Factors Involved in the Use of In and On

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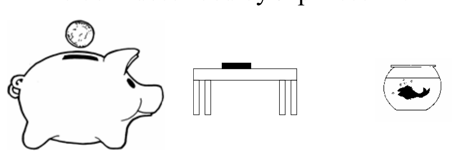
Abstract

What factors influence people's use of spatial prepositions? In this paper, we examine the influence of four factors – geometry of the Ground, function of the Ground, animacy of the Ground, and animacy of the Figure – on the use of English *in* and *on.* We find evidence for all four of these factors. We conclude that spatial prepositions appear to involve a complex set of spatial and non-spatial interacting factors.

Introduction

In recent years, the semantics of spatial relational terms has excited substantial interest in linguistics and cognitive science. This is due in part to a paradox presented by spatial terms. On the one hand, spatial terms seem simple, tractable, and obvious. For example, there is no doubt in the minds of native speakers of English which term to use to describe the position in each of the pictures in Figure 1 of the located object, which following Talmy (1983) we'll be referring to as the Figure, with respect to the reference object, or Ground. Despite this, as many researchers have shown (e.g., Bowerman & Pederson, 1996; Cienki, 1989; Levinson, 1996), there is marked cross-linguistic variability in how linguistic terms map on to the world. For example, the three-way English distinction presented in Figure 1 corresponds to a two-way distinction in Spanish, where the situations described by English *on* and *in* are both described by Spanish *en*, and to a separate two-way distinction in Japanese, where the scenes described by English *over* and *on* are both described by Japanese *ue*.



over	on	in
sobre	en	en
ue	ue	naka

Figure 1: English, Spanish, and Japanese descriptions of the same scenes

As a result of this variability, spatial relational terms are among the most difficult expressions to acquire when learning a second language. They are also slow to be acquired by children, relative to their high frequency. Investigations into the semantics of spatial relational terms across languages have shown that they encode a variety of factors of the scenes they are used to describe (Bowerman, 1996; Levinson, 1996; Sinha & Thorseng, 1995). Among these are the geometry of the Ground (Jackendoff & Landau, 1991; Landau & Jackendoff, 1993; Talmy, 1983), the geometry of the Figure (Brown, 1994; Levinson, 1996), the geometrical relation between the Figure and the Ground (Bennett, 1975; Bowerman & Pederson, 1996; Carlson-Radvansky & Regier, 1997; Herskovits, 1986; Miller & Johnson-Laird, 1976; Regier, 1996; Talmy, 1983), the functional relation between the Figure and the Ground (Coventry, Carmichael, & Garrod 1994; Vandeloise, 1991, 1994), and the qualitative physics of the scene (Bowerman & Choi, 2001; Bowerman & Pederson, 1996; Forbus, 1983, 1984; Talmy, 1988). Interestingly, very little importance is accorded in English to the Figure object, which is often treated as though it were a point (Landau & Jackendoff, 1983; Talmy, 1983).

In this paper, we examine the influence of four of these factors on the applicability of the English spatial prepositions *in* and *on*. In particular, we test the influence of (a) the geometric relation between the Figure and the Ground, as a function of the Ground's geometry; (b) functional information about the Ground; (c) the animacy of the Ground; and (d) the animacy of the Figure.

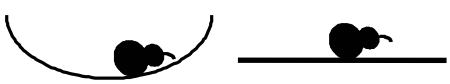
To do this, we adapted Labov's (1973) classic method for studying complex interacting factors on the use of English nouns such as *cup, bowl,* and *vase*. Labov varied the width-to-depth ratio on a series of cuplike objects and asked speakers what the objects would be called in various contexts. In this way, he could independently vary geometric and functional information. He found that both manipulations influenced participants' naming choices.

Based on Labov's technique, we used an analogous design to independently vary information about the four factors we wished to test. Then we presented the resulting pictures to English speakers and asked them to choose which preposition – *in* or *on* – best applied. Before describing the study, we discuss the set of factors.

Rationale Behind the Factors

Geometry of the Ground

Geometric factors reflect the topology of the situation, including specifics of the shapes of the Figure and the Ground and information about contact between the Figure and the Ground. Geometric approaches to the semantics of spatial prepositions in English tend to stress that the Figure must be located at the interior of the Ground (which, as a result, must have an interior) for an appropriate use of *in*, while the Figure must be in contact with the surface of the Ground (which, as a result, must have a surface) for an appropriate use of *on*. By placing the Figure in contact with the surface of the Ground, then manipulating the concavity of the Ground such that the surface in contact with the Figure becomes an interior, one can manipulate the extent to which the geometry portrayed fits the requirements of either *in* or *on*. This is illustrated in Figure 2: the Ground in Figure 2a has high concavity, resulting in the presence of an interior which would allow the use of *in*; the Ground in Figure 2b has low concavity, resulting in the existence of a flat surface which is in contact with the Figure, allowing the use of *on*.



(a) (b)

Figure 2: Two scenes differing in the concavity of the Ground

Function of the Ground

Functional factors important to spatial semantics include the typical function of the Ground and the extent to which the Ground is fulfilling this function. Coventry and his colleagues (Coventry et al., 1994) found empirical evidence that information about the typical function of the Ground influences the use of English spatial prepositions. In their study, the usage of *in* was found to be more prevalent when solid Figures (such as apples) were placed with respect to a bowl (which typically holds solids) than when they were placed with respect to a jug (which typically holds liquids). They concluded that knowledge about the particular function typical of an object contributes to preposition use.

Animacy

There are many reasons to believe that animacy may affect the applicability of English spatial relational terms. First, animacy plays a role in other linguistic phenomena, including the dative alternation[1] (Levin, 1993) and classifier usage (Comrie, 1981; Lucy, 1992). Additionally, the animacy of the Figure plays a role in the use of the Dutch preposition *op*, which is used when "a living figure finds support in any orientation" (Bowerman, 1996, p.153). Finally, an animate Ground may be able to exert volitional control over other objects, and specifically over the location of the Figure. Arguably, if the Ground is able to exert volitional control over the location of the Figure, it can better serve as a container for the Figure, as it can prevent the Figure from exiting the configuration. As the Ground better serves as a container for the Figure, the applicability of *in* should increase. In keeping with this hypothesis, previous research found that scenes depicting an animate Ground did receive a higher proportion of *in* responses than did scenes depicting an inanimate Ground (Feist & Gentner, 1997). Conversely, the fact that an animate Figure is able to exert control over its own position, thereby entering and exiting a configuration at will, suggests that it might be a less ideal participant than an inanimate Figure in what Vandeloise (1991, 1994) has called the container/contained relationship. As the Figure becomes less "containable", the applicability of *in* should decrease.

Why include properties of the Figure?

Most previous research has concluded that the Figure has little or no effect on the use of English prepositions (e.g., Landau & Stecker, 1990; Talmy, 1983). However, this is clearly not the case for all languages, as demonstrated by the myriad spatial terms dependent on the Figure found in Mayan languages such as Tzeltal (Brown, 1994; Levinson, 1996). Because there are potentially many ways in which the Figure could have an effect on the use of spatial terms, a closer examination of the Figure's role in English terms may be in order.

In this study, we decided to explore the possibility that the animacy of the Figure influences preposition choice in English, motivated in part by the discussion above. Additional motivation comes from the research of Sinha and Kuteva (1995), who noted indirect effects of the animacy of the Figure on preposition selection.

[1] The dative alternation refers to the equivalence of alternate forms such as *I sent the book to Sue* and *I sent Sue the book*. However, the recipient of the action must be animate in order to appear outside of a prepositional phrase; we can only say *I sent the book to Spain* and not *I sent Spain the book*.

For example, preposition choice is influenced by the motive, if any, attributed to the Figure for entering the spatial relation. This is illustrated by the contrast shown in (1) and (2) (Sinha & Kuteva, 1995, examples (27) and (28)). The use of *in* suggests that the Ground is the Figure's final destination, while the use of *at* suggests that the Figure has merely reached the Ground en route to its final destination.

(1) Rommel is *in* Cairo. (Figure's attributed intention = Ground as goal)

(2) Rommel is *at* Cairo. (Figure's attributed intention = Ground as sub-goal)

Testing the Factors

In previous work we used an inanimate Ground that was described as an artifact and found that functional information about the Ground mattered in the choice of *in* vs. *on* (Feist & Gentner, 1998). In the current study we included two conditions in which the Ground is described as a non-artifact (a slab and a rock) so as to test an extended range of functionality. We also added an animate Ground to test for effects of the animacy of the Ground.

Method

Manipulating the factors We individually manipulated each of the factors we tested – the geometry of the Ground, the function of the Ground, the animacy of the Ground, and the animacy of the Figure – so as to separate out each of their influences on the use of *in* and *on*.

The difference in the applicability of *in* and *on* for a flat Ground vs. a concave one motivated the variations in the geometry of the Grounds depicted in the set of scenes used in our experiment. Assuming the importance of geometry to prepositional choice, we predict that greater concavity of the Ground will correspond to a higher proportion of *in* responses from our participants.

To vary the perceived function of the Ground, we varied the label applied to it. This takes advantage of the relation between nominal label and perceived object function to specify the Ground's function (Labov, 1973). Coventry et al. (1994) found that this manipulation influenced the usage of *in* and *on* when the Ground object, a shallow dish, was labeled as either a *dish* or a *plate*.

In order to investigate the possibility that functional information about the Ground, as communicated through its label, influences the use of the English spatial prepositions *in* and *on*, we varied the noun applied to the inanimate Ground in our experiment. The five labeling conditions introduced the animate Ground as a *hand* and the inanimate Ground as one of: *dish, plate, bowl*, *slab,* or *rock*. Taken in isolation, the noun *bowl* tends to denote objects that function as containers; the noun *plate*, objects that function as surfaces; the noun *slab*, afunctional surfaces; and the noun *rock*, afunctional solids. The fifth noun, *dish*, is a superordinate of both *bowl* and *plate* and is therefore expected to have a function that is ambiguous between a container and a surface: a dish might sometimes be considered a container and other times a surface. Assuming the importance of functional information about the Ground, we predict that we will find the highest proportion of *in* responses for the inanimate Ground when it is labeled as a *bowl*, a somewhat lower proportion when it is labeled as a *dish*, a still lower proportion when it is labeled as a *plate*, and the lowest proportion when it is labeled with the afunctional *slab* and *rock*.

We investigate the role of the animacy of the Ground by having each of the scenes shown to participants depict either a hand (animate Ground) or a dishlike tray (inanimate Ground). We predict that the usage of *in* will be more prevalent for scenes involving the animate Ground than for those involving the inanimate one. We investigate the role of the animacy of the Figure by having each of the scenes shown to participants depict either a firefly (animate Figure) or a coin (inanimate Figure). We expect to find a lower proportion of *in* responses to scenes depicting the animate Figure than to comparable scenes depicting the inanimate one.

Participants Ninety-one Northwestern University undergraduates received course credit for their participation in this experiment. All reported being fluent speakers of English.

Stimuli We used a set of concavity-matched stimuli created using Autodesk 3D Studio (see Feist & Gentner, 1997). These stimuli depicted two Grounds (an ambiguous dishlike tray and a hand) paired with two Figures (a firefly and a coin) at three levels of concavity, for a total of twelve pictures. The model for the inanimate Ground was overlaid on the model for the hand at each concavity level to ensure that the concavities and the placement of the Figures would be identical. Example stimuli are shown in Figures 3 and 4.[2]

Procedure Stimuli were presented in two randomized blocks, each consisting of the entire set of twelve pictures. Each of the stimuli was presented for five seconds on a computer screen. Participants were given answer sheets containing sentences of the form:

The *Figure* is IN/ON the *Ground*.

[2] The actual stimuli shown in the experiment were full color.

concavity was .38; medium concavity, .46; and high concavity, .54, $F(2,172) = 28.34$, $p < .0001$.

Figure 3: Dishlike tray paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)

Figure 4: Hand paired with firefly at three concavity levels: low (approximately flat), medium, and high (deeply curved)

where *Figure* was filled in with the noun referring to the Figure (i.e., *firefly* or *coin*), and *Ground* was filled in with *hand* when the animate Ground was shown and the noun corresponding to the labeling condition (*dish, plate, bowl, slab,* or *rock*) when the inanimate Ground was shown.

Participants were told to circle *in* or *on* to make each sentence describe the corresponding picture on the computer screen.

Design We used a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) x 5 (labeling condition) design. Ground, Figure and concavity were varied within subject and labeling condition was varied between subjects. Each participant was given only one of the five labels for the inanimate Ground.

Results

As predicted, we found that participants' choice between *in* and *on* to describe the scenes was influenced by the labeling condition as well as by the concavity of the Ground, the animacy of the Ground, and the animacy of the Figure. These results were confirmed by a 2 (Ground: hand or dishlike tray) x 2 (Figure: firefly or coin) x 3 (concavity) x 5 (labeling condition) repeated measures analysis of variance (ANOVA).

The effect of the Ground's concavity was demonstrated by an increase in *in* responses with concavity (Figure 5). (The proportion of *on* responses is just 1-proportion of *in* responses.) Averaged across both Figures, both Grounds and all five labeling conditions, the proportion *in* responses to scenes depicting low concavity was .38; medium concavity, .46; and high concavity, .54, $F(2,172) = 28.34$, $p < .0001$.

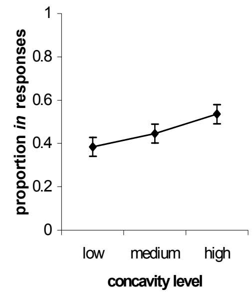


Figure 5: Proportion of *in* responses as a function of concavity

Participants' choice between *in* and *on* was also influenced by functional information about the Ground, as communicated by the label applied to it ($F(4,86) = 10.77$, $p < .0001$). (There was also an interaction between the animacy of the Ground and the functional labeling condition ($F(4,86) = 5.43$, $p = .001$), reflecting the fact that the label was only changed for the inanimate Ground). Averaging across all concavities, when the inanimate Ground was referred to as a *bowl*, which should function as a container, the proportion of *in* responses was highest ($M = .65$). When we referred to the inanimate Ground as a *plate*, which should function as a surface, the proportion of *in* responses was quite low ($M = .09$). When it was labeled as a *dish*, (the superordinate term for *bowl* and *plate*) the proportion of *in* responses was in between ($M = .50$). Finally, the proportion of *in* responses was quite low when the afunctional labels *rock* and *slab* were applied (*M*s for *slab* = .08; for *rock* = .07) (Figure 6).

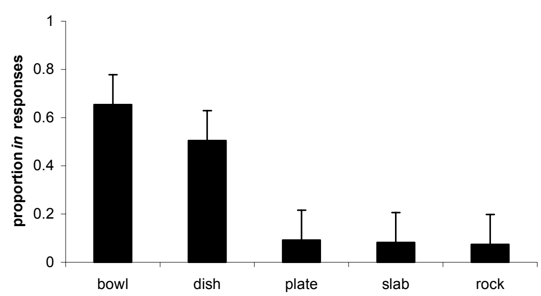


Figure 6: Proportion *in* responses to the inanimate Ground as a function of labeling condition

Scenes depicting an animate Ground received a higher proportion of *in* responses than did those depicting an inanimate one (Figure 7), demonstrating an influence of the animacy of the Ground on the use of *in* and *on*. Averaged across both Figures, all five labeling conditions and all three concavities, the proportion *in* responses to scenes depicting the hand was .63; to scenes depicting the dishlike tray, .28, $F(1,86) = 65.59$, $p < .0001$.

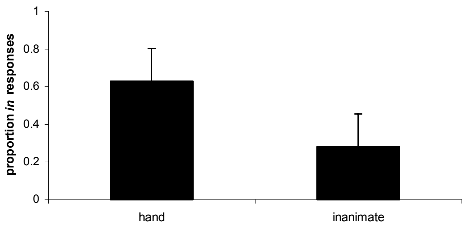


Figure 7: Proportion *in* responses as a function of the animacy of the Ground.

Finally, participants were more likely to choose *in* to describe scenes depicting the inanimate Figure than to describe those depicting the animate Figure (Figure 8), demonstrating an influence of the animacy of the Figure. Averaged across both Grounds, all three concavities, and all five labeling conditions, the proportion *in* responses for *coin* as Figure was .49; for *firefly* as Figure, .43, ($F(1, 86) = 9.69$, $p < .005$).

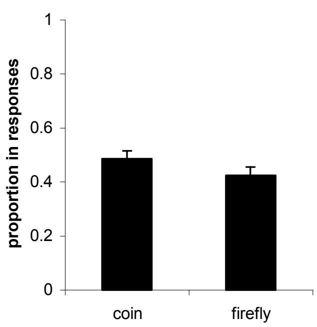


Figure 8: Proportion *in* responses as a function of the animacy of the Figure

Discussion

The results of these studies suggest that the appropriate use of spatial prepositions in English is influenced by a complex set of interacting factors. We found evidence that the geometry of the Ground, functional information about the Ground, the animacy of the Ground, and the animacy of the Figure are all taken into account when choosing an appropriate preposition to apply to a scene. It appears that to appropriately capture the meanings of English spatial relational terms, one must incorporate the influences of multiple factors of spatial scenes.

An important future direction is to broaden the systematic studies of spatial semantics beyond English spatial prepositions. The languages of the world have been shown to encode a variety of different factors into the meanings of their spatial terms (Bowerman, 1996; Bowerman & Pederson, 1996; Levinson, 1996). Factors identified in one language may be worth investigating in languages where they have not yet been identified. As a case in point, although previous studies had suggested that the nature of the Figure does not contribute to the use of English spatial prepositions (*e.g.,* Landau & Stecker, 1990), we were led to investigate this factor by noting the findings for Mayan languages such as Tzeltal, in which properties of the Figure play a prominent role in spatial terms (Brown, 1994; Levinson, 1996). The effect of the Figure's animacy that we found, while small, nonetheless shows that some aspects of the Figure do influence English prepositional usage. It might have been overlooked had we not taken inspiration from the spatial semantics of other languages. What other insights might be gleaned from broader cross-linguistic work?

Cross-linguistic studies could also illuminate the aspects of animacy that matter for spatial language. In our study we used a fairly broad definition of animacy: things that are capable of self-determination (e.g., human hands and fireflies) were taken as animate, while objects incapable of self-determination (e.g., dishes and coins) were not. But the notion of animacy itself varies cross-linguistically. One way in which animacy is manifest is in such syntactic distinctions as whether something can be counted or pluralized. For example, in English, there is a count-mass distinction such that humans, animals, and objects (all typically denoted by count nouns) can be counted simply (e.g., *four chairs*); but substances (denoted by mass nouns) require a unitizer (e.g., *four pieces of wood*). In Yucatec Mayan, however, this 'countability' privilege extends only to animate entities (humans and animals); and in Japanese, the cut is made after humans; even animals require a classifier to be counted (Imai & Gentner, 1997). It is intriguing to ask whether this "animacy continuum" (Lucy, 1992) in grammatical distinctions influences the semantics of spatial terms.

Our results indicate that a broad range of factors enter into the semantics of English spatial prepositions. Their use is influenced not only by the geometry of scenes, but also by nonspatial factors such as function and animacy. Underlying the seemingly simple task of localizing objects is a host of subtle factors to which humans naturally and fluently attend.

Acknowledgments

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References

Bennett, D. C. (1975). *Spatial and temporal uses of English prepositions: An essay in stratificational semantics*. London: Longman.

Bowerman, M. (1996). The origins of children's spatial semantic categories: Cognitive vs. linguistic determinants. In Gumperz, J. and Levinson, S. (Eds.), *Rethinking Linguistic Relativity*. Cambridge, England: Cambridge University Press.

Bowerman, M. & Choi, S. (2001). Shaping meanings for language: Universal and language specific in the acquisition of spatial semantic categories. In M. Bowerman & S. C. Levinson (Eds.), *Language acquisition and conceptual development*. Cambridge, UK: Cambridge University Press.

Bowerman, M., & Pederson, E. (1996). *Cross-linguistic perspectives on topological spatial relationships*. Manuscript in preparation.

Brown, P. (1994). The INs and ONs of Tzeltal locative expressions: The semantics of static descriptions of location. *Linguistics, 32*, 743-790.

Carlson-Radvansky, L. A., & Regier, T. (1997). An empirical and computational investigation into the shape of linguistic spatial categories. Paper presented at the *Fourteenth National Conference on Artificial Intelligence, Workshop on Language and Space.*

Cienki, A. J. (1989). *Spatial cognition and the semantics of prepositions in English, Polish, and Russian*. Munich, Germany: Verlag Otto Sagner.

Comrie, B. (1981). *Language universals and linguistic typology: Syntax and morphology.* Oxford, UK: Basil Blackwell.

Coventry, K., Carmichael, R., & Garrod, S. C. (1994). Spatial prepositions, object-specific function, and task requirements. *Journal of Semantics, 11,* 289-309.

Feist, M. I., & Gentner, D. (1997). *Animacy, control, and the IN/ON distinction*. Paper presented at the Fourteenth National Conference on Artificial Intelligence, Workshop on Language and Space, Providence, RI.

Feist, M. I., & Gentner, D. (1998). On plates, bowls, and dishes: Factors in the use of English IN and ON. *Proceedings of the Twentieth Annual meeting of the Cognitive Science Society*, 345-349.

Forbus, K. D. (1983). Qualitative reasoning about space and motion. In D. Gentner & A. L. Stevens (Eds.), *Mental models*. Hillsdale, NJ: Lawrence Erlbaum.

Forbus, K. D. (1984). Qualitative process theory. *Journal of Artificial Intelligence, 24,* 85-168.

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

Imai, M., & Gentner, D. (1997). A cross-linguistic study of early word meaning: Universal ontology and linguistic influence. *Cognition, 62,* 169-200.

Jackendoff, R., & Landau, B. (1991). Spatial language and spatial congnition. In D. J. Napoli & J. A. Kegl (Eds.), *Bridges between psychology and linguistics* (pp. 145-169). Hillsdale, NJ: Lawrence Erlbaum.

Labov, W. (1973). The boundaries of words and their meanings. In C-J. N. Bailey and R. W. Shuy (Eds.), *New ways of analyzing variation in English*. Washington, D.C.: Georgetown University Press.

Landau, B. (1996). "Multiple geometric representations of objects in languages and language learners." In Bloom, P., Peterson, M. A., Nadel, L., and Garrett, M. F. (Eds.), *Language and Space*. Cambridge: MIT Press.

Landau, B., & Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences, 16,* 217-265.

Landau, B., & Stecker, D. S. (1990). Objects and places: Geometric and syntactic representations in early lexical learning. *Cognitive Development, 5*, 287-312.

Levin, B. (1993). *English verb classes and alternations: A preliminary investigation*. Chicago: The University of Chicago Press.

Levinson, S.C. (1996). Relativity in spatial conception and description. In Gumperz, J. and Levinson, S. (Eds.), *Rethinking Linguistic Relativity*. Cambridge, England: Cambridge University Press

Lucy, J. A. (1992). *Grammatical categories and cognition.* Cambridge, UK: Cambridge University Press.

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

Regier, T. (1996). *The human semantic potential: Spatial language and constrained connectionism.* Cambridge, MA: MIT Press.

Sinha, C., & Kuteva, T. (1995). Distributed spatial semantics. *Nordic Journal of Linguistics*, *18*, 167-199.

Sinha, C. & Thorseng, L. A. (1995). A coding system for spatial relational reference. *Cognitive Linguistics, 6-2/3*, 261-309.

Talmy, L. (1983). How language structures space. In H. Pick and L. Acredolo (Eds.), *Spatial orientation: Theory, research, and application.* New York: Plenum Press.

Talmy, L. (1988). Force dynamics in language and cognition. *Cognitive Science, 12,* 49-100.

Vandeloise, C. (1991). *Spatial prepositions: A case study from French.* Chicago: University of Chicago Press.

Vandeloise, C. (1994). Methodology and analyses of the preposition *in*. *Cognitive Linguistics, 5 (2),* 157-184.