

Research Report

THE INFLUENCE OF FUNCTIONAL RELATIONS ON SPATIAL TERM SELECTION

Laura A. Carlson-Radvansky and Gabriel A. Radvansky

University of Notre Dame

Abstract—Expressions describing the spatial relation between two objects can be interpreted from a perspective defined by the objects (*intrinsic*) or by the viewer or the environment (*deictic-extrinsic*). Identifying the factors that govern the selection of one perspective over another is an important step in understanding the interaction between language and perception. In two experiments, we explored the influence of a functional relation between two objects on the formulation of a spatial expression relating the objects. Both rating and production tasks showed that people preferred to use intrinsic descriptions in the presence of a functional relation and deictic-extrinsic descriptions in the absence of such a relation. These results suggest that contextual aspects of the scene influence spatial term selection.

Consider a coffee cup on a desk. Its location could be described by any of the following utterances:

- (1) The coffee cup is to the left of the monitor (from the viewer's perspective).
- (2) The coffee cup is in front of the printer.
- (3) The coffee cup is to the right of the door.

The description that is ultimately selected reflects aspects of the perceptual representation and the mapping of language onto that representation (Jackendoff & Landau, 1991; Landau & Jackendoff, 1993; Levelt, 1982, 1984; Talmy, 1983).

Understanding what influences the formulation of such spatial expressions is an important goal in cognitive psychology (e.g., Carlson-Radvansky & Irwin, 1993, 1994; Garnham, 1989; Levelt, 1982, 1984; Talmy, 1983; Tversky, 1991; Ullmer-Ehrich, 1982; Wunderlich, 1981). The experiments reported here assessed whether a functional relation between two objects influences the formulation of a spatial expression involving those objects.

Interpreting the direction indicated by the spatial terms in Utterances 1 through 3 requires the use of a *reference frame*, a set of three coordinate axes, one vertical and two horizontal, corresponding to "above/below," "front/back," and "left/right," respectively (Farah, Brunn, Wong, Wallace, & Carpenter, 1990; Friederici & Levelt, 1990; Hinton & Parsons, 1988; Miller & Johnson-Laird, 1976). The orientation of a reference frame's axes guides the assignment of directions to spatial terms (e.g., Carlson-Radvansky & Irwin, 1994; Logan, 1995); for example, "above" is assigned to the direction indicated by one end of the vertical axis.

Different factors determine the axes' orientation. In a

viewer-centered reference frame, the axes are aligned in accordance with the retinotopic, head-centric, or body-centric orientation of the viewer (e.g., Utterance 1). In an *object-centered* reference frame, the axes are oriented with respect to the intrinsically defined sides of an object (e.g., Utterance 2). In an *environment-centered* reference frame, the axes are oriented with respect to salient aspects of the environment (e.g., Utterance 3). Spatial terms used within the viewer-centered reference frame are referred to as *deictic*; those within the object-centered reference frame are called *intrinsic*; and those within the environment-centered reference frame are called *extrinsic* (Fillmore, 1975; Miller & Johnson-Laird, 1976).

For successful communication, the reference frame being used must be identified. This is important because the axes of different reference frames are not always oriented in the same way; consequently, different spatial terms can be assigned to the same spatial configuration, as in Utterances 1 through 3 (see also Levelt, 1982; Miller & Johnson-Laird, 1976; Talmy, 1983; Ullmer-Ehrich, 1982; Wunderlich, 1981). Similarly, consider the picture of the mail carrier and the mailbox in Figure 1a. If the viewer is upright, the viewer-centered and environment-centered reference frames coincide. Thus, "above," "below," "left," and "right" are assigned analogously by the environment¹ and the orientation of the viewer's body; "front" and "back" ("behind") are assigned to directions closest and furthest in the picture plane, respectively. Within such a reference frame, an acceptable description is "The mail carrier is to the left of the mailbox."

An object-centered frame whose axes are defined by the intrinsic sides of the mailbox would orient the "above/below" axis as the viewer- and environment-centered reference frames do. However, the "front/back" and "left/right" axes would be exchanged. For example, "front" would refer to the direction extending from the opening in the mailbox and "back" to the opposite direction. Within such a reference frame, an acceptable description is "The mail carrier is in front of the mailbox."

Researchers have documented use of spatial terms when reference frames compete by examining descriptions of room layouts (Ehrich & Koster, 1983; Ullmer-Ehrich, 1982), imagined environments (Franklin & Tversky, 1990), and arrangements of colored balls (Levelt, 1982). Given such ambiguity, the speaker decides to highlight certain aspects of a perceptual event at the expense of others (Talmy, 1983). Deictic terms highlight the relation of the objects with respect to the viewer and are thus more perceptual, whereas intrinsic terms focus attention on the object and are more functional (Miller & Johnson-Laird, 1976; Ullmer-Ehrich, 1982). Therefore, the presence of a functional

1. There are many coincident environments available, such as the Earth, the room, and the picture. For these experiments, we adopt the picture as the pertinent one.

Address correspondence to Laura A. Carlson-Radvansky, Department of Psychology, University of Notre Dame, Notre Dame, IN 46556; e-mail: laura.c.radvansky.2@nd.edu.

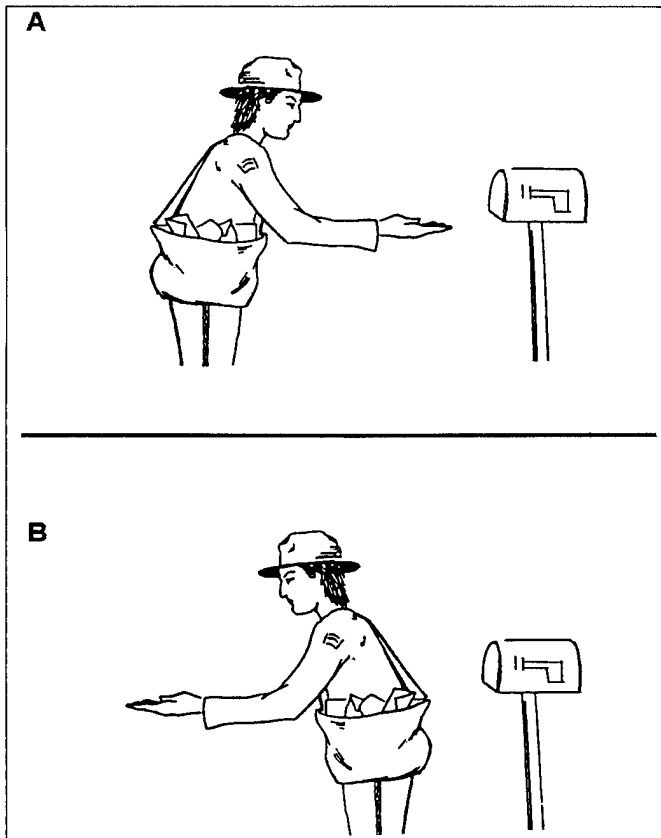


Fig. 1. Sample pictures illustrating a functional relation (a) and a nonfunctional relation (b) between mail carrier and mailbox.

relation between the two objects should encourage a preference for intrinsic descriptions, whereas in the absence of a functional relation, deictic-extrinsic descriptions should be preferred. For example, consider the picture of the mail carrier and the mailbox in Figure 1b. All three reference frames are oriented as in Figure 1a. According to the viewer- or environment-centered reference frame, an acceptable description is "The mail carrier is to the left of the mailbox." According to the object-centered reference frame, an acceptable description is "The mail carrier is in front of the mailbox." However, because mail carriers and mailboxes do not typically interact in the depicted fashion, the deictic-extrinsic description should be preferred over the intrinsic description.

These predictions were tested in Experiment 1, in which statements containing intrinsic or deictic-extrinsic terms were rated for their acceptability as descriptions of pictures that either did or did not depict a functional relation.

EXPERIMENT 1

Method

Fifty-nine undergraduates participated in this study. Ten picture pairs were created. Each picture contained a *located object*, whose location was described, and a *reference*

Table 1. Located and reference objects and their corresponding intrinsic and deictic-extrinsic terms, Experiments 1 and 2

Object		Spatial term	
Located	Reference	Intrinsic	Deictic-extrinsic
Hammer	Nail in wall	Above	Left
Crown	Girl	Above	Left
Chef	Stove	Front	Right
Man in bed	Television	Front	Below
Mail carrier	Mailbox	Front	Left
Arrow	Target	Front	Above
Astronomer	Telescope	Behind	Below
Projector	Man	Behind	Left
Police car	Car	Behind	Right
Skier	Starting gate	Behind	Above

object from which to direct search for the located object (Lev-elt, 1984). In Figure 1, for example, the mailbox is the reference object and the mail carrier is the located object. The critical manipulation was the type of relation between the objects. Specifically, for each picture pair, one picture was a functional version that depicted two objects in a typical interactive relation (e.g., Fig. 1a). The other picture was a nonfunctional version that depicted the same objects in a nonfunctional relation (e.g., Fig. 1b). The nonfunctional version was created by reflecting the located object. A list of objects appears in Table 1.

Each picture was paired with a sentence of the following form: "The *located object* is _____ the *reference object*." There were two versions of each sentence. For the deictic-extrinsic version, the spatial term was based on the viewer- or environment-centered reference frame (e.g., "The mail carrier is to the left of the mailbox"). For the intrinsic version, the spatial term was based on the object-centered reference frame (e.g., "The mail carrier is in front of the mailbox").²

Picture version (functional or nonfunctional relation) was crossed with sentence version (intrinsic or deictic-extrinsic term), yielding four conditions. Four response sheets were constructed so that each picture version-sentence version combination appeared once across all four sheets. Each response sheet contained items from each condition in a random order. On the response sheet, each sentence was followed by a rating scale numbered from 1 to 5, with 1 labeled "not at all acceptable," 3 labeled "moderately acceptable," and 5 labeled "perfectly acceptable."

Each picture was presented on an overhead projector for 30 s. Subjects rated the acceptability of the sentence as a description of the picture; they were encouraged to use the entire range of the scale.

2. To ensure that the labeling of the intrinsic sides of the reference objects was unambiguous, we presented 50 subjects with pictures of the reference objects and asked them to label the intrinsic sides. Median agreement between our and subjects' labels was .91.

Influence of Functional Relations

Results and Discussion

The results for Experiment 1 are summarized in Figure 2. The ratings were submitted to separate 2 (picture version) \times 2 (sentence version) analyses of variance, one with subjects as the random variable (subscript 1) and the other with items as the random variable (subscript 2). Unless otherwise noted, the adopted level of significance was $p < .05$. As predicted, for functional pictures, intrinsic terms were more acceptable than deictic-extrinsic terms (ratings of 3.4 vs. 3.2), whereas for nonfunctional pictures, deictic-extrinsic terms were more acceptable than intrinsic terms (ratings of 3.0 vs. 2.5). The Picture Version \times Sentence Version interactions were significant, $F_1(1, 58) = 7.74$, $MSE = 0.968$, and $F_2(1, 9) = 8.08$, $MSE = 0.331$. Planned t tests by subjects showed a significant difference in the use of the deictic-extrinsic and intrinsic terms for nonfunctional pictures, $t_1(58) = 2.24$, and a significant difference in the use of intrinsic terms for nonfunctional and functional pictures, $t_1(58) = 4.21$; by items, there was a significant difference in the use of intrinsic terms for nonfunctional and functional pictures $t_2(9) = 4.14$.

The results show that when a picture depicted a functional relation, descriptions containing the intrinsic term were more acceptable; however, when a picture depicted a nonfunctional relation, descriptions containing the deictic-extrinsic term were more acceptable. Thus, the relation between the objects in the picture was used during the assessment of the spatial expression. These results suggest that understanding the formulation and comprehension of spatial expressions requires a more de-

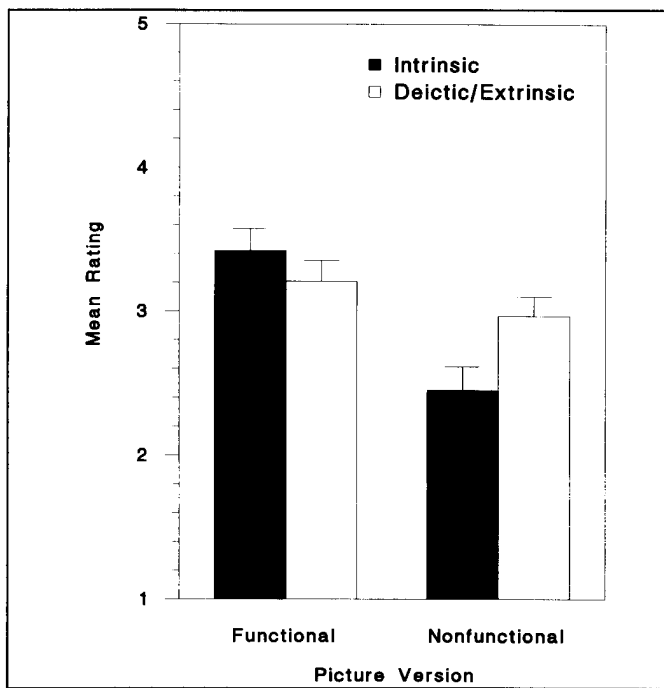


Fig. 2. Mean acceptability ratings by picture version and spatial term for the rating task in Experiment 1. The higher the rating, the greater the acceptability of the description.

tailed investigation of the process of reference frame selection, taking into account meaningful aspects of the scene and its objects.

EXPERIMENT 2

Experiment 2 used a production task in a conceptual replication of Experiment 1. Because subjects were provided with descriptions of pictures in Experiment 1, there was no indication whether these deictic-extrinsic and intrinsic terms would be used if subjects were asked to describe the pictures. In a previous study (Carlson-Radvansky & Irwin, 1993), the pattern of spatial term preferences determined by a rating task was largely similar to the pattern found in a production task. Therefore, we expected that subjects would be more likely to use an intrinsic term when there was a functional relation between the objects and a deictic-extrinsic term when such a relation was absent.

Method

Forty-two undergraduates participated in this experiment. We used the picture sets from Experiment 1 and modified the response sheets by replacing the spatial term in each sentence with a blank line and removing the rating scales.

The general procedure was the same as in Experiment 1. For each picture, the subject's task was to fill in the corresponding sentence frame with one of the following terms: "above," "below," "to the left of," "to the right of," "in front of," or "in back of."³ Subjects were tested in groups of 10 to 20.

For each picture set, the completions were scored "deictic-extrinsic" or "intrinsic" if they corresponded to the terms defined as deictic-extrinsic or intrinsic for that picture set in Experiment 1, and "other" if they were different.

Results and Discussion

The results for Experiment 2 are summarized in Figure 3. The completions were submitted to separate 2 (picture version) \times 2 (term type) analyses of variance. For functional pictures, intrinsic terms were used more often than deictic-extrinsic terms (46% vs. 38%), whereas for nonfunctional pictures, deictic-extrinsic terms were used more often than intrinsic terms (37% vs. 13%). The Picture Version \times Term Type interactions were significant, $F_1(1, 41) = 29.3$, $MSE = 375$, and $F_2(1, 9) = 4.77$, $MSE = 523$, $p = .057$. Planned t tests by subjects showed significant differences in the use of an intrinsic term for functional versus nonfunctional pictures, $t_1(41) = 8.8$, and in the use of intrinsic versus deictic-extrinsic terms for the nonfunctional pictures, $t_1(41) = 5.6$. By items, there was a significant difference in the use of intrinsic terms for functional and nonfunctional pictures, $t_2(9) = 3.2$.

Finally, the rate of reporting "other" terms was greater for

3. Pilot studies showed that open-ended instructions elicited too few spatial terms for analyses.

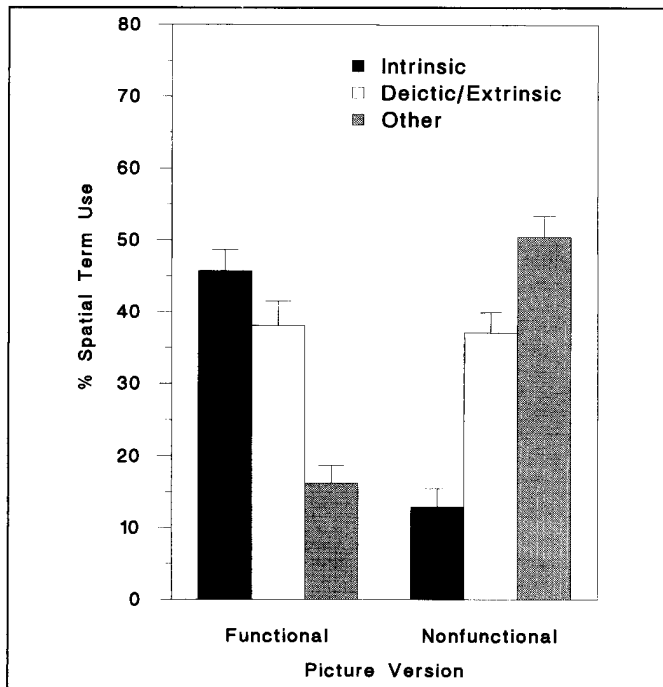


Fig. 3. Mean percentages of use of deictic-extrinsic, intrinsic, and other spatial terms for the production task in Experiment 2.

nonfunctional pictures (50%) than functional pictures (17%), $t_1(41) = 8.4$, $t_2(9) = 3.5$. This difference may have occurred because the nonfunctional pictures were more ambiguous, thus allowing for greater breadth in interpretation and in the number of possible spatial terms. However, such a difference does not alter our general conclusion: As illustrated in Figure 3, there is a clear difference in the type of spatial terms selected to describe the pictures, with intrinsic terms strongly preferred over deictic-extrinsic terms for describing functional pictures and deictic-extrinsic terms strongly preferred over intrinsic terms for describing nonfunctional pictures.

GENERAL DISCUSSION

Our results support the hypothesis that people are more willing to adopt the object-centered reference frame to express the spatial relation between objects when there is a functional relation between them, and to adopt the viewer- or environment-centered reference frame when there is no functional relation. These preferences were exhibited in both an acceptability judgment and a production task. These data indicate that selection of a reference frame is affected by contextual aspects of the situation, including meaningful relations between objects.

The linking of intrinsic terms with functional pictures and deictic-extrinsic terms with nonfunctional pictures depends on the characterization of the reference frames. The intrinsic perspective has been described as functional (Miller & Johnson-Laird, 1976; Ullmer-Ehrich, 1982) because the assignment of intrinsic sides may depend on the function of the object (e.g., for a person seated at a desk, the front of the chair faces the

opposite direction than the front of the desk). As adopted here, the term functional can be extended to refer to the relation between two objects (see also Ehrich & Koster, 1983). Thus, it makes sense that intrinsic terms are preferred for pictures that emphasize interobject relations. In contrast, the deictic perspective has been described as perceptual (Miller & Johnson-Laird, 1976; Ullmer-Ehrich, 1982) because it depends on the viewer and his or her relation to the reference object. The deictic perspective is also considered the default or dominant system for most speakers (e.g., Hill, 1982; Levelt, 1982, 1984; Wunderlich, 1981). Thus, it makes sense that deictic-extrinsic terms are preferred for nonfunctional pictures that emphasize the relation of the viewer or the environment to the objects.

Furthermore, in pilot studies, we examined the impact of functional relations on assignment of spatial terms using a different definition of nonfunctional. In Experiments 1 and 2, nonfunctional meant that there was an absence of a typical interactive relationship between two objects, created by changing the orientation of the located object. In contrast, in the pilot rating and production experiments, nonfunctional meant there was a relation between two objects that typically do not interact in the world. To create such pictures, we replaced the reference object with an object similar in size and shape while maintaining the located object's orientation and location. For example, a nonfunctional picture would be similar to Figure 1a except that a birdhouse would replace the mailbox. Using such picture sets, the same pattern was found: Deictic-extrinsic terms were preferred for nonfunctional pictures, and intrinsic terms were preferred for functional pictures.⁴

These data suggest that theories that strive to account for the use of spatial terms must acknowledge the influence of such functional relations on the formulation and comprehension of spatial expressions. The presence of a functional relation between two objects can be added to the growing list of factors that influence the selection of a reference frame, such as coordination between the listener and speaker (Garrod & Anderson, 1987; Schober, 1993), the relative communicative ease of the speaker and listener (Clark & Wilkes-Gibbs, 1986), and aspects of individual objects in the scene, such as movement (Fillmore, 1975; Levelt, 1982).

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4. For the rating task, deictic-extrinsic terms were rated as more acceptable for nonfunctional (3.5) than for functional (3.1) pictures, whereas intrinsic terms were rated as more acceptable for functional (3.6) than for nonfunctional (2.9) pictures, $F(1, 83) = 88.64$, $MSE = 0.452$. For the production task, deictic-extrinsic terms were produced more often for nonfunctional (47%) than for functional (38%) pictures, whereas intrinsic terms were produced more often for functional (49%) than for nonfunctional (29%) pictures, $F(1, 62) = 50.86$, $MSE = 230$.

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