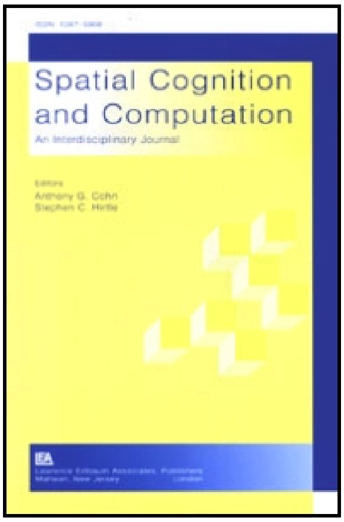

Spatial Cognition & Computation
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t775653698

Context Affects Scale Selection for Proximity Terms

Michele Burigo[a]; Kenny Coventry[bc]
[a] Language and Cognition Group, Cognitive Interaction Technology (CITEC), Bielefeld University, Bielefeld, Germany [b] Cognition and Communication Research Centre, Northumbria University, Newcastle Upon Tyne, UK [c] Hanse Institute for Advanced Studies, Delmenhorst, Germany

Online publication date: 05 November 2010

To cite this Article Burigo, Michele and Coventry, Kenny(2010) 'Context Affects Scale Selection for Proximity Terms', Spatial Cognition & Computation, 10: 4, 292 — 312
To link to this Article: DOI: 10.1080/13875861003797719
URL: http://dx.doi.org/10.1080/13875861003797719

Spatial Cognition & Computation, 10:292–312, 2010

ISSN: 1387-5868 print/1542-7633 online
DOI: 10.1080/13875861003797719

Taylor & Francis
Taylor & Francis Group

Context Affects Scale Selection for Proximity Terms

Michele Burigo[1] and Kenny Coventry[2,3]
[1]Language and Cognition Group, Cognitive Interaction Technology (CITEC), Bielefeld University, Bielefeld, Germany
[2]Cognition and Communication Research Centre, Northumbria University, Newcastle Upon Tyne, UK
[3]Hanse Institute for Advanced Studies, Delmenhorst, Germany

Abstract: Spatial proximity terms, such as *near* and *far*, communicate information regarding the distance in which a "located" object can be found with respect to a "reference" object. The present paper investigates whether people take into account the location of an object extraneous to the located object and reference object pair, when setting the scale for proximity language judgements. Across three experiments participants rated the appropriateness of *near* and *far* to describe spatial scenes that included a third (distractor) object positioned the same distance as the located object from the reference object, but at varying distances from the located object. The results show that the presence of other spatial relations affects scale setting, resulting in differences in appropriateness ratings for those spatial terms.

Keywords: spatial language, proximity prepositions, scale, distance, context

1. INTRODUCTION

Spatial language expressions, of the form *Object A is PREPOSITION Object B* direct a hearer's attention so that A (the "located object," LO) can be found with reference to B (the "reference object," RO), with the preposition determining the region and/or direction in which the hearer should search. Spatial prepositions have been the subject of a great deal of empirical investigation over the last 20 years or so (see Coventry & Garrod, 2004, for a comprehensive review). In particular, much focus has been given to the so-called "projective" prepositions, such as *in front of*, *to the left of*, that

Correspondence concerning this article should be addressed to Michele Burigo, Language and Cognition Group, Cognitive Interaction Technology (CITEC), Bielefeld University, 33615, Bielefeld, Germany. E-mail: mburigo@cit-ec.uni-bielefeld.de

specify the direction in which a LO is positioned with respect to a RO, first dependent on the selection of an appropriate reference frame (e.g., my left? on the left side of the reference object? North of the reference object?).

In contrast, direction is usually regarded as irrelevant for so-called "proximity" prepositions such as *near* and *far* (cf. Coventry and Garrod, 2004; but see Ashley & Carlson, 2007), and perhaps as a result they have been seldom investigated empirically. This paper considers the constraints that operate on proximity terms, and in particular, how contextual information affects scale setting for the comprehension of *near* and *far*. We first provide a brief review of variables that are known to affect the comprehension of these proximity terms followed by a discussion of the role of context on proximity judgements more widely.

1.1. *Near* and *Far* In Context

Spatial language comprehension across a range of spatial terms involves parameters that are both geometric and "extrageometric" (cf. the "functional geometric framework"; Coventry & Garrod, 2004), and proximity terms are no exception. In addition to the metric distance between two objects (see Kemmerer, 1999, for discussion), the comprehension of *near* and *far* is affected by the objects involved and the context within which they are used. The size of objects denoted by nouns, and their relative size, affects the distance associated with these terms in context. *A pencil near an eraser* is associated with a smaller distance than *a car near a garage*. Moreover, proximity terms can also be associated with differing distances for the same objects as a function of context. *The ball is near the hole* is associated with a shorter distance in the context of a game of snooker/pool than in the context of a golf course (see Carlson & Covey, 2005, for empirical evidence; see also Coventry & Garrod, 2004; Miller & Johnson-Laird, 1976). Movability has also been noted as an important constraint on the type of objects that can occur as LOs and ROs for proximity expressions. For example, one can say *the bicycle is near the mailbox*, but *the mailbox is near the bicycle* is less acceptable (Talmy, 1983).

In addition to relative size of objects, how objects interact is also important for proximity terms. Ferenz (2000) found that descriptions using various pairs of objects, placed at the same distance, were judged as more *near* when the position of the two objects allowed functional interactions (e.g., a couch and a TV) than when a pair of objects could not functionally interact (e.g., a bicycle and a cooker). Carlson and Kenny (2006) also found that *near* was rated as more appropriate to describe objects that are aligned in such a way that they can interact. For example, *near* was preferred to describe the location of a 3D cross-shape when it was aligned with the correct hole for that shape in a (child's) shape sorter than when it was misaligned with the correct hole.

It is also the case that judgements of proximity are affected by the presence of another object that is nearer or further from the reference object than the located object. Hund and Plumert (2007) showed that both young children and adults use relative distance to make judgements about nearbyness. *By* was more appropriate to describe the location of an object when intervening objects were absent than when they were present (see also Costello & Kelleher, 2006, for similar results for *near* and *far*). These results are consistent with Herskovits (1986), who noted that a sentence like "A is to the right of B" may be judged as less appropriate when the scene also contains a distractor object (X) on the right of B because people compare and contrast the distractor's relation to the RO with the relation between the LO and the RO. In the same vein van der Zee, Adams, and Niemi (2009) showed that, in processing proximity spatial prepositions *near* and *far*, people take into account the relative position of a third irrelevant object (a bar) to set a scale on the scene.

There is also a body of data relating to (non-linguistic) distance estimation judgements that implicate the importance of a number of further variables for the comprehension of proximity terms. When asked "*how far is it from A to B*?", the estimated distance (measured in various ways; see Montello, 1997) deviates from the metric distance. For example, the estimated distance between A and B is not necessarily the same as the estimated distance from B to A (distance estimation sometimes violates the geometric axiom of symmetry).

Sadalla, Burroughs, and Staplin (1980; see also Newcombe, Huttenlocher, Sandberg, Lie, & Johnson, 1999) originally found that distance estimates from reference points (well-known places with historical/cultural significance) to nonreference points were different from those estimated in the reverse direction. So, when the judgement is anchored at a reference point, distance estimates are shorter. Similar results also hold for judgements of distance in interpersonal space (e.g., Codol, Jarymowicz, Kaminska-Feldman, & Szuster-Zbrojewicz, 2006) and also for judgements of the relative positions of objects in arrays in small-scale space (e.g., Hirtle & Mascolo, 1986). McNamara and Diwadkar's (1997) "contextual scaling model" is able to account for such deviations between actual distance and estimated distance. In this model, information about stimulus properties is retrieved from long-term memory and then scaled by the context in which that retrieval takes place.

More generally there is evidence that focusing on an initial value affects future judgements. This effect—the so-called "anchor" effect—is a bias in judgement towards an irrelevant given cue and is a well-established and robust phenomenon. For example, Tversky and Kahneman (1974) found that estimations of quantities (e.g., the percentage of African nations in the UN) were affected by initially asking participants whether the quantity was higher or lower than a given value. When this value was low participants' final percentage estimates tended to be significantly lower than when the given value was high. Thus the final magnitude estimation remains ‘anchored’ to the originally considered value (Tversky & Kahneman, 1974; Jacowitz & Kahneman, 1995).

Effects of anchoring have been examined across a range of domains, including social cognition (Strack & Mussweiler, 1997), decision making (Rottenstreich & Tversky, 1997) and probability estimation (Plous, 1989). There is also evidence suggesting that an initial anchor value affects distance estimation as well as time estimation in a similar manner (LeBoeuf & Shafir, 2009). Such effects have been explained in terms of priming effects (Mussweiler & Strack, 2001; Strack & Mussweiler, 1997). Moreover, anchor effects are difficult to avoid; even when people are explicitly asked to avoid them (Wilson, Houston, Etling, & Brekke, 1996) or when the anchor is presented subliminally (Reitsma-van Rooijen & Daamen, 2006), anchor effects still occur.

In the remainder of this paper, we first ask whether the comprehension of the spatial terms *near* and *far* is affected by context in the form of an additional spatial relation in the scene present due to the presence of a third object in the scene. More specifically, we investigate whether the additional spatial relation generated acts as an anchor pulling the proximity judgements towards an initially presented distance, or alternatively whether the spatial relation acts as a comparison distance similar to the effect of an intervening object found in Hund and Plumert (2007) and Costello and Kelleher (2006).

It is important to note that the additional spatial relation we presented was never between the new third object and the RO, but was always between the LO and the third object. As such, this is different from a direct distance comparison between the LO and RO and the intervening object and the RO (as in Hund & Plumert, 2007 and Costello & Kelleher, 2006). Thus an effect of an additional spatial relation, if present, goes beyond a natural comparison between two spatial relations involving the same RO. An example will make this clear.

Consider the images in Figure 1, and how appropriate *the wheel is near the cog* is to describe these images. The scenes represent three objects; the LO (*the wheel*) and the RO (*the cog*) as denoted in the sentence, and a distractor object (D, *the fan*). Although the distance between the wheel and the cog is the same in each image, we expected that people’s judgements of proximity relations would be affected by the distance between the LO and D when presented prior to the distance between the LO and RO as we thought that this distance would act as a comparison for the distance between the RO-LO in the same way as a distance between the distractor and RO. In scenes where the initial distance (e.g., LO-D distance) is greater than the RO-LO distance (picture C) there should be a greater preference to use a *near* description compared to when the initial distance is smaller than the RO-LO distance (picture A) because the initial distance represents a more appropriate NEAR distance. The opposite should be true for the spatial preposition *far*.

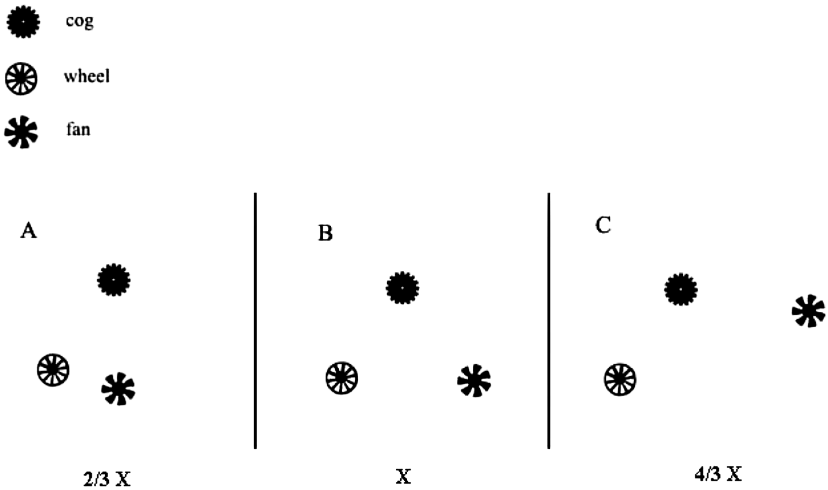

Figure 1. *The wheel is near the cog*. The RO-LO distance is the same across pictures, as is the RO-D distance. The LO-D distance alone is manipulated. Original stimuli were white on a black background.

However, it is also possible that people do not use the LO-D distance as a comparison, but rather as an anchor leading to different predictions. If anchoring is at play, presenting a larger LO-D distance than the RO-LO distance should lead participants to overestimate the other distance and consequently to judge *far* as being more acceptable and *near* less acceptable. The opposite should be true for shorter LO-D distances.

Ensuring that the distance between the RO and D was the same as the distance between the RO and the LO eliminates a trivial effect of comparison (if X is the LO, Y the RO, and Z the Distractor, then if Z were nearer Y than X, *far* would be a better description of X in relation to Y), and therefore would provide evidence that distances are set in the context of other spatial relations in scenes.

The experiments reported below test these predictions. Experiment 1 varied the order of presentation of the three objects (two objects presented followed by the third object) to test whether an additional spatial relation affects proximity judgements, and whether such effects are larger when the comparison distance is presented prior to the RO-LO distance. The remaining experiments begin to unpack the nature of this context effect. Experiment 2 compared the presentation of scenes with three objects (hence with a distractor) to scenes where only two objects are present in order to establish whether proximity judgements overall are affected by the presence of a third object. Experiment 3 presented all three objects simultaneously in order to establish whether comparison occurs only when comparison is cued temporally or alternatively whether it occurs without such temporal cueing.

To preview the results, we show that the extraneous distance between the located object and the distractor affects *near* and *far* judgements, but only when spatial relations are presented in a temporal sequence.

2. EXPERIMENT 1

This experiment tested whether LO-D distance affects proximity term judgements, and whether the presence of such an effect is dependent on when the LO-D distance is displayed.

2.1. Method

2.1.1. Participants. Thirty participants (25 females and 5 males; age range from 20 to 42, mean age = 24) participated on a voluntary basis in this study. All participants were Italian native speakers and had normal, or corrected to normal, vision. Participants were unaware of the purpose of the study.

2.1.2. Design and Materials. An acceptability rating task was used to measure the appropriateness of the Italian spatial prepositions *vicino* (*near*) and *lontano* (*far*) to describe spatial scenes. Each scene showed three objects; a Reference Object (*RO*), a Located Object (*LO*) and a third distractor object (*D*) not mentioned in the sentence to be rated. Two distances were used between the RO and LO; a shorter distance of 200 pixels and a longer distance of 400 pixels. The RO-LO distance was always the same as the RO-D distance. Distances between the LO and the D were calculated in relation to the distances between the RO and the LO, to keep the proportions between distances always constant. The possible LO-D distances were: 2/3X, X and 4/3X, where X was always the RO-LO distance. The selection of these fractions was imposed by the constraints of the limited size of the monitor (larger fractions did not fit within the screen bounds). All distances between the objects were measured from their center-of-mass to control for perceptual differences produced by irregular bounds/shapes.

We manipulated the presentation order in which the objects were shown in order to establish whether the LO-D distance matters for judgements, and whether this only occurs, or is at its strongest, when the distance is presented first. This is because we thought that participants would be forced to consider the LO-D distance when presented alone on the screen first, thereby maximising the changes of its influence on later judgements. Therefore two objects were first presented followed by the remaining object in three sequences; LO-D pair first, then RO; RO-LO pair first, then D; RO-D first, then LO. Object locations were randomised, thus participants did not see the three objects always at the same location (6 series of coordinates were randomly allocated to the *near/far* trials[1]).

All the objects were the same size (150 × 150 pixels) and shape (circular) to control for the possible influence of "center-of-mass" and "proximity" factors on spatial language judgements (Regier & Carlson, 2001). Pictures were white on a black background and the level of brightness was the same for all of them. The stimuli set comprised eight objects: a shield, an ashtray, a wheel, a cog, a port hole, a circle, a fan, and a football.

In summary, the experiment included the following variables; 2 RO-LO distances, 3 LO-D distances, 2 spatial prepositions, and 3 presentation orders, across 8 combinations of objects randomly chosen from the set of circular shaped objects with the constraint that an object could only appear once in a scene. That made a total of 288 trials. All the variables were tested within-participants.

2.1.3. Procedure. During the briefing, participants were shown a hard-copy of all objects used in the experiment to facilitate later recognition (to eliminate any potential confusion arising from similarities between objects). The experiment was then presented on a computer screen using the experiment generator E-prime™. Instructions to participants explained that the task was to rate how appropriate sentences were to describe pictures that followed. The experiment was self-paced and each trial began with a sentence shown in the following format «The "LO" is *spatial preposition* the "RO"» where the spatial prepositions were *near* or *far* and the LO and RO were objects from the object set (always different objects).

[1]Coordinates for the three objects were (a,b) for object1, (c,d) for object2 and (x,y) for object3. The distance between object1 (a,b) and object2 (c,d) is called R, whereas the distance between object2 (c,d) and object3 (x,y) is called P. To calculate the coordinates of object3 (x,y) considering the relative coordinates for object1 and object2, we used the following formulae:

$$q = (b - d)/(c - a)$$

$$s = (R^2 - p^2 - a^2 + c^2 - b^2 + d^2)$$

$$\alpha = (q^2) + 1$$

$$\beta = ((q * s) - (a * q) - b)$$

$$\gamma = ((s - a)^2) + (b^2 - R^2)$$

$$y = ((-\beta) + \sqrt{}(\beta^2 - (\alpha * \gamma))/\alpha$$

$$x = (q * y) + s$$

The sentence remained on the screen until participants pressed the space bar (to ensure they had attended sufficiently to remember the sentence). Once the sentence disappeared a blank screen was shown for 300 ms followed by the first pair of objects. Then, 1500 ms later, the third object appeared. These three objects remained on the screen until the participant pressed a key indicating their appropriateness rating using a scale from 1 to 9 (where 1 = not at all acceptable; 9 = perfectly acceptable). After the response was made, there was a gap of 600 ms before the next trial began. The experiment also included a number of additional questions regarding objects mentioned in sentences (e.g., "Was the word SHIELD mentioned in the last sentence?") presented randomly (about every 50 trials) in order to check that participants were attending to the sentences. All the participants included in the analysis answered the random questions correctly, indicating that they were attending to the nouns presented in the sentences to be rated and were easily able to identify the objects visually.

3. RESULTS AND DISCUSSION

The mean acceptability rating data (and SDs) are displayed in Table 1. Ratings were submitted to a 2 (spatial preposition; *vicino/lontano,* the Italian equivalents of *near/far*) $\times$ 2 (RO-LO distance; X = 200 pixels, X = 400 pixels) $\times$ 3 LO-D distances (2/3X, X, and 4/3X) $\times$ 3 (presentation orders; LO-D first, RO-LO first, and RO-D first) repeated measures ANOVA. A significance α level of $p < 0.5$ was adopted unless otherwise specified, and where follow-up analyses are reported, LSD tests were used.

There was a main effect of RO-LO distance, $F(1, 29) = 10.13$, $MSE = 0.58$, $p < 0.01$, and the interaction between RO-LO distance and spatial

Table 1. Mean acceptability ratings (and SDs) for *near* and *far* as a function of LO-D distance, LO-RO distance (pixels) and presentation order (Pres. 1 = LO-D first, then RO; Pres. 2 = RO-LO first, then D; Pres. 3 = RO-D first, then LO) in Experiment 1

		Spatial preposition					
		FAR			NEAR		
LO-RO distance	LO-D distance	LOD-RO	ROLO-D	ROD-LO	LOD-RO	ROLO-D	ROD-LO
200	2/3 X	2.5 (0.16)	2.4 (0.14)	2.6 (0.16)	6.8 (0.17)	7.4 (0.14)	7 (0.16)
	X	2.2 (0.16)	2.1 (0.14)	2.3 (0.13)	7.5 (1.6)	7.6 (0.17)	7.3 (0.19)
	4/3 X	2.2 (0.16)	2.2 (0.12)	2.3 (0.15)	7.1 (0.18)	7.4 (0.18)	7.4 (0.18)
400	2/3 X	7 (0.2)	6.9 (0.21)	7.1 (0.19)	2.9 (0.23)	3 (0.25)	3 (0.23)
	X	6.8 (0.2)	6.6 (0.23)	6.8 (0.22)	3 (0.22)	2.9 (0.24)	2.8 (0.22)
	4/3 X	6.9 (0.2)	6.8 (0.22)	7.2 (0.2)	3.1 (0.22)	3.2 (0.22)	2.9 (2.1)

preposition was also significant, $F(1,29) = 127.88$, $MSE = 28.84$, $p < 0.0001$; *far* received higher ratings ($M = 6.63$) for the larger RO-LO distance than for the shorter distance ($M = 2.79$; $p < 0.001$) while *near* received higher ratings for the short distance ($M = 6.7$) compared to the long distance ($M = 3.15$; $p < 0.001$), as expected.

Of most interest were effects involving LO-D distance. First, there was a significant main effect of LO-D distance, $F(2,58) = 3.49$, $MSE = 1.31$, $p < 0.05$, and the interaction between LO-D distance and spatial preposition was also significant, $F(2,58) = 19.37$, $MSE = 4.3$, $p < 0.0001$, illustrated in Figure 2. Acceptability ratings for the spatial preposition *near* increased as a function of increasing LO-D distance; trials with the LO-D distance set at 2/3X received the lowest ratings ($M = 4.78$), while trials with the LO-D distance set at X ($M = 5.15$) and 4/3X ($M = 5.30$) received respectively higher ratings. However, only the 2/3X and the 4/3X distances were significantly different from one another ($p < 0.001$). For *far* trials, the opposite pattern was the case: lowest ratings were given to trials with the LO-D distance at X ($M = 4.39$) and 4/3X distances ($M = 4.48$), while the highest acceptability ratings were for trials with the LO-D distance set at 2/3X ($M = 5.03$). The later condition was significantly different from both the X and 4/3X distances ($p < 0.0001$). These results show that LO-D distance is important for spatial proximity term comprehension consistent

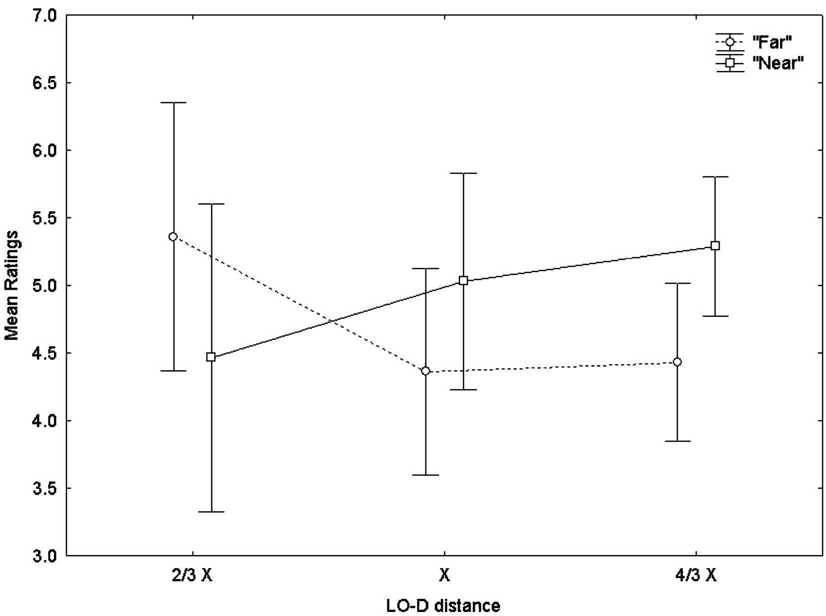

Figure 2. The interaction between the LO-D distance and spatial preposition in Experiment 1.

with the view that the additional spatial relation is used as a comparison rather than an anchor for proximity term judgements. However, further interactions are informative regarding the circumstances under which the LO-D distance matters.

There was also a significant 3-way interaction between LO-D distance, RO-LO distance and spatial preposition, $F(2, 58) = 18.07$, $MSE = .477$, $p < 0.0001$, illustrated in Figure 3, and the 4-way interaction between LO-D distance, RO-LO distance, spatial preposition and sequence was also reliable. We take each of these interactions in turn.

As shown in Figure 3, one can ask how the two-way interaction between LO-D and spatial preposition is affected by RO-LO distance. To answer this question, one-way ANOVAs for each of the preposition-RO-LO distance combinations (i.e., each of the line patterns in Figure 3) were performed, the independent variable being LO-D distance. Significant effects (critical p-values were adjusted accordingly to 0.05/4 = 0.0125) of LO-D distance were found for all four preposition-RO-LO distance combinations, indicating that the effect illustrated in Figure 2 is robust across distance-term combinations. However, the effect sizes were more marked for the shorter RO-LO distance (for *near*, $F(2, 58) = 21.38$, $MSE = 0.497$, $p < 0.0001$, $\eta^2 = .526$ and for *far*, $F(2, 58) = 19.20$, $MSE = 13.85$, $p < 0.001$, $\eta^2 = .435$) than for the longer RO-LO distance (*far*, $F(2, 58) = 13.64$, $MSE = 0.44$, $p <$

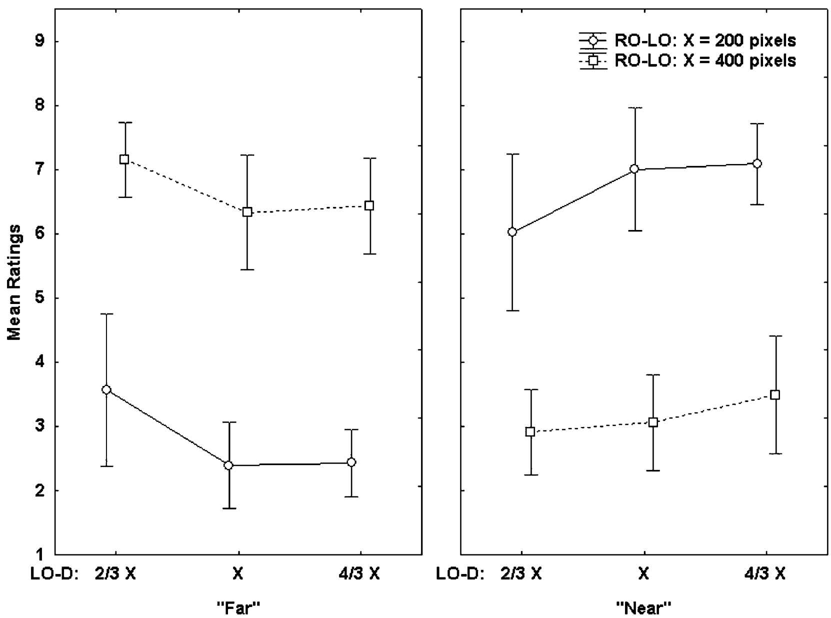

Figure 3. The 3-way interaction between LO-D distance, RO-LO distance and spatial preposition in Experiment 1.

0.0001, $\eta^2 = .376$ and *near*, $F(2, 58) = 5.28$, $MSE = 0.51$, $p < 0.01$, $\eta^2 = .191$).

The significant 4-way interaction, $F(4, 116) = 4.49$, $MSE = .182$, $p < 0.05$, is informative regarding whether the LO-D distance effect is mediated by sequence in combination with other variables. We ran three separate analyses, one for each presentation order. For all three presentation orders, critically the two-way interaction between LO-D distance and preposition was reliable, and in the same direction as reported above (LO-D first, $F(2, 58) = 19.42$, $MSE = 1.943$, $p < 0.0001$, $\eta^2 = .401$; RO-LO first, $F(2, 58) = 18.046$, $MSE = 1.62$, $p < 0.0001$, $\eta^2 = .384$; RO-D first, $F(2, 58) = 12.23$, $MSE = 1.5$, $p < 0.0001$, $\eta^2 = .297$). However, the magnitude of the interaction was greatest when the LO-D distance was presented first ($\eta^2 = .401$) and weakest when the RO-D distance was presented first ($\eta^2 = .297$). None of the other main effects or interactions were significant.

These results provide evidence that the presentation of a larger or smaller LO-D distance relative to the RO-LO distance matters for the comprehension of spatial proximity terms, that the additional spatial relation is used as a comparison rather than an anchor for proximity term judgements, and that the effect is robust across spatial terms and RO-LO distances. Further consideration of the presentation order (sequence) manipulation has shown that the strongest effects of LO-D distance occur when this relation is presented prior to the RO (and hence prior to the LO-RO distance). However, effects of LO-D distance were also found with the other sequences. This suggests either that the presentation order itself cues consideration of the LO-D distance, or alternatively that participants simply contrast the RO-LO distance with the LO-D distance irrespective of sequencing. To test between these possibilities we ran two further experiments. Experiment 2 tested whether proximity judgements overall are affected by the presence of a third object in the scene compared to when the RO-LO relation is presented alone. Experiment 3 then tested whether the context effect occurs only when an initial distance is temporally cued by testing the case where all three objects are presented simultaneously.

4. EXPERIMENT 2

The aims of this experiment were twofold. First, we aimed to replicate the findings of the first experiment with respect to the effect of LO-D distance on proximity judgements when the LO-D distance is different from the RO-LO distance. Second, we wanted to establish whether the presence of a distractor object itself affects proximity term judgements by comparing acceptability ratings for scenes where the LO-D distance is the same distance as the RO-LO distance, to scenes where the distractor object is simply not shown.

4.1. Method

4.1.1. Participants. Twenty-six participants (21 females and 5 males; age range from 23 to 48, mean age = 29) participated on a voluntary basis in this study. All participants were Italian native speakers and had normal, or corrected to normal, vision. Participants were unaware of the purpose of the study. None of the participants took part in Experiment 1.

4.1.2. Design and Materials. An acceptability rating task similar to that used in Experiment 1 was used to measure the appropriateness of the Italian spatial prepositions *vicino* (*near*) and *lontano* (*far*) to describe spatial scenes. Each scene showed two or three objects; 3/4 of trials showed the RO, the LO and the distractor defined by the sentence to be rated (as in Experiment 1) and 1/4 of the trials showed the RO and the LO alone. As in Experiment 1 two distances were used between the RO and LO; a shorter distance of 200 pixels and a longer distance of 400 pixels.

The possible LO-D distances were: 2/3X, X, 4/3X and noD (scenes where no distractor was presented). X was always the RO-LO distance. Distances between the LO and the D were calculated in the same way as in the previous experiment. In this study we did not manipulate presentation order; the LO-D distance was always presented first followed by the RO. This was done for two reasons. First, the strongest context effect in the previous experiment was observed with this order of presentation. Second, using a single presentation order meant that the experiment was of acceptable length for participants. The objects used and method of presentation were the same as those used in Experiment 1.

In summary, the experiment included the following variables; 2 RO-LO distances, 4 LO-D distances, 2 spatial prepositions, across 8 combinations of circular shaped objects, comprising a total of 128 trials. All the variables were tested within-subjects.

4.1.3. Procedure. The procedure was the same as that used in Experiment 1 with the difference that 1/4 of trials scenes showed only two objects (the RO and the LO).

5. RESULTS AND DISCUSSION

The mean acceptability rating data (and SDs) are displayed in Table 2. Ratings were submitted to a 2 (spatial preposition; *vicino/lontano*, the Italian equivalents of *near/far*) $\times$ 2 (RO-LO distance; X = 200 pixels, X = 400 pixels) $\times$ 4 (LO-D distance; noD, 2/3X, X and 4/3X) repeated measures ANOVA. A significance level of $p < 0.05$ was adopted unless otherwise specified, and where follow-up analyses are reported, LSD tests were used.

Table 2. Mean acceptability ratings (and SDs) for *near* and *far* as a function of LO-D distance and RO-LO distance (pixels) in Experiment 2

RO-LO distance	LO-D distance	Spatial preposition	
		FAR	NEAR
200	no X	2.3 (0.22)	7.7 (0.16)
	2/3 X	3.1 (0.23)	6.4 (0.22)
	X	2.1 (0.14)	7.3 (0.19)
	4/3 X	2 (0.15)	7.3 (0.23)
400	no X	7.1 (0.14)	2.9 (0.12)
	2/3 X	7.2 (0.15)	2.7 (0.16)
	X	6.6 (0.16)	2.9 (0.15)
	4/3 X	6.3 (0.17)	3.3 (0.17)

The results revealed a main effect of spatial preposition, $F(1, 25) = 6.09$, $MSE = 4.014$, $p < 0.05$, with *far* judged as less acceptable ($M = 4.58$) than *near* ($M = 5.1$). This could be as the (small) dimensions of the objects presented on the monitor were always near each other relative to the distance between the viewer and the screen. The interaction between RO-LO distance and spatial preposition was also significant, $F(1, 25) = 127.88$, $MSE = 2.16$, $p < 0.0001$; *far* received higher ratings ($M = 6.8$) for the larger RO-LO distance than for the shorter distance ($M = 2.35$; $p < 0.001$) while *near* received higher ratings for the shorter distance ($M = 7.21$) compared to the longer distance ($M = 2.93$; $p < 0.001$), as expected.

Of most interest were effects involving LO-D distance. First, there was a significant main effect of LO-D distance, $F(3, 74) = 8.34$, $MSE = 0.246$, $p < 0.01$, and the interaction between LO-D distance and spatial preposition, illustrated in Figure 4, was also significant, $F(3, 75) = 21.66$, $MSE = 0.62$, $p < 0.0001$. As found in the previous experiment acceptability ratings for *near* increased as a function of increasing LO-D distance; trials with the LO-D distance set at 2/3X received the lowest ratings ($M = 4.59$), while trials with the LO-D distance set at X ($M = 5.09$) and 4/3X ($M = 5.3$) received respectively higher ratings. Acceptability ratings for the spatial preposition *far* showed the opposite pattern—ratings were higher with the LO-D distance set at 2/3 X ($M = 5.13$) followed by trials with the LO-D distance set at X ($M = 4.36$) and 4/3X ($M = 4.14$).

To establish whether the addition of a distractor object itself affects proximity term judgements, the key comparison of interest is to contrast judgements when only two objects are presented with judgements for the same distances when three objects are presented. Post hoc analysis revealed that for *near* judgments the 2/3X distance was significantly different from all the other conditions including the noD condition ($p < 0.01$). There

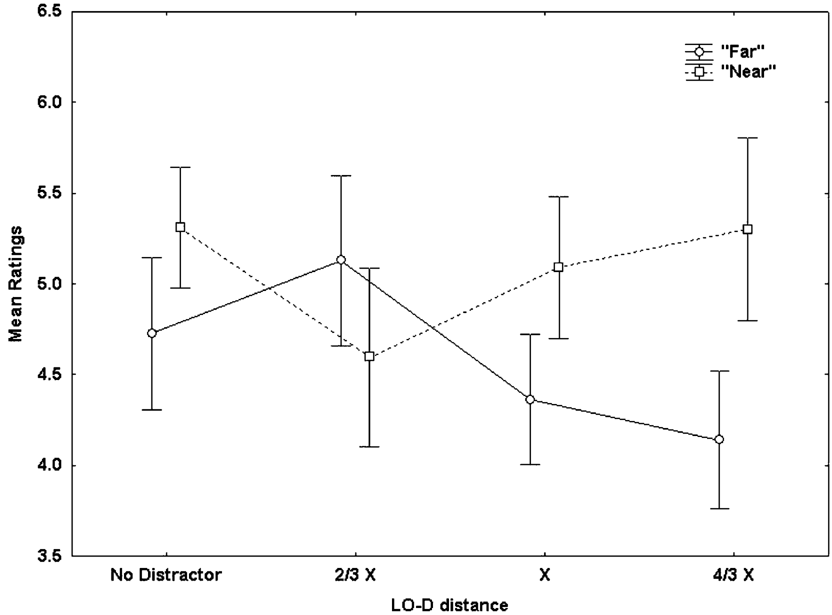

Figure 4. The interaction between the LO-D distance and spatial preposition in Experiment 2.

was no significant difference between the no distractor condition and the condition with the LO-D distance set at X. None of the other differences were reliable. For *far* judgements, the opposite pattern was the case: lowest ratings were given to trials with the LO-D at X ($M = 4.36$) and 4/3X distance ($M = 4.14$), while the highest acceptability ratings were for trials with the LO-D distance set at 2/3X ($M = 5.13$) and for trials without the distractor ($M = 4.74$). All comparisons were significant ($p < 0.05$) excluding distance X vs. distance 4/3X. The difference between the no distractor condition and the LO-D = X condition was significant ($p = 0.04$).

The three-way interaction between LO-D distance, RO-LO distance and spatial prepositions was also significant: $F(3, 75) = 12.64$, $MSE = .355$, $p < 0.0001$. As for Experiment 1, we ran four separate ANOVAs, one for each combination of spatial terms and RO-LO distances.

Significant effects (critical p-values were adjusted accordingly to 0.05/4 $= 0.0125$) of LO-D distance were found for all two preposition/RO-LO distance combinations, indicating that the effect illustrated in Figure 4 is robust across distance-term combinations. However, the effect sizes were more marked for the shorter RO-LO distance (for *near*, $F(3, 75) = 18.39$, $MSE = 0.419$, $p < 0.0001$, $\eta^2 = .424$; for *far*, ($F(3, 75) = 12.16$, $MSE = 0.5$, $p < 0.001$, $\eta^2 = 0.327$) than the longer RO-LO distance (for *far*, $F(3, 75) = 19.95$, $MSE = 0.25$, $p < 0.0001$, $\eta^2 = 0.444$; for *near*,

$F(3, 75) = 3.57$, $MSE = 0.375$, $p < 0.01$, $\eta^2 = 0.125$). For each of these analyses we also compared the no distractor condition to the condition where the LO-D distance was the same as the RO-LO distance in order to test for the possible effect of presence of distractor on ratings for *near* and *far*. There were no significant differences between the no distractor and LO-D distance = RO-LO distance conditions (all $p > 0.05$) except for the analyses for *far* when the RO-LO distance was larger. In this case, ratings for the no distractor scenes ($M = 7.18$) were significantly higher ($p < 0.01$) than ratings for the scenes where the LO-D distance was matched to the RO-LO distance ($M = 6.65$). None of the other main effects or interactions were significant.

In summary the results from Experiment 2 corroborate the hypothesis that the presence of a distractor object and its distance from the LO relative to the distance between the RO and LO are important for the comprehension of spatial prepositions *vicino* and *lontano*, the Italian equivalents of *near* and *far*. The results show that the presence of a distractor object in itself does affect proximity term judgements, but only under somewhat limited circumstances (i.e., for judgements of *far* when the RO-LO distance is large). One possible reason for this is that the LO-D distance may be scaled against the total distance between all three objects in the scene—the RO, LO and Distractor. Larger distances between the LO, RO and Distractor may lead to the perception that the LO is nearer the RO than it is (relative to the overall distance between all three objects).

6. EXPERIMENT 3

The results across two experiments show that people take into account the distractor object and the distance between it and the LO when judging the proximity between the LO and RO. In both experiments; however, spatial relations were presented in sequence. It is possible therefore that an effect of the LO-D distance may only occur when the presentation order itself forces consideration of other spatial relations. In order to test whether this is the case, Experiment 3 presented all three objects together. If cueing is required, we expected that the effects of LO-D distance would disappear. Alternatively, if participants automatically consider any distance information presented to them, effects should remain without explicit cueing. Experiment 3 tested between these possibilities.

6.1. Method

6.1.1. Participants. Twenty eight people (1 male and 27 female, age range from 19 to 56, mean age = 38) participated in the experiment on a voluntary basis. All the participants were Italian native speakers with normal, or corrected to normal, vision. None of them participated in Experiments 1 or 2.

6.1.2. Design and Materials. The experiment was identical to Experiment 1 in all respects, except that presentation order was not manipulated; the three objects (LO - RO - D) were showed on the screen simultaneously.

6.1.3. Procedure. The procedure was the same as Experiment 1, except that presentation order was not manipulated.

7. RESULTS AND DISCUSSION

The mean acceptability rating data (and SDs) are displayed in Table 3. Ratings were submitted to a 2 (spatial preposition; *vicino/lontano*, the Italian equivalents of *near/far*) $\times$ 2 (RO-LO distance; X $=$ 200 pixels, X $=$ 400 pixels) $\times$ 3 (LO-D distance; 2/3X, X, and 4/3X) within participants ANOVA.

There were significant main effects of preposition, $F(1, 27) = 52.36$, $MSE = 1.73$, $p < 0.0001$, and RO-LO distance, $F(1, 27) = 6.03$, $MSE = 0.33$, $p < 0.05$. Overall ratings were higher for *near* ($M = 5.39$) than for *far* ($M = 4.35$), and for the longer ($M = 4.95$) than for the shorter ($M = 4.79$) distance. The first effect is consistent with the effect found in the previous experiment. The main effect of RO-LO distance may indicate an advantage in estimating the more perceptually distinguishable difference (that is the longer distances).

In addition there was a 2-way interaction between spatial preposition and RO-LO distance, $F(1, 27) = 86.2$, $MSE = 4.88$, $p < 0.0001$. Follow up analyses showed that the preposition *near* was more appropriate to describe the shorter RO-LO distance ($M = 6.43$) than the longer RO-LO distance ($M = 5.35$) ($p < 0.001$). *Far* was more appropriate to describe the longer RO-LO distance ($M = 5.54$) than the shorter RO-LO distance ($M = 3.15$) ($p < 0.001$).

Table 3. Mean acceptability ratings (and SDs) for *near* and *far* as a function of LO-D distance and RO-LO distance (pixels) in Experiment 3

RO-LO distance	LO-D distance	Spatial preposition	
		FAR	NEAR
200	2/3 X	3.1 (0.24)	6.23 (0.22)
	X	3.2 (0.21)	6.6 (0.18)
	4/3 X	3.2 (0.2)	6.5 (0.15)
400	2/3 X	5.5 (0.13)	4.23 (0.18)
	X	5.5 (0.12)	4.5 (0.15)
	4/3 X	5.6 (0.13)	4.3 (0.22)

None of the other main effects or interactions were reliable (all $F < 1$). This indicates that LO-D distance does not affect proximity term comprehension when all three objects are shown simultaneously.

8. GENERAL DISCUSSION

In three experiments we tested whether the presence of a distance cue other than the distance between a located object and a reference object affects judgements to describe the proximity relation between a located object and a reference object. In Experiment 1, where the order in which the objects were presented was manipulated, the results were very clear. The distance between the LO and a distractor object affected judgements for proximity terms; a larger LO-D distance than the distance between the RO and the LO reduced the appropriateness of *lontano*, the Italian equivalent of *far* to describe that relation and increased the appropriateness of *vicino*, the Italian equivalent of *near*, and vice versa for a smaller RO-D distance than the distance between the RO and LO. Experiment 2 replicated this effect, while also showing that the presence of an additional object itself affects acceptability judgements only for *far* when the RO-LO distance is longer. Experiment 3 showed that the effects disappear when the three objects, LO, RO and D, are presented at the same time.

This pattern of results is consistent with work on distance estimation that recognises the importance of context in the determination of scale. Distance is a relative concept; the perception of nearness and farness depends on a scale set using available information that has been brought into attention. The results extend the findings of Hund and Plumert (2007) and Costello and Kelleher (2006) by showing that a distance comparison is made even when the comparison distance does not involve the reference object. It remains to be established whether an unrelated additional spatial relation generated by presenting two distractors also affects scale selection in a similar way as shown in the present study. The addition of more objects in the scene also affords testing of the extent to which moving attention around a visual scene in itself affects proximity term ratings, following the preliminary result of presence/absence of distractor observed in Experiment 2.

The results also showed that the distance comparison process does not occur under all circumstances. In order for a distance cue (e.g., the LO-D distance) to be used, the comparison distance needs to be presented in such a way as to capture attention. Effects of LO-D distance were strongest when the LO-D distance was presented first, but effects were present even when the LO-D distance was presented second (but still before judgements were made). In contrast, when the objects were all presented together, the effect of LO-D distance disappeared. These findings are congruent with theories of attention that claim that the portion of space where the objects suddenly appear captures spatial attention automatically (Eriksen & St. James, 1986; Posner, 1980;

Posner & Cohen, 1984). Therefore, the LO-D distance becomes a comparison distance as it is attended to when presented temporally dissociated from the RO-LO distance.

With simultaneous presentation (Experiment 3), the judgment to be made focuses attention on the RO-LO distance, and the LO-D distance is simply not considered. However, we note that overall ratings in Experiment 3 were more compressed compared to the ratings given in Experiments 1 and 2 suggesting that the absence of the LO-D effect may also be related to decreased sensitivity. Future work using eye tracking would help establish whether the degree of attention paid to an LO-D distance is indeed diagnostic of the extent to which that distance affects proximity term judgements.

The results also help flesh out how context affects the comprehension of proximity terms. Much of the work on spatial language to date for proximity terms has shown evidence for context effects in the form of the nature of objects being located, including the functional relations between objects (Carlson & Kenny, 2006; Ferenz, 2000) and the size and movability of those objects (e.g., Talmy, 1983). The present set of results show that context effects can occur for objects that share the same physical dimensions and are not functionally related to one another.

The importance of effects of information presented temporally prior to a relation to be judged may well go beyond the effect found for proximity relations. Carlson and Van Deman (2004) have shown that the speed with which a sentence involving a projective term (*above/below/left/right*) is verified as matching a picture is affected by whether a scene presented just previously involves the same or a different distance between located and reference objects. Thus Carlson and Van Deman have shown that distance is important for projective term comprehension. More widely, the extent to which one can regard an object as *in* other object, for example, may well depend on the degree of inness exhibited by two different objects just previously mentioned. This merits further testing.

In the wider context of the debate regarding whether spatial language and non-linguistic spatial judgements are associated with the same underlying representations (see for example Coventry, Valdés, Castillo, & Guijarro-Fuentes, 2008; Crawford, Regier, & Huttenlocher, 2000; Hayward & Tarr, 1995; Munnich, Landau, & Dosher, 2001), the present results suggest that the factors that affect distance estimation, such as the presence of a distractor object and cueing a specific distance, may also affect spatial language comprehension for those relations. However, the results failed to support anchoring as a contributor to such context effects, contrary to the evidence that (nonlinguistic) distance and time estimations are subject to anchoring (LeBoeuf & Shafir, 2009). The mapping between spatial proximity judgements and nonlinguistic distance judgements may be complex. Testing both linguistic and nonlinguistic judgements for proximity relations within the same study with the same participants is required before the extent of potential correspondence can be established adequately.

REFERENCES

Ashley, A., & Carlson, L. A. (2007). Interpreting proximity terms involves computing distance and direction. *Language and Cognitive Processes*, *22,* 1021–1044.

Carlson, L. A., & Covey, E. S. (2005). How far is near? Inferring distance from spatial descriptions. *Language and Cognitive Processes*, *20*, 617–631.

Carlson, L. A., & Kenny, R. (2006). Interpreting spatial terms involves simulating interactions. *Psychonomic Bulletin & Review, 13,* 682–688.

Carlson, L. A., & Van Deman, S. R. (2004). The space in spatial language. *Journal of Memory and Language, 51*, 418–436.

Codol, J.-P., Jarymowicz, M., Kaminska-Feldman, M., & Szuster-Zbrojewicz, A. (2006). Asymmetry in the estimation of interpersonal distance and identity affirmation. *European Journal of Social Psychology, 19,* 11–22.

Costello, F. J., & Kelleher, J. D. (2006) Spatial prepositions in context: The semantics of near in the presence of distractor objects. *Proceedings of the Third ACL-SIGSEM Workshop on Prepositions*, Trento, Italy.

Coventry, K. R., & Garrod, S. C. (2004). *Saying, seeing and acting*. New York: Psychology Press, Taylor & Francis Group.

Coventry, K. R., Valdés, B., Castillo, A., & Guijarro-Fuentes, P. (2008). Language within your reach. Near-far perceptual space and spatial demonstratives. *Cognition, 108*, 889–895.

Crawford, L. E., Regier, T., & Huttenlocher, J. (2000). Linguistic and non-linguistic spatial categorisation. *Cognition, 75,* 209–235.

Eriksen, C. W., & St. James, J. D. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Perception & Psychophysics*, *40*, 225–240.

Ferenz, K. (2000). *The role of nongeometric information in spatial language*. Unpublished doctoral dissertation, Dartmouth College, Hanover, NH.

Hayward, W. G., & Tarr, M. J. (1995). Spatial language and spatial representation. *Cognition, 55,* 39–84.

Herskovits, A. (1986). *Language and spatial cognition: An interdisciplinary study of the prepositions in English*. Cambridge: Cambridge University Press.

Hirtle, S. C., & Mascolo, M. F. (1986). The effect of semantic clustering on the memory of spatial locations. *Journal of Experimental Psychology: Learning, Memory and Cognition, 12,* 181–189.

Hund, A. M., & Plumert, J. M. (2007). What counts as *By*? Young children's use of relative distance to judge nearbyness. *Developmental Psychology*, *43*, 121–133.

Jacowitz, K., & Kahneman, D. (1995). Measures of anchoring in estimation tasks. *Personality and Social Psychology Bulletin, 21*, 1161–1166.

Kemmerer, D. (1999). “Near” and “far” in language and perception. *Cognition, 73,* 35–63.

LeBoeuf, R. A., & Shafir, E. (2009). Anchoring on the “here” and “now” in time and distance judgements. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*, 81–93.

McNamara, T., & Diwadkar, V. (1997). Symmetry and asymmetry of human spatial memory. *Cognitive Psychology, 34*, 160–190.

Miller, G. A., & Johnson-Laird, P. N. (1976). *Language and perception.* Cambridge: Cambridge University Press.

Montello, D. R. (1997). The perception and cognition of environmental distance: Direct sources of information. In S. C. Hirtle & A. U. Frank (Eds.), *Spatial information theory: A theoretical basis for GIS* (pp. 297–311). Berlin: Springer-Verlag, Lecture Notes in Computer Science 1329.

Munnich, E., Landau, B., & Dosher, B. A. (2001). Spatial language and spatial representation: a cross-linguistic comparison. *Cognition, 81,* 171–207.

Mussweiler, S. F. T., & Strack, F. (2001). The semantics of anchoring. *Organizational Behaviour and Human Decision Processes, 86*, 234–255.

Newcombe, N., Huttenlocher, J., Sandberg, E., Lie, E., & Johnson, S. (1999). What do misestimation and asymmetries in spatial judgement indicate about spatial representation. *Journal of Experimental Psychology: Learning, Memory and Cognition, 25*, 986–996.

Plous, S. (1989). Thinking the unthinkable: The effects of anchoring on likelihood estimates of nuclear war. *Journal of Applied Social Psychology, 19*, 67–91.

Posner, M. I. (1980) Orienting of attention. The VIIth Sir Frederic Bartlett Lecture. *Quarterly Journal of Experimental Psychology, 32*, 3–25.

Posner, M. I., & Y. Cohen (1984) Components of visual orienting. In H. Bouma and D. Bowhuis (Eds.), *Attention and performance, Vol. X* (pp. 531–556). Hillsdale, NJ: Lawrence Erlbaum Associates.

Regier, T., & Carlson, L. (2001). Grounding spatial language in perception: an empirical and computational investigation. *Journal of Experimental Psychology: General, 130*, 273–298.

Reitsma-van Rooijen, M., & Daamen, D. D. L. (2006). Subliminal anchoring: The effects of subliminally presented numbers on probability estimates. *Journal of Experimental Social Psychology*, *42*, 380–387.

Rottenstreich, Y., & Tversky, A. (1997). Unpacking, repacking, and anchoring: Advances in support theory. *Psychological Review*, *104*, 406–415.

Sadalla, E. K., Burroughs, W. J., & Staplin, L. J. (1980). Reference points in spatial cognition. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 516–528.

Strack, F., & Mussweiler, T. (1997). Explaining the enigmatic anchoring effect: Mechanisms of selective accessibility. *Journal of Personality and Social Psychology, 73*, 437–446.

Talmy, L. (1983). How languages structures space. In H. Pick & L. Acredolo (Eds.), *Spatial orientation: Theory, research and practice* (pp. 225–282). New York: Plenum Press.

Tversky, A., & Kahneman, D. (1974). Judgement under uncertainty: Heuristics and biases. *Science, 185*, 1124–1131.

Wilson, T. D., Houston, C., Etling, K. M., & Brekke, N. (1996). A new look at anchoring effects: Basic anchoring and its antecedents. *Journal of Experimental Psychology: General, 4*, 387–402.