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Spatial Prepositions, Object-Specific Function, and Task Requirements

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Abstract

Two separate issues were looked at in this experimental study of the semantics of spatial prepositions. In the context of work to specify general factors of a functional geometry mediating the use of spatial prepositions (Garrod & Sanford 1989; Coventry 1992, 1993), object-specific effects were investigated. Subjects described video scenes of various objects and their responses of *in*, *on*, *over*, and *beside* were monitored. The independent variables involved the manipulation of functionality specific to various types of objects. It was concluded that knowledge about how particular objects interact with each other contributes to the representation of functional relations which determine preposition usage. Therefore a specification of functional geometries cannot proceed without a prior formulation of our knowledge about the physical and social worlds.

Additionally two different experimental measures of prepositional covariance with the scenes were used: Lickert-scale judgements and sentence completions. Responses from two separate groups were compared. The findings indicated some agreement between the two measures, but also some differences in patterns of response. It is suggested that the measures are tapping different processes, and that a variety of methods need to be used to abstract to lexical representation.

INTRODUCTION

Background to the approach

Most approaches to the semantics of spatial prepositions have assumed that language maps on to geometric relations in the world, and invoke spatial concepts directly in the lexical entries for spatial prepositions. For example, Bennett (1975), in his componential analysis, labels components such as *interior*, *superior*, and *anterior*, and Herskovits (1986) refers to various geometrical notions such as *interior*, *outline*, and *contiguous*. Whether or not the approach adopted is towards minimal specification of lexical entries (e.g. Bennett 1975; Cooper 1968; Leech 1969; Lindkvist 1950; Lindner 1981; Miller & Johnson-Laird 1976; Miller 1985; Sandhagen 1956) or full specification (e.g. Brugman 1981, 1988; Brugman & Lakoff 1988; Casad 1982; Hawkins 1984; Herskovits

1985, 1986, 1988; Janda 1984; Lakoff 1987; Rudzka-Ostyn 1983), a spatial preposition is taken to have more than one sense if the geometric relations change in the world. For example, if we consider the pictures in Figure 1 below, we may postulate that *in* (which may be used to desribe the relationship between the objects concerned) means something different in each picture, and thus has three distinct (though related) senses, which are usually taken to be lexically represented.

Recently this approach to sense delineation has come into question (Coventry 1992, 1993). Furthermore, the idea that the lexical entries of spatial prepositions consist solely of geometric concepts has been challenged (Garrod & Sanford 1989; Talmy 1988; Coventry 1992, 1993; Coventry & Ludwig 1991). Not only does the empirical evidence suggest that purely geometric concepts cannot determine usage (shortly to be reviewed), but the geometric concepts themselves are rather complex and varied (Crangle & Suppes 1989; Suppes 1991). Coventry (1992, 1993) points out that, if a variety of geometries underlie spatial language as Suppes and colleagues maintain, one then needs to give an account of how the relevant geometry is selected in context. Unfortunately, an account of how one selects a particular geometry in context has not been forthcoming.

It is not the purpose of this paper to deal with issues of sense delineation and lexical semantic methodology (see Coventry 1992; 1993 for a discussion). Here we focus on the issue of the factors which influence the covariance between spatial language usage and the world, to further investigate functionality effects proposed by Garrod & Sanford (1989) and Coventry (1992, 1993).

Spatial prepositions and functional relations

Garrod & Sanford (1989) have argued that mental models are used as interfaces between language and the spatial world, and that functional relations underlie the meaning of the spatial prepositions *in*, *on*, and *at* (see Coventry 1992, 1993 for a detailed discussion).

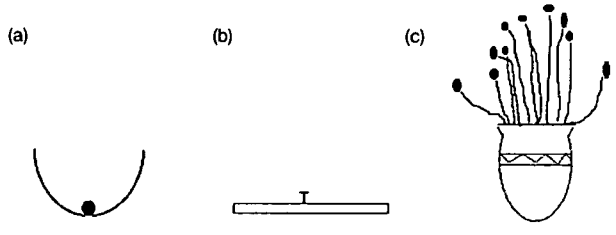

Figure 1 Sample scenes often taken to represent different senses of *in*

Functional relations have to do with how objects are interacting with each other, and what the functions of the objects are. These issues cannot be separated. Michotte (1963) has made this point clearly. He argued: 'It is by coming to know what things do that we learn what they are. What they are for is much more than their shape, their size, and their colour; it is above all what they are capable of doing, or what can be done with them.' Garrod & Sanford (1989) provide the starting point for functional contents associated with spatial prepositions, and this line has been developed by Coventry (1992, 1993). Coventry proposes that the lexical entry for *in* is something like;

> **in**: functional containment—*in* is appropriate if the ground is conceived of as fulfilling its containment function.

Whether or not *in* is appropriate depends on the mental model adopted in the specific situation, where a mental model is defined as a temporary structure in working memory which serves as an interface between language and the world. Garrod & Sanford argue that spatial mental models are typically built around conceptual relations such as containment, support, or functional coincidence, which have both a functional and a spatial significance. Take, for instance, *containment*, the relation underlying the preposition *in*. First, this involves a functional relation, which we might call locational control, whereby the location of the ground controls the location of the figure. So if the container is moved, its contents should move with it, and in order to move the contents independently of the container, the control relation must be overcome, e.g. the contents would first need to be taken *out* of the container. But it also involves a spatial relation corresponding roughly to enclosure of figure by ground.[2]

We assume that mental models mediate the use of prepositions according to the scheme represented in Figure 2. The box on the left-hand side of the diagram represents the information the user of a language brings to each situation. That is, the box represents information in memory associated with the word in question (in this case, the word *in*). The box on the right-hand side specifies the information that is apparent in the world in the form of a visual scene or situation. The circles in the middle represent the range of possible mental models (cf. Garrod & Sanford 1989; Coventry 1992, 1993).

If we take the encoding problem, we have a spatial scene in the world from which a variety of mental models can be derived (denoted by the bold arrows). The appropriateness or not of the spatial preposition is then dependent on the mental model adopted, that is, whether or not it contains the appropriate underlying functional geometry. With the decoding problem, the language itself can suggest a particular model of the scene. The mental model constructed can then be imposed on the actual scene in the world, at which point the visual scene in the world can be said to be a valid, or invalid, visual representation of the language used.

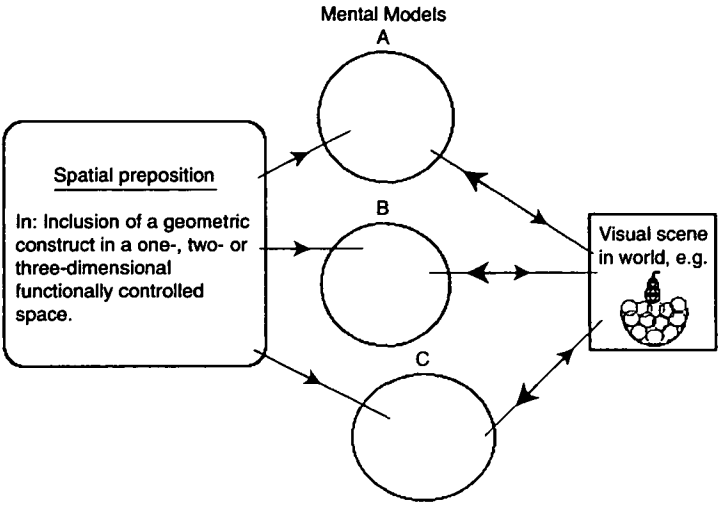

Figure 2 The role of mental models mediating the use of spatial prepositions

What are the factors that determine, in the case of *in*, whether the container is fulfilling its function or not? One such factor must be perceptual evidence for locational control. For example, if it can be demonstrated that the container is controlling the location of the figure over time, then it is clearly fulfilling its function, and hence *in* would be appropriate. Another factor relates to prior knowledge about objects and how they interact. We would expect stereotypic containers to invoke models which represent containment relations. For example, calling an object a *dish* versus a *plate* may suggest alternative functional geometries, and therefore directly influence prepositional usage.

In the mental model framework, the appropriateness crucially depends on the model adopted, so the factors governing appropriateness may vary not only across scenes, but also contexts in which scenes are interpreted, which includes the nature of the communicative situation in which the speaker finds himself. It is these factors the present paper deals with. We briefly review the empirical evidence for the approach before examining it further.

Empirical support for mental models and functional relations

Coventry (1992, 1993) and Ferrier (1991) have tested directly whether functionality affects the use of spatial prepositions, mainly dealing with *in*. In Coventry's study subjects were presented with a video experiment under the guise of a memory test. They were told that they were the experimental group in an experiment designed to test the effects of text on memory for visual

scenes. What they had to do was to watch each scene (natural objects filmed) and produce a sentence (i.e. *say* a sentence) linking the figure and ground in the scene. After every ten scenes, a memory test was run in order to maintain the cover of a memory experiment. As a result of the cover, the experiment yielded the spontaneous use of language to describe the visual scenes, and on analysis several key findings emerged.

Contiguity of movement of figure with ground was found to significantly increase the use of *in*. For example, *in* was used significantly more in Figure 3g as compared with 3h.[3] Thus a demonstration of locational control clearly increases the use of *in*. Conversely, movement of the figure independently of the ground was found to reduce the use of *in*, although not significantly in every case (e.g. *in* was used significantly more in 3e than in 3f).

Comparing static scenes involving a jug and a bowl, the ground was found to have a significant effect on the use of *in*. *In* was used significantly more with the bowl as ground than with the jug as ground when the pile was high (e.g. *in* was used significantly more in Figure 3k than in 3l). The use of *in* was greater in all the bowl scenes as compared with jug scenes when the pile of objects rose above the level of the container, although not all these effects were significant at the 5% level. It would seem that object-specific properties affect the use of *in*.

In the absence of clear evidence for functional control, other information in the scene may be used to build a model of that scene. Comparing static scenes where geometric relations remained constant, it was found that contact of the figure via other objects (continuity preserved or otherwise) increased the use of *in*. For example, *in* was used significantly more in Figure 3a than in Figure 3b. Thus the use of *in* is not governed by geometric position alone. Non-continuity produced a significant reduction in the use of *in* when the pile was high in static scenes. (For example, *in* was used significantly more in Figure 3c than in Figure 3d.) No differences in the use of *in* were found with low piles, even in the non-continuity conditions.

Tilting the container (away from canonical orientation) has the effect of reducing the use of *in* (e.g. comparing Figure 3i with 3j, *in* was used significantly more in 3i).

Turning to reference objects, when the pile was high, there was a significant increase in the use of other objects as reference objects, rather than immediate reference to the ground unless figure and ground moved together.

These findings, broadly supported by Ferrier (1991, employing a rating methodology), show that there is much more to spatial prepositional use than geometry alone. They are explicable in terms of the type of lexical entry for *in* proposed by Garrod, Sanford & Coventry. The case of contiguity of movement of figure with ground demonstrates that the container is fulfilling its function as the relative positioning of figure and ground remain constant over time. However, in static scenes, it would appear that subjects use other information to

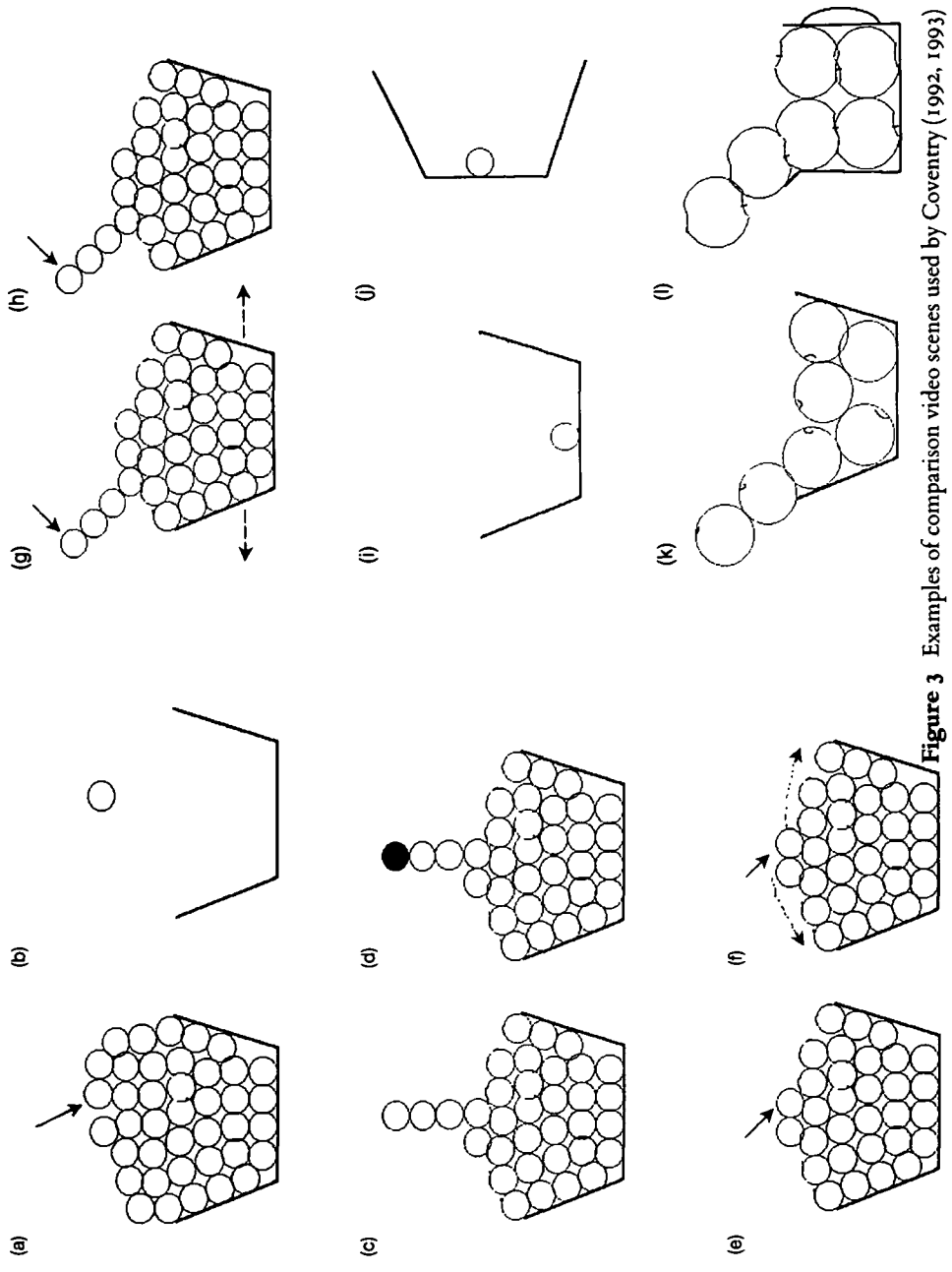

Figure 3 Examples of comparison video scenes used by Coventry (1992, 1993)

make decisions about appropriateness. The fact that *in* is used less with the jug versus the bowl with high piles suggests that the bowl is conceived of as a container of solids, but the jug is conceived of as a container of liquids. Discontinuity of figure with ground also seems to play a part, but only in static cases. Contiguity of movement of figure with ground appears to override any other information apparent in the scenes.

In can even be used in situations where any normal geometric constraints would appear to be flouted. In the context of a game where the goal is to get the pear positioned as depicted in Figure 4, some subjects naturally say, 'the pear is in the bowl' (Coventry 1992).

The present study explores further the role of object specific functions in the determination of prepositional usage in static scenes. These are outlined in the next section.

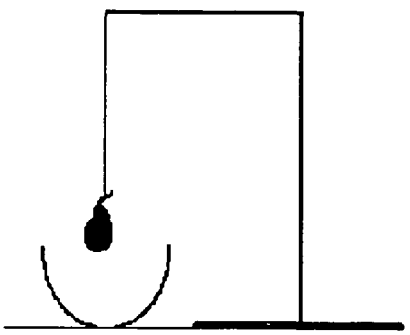

Figure 4 'End of game' scene used by Coventry (1992)

THE EXPERIMENT

Introduction and rationale

The aims of the present study are twofold. The primary aim is to elucidate further object-specific properties which may contribute to the building of mental models of spatial scenes involving *in*, *on*, *over*, and *beside*. We also examine how labelling of an object affects the building of models of scenes.

A secondary aim is to examine to some extent the relative merits of free use (in the form of a sentence competion task)[4] and Lickert-scale judgement measures for studying the semantics of spatial prepositions. Although the studies of Coventry and Ferrier produced a similar pattern of results, there were some differences. Ferrier found an interaction between the dynamic/static factor and the position of the ball in relation to the bowl. She also found grading of appropriateness of *in* in static scenes in relation to the height of the pile. The

continuity/discontinuity contrast was also found to be present at low heights, and interacted with the height of pile. Neither of these effects came out in the Coventry study. As a consequence the study employs both measures across manipulations of scenes so that a comparison can be facilitated. We will deal with each manipulation separately.

Manipulations involving use of *in* and *on*

Highlighting of object-specific function. In static scenes *in* was used more frequently with the bowl than with the jug when the pile was high (Coventry 1992, 1993). The explanation proposed was that the specific function of a jug is to contain liquids, and not solids. If this is the case, then factors which highlight specific function should effect the use of *in* across scenes. One such factor is the addition of liquid to the jug and bowl (filled with solids). It is hypothesized that the addition of liquid to the jug will increase the salience of the object-specific function of the jug, and therefore will lead to a reduction in the use of *in* as compared with the jug without the liquid present. This is because the typical function of a jug as a container of liquids will be made salient and therefore the objects piled on top will seem less functionally controlled by the jug. Therefore, our first hypothesis is that frequency of the use of *in* will be greater when the liquid is present than when it is not present. Such effects should not be apparent with the bowl as the containment of liquid is not associated with the bowl's specific function.

Naming the ground. Differences in preposition use can arise from differences in the conceptualization of the same objects. It is predicted that a shallow dish referred to as 'the plate' will result in greater use of *on* and less use of *in* than when the same ground object is referred to as 'the dish'.

Manipulation of perspective. The effects of perspective on the use of referents in locative expressions are examined. This was primarily chosen as another aspect of preposition use on which to compare the Lickert scale and sentence completion measures.

A plate of fruit on a table was filmed from three distances and the use of *table* or *plate* was compared across scenes. It was predicted that the use of *table* will be greater for scenes of the fruit from further away as the useful description of where the fruit is will change according to the speaker's point of view.

Manipulations involving use of *over*

Most of the function work carried out thus far has dealt most systematically with the preposition *in*. Coventry (1992) has proposed that the lexical entry for *over* is something like;

over: functional aboveness—*over* is appropriate if the figure is located spatially higher than the ground in a manner that is functionally appropriate for the figure and ground.

If this lexical entry is appropriate, then one might expect differences in the use of *over* with scenes where object-specific function is manipulated. Several possible object-specific function manipulations are examined here.

Highlighting of specific function. It is hypothesized that there will be increased use of *over* for scenes with a jug of liquid poised above a glass than for scenes of a similarly poised empty jug. The presence of liquid in the jug may emphasize the interaction between jug and glass, and hence highlight the functional relationship between figure and ground.

Blocking of specific function. It is hypothesized that the presence in a scene of a saucer covering a glass will reduce the use of *over* to describe the position of a jug to the glass below as it interferes with the functional relation between the jug and glass; liquid can no longer be poured into the glass.

Similarly, if the glass below the jug is not in its canonical orientation (i.e. is inverted), its capacity for functionally interacting with the jug is also reduced and so reduced use of *over* is predicted.

Manipulations involving use of *beside*

The preposition *beside* will be looked at to see if functionality influences the use of this term. *Beside* has not been examined before, hence these manipulations are particularly exploratory.

Direct manipulation of functionality. It is predicted that an orange will be less *beside* a jug of liquid than a glass of liquid the same distance away. This is because the jug and glass have a specific associated interaction, whereas a jug and an orange do not.

Highlighting of specific function. It is predicted that *beside* will be used more in scenes with a glass and jug when the glass and jug both contain liquid than when they are empty, because the liquid heightens the functional relation.

Method

Subjects

Forty subjects were tested. These formed two groups of 20 for the two measures used: Lickert scales and sentence completions. The subjects were undergraduate students of mixed sex. All subjects were native speakers of English.

Apparatus and materials

One hundred and three scenes of objects in various positions were filmed in colour without sound using a Canon V-20 colour video camera. The materials filmed were as follows: a glass fruit bowl, a coffee jug, oranges, apples, bananas, a blue tennis ball, an orange tennis ball, ping-pong balls, a table lamp, a book, a glass mug, water, blackcurrant cordial, and a saucer.

Six seconds of each scene were edited on to a video tape using a Panasonic NV-A500 editing controller and two VHS video cassette recorders. Approximately 10 seconds of blacked-out tape was left between each scene.

The order of the scenes on the edited tape was compiled by random stratified sampling, so that scenes which would be compared on preposition use (and rating) did not appear consecutively on the tape. Not all scenes were included for comparison. A large number of scenes were included to provide variety and to break up the presentation of target scenes to avoid priming effects. A VHS video cassette and television were used during presentation of the video to the subjects.

Booklets of numbered sentences (with accompanying Lickert scales) corresponding to the scenes on the edited tape were compiled and photocopies made. These scales were presented as follows:

The ball is in the jug 1 2 3 4 5

The same was done for the sentence completion group. In this case subjects had to complete sentences of the following type:

The ball is _____ the jug

Each booklet contained the sentence for ten scenes (except for the last booklet which covered scenes 91–103).

On the back of each booklet was a blank piece of paper for the subjects' drawings during recall. On the front of the first booklet was a sheet of instructions. Sample comparison scenes are reproduced in line-drawing form in the Appendix.[5]

Procedure

Subjects were seated at a desk near the television on which the video was to be shown, and each given a set of ten booklets. The subjects read an instruction sheet which either asked them to rate a group of sentences individually on a scale of 1–5 for appropriateness of the correspondinrg scene (for the Lickert-scale group), or to complete a sentence with the word(s) they felt were most appropriate to the scene. After they had read these instructions and any queries had been answered the video was started. Importantly, following Coventry

(1992, 1993), the experiment was presented to subjects under the guise of a memory test. Subjects were told, 'You are going to take part in an experimental study of the effects of language task performance on memory for visual scenes'.

After every ten scenes the video was paused and the subjects were asked to sketch on the blank sheet at the back of each booklet, those of the scenes which they could recall. They were asked not to refer back to the sentences and told that they did not need to give the number of the scene of the sketch or to worry about their standard of drawing. The subjects were given approximately three minutes to do their sketches. A couple of minutes break was allowed after scene 50. After recall of the final scenes booklets were collected from each subject.

Results and discussion

The Lickert-scale data was statistically analysed using nonparametric Wilcoxon matched-pairs tests. The exception to this was the naming of referent data which were analysed using nonparametric Mann-Whitney tests (between subjects).

The sentence completion data generated frequencies of use of a particular preposition which were analysed using nonparametric Chi-square tests. Here the results are reported in terms of specific scene comparisons. Test values are only reported when significant.

Manipulations involving use of *in* and *on*

As can be seen from Tables 1 and 2, the prediction that objects are less *in* the jug with the addition of liquid has been supported. Comparing the jug to the bowl in the no liquid scenes there was a significant difference in the judgements of *in*

Table 1 Jug and bowl comparison pooled group data for *in* (Lickert-scale group)

	Bowl (mean of summed Lickert-scale ratings)	Jug (mean of summed Lickert-scale ratings)	Bowl versus jug (Wilcoxon T)
No liquid	20.8	18.1	15*
Liquid	21.5	16.8	12**
No liquid versus liquid (Wilcoxon T)	Nonsignificant	Nonsignificant	

* $p < 0.05$ one-tailed.
** $p < 0.01$.

Table 2 Jug and bowl comparison pooled group data for *in* (sentence completion group)

	Bowl (frequency of use)	Jug (frequency of use)	χ^2
No liquid	69	60	<2.71
Liquid	76	52	4.13*
χ^2	<2.71	<2.71	

* $p < 0.05$ one-tailed.

but not in the use of *in* on the sentence completion task. This finding concurs with the findings of Coventry (1992, 1993) and Ferrier (1991). Coventry found a difference between the jug and the bowl only when the pile of objects was high using a free use task. The height of pile used in the present study was lower than that required to obtain an object-specific effect in the Coventry study. Therefore it is not surprising that a significant effect did not occur.

In the study by Ferrier, although object-specific effects were not examined directly, she did find differences in ratings with low piles involving continuity/discontinuity of figure with ground. Therefore, the fact that a significant effect occurred with a low pile using a Lickert-scale task is again not surprising.

The addition of a liquid to the jug and bowl influences the use and judgements of *in*. With the liquid, there was a significant difference between both use and judgements of *in*. *In* is used significantly more and is judged to be significantly more appropriate when the bowl has the liquid in it than when the jug has the liquid in it as predicted. The addition of liquid emphasizes/draws awareness to the specific function of the jug, but does not affect the specific function of the bowl. This comparison provides the greatest specific function contrast, and one would expect, if an effect was to occur at all, that it should occur with this comparison.

No differences in use were found between jug contrasts. From an examination of the data in Tables 1 and 2, we can see that *in* was used less with the jug than the bowl, although this result did not reach significance. In fact, the ordering of frequency of use and Lickert ratings appears almost identical when comparing the two measures across bowl and jug liquid/no liquid scenes. *In* was judged least appropriate and was used least frequently in the case of the jug with liquid, and was used most and rated most appropriate in the case of the bowl with the liquid. The addition of liquid does indeed influence both use and judgements of *in* for the jug. If anything, with the addition of liquid to the bowl, the use of *in* looks as if it may increase slightly.

On analysis thus far, there is clear evidence for object specific effects influencing the use of *in* with visual scenes. We might venture further that the jug perhaps has a sphere of influence associated with its function which is called to mind by the liquid (see Figure 5).

The effects on the use and judgements of *in* and *on* as a result of naming the referent either 'plate' or 'dish' were tested by comparing data from single scenes, with only half the usual number of subjects (between subjects). These data are displayed in Tables 3 and 4. Both measures produced significant differences in use with scenes involving 'fruit' as ground where the name for the referent was manipulated. The Lickert-scale data also produced significant effects when the ground was 'apple'. In this case the sentence completion data was not significant, although, as can be seen from Table 4, the effects were in the predicted direction. Clearly when one changes the name of the ground the spatial preposition appropriate to describe the scene changes. Objects are said and rated to be more *in a dish* and *on a plate* (than *on a dish* and *in a plate* respectively) although the container remains invariant. This finding is intuitively obvious, but this is the first empirical demonstration of the effect.

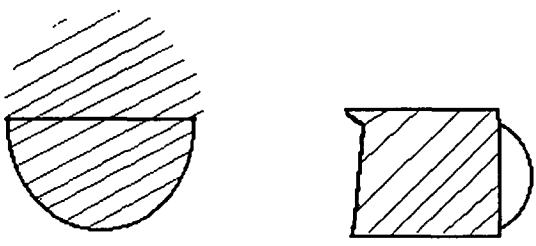

Figure 5 Spheres of functional influence associated with jugs and bowls

Table 3 Naming of the referent and ratings of *in* and *on* (Lickert-scale group)

	Mean of summed Lickert-scale ratings for *in*	Mean of summed Lickert-scale ratings for *on*
Fruit and 'plate'	3.4	3.2
Fruit and 'dish'	4.3	4.5
Mann-Whitney U	26*	24*
Apple and 'plate'	2.7	4.9
Apple and 'dish'	4.1	3.8
Mann-Whitney U	26*	26.5*

*$p < 0.05$ one-tailed.

Table 4 Naming of referent and use of *in* and *on* (sentence-completion group)

	Frequency of use of *in*	Frequency of use of *on*
Fruit and 'plate'	0	10
Fruit and 'dish'	7	3
χ^2	5.14*	2.77*
Apple and 'plate'	1	9
Apple and 'dish'	5	4
χ^2	<2.71	<2.71

*$p < 0.05$ one-tailed.

The prediction that a close-up view of a plate of fruit on a table would lead to less choice of *table* as the referent than a more remote view of the fruit which would produce more choice of *table* as the appropriate referent for the relation of functional support was not reliably supported. The results are displayed in Tables 5 and 6.

No significant differences were found in judgements or use of *table* as referent for the three conditions. However, the direction of the results in the Lickert-scale group was as predicted.

Manipulations involving use of *over*

When water is added to the jug and glass *over* is judged to be significantly more appropriate than when water is not present (see Table 7). This was not the case with the sentence completion group (see Table 8).

Table 5 View of scene and use of reference objects (Lickert-scale group)

View	Mean of Lickert-scale ratings for *table*
Close	3.7
Medium	3.8
Remote	4.4
Close versus medium (Wilcoxon T)	Nonsignificant
Close versus remote (Wilcoxon T)	Nonsignificant
Medium versus remote (Wilcoxon T)	Nonsignificant

Table 6 View of scene and use of reference objects (Sentence-completion group)

View	Frequency of use of *table*
Close	9
Medium	7
Remote	9

Table 7 Jug of liquid versus empty jug pooled group data for *over* (Lickert-scale group)

	Mean of summed Lickert-scale ratings
Jug of liquid	12.7
Empty jug	10.7
Wilcoxon T	39*

* $p < 0.05$ one-tailed.

Table 8 Jug of liquid versus empty jug pooled group data for *over* (sentence-completion group)

	Frequency of use of *over*
Jug of liquid	21
Empty jug	21
χ^2	<2.71

Blocking specific functions had no significant effect on the judgements or use of *over* (Tables 9 and 10), either when the glass is up turned or covered with a saucer. It would appear, therefore, that highlighting specific function affects the building of models, but that blocking of function has no such effect.

Manipulations involving use of *beside*

Judgements and use of *beside* did not differ significantly for the jug and glass versus the jug and orange (see Tables 11 and 12). The direction of both measures was again as predicted. Judgements of *beside* were greater for a jug and glass both containing liquid than for an empty jug and glass, but no effect was found for use, although the findings are in the same direction.

Table 9 Effects of covering and inverting glass on use of *over* (Lickert-scale group)

	Mean of summed Lickert-scale ratings for *over*
With saucer	11.2
Without saucer	11.85
Wilcoxon T	Nonsignificant
Glass in canonical orientation	4.2
Glass inverted	4.2
Wilcoxon T	Nonsignificant

Table 10 Effects of covering and inverting glass on use of *over* (sentence-completion group)

	Frequency of use of *over*
With saucer	18
Without saucer	24
χ^2	<2.71
Glass in canonical orientation	8
Glass inverted	4
χ^2	<2.71

Table 11 Rating of *beside* (Lickert-scale group)

	Mean of summed Lickert-scale ratings
Liquid in jug and glass	13.85
Empty jug and glass	12.70
Wilcoxon T	Nonsignificant
Orange and jug	11.95
Glass and jug	12.25
Wilcoxon T	Nonsignificant

It would appear that there is considerable agreement between measures in most cases as the direction of the effects in all but one case (that of reference objects) is the same for both measures. The Lickert-scale measure produces more significant effects than the sentence completion measure, so it may be the case that the Lickert-scale paradigm is more sensitive. What is likely is that the measures are tapping different processes. A sentence-completion task is a

Table 12 Use of *beside* (sentence-completion group)

	Frequency of use
Liquid in jug and glass	31
Empty jug and glass	26
χ^2	<2.71
Orange and jug	14
Glass and jug	23
χ^2	<2.71

production task where the subject has the choice of using the word which is most appropriate as compared with other words. The production of a word gives no indication as to the nearness of the selection of another word. On the other hand, the Lickert-scale task taps comprehension of situations in that a degree of appropriateness for a word has to be directly assessed.

General discussion

We have further evidence from the present study that the use of spatial language is underdetermined by spatial information alone. Yet there appears to be considerable agreement between subjects in previous studies as to when a particular spatial term is appropriate (or inappropriate). We have suggested that this is because a large part of their meaning reflects additional constraints, constraints which are non-spatial in nature. One can then address the issue of whether spatial constraints or these other functional constraints are the best predictors of usage. Effects have been presented which cannot be predicted by space, but are predicted by function alone. It must be the case that knowledge of what objects are for and how objects interact with each other, as Michotte (1963) has stated, provides the basis for conceptions of spatial arrangements. Thus the construction of mental models of space have more to do with functional constraints than fine geometric distinctions.

One can address the issue of the proportions of spatial language that have to do with space and with functionality. What constraints does space impose? The problem with this is that spatial relations and functional relations are highly correlated. To get at this issue it is necessary to run experiments which clearly attempt to separate out the two factors. It is unlikely that any other type of methodology can adequately do this. Furthermore, different task requirements tap different model-building aspects of the same situation. With the Lickert-scale paradigm gradings of response for enclosure, for example, can be tapped. At the same time, free use tasks tap the production of language which relates

more to communicative situations. Therefore the utilization of a number of experimental methodologies seems the most prudent way to proceed.

Aside from the issue of the proportions of functionality and space in the determination of the building of mental models of spatial scenes, the importance of the conceptualizations themselves must not be underplayed. Mental models provide an interface between language and the world and are built around factors that go beyond information in visual scenes. Thus it is possible to use a spatial term in a context where it would not normally apply without the need to address issues of sense delineation directly. Models help explain the flexibility in the use of language without the need for extensive polysemy.

In conclusion, we can return theoretically to the issues of the factors that go into the building of a mental model as an interface between language and the spatial world. It has been demonstrated that object-specific function effects play an important part in the construction of models. This is the case, not only with *in*, but also with other prepositions, as has been suggested with the case of *over* and *beside*.

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NOTES

1 Some of this work was carried out as part of the degree of MA Honours in Psychology at the University of Dundee. Requests for reprints should be addressed to the first author. Dr K. R. Coventry (address as above), E-mail po2218@uk.ac.plymouth.prime–a.

2 Note, however, that the spatial enclosure relation may be underspecified and only contributes a small but necessary criterion on containment.

3 The figures represented in this section are line drawing representations of the scenes used. It is important to note that the scenes used were filmed 'real' objects, hence preserving ecological validity.

4 The use of a sentence completion task was adopted rather than the free use task used by Coventry (1992, 1993) so that both tasks used were written tasks. There is some evidence that spoken and written language differ in crucial ways (Miller 1985), and therefore the use of a spoken task to be compared with a written task may have confounded the results.

5 These are not presented in order of presentation, but are grouped in order for comparison.

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

Rudzka-Ostyn, Brygida (1983), *Cognitive Grammar and the Structure of Dutch Uit and Polish Wy*, Linguistic Agency, University of Trier, Trier, West Germany.

Sandhagen, H. (1956), *Studies on the Temporal Senses of the Prepositions AT, ON, IN, BY and FOR in Present-day English*, the author, Trelleborg.

Suppes, P. (1991), 'The principle of invariance with special reference to perception', in J. Doignon & J. Falmagne (eds), *Mathematical Psychology: Current Developments*, Springer-Verlag, New York, 35–53.

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

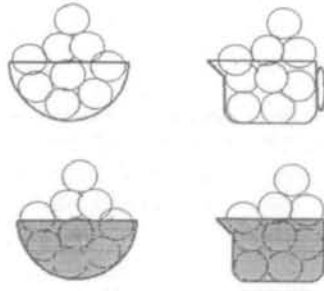
Vandeloise, C. (1984), 'The description of space in French', Ph.D. thesis, University of California, San Diego.

Wood, F. T. (1967), *English Prepositional Idioms*, Macmillan, London.

Appendix - Samples comparison scenes[1]

Manipulations involving *In and On*

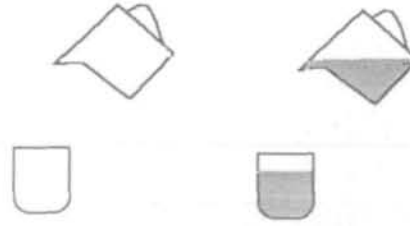
Jug/Bowl/Liquid/No liquid Comparisons



"Plate" versus "dish" Comparisons

Manipulations involving *Over*

Jug\Glass/Liquid/No liquid Comparison



[1]Not all comparison scenes are reproduced here. In many cases the figures were changed although the geometric relations were identical.

REFERENCES

Bennett, D. C. (1975), *Spatial and Temporal Uses of English Prepositions: An Essay in Stratificational Semantics*, Longman, London.

Brugman, C. (1981), 'The story of "over"', MA thesis, University of California, Berkeley, reprinted by the Indiana University Linguistics Club.

Brugman, C. (1988), *The Story of 'Over': Polysemy, Semantics and the Structure of the Lexicon*, Garland Press.

Brugman, C. & Lakoff, G. (1988), 'Cognitive topology and lexical networks', in G. W. Cottrell, S. Small, & M. K. Tannenhause (eds), *Lexical Ambiguity Resolution: Perspectives from Psycholinguistics, Neuropsychology and Artificial Intelligence*, Morgan Kaufman Publishers, San Mateo, CA.

Casad, E. (1982), 'Cora locations and structured imagery', Ph.D. thesis, University of California, San Diego.

Cooper, G. S. (1968), *A Semantic Analysis of English Spatial Prepositions*. (Report No. 1587.) Cambridge, MA: Bolt Beranek and Newman.

Coventry, K. R. (1992), 'Spatial prepositions and functional relations: the case for minimally specified lexical entries', Ph.D. thesis, University of Edinburgh.

Coventry, K. R. (1993), 'Spatial Prepositions and Functional Relations: The Case for Minimally Specified Lexical Entries', working paper, Department of Psychology, University of Plymouth.

Coventry, K. R. & Ludwig, A. (1991), 'The semantics of prepositions: a literature review and proposed framework for future treatment', Centre for Cognitive Science Research Paper EUCCS/RP-45, University of Edinburgh.

Crangle, C. & Suppes, P. (1989), 'Geometric semantics for spatial prepositions', *Midwest Studies in Philosophy*, **XIX**, 399–422.

Ferrier, G. (1991), 'An experimental study to investigate the factors that contribute to a functional geometry of spatial prepositions', Maxi project, Department of Psychology, University of Glasgow.

Garrod, S. C. & Sanford, A. J. (1989), 'Discourse models as interfaces between language and the spatial world', *Journal of Semantics*, **6**, 147–60.

Hawkins, B. W. (1984), 'The semantics of English spatial prepositions', Ph.D. thesis, University of California, San Diego.

Herskovits, A. (1985), 'Semantics and pragmatics of spatial prepositions', *Cognitive Science*, **9**, 341–78.

Herskovits, A. (1986), *Language and Spatial Cognition: An Interdisciplinary Study of the Prepositions in English*, Cambridge University Press, Cambridge.

Herskovits, A. (1988), 'Spatial expressions and the plasticity of meaning', in Rudzka-Ostyn (ed.), *Topics in Cognitive Linguistics*, John Benjamins Publishing Company, Amsterdam/Philadelphia.

Janda, L. (1984), 'A semantic analysis of Russian verbal prefixes ZA-, PERE-, DO-, and OT-' Ph.D. thesis, University of California, Los Angeles.

Lakoff, G. (1987), *Women, Fire and Dangerous Things*, Chicago University Press, Chicago.

Leech, G. N. (1969), *Towards a Semantic Description of English*, Longman, London.

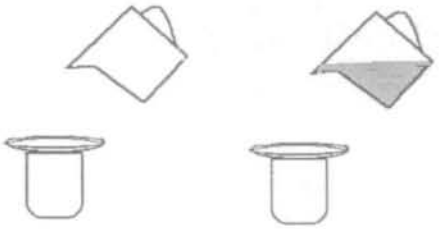
Lindkvist, K. G. (1950), *Studies on the Local Sense of the Prepositions IN, AT, ON, and TO in Modern English, Lund Series in English*, **22**, Munksgaard, Lund and Copenhagen.

Lindner, S. (1981), 'A lexico-semantic analysis of verb-particle constructions with *up* and *out*', Ph.D. thesis, University of California, San Diego, University of Indiana Linguistics Club.

Michotte, A. (1963), *The Perception of Causality*, translated from *La Perception de la causalité* (1946), Methuen & Co. Ltd., London.

Miller, J. (1985), *Semantics and Syntax: Parallels and Connections*, Cambridge University Press, Cambridge.

Jug/Saucer/Glass Comparisons



Jug\Glass/Liquid/No liquid Comparison

Jug/Glass/Orange Comparisons

Manipulations involving *beside*