecture--that language will be successful in communication to the extent that language and 'ception schematize similarly--receives support, along with a speculative explanation.

At the outset we observed that perception inevitably affects language, that at least in part, people develop vocabularies and syntax to communicate about things in the world as they perceive them, and as they need to talk about them. It is equally clear that language influences perception. Language calls attention to particular things and states and qualities and distinctions in the world and ignores others. Over repeated experience, the selective attention encouraged by language can become habitual, so that it seems as if language is no longer involved. Undoubtedly, habitual attention to certain things, states, qualities, and distinctions in space affects the way space is schematized, further intertwining the schematization of language and cognition.

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