

## 1. Ways of Talking About Spatial Locations.

Spouse 1: Honey, where's the baby?

Spouse 2: Here. At 132 Maple. By the sofa. In front of me. Two feet behind you. Go down the hall, go right, then go down until you get to the kitchen. At Joey's house, which is just north of the library and east of the coffee shop.

How do we tell someone where something is? This simple question turns out to have not so simple answers. The first thing to notice about the answers to the "where" question is that they are relative to a reference object and frame of reference. The next thing to notice is that the selection of reference object and reference frame depends on what the information provider, Spouse 2, presupposes about the state of knowledge of the information receiver, Spouse 1. Finally, providing location often entails other information, such as direction and distance. Let us examine the answers more closely, as they reveal some of the techniques that people use to convey location.

"Here." This is the easiest way to convey location, if it works. Like all answers, it depends on common ground between provider and receiver of information. Here, they must share an understanding of where "here" is and what "here" is. "Here" is context-bound. For one thing, it means something different when interlocutors are in close proximity than when they are distant; it may refer to one's person or one's country.

"At 132 Maple." Another direct way to convey location is to give an address. At first, an address like 132 Maple Avenue, Highland Park, Illinois or the GPS coordinates for that location might seem like absolute locations, but of course they are relative as well, referring to streets in cities in states or to longitude, latitude, altitude relative to Greenwich. Nevertheless, if the speaker has reason to believe that the listener knows the reference points and frame, then specifying a location with an address can be very effective. What makes addresses so easy is that they refer to points or to regions or volumes that can be conceived of as points (e. g., Talmy, 1983). The baby's at 132 Maple; exactly where in the house or on the lot is not needed.

"By the sofa." It is not always practical or appropriate to convey location by means of an address. Fortunately, people have many other ways to do that. Another simple way to convey location is relative to a landmark, in this case, the sofa. Like an address, using a landmark to convey location only requires thinking about points, in this case, proximity to a point rather than identity with a point. This way of locating is slightly more complex than an address as both a landmark and a relationship to a landmark are indicated. However, it is not necessary to know or state the exact spatial relationship of the landmarks to the object.

"In front of me." This way of specifying location also uses a landmark, "me," and a spatial relationship, specifically, a direction, "in front of." However, both landmark and spatial relationship are more complex than in the preceding, "by the sofa" example. The landmark is regarded as a volume, not as a point, and not as an undifferentiated volume, but as one with intrinsic sides, typically six of them, front, back, left, right, top, and bottom. Direction is specified as a projection from one of the intrinsic sides. Here, it is conceived of in two or three dimensions; it refers to a portion of the space around the landmark, the region projected from the intrinsic side.

Although a portion may seem like too large to help specify location, people seem to agree on the most likely places within the portion (e. g., Franklin, Henkel, and Zangas, 1995; Hayward and Tarr, 1995; Logan and Sadler, 1996; Regier, 1996). They even agree on locations that are hedged, such as “mid-left” or “far right”(Franklin, et al., 1995). People also condition their expectations about places in portions depending on the context, for example, “near” a wall is understood to be a different distance for ants than for elephants (Morrow and Clark, 1988).

“Two feet behind you.” As before, this way of specifying location adds an additional element of complexity to the preceding. This expression includes a landmark, a projected direction, and a distance. Not only is adding distance an additional complexity, another feature to keep in mind, but it is also a feature that is vague. People’s minds do not contain yardsticks or scales. On the contrary, people’s estimates of distance, weight, size, and other quantities are approximate, despite metric terminology (e. g., Leibowitz, Guzy, Peterson, and Blake (1993).

“Go down the hall, then go right and go down until you get to the kitchen.” This answer is again more complex than the previous ones. Instead of specifying a location, it specifies a procedure for arriving at the location. Such an expression can require all of the previous elements (in this case, for brevity, it eliminates some) as well as conceptions of paths and turns. Paths can be specified similarly to portions, above, as directional projections from intrinsic sides. However, they are conceived of as one-dimensional lines. They can also be specified as links between landmarks. Turns are with reference to paths; they are typically specified as projections from intrinsic sides at a specified point and orientation on a path. Such procedures have been termed route descriptions (e. g., Perrig and Kintsch, 1985; Taylor and Tversky, 1992b). They describe the locations of landmarks relative to the intrinsic sides of an observer changing position and orientation along paths in an environment.

“At Joey’s house, which is just north of the library and east of the coffee shop.” This answer illustrates yet another complex way of specifying location. Instead of prescribing a method of arriving at the location, it sets the scene the target is part of and specifies the location within the scene. This way of specifying location rests on the locations of other landmarks and the directions projected from the surrounding environment. Such scene settings for spatial location have been termed “survey” descriptions (e. g., Perrig and Kintsch, 1985; Taylor and Tversky, 1992b). They describe the locations of landmarks relative to one another using the directions of the encompassing environment.

**1.1. Elements of Location Expressions** Note the richness of spatial language that is readily invoked simply to say where the baby is. And this is only a hypothetical example; real life examples usually supply additional surprises. Nevertheless, let us review the types of spatial language that can be used to specify location that these examples illustrate. Points, planes, paths, and portions seem to be the key elements, along with directions and distances. Points are typically landmarks, identified by names. They can be intersections, or other features; the essence of points is that they are conceptualized as dimensionless locations. Landmarks in and of themselves can be conceived of as points, but also as one-dimensional paths, two-dimensional planes, or three-dimensional volumes. Paths are one-dimensional connectors. They can be identified in several ways: as lines between landmarks, as known roads or links in an environment, or as lines emanating at a direction from a landmark. In everyday speech, directions are given approximately, not in degrees (e. g., Franklin, Henkel, and Zangas, 1995).. Direction can be expressed relative to the intrinsic sides of the landmark (viewed as a dot or a line or a plane or a volume) or relative to the encompassing environment (viewed as a plane or a volume). Distance can be expressed in standard units such as feet and miles. More typically in spontaneous speech,

distance seems to be expressed in the approximate units of experience, such as blocks or even time. Route and survey (scene-setting) descriptions use combinations of points, paths, portions, distances, and directions.

Expressing location, then, can invoke considerable complexity and richness of spatial language. What elements seem to be preferred, and why? It is tempting to make a case for simplicity, the less the better. Specifying location is a communication task, typically between two people, but conceivably between the same person at two different times. Communication is easier when there is less to compute in order to produce an utterance and less to compute in order to understand and to remember an utterance. Thus, the emphasis on ease and simplicity takes into account both the cognitive and the social nature of communication. Both provider and receiver are presumably to some degree aware of what is easy for each to produce and comprehend. In actual communication, simplicity does not always prevail; for one thing, communication is fallible, so redundancy diminishes error.

Here, I present evidence from some of our research that shows preferences for using some kinds of information over others in specifying location. First, the conclusions. Using a landmark alone should be ideal, where it is sufficient. Adding direction information is often needed, but computing and comprehending directions adds to the cognitive burdens of both providers and receivers of spatial information. Some directions are easier to compute and comprehend than others, and the easier ones should be preferred. Directions are more easily conveyed approximately, typically as categories plus hedges, than analogically, as, for example, projections from the sides of the body or the cardinal directions rather than degrees. Distance information is problematic for one of the reasons direction information is problematic. People have only vague and approximate knowledge of distances, so distance information can be unreliable. Finally, minimal utterances may be easier to compute and to comprehend, but minimal utterances run the risk of being misunderstood or forgotten. Most effective human communication is redundant.

In the interest of redundancy, I repeat the claim: To express location, where possible, landmarks should be preferred, directions should be avoided, especially those that are hard to compute and comprehend, and distances should be avoided. Direction and distance information will be given when proximity to landmarks is not sufficient, but it will be in hedged categories. The evidence I will bring to bear on the claims comes from several research projects, some investigating production of location expressions, others investigating comprehension of location expressions.

## **2. Constructing Location Expressions**

**2.1. Locating One of Two Identical Targets.** You are Secret Agent U working with Secret Agent Z. You are in different places in the lobby of a hotel looking at a pair of potted palms, identical except that one hides a cache of stolen diamonds. You need to write a brief message on your secret communicator to let Z know which palm hides the diamonds. This was the “tell other” task that Mainwaring, Ogishi, Schiano and I presented to participants. (Mainwaring, Tversky, Ogishi, and Schiano, 2000). In the “ask other” variant, U asked Z a yes/no question whose answer would reveal the target. In the “tell self” variant, Agent U wrote a brief reminder for U to use later. Participants used depictions to understand the scenes. The depictions were maps that provided the elements that could be used to identify the location of the target. The depictions always included the relative locations of U and Z and of the identical objects. U and Z were either displaced 180 degrees facing each other or displaced 90 degrees. The pair of objects were either lined up with U or not. The depictions could also include a landmark that was informative, that is, closer to one object than the other, or a landmark that was uninformative, that is, equidistant between the objects. Finally, the depictions could include the direction of

north, or both a landmark and an indication for cardinal directions. This task was expanded from a task used by Schober (1995); it was developed to investigate whether providers of information favored their own perspective or that of the receivers of the information. We also wanted to know if information providers would select a perspective that was neither their own nor their interlocutors when the presence of landmarks or cardinal directions enabled neutral perspectives.

As expected, participants used all of the locating devices we expected them to use, and invented some we hadn't expected as well. One surprise was using Agent Z's perspective in the "tell self" task. Since Agent Z wasn't part of the communication, it can't be an example of using the other's perspective. Rather, participants seem to be using Agent Z as a landmark, coding the target as the one that is closer to Agent Z. We then began examining the other tasks and layouts more closely and found that almost wherever possible, information providers chose to use "near" a landmark, whether the landmark was an object or an interlocutor in the scenario. When scenarios contained no landmarks or cardinal directions, all other things being equal, information providers tended to favor the perspectives of the information receivers in the tell other task. This is presumably because the information provider wants to ease the cognitive burden of the information receiver. The notable exceptions to using the other's perspective were when "near me" or "in front of me" could be used, especially to avoid the direction terms "right" and "left."

Not only was using a landmark without a direction term preferred in most situations where it was sufficient, but also "near" was preferred to "far." This is despite the fact that by considerations of markedness, "far" should be preferred, as the term for the dimension is "distance." Why was "near" preferred? We think it is because there is less ambiguity about where "near" is. "Near" is a region surrounding and close to the landmark. The region defined by "far" radiates in increasing and unbounded distance in all directions from the landmark.

Wherever reasonable, then, providers of information chose to express location using closeness to a landmark rather specifying a direction. When they did need to specify a direction, they preferred "in front" to "left" or "right." "Front" and "back" are with reference to asymmetric, easily distinguished parts of the body as well as easily distinguished parts of objects (e. g., Franklin & Tversky, 1990). By contrast, the left side of a body or an object is usually quite similar to the right side. "Front" and "back" are easier to discern, hence easier labels to produce and to comprehend. In tasks requiring pointing to or remembering directions around the body or around a doll, participants used a larger region for front and back than for left and right (Franklin, et al., 1995). Participants in the secret agent study also used cardinal directions; for those, there was no preference of one axis, north-south or east-west over the other.

**2.2. Descriptions of Environments.** In a series of experiments, Taylor and Tversky (1992a; 1996) gave participants one of a variety of maps to memorize, including maps for a museum, a park, a theme park, a recreational area, a zoo, a convention center, a town. After studying the map, participants were asked to write a description of the environment the map depicted. One variable of interest was the perspective of the description. Participants used one of two perspectives, or, surprising the linguists, a combination of both. In a *survey* perspective, a fixed viewpoint above the environment was established and landmarks were described relative to each other in terms of north, south, east, and west. A survey perspective sets a scene and locates landmarks within it. In a *route* perspective, the viewpoint was the changing viewpoint of a traveler in the environment; landmarks were located with respect to the traveler in terms of left, right, front, and back. A route perspective provides procedures for travelling through the environment, locating landmarks en route. In both perspectives, the direction terms preferred are categorical,

drawn from the sides of the body or the cardinal directions. Distances are rarely given; instead, action points on paths are delineated by landmarks or intersecting paths. Overall, environments that had a single path and landmarks at a single size scale attracted relatively more route perspectives and environments that had multiple paths and size scales attracted relatively more survey descriptions. Characteristics of the environments, then, determined description perspective, at least in part.

**2.3. Depictions and Descriptions of Routes.** Lee and I (Tversky and Lee, 1998, 1999) stopped students outside a dormitory and asked them if they knew where a popular fast-food joint was. If they did, they were asked to write down directions or else draw a map to the place. Both maps and directions could be segmented according to a system developed by Denis (1997) into sequences of four elements: *start point*—you exit the train station--, *reorientation*—you turn right--, *path/progression*—you go straight--, and *end point*—until you reach the hotel. Moreover, the ways that the elements were represented corresponded so closely that automatic translation between route depictions and directions seems possible. This is because although the route maps could allow analog representation of landmarks, paths, turns, and distances, the route maps tended to code these discretely. For example, intersections or turns were drawn as approximately 90 degrees; the deviations in drawing did not correspond to deviations of the intersections from 90 degrees in the world. Similarly, in language, turns were conveyed as “take a,” “make a,” or “turn” without specifying degrees of turn. Paths were drawn as straight or curved; the curve was again approximate, not accurate. Descriptions also made a two-way distinction. For straight paths, the corresponding description was “go down”; for curved paths, the corresponding description was “follow around.” Even distance was only schematically represented in the route maps; in fact, larger space seemed to be allocated to more complex intersections, not necessarily to longer distances. Longer distances were often indicated by broken lines, an explicit violation of the spatial correspondence of distance in representing space reflecting distance in real space. In both depictions and descriptions, distance was delineated indirectly and inexplicitly as the path between two readily recognized landmarks. That is, the information provider seems to be relying on the ability of the receiver to recognize and keep track of landmarks, not explicit distances.

For both the extended descriptions of environments and the route directions, people used landmarks and paths. The paths were typically defined by landmarks that demarcated a start point and then either a direction or another landmark serving as an end point. On occasion, number of blocks was used. Thus distance was rarely expressed directly, and even more rarely in conventional units.

Presumably, had degree of turn or curvature or distance been critical to wayfinding, further distinctions would have been made in both depictions and directions. Nevertheless, the hedges given in actual discourse are rarely in conventional units, but rather in descriptors like “a little bit to the left” or “a wide turn” (e. g., Franklin, et al., 1995). The important point is that both depictions and directions for routes are schematic, they tend to be categorical rather analog, they discard information not necessary for keeping on track. Furthermore, both maps and directions schematize in similar ways. The critical elements are landmarks and paths, with direction and distance indicated only approximately.

**2.4. Directions as Fields and Lines.** The use of direction terms in conveying which object is the target and in giving route directions differ in subtle ways. In the case of distinguishing the target object, terms like “front” or “west” designate two- or three-dimensional region projected from an intrinsic side of a person or object. The target is said to be somewhere in that region. What is interesting is that there are shared expectations about the likelihood of different parts of the region (e. g., Carlson-Radvansky and Irwin, 1993; Franklin, et al., 1995; Hayward and Tarr, 1995; Logan and Sadler, 1996; Morrow

and Clark, 1988; Regier, 1996). The presupposition is that the language specifying region combined with perceptual information in the environment is sufficient to pick out the target. In the case of providing route instructions, direction terms like “right” and “east” are used as direction lines; they describe one-dimensional paths in the environment.

This review of research on production of location expressions in a variety of situations has illustrated that people prefer to locate objects as near a known landmark if possible. If further information is needed, people add specific information conveying the direction from a landmark; they prefer directions that are easier to compute, that is, they prefer to use “front” or “back” to “left” or “right.” Here, direction terms define a region projected from the intrinsic sides of a body or object. For complex location expressions that entail several segments, direction terms serve to define paths from one landmark to another.

Thus, landmarks are the first thing used, alone, if possible, or with spatial relation terms if needed. Spatial relations expressing proximity, such as “near” are preferred to spatial relations expressing direction. Directions with natural asymmetries are preferred to those without. The directions most used are gross categorical ones. Distances are most often defined by initial and final landmarks rather than quantitative units. When units are used, experiential ones, such as blocks or time, are preferred to standard units, such as degrees or miles.

## **Comprehending Location Expressions.**

**2.5. Accessing Regions Defined by Directions.** “You are at the local museum of Natural History, visiting the Space Exhibit, which occupies two floors of the building. A large section of the second-story floor is missing so that large objects can be displayed in an open area spanning the two floors. You are standing on the second floor on the walkway that surrounds this open area. As you look in front of you, you see a handsome portrait of John Glenn. The portrait is a bright watercolor painting, signed by the artist. Directly to your left a large, rocky meteorite sits on a heavy table. It is about the size of a small boulder, but it looks to you to be dense enough to weigh a ton. Looking behind you, you see a map of the solar system, including the orbit paths of all the planets. The map is large enough for you to read from where you stand. You now look directly upward, where a full-sized spacesuit hangs from the ceiling. It is shiny and white, and it looks like it was never used. Peering downward toward the first floor, you see a communications satellite directly below where you are standing. It consists of a metal ball, 2 feet in diameter, with a metal dish attached to it.”

Participants studied descriptions like these that located 6 objects to each side of an observer, addressed as “you.” Then the observer was reoriented to face another object in the environment, and probed for the objects currently at various directions from the body by the direction terms, “front,” “back,” “head,” “feet,” “left,” and “right.” Although the descriptions did not favor one area of space over another, reaction times to the probes differed systematically. Specifically, when the observer was described as upright in the environment, responses to head and feet were fastest, followed by responses to front and back. Responses to left and right were slowest (Franklin and Tversky, 1990). Franklin and Tversky explained these findings by the *spatial framework theory*. According to the spatial framework theory, observers construct a spatial mental framework consisting of projections of the axes of the body, and associate objects to it. The axes vary in accessibility depending on asymmetries in the body axes and in the environment, as in the upright case, the head/feet axis of the body is aligned with the only asymmetric axis of the world, the axis formed by gravity. The head/feet axis, like the front/back axis has salient asymmetries. Because of the confluence of body and environmental axis asymmetries,

head/feet is fastest for upright observers, followed by front/back, followed by right/left, as that axis lacks salient asymmetries. The reclining observer turns from side to front to side to back, so no axis of the body is aligned with gravity. In the reclining case, relative access times rely solely on body asymmetries. The front/back axis importantly separates the world that can be seen and manipulated from the world that cannot be seen or manipulated, and indeed, in the reclining case, retrieval times are fastest to front/back, and next fastest to head/feet.

These results have been replicated in several variants of the original situation, varying viewpoints (surrounded by objects or looking onto them), numbers of observers, whether person or room is moving, and mode of input (language, diagram, model, actual environment) among other things (e. g., Bryant and Tversky, 1999, Bryant, Tversky, and Franklin, 1992; Bryant, Tversky, and Lanca, in press; Franklin, Tversky, and Coon, 1992; Tversky, Kim, and Cohen, 1999). The same or systematically varying pattern of retrieval times to the regions around the body emerges. These biases in comprehension converge with the biases in production observed in the earlier studies. The same regions, defined by directions from the sides of the body, that are easier to produce are also the regions that are easier to comprehend.

**2.6. Comprehending Extended Descriptions.** As noted earlier, environments are typically described using either a route perspective or a survey perspective or a combination of both. Do mental representations established by the two perspectives differ? The results of Taylor and Tversky (1992b) for limited environments well-acquired through descriptions suggests that perspective-free mental representations can be established. Participants studied equivalent route or survey descriptions of environments. They then verified verbatim and inference statements from both perspectives. The inference statements contained information that was available in the texts, but was not explicit, such as spatial relations from a different viewpoint. Verbatim statements in the perspective not read were equivalent to inference statements. On the whole, error rate was low. Nevertheless, participants were faster and more accurate on verbatim statements than inference ones. For the inference statements, there were no differences in either reaction time or errors for statements from the read perspective and the other perspective for both perspectives. This suggests two generalizations about representing discourse. First, there seems to be a representation of the text per se, conferring an advantage to verbatim statements. Second, there seems to be a spatial mental representation that is perspective-free. Such a representation may be like an architect's model, more general than either a route or a survey perspective, one that allows the taking of either of those two perspectives with equal facility.

In research in progress, Lee and Tversky are investigating the online construction of spatial mental models from route and survey descriptions. In a typical experiment, participants read several sentences describing an environment from one perspective and then a target sentence from the same or other perspective. This was followed by true/false statements in both perspectives. Switching perspectives did exact a cost in reading time and in errors. Thus, perspective matters in establishing mental representations, but may not matter once mental representations are well-established, at least for these relatively small and well-learned environments. Follow-up studies using sentences that mix perspectives indicate that the largest cost in perspective-switching is a change in direction terms, rather than a change in reference object.

### **3. In Sum.**

The results from comprehension tasks converge with those from the production tasks. Landmarks are relatively easy. Direction terms can be difficult to comprehend. "Left" and "right" are more difficult than "front" and "back" or "head" and "feet" or "above" and

“below.” There is no strong evidence that egocentric reference terms are easier or harder than environmental reference terms, though some languages avoid egocentric reference terms (Levinson, 1996). Conventional direction and distance units are avoided. In fact, explicit distance is rarely provided. Rather, the beginning and end of a path is indicated by the landmarks located at the beginning and end.

What makes an expression “easy?” Language habits and conventions develop in social situations where speakers and hearers collaborate in conveying information (e. g., Clark, 1996). Through these interactions, users have the opportunity to learn what kinds of expressions are effective and what kinds are not. As a result, common ground is established and language becomes more efficient. Many of the same phenomena occur when a person communicates with him or herself, that is, when a person commits something to memory and then retrieves it. Failures of communication to self or other warn what expressions should be avoided and successes of communication teach what expressions should be adopted. Efficient language capitalizes on expressions that are relatively easy and accurate for speakers to produce and for listeners to comprehend. For spatial language, ease and accuracy depend on human information processing skills but also on spatial knowledge. The spatial knowledge that is more readily encoded and represented in everyday interactions in the world is undoubtedly knowledge that is more readily conveyed in language. Thus, linguistic habits and conventions can reveal spatial knowledge (e. g., Talmy, 2000). What the work on language suggests is that people are especially adept at recognizing and remembering landmarks and paths and that directions and distances are approximate, and wherever possible, delineated by landmarks and paths rather than quantitative units. These linguistic practices in fact reflect spatial knowledge (e. g., Tversky, 2000a, 2000b).

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