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CHILDREN'S PRODUCTION OF LOCATIVE EXPRESSIONS IN ENGLISH: THE INFLUENCE OF GEOMETRIC AND EXTRA-GEOMETRIC FACTORS.

By

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Children's Production of Locative Expressions in English: The Influence of Geometric and Extra-Geometric Factors

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Abstract

The research in this thesis examines the influence that both geometric and extra-geometric factors have on children's spatial language production. Over the years it has widely been assumed that spatial prepositions identify *where* objects are in the world (geometric factors) and that this is reflected in the semantic representations of these words. More recently, researchers investigating the lexical semantics of spatial prepositions have begun to question this assumption by demonstrating that *what* objects are and how they are interacting can also affect the way we describe where they are in the world (extra-geometric factors). Following on from research conducted with adults that has demonstrated the importance of both of these factors on spatial language, the main aim of this thesis was to ascertain for the first time whether these factors also influenced children's spatial language production, and if so, when they became important in children's development of spatial expressions. Additionally, due to the paucity of research investigating the *production* of spatial terms, the Experiments reported in this thesis set out to redress the balance. The research in this thesis demonstrated for the first time that both geometric and extra geometric factors influence the production of children's spatial expressions from an early age. In doing so, however, the Experiments reported here were not necessarily revealing as to the nature of the semantic representation of spatial terms, rather they highlighted a different issue; how people make distinctions during a verbal interaction. Evidence is presented that suggests a level of agreement between people regarding the *nonconventional* use of words. In order to distinguish between functional and non-functional situations, both adults and children used different types of spatial terms to locate an object even when they had a limited number of words in their lexicon. An approach to the whole process of prepositional production is suggested rather than concentrating on what is represented in an individual's lexicon.

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

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1. Chapter 1: Introduction

"*We have to understand that the world can only be grasped by action, not by contemplation. The hand is more important than the eye...The hand is the cutting edge of the mind.*" Jacob Bronowski, The Ascent of Man, 3.

Locative prepositions such as *in*, *on*, *over* and *in front of* not only tell us where objects/people are located in space, but they can also imply *extra-geometric* relations between objects such as whether or not those objects/people are interacting with each other. Consider the sentence *the woman is at the computer*. The preposition *at* not only suggests a spatial relationship where the location of *the woman* and *the computer* coincide with each other, but it also suggests that the woman is engaged in an interaction with the computer. The research described in this thesis examines for the first time the relative influence of geometric and extra-geometric factors on children's production of English locative expressions. Communicating the whereabouts of objects and people is a fundamental aspect of our lives and of language itself. How this develops in children learning their first language is a key area of research within spatial cognition and language development.

Spatial relations are usually expressed in language by the use of spatial prepositions (e.g., words such as *in*, *on*, *above* and *in front of*). Spatial prepositions belong to a *closed class* of the vocabulary, a relatively small set of linguistic forms that adds new members rarely and that Talmy (1983) argues can be used as a structuring tool for other semantic domains (e.g., temporal expressions, signification of emotional states). They are among the first words learned by a child, yet at the same time, they are still being developed during a child's early school years and beyond (e.g., E. Clark, 1973; Durkin,

1980). Moreover, spatial prepositions are notoriously difficult to acquire during second language learning as they appear to have a wide range of uses. Indeed, spatial language development is both an interesting and an important area of research as it requires the co-ordination of language and the perceptual system. Research into this area will ultimately help us to understand how these two systems relate to one another (Landau & Jackendoff, 1993). Additionally, although spatial prepositions (e.g., *over*, *under* and *in front of*) are often experienced in non-spatial domains (e.g., temporal, musical, mathematical and metaphorical senses), it is in their spatial sense that they are first acquired (e.g., Weist, 1991).

Over the years, it has largely been assumed that spatial prepositions define *where* objects are in the world and research into the semantics of spatial language has often reflected this assumption (e.g., Hayward & Tarr, 1995; Leech, 1969; Logan & Sadler, 1996). Therefore, it has been suggested that it is the geometry of the scene that underlies the meaning of the spatial preposition that has been used to describe it (e.g., Cooper, 1968; Leech, 1969). However, more recently research has begun to challenge this view. *What* objects are and how they are interacting is also an important factor affecting how we talk about the locations of such objects in the world (e.g., Coventry, Carmichael & Garrod, 1994; Garrod & Sanford, 1989; Vandeloise, 1991, 1994). This relates to the view that areas of the brain are specialised for object identification (the "what" system) and object location (the "where" system; e.g., Farah, Hammond, Levine & Calvanio, 1988; Ungerleider & Mishkin, 1982).

The main purpose of this thesis is to look at the relative influence of geometric and extra-geometric factors on children's spatial language production. This is an interesting area of research for three main reasons. Firstly, while the importance of extra-geometric factors in adults has already been established, there has been no research to date looking at these factors in children's spatial language production. Secondly, it has been argued that it

might be the case that geometry is the central factor underlying the comprehension and production of spatial language, with extra-geometric factors only affecting the representation of spatial terms at a later date (Landau & Munnich, 1998). Conversely, Vandeloise (1991, 1994) has argued that function is more fundamental. Landau and Munnich (1998) suggested that one way to assess this claim would be to look at this from a developmental perspective. If we can ascertain which comes first in children's spatial language, geometric or extra-geometric factors, it will allow us to evaluate these claims. Finally, although there has been a fair amount of research that has investigated children's spatial language development (as reviewed in Chapter 2 of this thesis), much of this research has looked at children's comprehension of spatial terms rather than their production. As Bock (1996) has argued, production is often the poor relation in psycholinguistic research despite its obvious centrality.

Before we examine these issues further, we first need to define what spatial prepositions are more carefully. It is to this issue we now turn.

1.1. Spatial Prepositions: Classifications and Boundaries

Prepositions as a whole are one of the closed-class sets of words that not only contain relatively few items, but also admit new members very rarely. Closed-class forms can be contrasted with open-class sets such as verbs and nouns that contain many members and admit new forms readily.

Prepositions have both concrete uses (spatial and temporal) and grammatical uses. The function of prepositions within syntax is to control the direction of a verb in relation to a noun. Prepositions include words such as *of*, *to*, *in*, *for*, *with*, *under*, *about*, *inside*, *after* and *in front of*. These are called prepositions because in most languages (e.g.,

English, Greek, Latin) they precede the noun. Some prepositions, such as *of*, have a purely grammatical function. Other prepositions, however, express identifiable meanings. These meanings can be temporal, where they might indicate the order of events over time. For example, in the sentence *Peter had lunch between meetings* the preposition *between* is used in its temporal sense, roughly meaning "some time after one event and before a second event". Prepositions can also have concrete, spatial meanings where they might indicate the location of objects and people. In the sentence *the red car is behind the blue car* the preposition *behind* is used to identify the *location* of the red car with reference to the blue car, roughly meaning "in the space directly to the rear of the blue car". As mentioned earlier, the focus of this thesis is to further explore the way children produce prepositions in terms of their concrete, spatial uses as part of simple locative expressions, rather than their temporal or grammatical uses.

Simple locative expressions involve the use of a single prepositional phrase; a spatial preposition along with two noun phrases, as in the following:

The teapot is over the cup

The chef is in front of the cooker

The orange is in the bowl

In such expressions, the teapot, the chef and the orange are known as the *located objects*, and the cup, the cooker and the bowl are known as the *reference objects*. Other terms that have been commonly used for the located and reference objects are *figure* and *ground*, *trajector* and *landmark* and *referent* and *relatum* (see Retz-Schmidt, 1988 for a review of terminology). However, in this thesis, they will be referred to simply as located and reference objects.

When used in natural language simple locative expressions can be embedded in more complex expressions such as, *the orange is rolling on top of a pile of apples in the bowl.* Although this thesis focuses mainly on simple spatial expressions using a single

prepositional phrase, we will also consider how children talk about the location of objects using longer, two prepositional phrases. The above example is an actual utterance given by a young child in order to describe the position of an orange in a spatial scene. As the aim of this thesis is to look at the way children produce locative expressions, the focus will be on the prepositions used, rather than on lexical terms such as verbs. Therefore, the above sentence is an example of a two prepositional phrase with *on top of a pile of apples* being the first prepositional phrase, and *in the bowl* being the second prepositional phrase. We will see later on in Chapter 3 that the order of these prepositional phrases in natural language can serve a functional purpose in the communicative interaction.

In addition to prepositions, other words in the English language also identify where objects are by specifying a location with respect to a reference object. For example, the adjectival role of *close* in *the rabbit was close to his burrow*, serves to locate the rabbit with reference to the burrow. However, such words are few in number, as are the verbs that might incorporate spatial relations (e.g., *enter*, *approach* and *cross*). Moreover, the adjective *close* is synonymous with the preposition *near*. Similarly Landau and Jackendoff (1993) point out that the verbs *enter*, *approach* and *cross* can usually be paraphrased by a simpler verb plus a preposition; *enter* can be paraphrased by *go into*, *approach* can be paraphrased by *go toward* and so on. This leaves us with the preposition as the key feature in the way that the English language expresses location. We can therefore comprehensively understand the way native speakers of English might express spatial locations by looking at the way in which they use spatial prepositions.

Table 1.1 below represents a fairly comprehensive list of the prepositions within the English language. It has been noted that, compared to the number of nouns we typically have at our disposal, there are surprisingly few prepositions (Landau & Jackendoff, 1993). However, although there are relatively few spatial prepositions in the

Table 1.1. The Prepositions of the English Language.

About	Behind	Into	Throughout
Above	Below	Near	To
Across	Beneath	Nearby	Toward
After	Beside	Off	Under
Against	Between	On	Underneath
Along	Betwixt	Onto	Up
Alongside	Beyond	Opposite	Upon
Amid(st)	By	Out	Via
Among(st)	Down	Outside	With
Around	From	Over	Within
At	In	Past	Without
Atop	Inside	Through	
Compounds:			
Far from	In between	In line with	To the left/right of
In back of	In front of	On top of	To the side of
Intransitive prepositions			
Afterward(s)	Downward	*N*-ward	South
Apart	East	(e.g., homeward)	There
Away	Forward	North	Together
Back	Here	Outward	Upstairs
Backward	Inward	Right	Upward
Downstairs	Left	Sideways	West
Non-spatial prepositions:			
Ago	Before	For	Since
As	Despite	Like	Until
Because of	During	Of	

Note: Source: Landau and Jackendoff (1993).

English language, they are fairly common in production; most of the words in Table 1.1 are listed amongst the first 500 words in the Thorndike-Lorge (1944) count.

We have now established how spatial prepositions describe the relation of one object with reference to another. It should be noted, however, that some spatial relations can be considered more simple than other spatial relations. It has been suggested that words such as *in*, *on, at* and *near* represent primitive, topological relationships such as proximity and separation, order and enclosure (e.g., Herskovits, 1986; Piaget & Inhelder, 1956). These are thought to be the fundamental spatial concepts learned by children at a very early age and form the basis of their spatial knowledge (Piaget & Inhelder, 1956). In contrast prepositions such as *in front of*, *behind*, *left of*, *right of*, *above* and *below* express additional information regarding the direction of the located object to the reference object. Such projective prepositions require the speaker and listener to be able to relate these objects to one another and to a viewpoint. This viewpoint can be one's own, that of another observer or that of the reference object.

This last point relates to the system of referencing that is used. As will become apparent in Chapter 5 of this thesis, the issue of spatial frames of reference can be rather complex. Researchers have distinguished between different frames of reference, and these distinctions do not directly map onto one another (Levinson, 1996). Therefore, for the purpose of this thesis, we have adopted the distinctions and labels proposed by Levinson (1996). Levinson classifies reference frames into three distinct categories; *intrinsic*, *relative* and *absolute* frames of reference. Precise definitions of each of the reference frames and how we use them are complex. We will therefore explain them in greater depth in Chapter 5 when we present a more detailed review of the literature, along with two experiments conducted to investigate how children and adults use them. For the moment, let us look at a simple illustration in order to get the flavour of what we mean by frames of reference and how they are used.

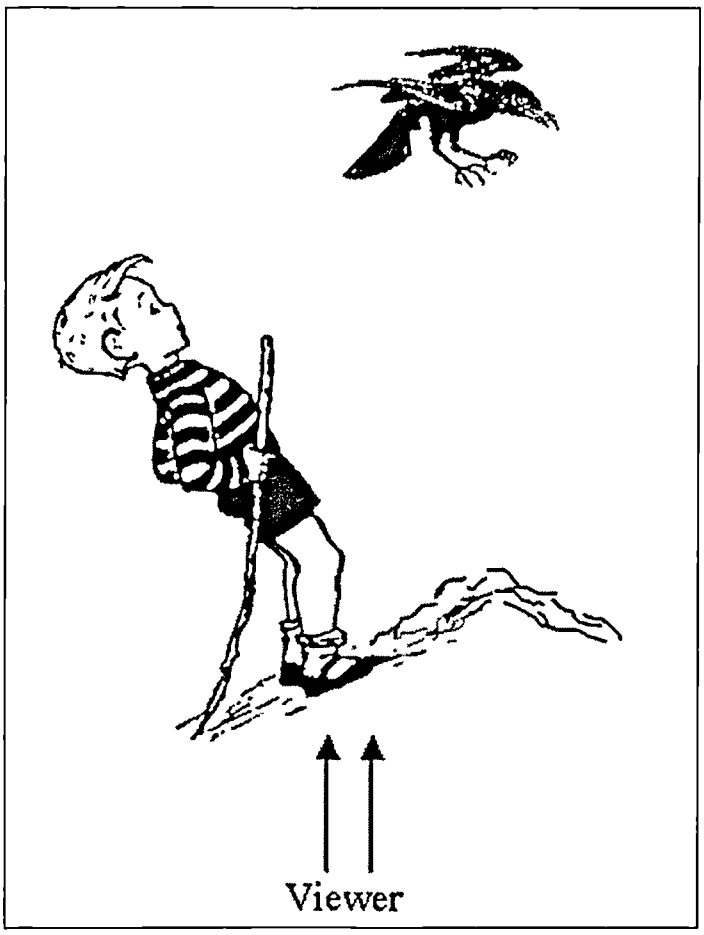
Consider the scene in Figure 1.1 below, where we might describe the position of the bird in a number of ways. For example, we might say:

(a) the bird is *in front of* the boy

(b) the bird is *to the right of* the boy

(c) the bird is *above* the boy

Figure 1.1. Where's the Bird?



Each description takes a different reference point as its starting place. Description (a) *the bird is in front of the boy*, locates the bird according to the *intrinsic* properties of the boy, in this instance, his front. Description (b) *the bird is to the right of the boy*, takes a subjective viewpoint of the located and reference objects and therefore adopts a more *relative* perspective of the scene by locating the bird to the boy according to the viewer's perspective. Finally, description (c) *the bird is above the boy*, locates the bird according to

more *absolute* references, for example gravity and salient features of the environment. As we shall see later on in this thesis, the description that we ultimately use may depend on various things including contextual aspects of the scene such as meaningful relations between objects (e.g., Carlson-Radvansky & Radvansky, 1996).

One further issue to be considered is that, within any simple locative expression there is a kind of asymmetry between the located and reference objects in that only objects with certain properties can serve as located objects and reference points. For example, the located object is usually more movable than the reference object and tends to be smaller in size. Consider the following sentences:

The bicycle is next to the library

**The library is next to the bicycle*

Sentence (a) above quite naturally conforms to the canonical way in which we locate objects, whereas sentence (b) does not. This is because the library is a building that is immovable and as such has the properties that conform to those of a reference object (e.g., immovable, salient and larger in size than the located object).

However, there are times when the located and reference objects can be interchangeable:

The teapot is next to the kettle

The kettle is next to the teapot

Both kettle and teapot in these examples make for adequate located and reference objects.

To sum up, we have seen in this section that spatial prepositions are the key feature in the way that the English language expresses location, they are relatively few in number and can be topological or projective in character. Topological prepositions suggest more simple spatial relationships such as proximity and enclosure involving intrinsic elements of a single reference object. Conversely, projective prepositions often involve coordinating a perspective relationship between the reference object and the viewer or environmental

aspects of the scene. Spatial prepositions within language can form part of simple locative expressions along with the located and reference object, and there are certain constraints on the type of objects that can serve as reference points. As the purpose of this thesis is to look at whether geometric and extra-geometric factors are important in children's production of locative expressions, we will now look at what these factors are and how they have been used to underpin the semantics of spatial prepositions.

1.2. Examining the Semantics of Spatial Prepositions

1.2.1. Geometric Approaches and Limitations

Most approaches to spatial language have assumed in the main that spatial prepositions refer to the positions of objects in space. As such, specifying what these geometric relations are has been one of the main goals for researchers in this area. We will begin by considering how researchers in this area have defined the semantics of simple topological prepositions. We will then consider how theorists have attempted to specify the meanings of projective prepositions. In doing so, we will highlight some of the problems that this approach has encountered before looking to see whether extra-geometric variables might offer some solutions to these problems.

1.2.1.1. *"Simple Topological Prepositions":* in *and* on

In and *on* have been considered to be simple spatial prepositions that denote containment and support of the located object by the reference object. Therefore, it has been argued that they reflect the geometric notions of enclosure on the one hand and contiguity with a surface on the other. In order to understand how these geometric factors are realised, let us begin by examining the preposition *in*.

Approaches to the semantics of the preposition *in* which have focussed on geometry assume that its meaning is quite independent of contextual factors, objects and speakers. Therefore, in the expression *the x is in the y*, the preposition *in* denotes the relationship of enclosure; the inclusion of an X *in* a Y. Alternatively *in* might refer to dimensional properties of the location. These notions of geometry are reflected in the various attempts at specifying the semantics of the preposition *in* as set out in Table 1.2 below.

As can be seen from some of the accounts in Table 1.2 below, geometry can be understood in terms of the dimensionality of the reference object or it can be understood in topological terms. Let us first look at what is meant by the dimensionality of the reference object by considering, in purely simple terms, what it means to locate an object in space. For us to do so, we would invariably need to specify the location of that object with reference to other objects in space. From a geometric perspective, the other object in space can be a single reference point in the one-dimensional case, a reference line in the two-dimensional case and a reference plane in the three-dimensional case.

Table 1.2. Geometric Accounts of the Preposition *in*.

Cooper (1968)	*x* in *y*:	*x* is located internal to *y*, with the constraint that *x* is smaller than *y*
Leech (1969)	*x* in *y*:	*x* is "enclosed" or "contained" either in a two-dimensional or in a three-dimensional place *y*
Bennett (1972)	in *y*:	locative (interior (*y*))
Miller & Johnson-Laird (1976)	in (*x*, *y*):	A referent *x* is "in" a relatum *y* if: [part (*x*,*z*) & incl (*z*,*y*)]
Herskovits (1986)	in (*x*, *y*):	Inclusion of a geometric construct in a one-, two- or three-dimensional geometric construct

Take for example, *X is at/on/in Y*. The dimensional analyses of these prepositions propose that although all three prepositions *at*, *on* and *in* suggest A is located with B, each suggests that B is a uni- bi- and tri-dimensional space respectively (H. Clark, 1973). Therefore, *X is at Y* suggests some kind of simple co-occurrence spatial relationship where the location of *X* and *Y* coincide with one another. In contrast, *X is on Y* suggests a more complex property of the location, i.e., that it is a surface. Finally, *X is in Y* presupposes an even higher degree of complexity; that the location is within a space. It has therefore been argued from this geometric perspective that the preposition *at* is the most basic preposition, with *on* and *in* becoming more complex still (H. Clark, 1973). Moreover, it has also been suggested by H. Clark that such complexity will determine the order of

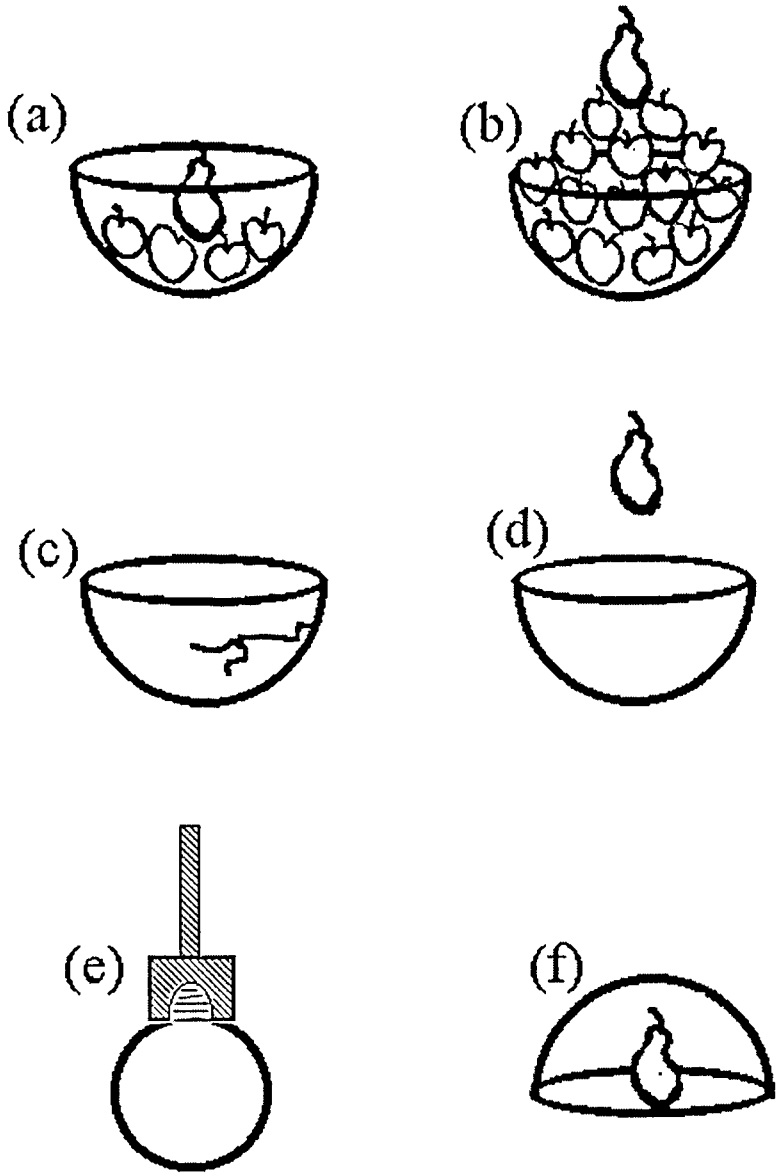
acquisition of spatial prepositions, beginning with the simplest and going on to the more complex words.

We can also see from Table 1.2 that there is another type of geometric specification; the general topological notion of the relationship of *x* to *y*. From this topological perspective, the relationship of *x* to *y* is one of inclusion, where *x* is internal to *y* and enclosed by *y*. The general pattern that emerges here is one which suggests that the borders of the reference object *y* include the borders of the located object *x*, with the exception of Miller & Johnson-Laird who specify *part* inclusion of *x*.

However, one of the problems with these types of accounts is that there are a large number of spatial relations that are appropriate for each spatial term. Additionally, there is not a one-to-one mapping between spatial relations and prepositional usage. A few simple examples are illustrated in Figure 1.2 below. Firstly, consider the description *the pear is in the bowl*. According to the approaches described above, (a) in Figure 1.2 would be a good example of this description but not (b). However, *the pear is in the bowl* can be used to describe (b) but because the pear is outside the interior of the bowl, and is not even partly contained, this is a problem for the above accounts. Moreover, *the pear is in the bowl* is not appropriate for (d), yet the geometric relations between the pear and the bowl in (b) and (d) are identical. Similarly, the sentence *the pear is under the bowl* would be a more appropriate description for the situation illustrated in (f), yet the geometric relation between the bowl and the pear is the same as (a). Moreover, although *under* can be considered appropriate to describe the position of the pear in (f), the preposition *in* rather than *under* would be appropriate to describe the position of the light bulb in (e). Finally, there is the problem of instances which suggest another sense of the preposition *in*. For example, although the use of *in* for the situation *the crack is in the bowl* as illustrated in Figure 1.2 (c) is acceptable because the crack is part of the bowl, it is a different spatial relation to the situation *the pear is in the bowl* as depicted in Figure 1.2 (a), and also for

other examples such as *the bird is in the tree.* These different senses of *in* are related to the issue of polysemy which will be discussed later.

Figure 1.2. An Illustration of the Limitations of the Geometric Semantics for the Preposition *in.*



We have seen just a few examples of the appropriate and inappropriate uses of the term *in* that are problematic for the semantic accounts outlined above. The purpose of these examples is to highlight some of the problems that are encountered. However, it is possible to generate many more (see Garrod & Sanford, 1989; Herskovits, 1986 and Vandeloise, 1991, 1994 for excellent accounts of these problems).

Essentially there are two types of case accountability problems that have been highlighted. The first case is where the definition generates examples that *should* fit the definition, but do not. These have been classified as *decoding* problems (e.g., Coventry, 1998; Herskovits, 1986). For example, the definitions for the preposition *in* in Table 1.2 above and the illustration of the pear *under* the bowl in Figure 1.2 (f). The second case is where the preposition is appropriate, but it *does not fit* the definition. These have been classified as *encoding* problems. We have already seen an example of this problem illustrated above for *the pear is in the bowl* (illustration (b) in Figure 1.2). Another example of this was mentioned earlier in the previous section on page 9; where we can say *the bicycle is next to the library*, but cannot say *the library is next to the bicycle.* Moreover, these accounts do not explain context dependencies (Fillmore, 1971; H. Clark, 1973). For example, the use of projective prepositions with reference frames (as illustrated earlier on page 8)

Therefore, we can see that the approaches to *in* which draw on notions of enclosure or the dimensionality of the reference object cannot fully account for the range of uses of the preposition *in*. Similar problems can be highlighted with *on*. Geometric approaches to the preposition *on* primarily highlight *contiguity* with a *surface*, although the notion of support does merit a mention in some of the accounts as seen in Table 1.3 below.

Table 1.3. Geometric Accounts of the Preposition *on*.

Cooper (1968)	*x* on *y*:	A surface of *x* is contiguous with a surface of *y*, with the constraint that *x* supports *y*
Leech (1969)	*x* on *y*:	*x* is contiguous with the place of *y*, where *y* is conceived of either as one-dimensional (a line) or as two dimensional (a surface)
Bennett (1972)	on *y*:	locative (surface (*y*))
Miller & Johnson-Laird (1976)	on (*x*, *y*):	A referent *x* is "on" a relatum *y* if: (i) (INCL (*x*, REGION (SURF (*y*))) & SUPRT (*y*, *x*); otherwise go to (ii) PATH (*y*) & BY (*x*, *y*)
Herskovits (1986)	on (*x*, *y*):	For a geometric construct *x* to be contiguous with a line or surface *y*; if *y* is the surface of an object O*y*, and *x* is the space occupied by another object O*x*, for O*y* to support O*x*

We can see from the examples given in Tables 1.2. and 1.3 (above) that the commonality amongst the proposed representations underlying *in* and *on* is one of geometry expressed through the notions of the topological spatial features of enclosure and contiguity. Although these geometrical notions have been widely purported to underlie the meaning of spatial prepositions, the precise details of how we classify all the different geometries that are needed in order to achieve a full geometric semantic analysis of prepositions has not been forthcoming. Indeed, recall the two very different geometries

that have been proposed to underlie the preposition *in*; one analysis draws on the notion of enclosure while the other draws on the dimensions of the reference object. In an attempt to define the various kinds of geometry that are needed to fully specify spatial prepositions, Crangle and Suppes (1989) found the notions of enclosure and contiguity to be too simple with which to define the prepositions *in* and *on* as illustrated in Table 1.4.

Table 1.4. Kinds of Geometry and Examples of Prepositional Use.

Topology	*The pencil is in the box* (box closed)
	One piece of rope goes over and under the other
Affine Geometry	*The pencil is in the box* (box open)
	Mary is sitting between Jose and Maria
Euclidean Geometry	*The pencil is near the box*
The Geometry of Orientated Physical Space	*The book is on the table*
	Adjust the lamp over the table
Projective Geometry	*The post office is over the hill*
	The cup is to the left of the plate
Geometries that Include Figures and Shapes with Orientating Axis	*The dog is in front of the house*
Geometry of Classical Space-Time	*She peeled apples in the kitchen*

Note: Table taken from Crangle & Suppes (1989).

The problem of case accountability and the wide range of geometric relations associated with individual prepositions are related to the issue of *polysemy*. Words such as *in* have many different, albeit related senses. We have already seen examples of the different senses of *in*; let us consider a few more:

(a) *the woman is in the queue*

(b) *the page in the book*

(c) *the nail in the wall*

(d) *the flowers in the vase*

(e) *the cow in the meadow*

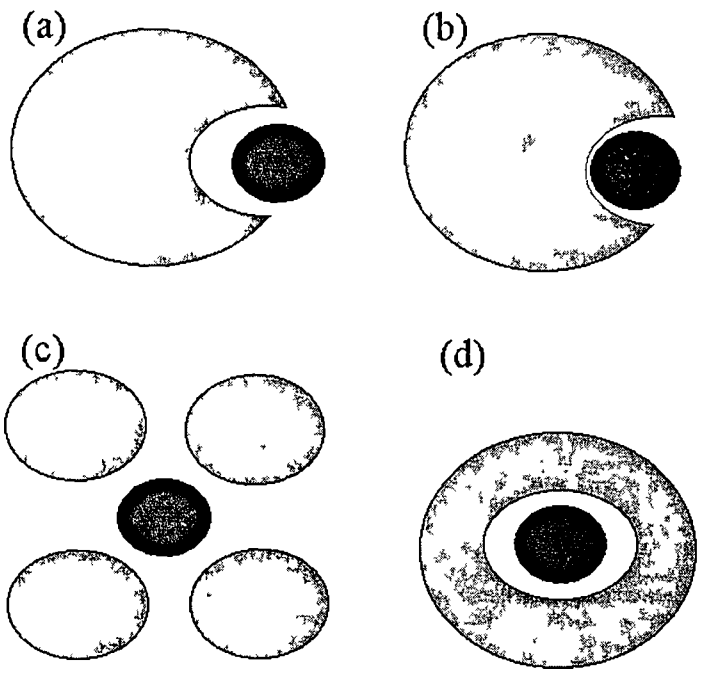
The above examples (and those mentioned earlier) serve to illustrate the difficulties that researchers in this area have had to overcome. The problem is whether all the meanings of the same word can be assimilated into a single concept and consequently be mentally represented by a single lexical entry, or whether each different meaning of the word has a separate lexical entry. The main difficulty here is, as there are a large number of spatial relations in the world that are appropriate for each preposition, finding a single concept underpinning all uses is problematic.

The problem of polysemy has led some researchers to suggest that we have a minimal specification in the lexicon for each preposition. They then demonstrate how this can be applied to each situation by the application of pragmatics (e.g., Miller & Johnson-Laird, 1976). Other researchers have attempted to fully specify the lexical entry. They then determine how the context of the situation affects sense selection (e.g., Herskovits, 1985, 1986). However, it has been argued that these views are essentially equivalent. In the case of minimal specification, you need pragmatics to extend the lexical entry, similarly, in the case of full specification pragmatics are required to select which sense is appropriate in context (see Coventry, 1998 for a detailed discussion of this point).

One way to overcome the problem of specifying all the geometries required for the semantics of spatial prepositions is to specify fundamental *regions of space* for prepositions (e.g., Cohn, 1996; Cohn, Bennett, Gooday & Gotts, 1997). Cohn and his colleagues have suggested that it is possible to define a range of spatial prepositions by using the two simple primitives of *connection* and *convexity*. Connection is a broadly defined relation from simple contact or overlap between regions to their identity. Convexity concerns the presence of one object in a region of interior spaces, in relation to

what has been described as the *convex hull* of the region. The *convex hull* has been defined as the smallest convex region to also include the region in question, and this region can be a single object, or this can be a group of objects (Cohn, 1996). In the case of a group of objects, the convex hull defines the *scattered inside* that is the smallest convex region that includes all the regions of the group. Consider the four regions of space for the construct of *enclosure* as depicted in Figure 1.3 below.

Figure 1.3. Different Degrees of *Enclosure* According to the Region Connection Calculus, Cohn, Bennett, Gooday & Gotts, (1997)

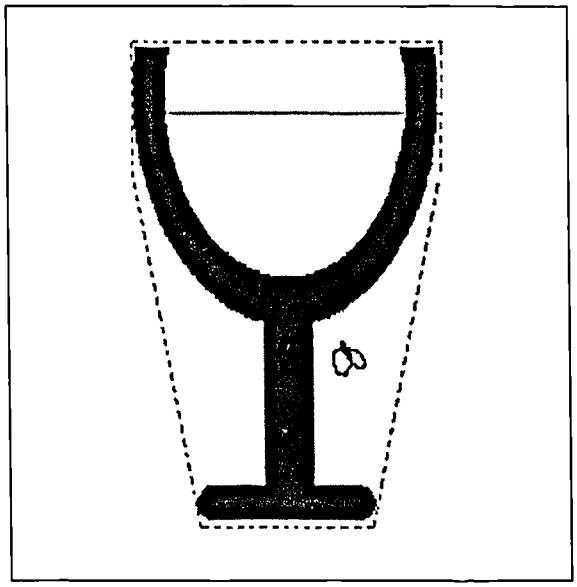


Note: Illustration adapted from Garrod, Ferrier & Campbell (1999)

Using a geometry such as Cohn's, one can capture the meaning of *in* in a number of ways. For example, Figure 1.3 (a) illustrates the circumstances where one object is *partially enclosed* by another object, as is the case for the situation described in the

following two sentences: *the flowers are in the vase* and *the egg is in the egg cup.* In contrast (b), illustrates *full enclosure*, as in *the coffee is in the cup*. Figure 1.3 (c) depicts a situation where one object is enclosed by a group of objects as part of their *scattered inside.* This is the case for *the bird in the tree* or *the woman is in the queue.* Finally, (d) illustrates total enclosure. Such is the case for the situation *the lion in the cage* or *the egg in the egg box.*

Figure 1.4. *The fly is in the glass?*



Although Cohn's qualitative geometry may help to account for a range of possible uses, the approach in a sense is too powerful as it creates both decoding and encoding problems. For example, it cannot explain why *the light bulb in the socket* is appropriate but *the pear is in the bowl* (when the bowl is inverted as in Figure 1.2 (f)) is still not appropriate. Additionally, consider Figure 1.4 above where the *convex hull* is depicted by the dotted line. According to Cohn's qualitative geometry *the fly is in the glass* is as acceptable as *the wine is in the glass*, yet the fly is most definitely not in the glass. The problem here is that the convex hull is not restricted to the containing parts of a container (Herskovits, 1985; Vandeloise, 1991, 1994).

In summary, we have looked at how some researchers have attempted to specify the semantics of simple prepositions such as *in* and *on* by drawing on the geometric aspects of a scene. However, we have also seen that by doing so, certain aspects of spatial prepositional use have been left unaccounted for. These case accountability problems of encoding and decoding errors directly relate to the problem of polysemy. In order to solve this problem researchers have gone down the route of either specifying a single lexical entry that does not appear to cover all cases, or they have argued that each geometric relation in the world that maps on to an individual spatial term has to be lexicalised. However, as we have seen, this does not explain why a word can be appropriate in one case, but not the other yet the spatial relations are the same. Before we examine how factors other than geometry might resolve some of these difficulties, we will now turn to look at how theorists have drawn on geometric aspects of a scene in order to account for the comprehension and production of projective prepositions.

1.2.1.2. Projective Prepositions

Words such as *over*, *above*, *next to* and *beside* involve more complex concepts than simple topological notions; they involve projective relationships of objects separated in space. Therefore, it is not surprising that given the extra complexity of comprehending and using words such as *in front of*, *behind*, *over* and *above*, they are acquired and developed much later on than the prepositions *in* and *on* (e.g., Johnston, 1984; Johnston and Slobin, 1979).

When we look at the preposition *over*, in a similar way to *in* and *on* it appears to be highly polysemous. Consider the following sentences involving the preposition *over*:

(a) *The plane flies over the hill*

(b) *The village lies over the hill*

(c) *Marie walked over the hill*

(d) *There is snow all over the hill*

(e) *The old man looked over the hill*

In each of the above sentences, the preposition *over* has a different sense. In sentence (a) *over* suggests an above and no-contact relation between the plane and the hill with dynamic movement of the plane along a path. This can be contrasted with (c) and (d), both of which involve contact, but only (c) suggests dynamic movement. Neither sentence (b) nor (e) involve dynamic movement or contact between located and reference objects. Indeed, Brugman and Lakoff (1988) have argued that the word *over* has almost 100 different related meanings. They represent this in a radial structure where core senses are represented as prototypes. Therefore, they argue that *over* appears to have many meanings radiated around three core prototypes, the *above and no contact* schema, the *by way of above* schema and the *covering* schema. The Brugman and Lakoff analysis is typical of a cognitive linguistic approach (see for example Langacker, 1986). However, we still have the problem of knowing how the correct term is actually selected in context. For example, consider the sentence *there is snow all over the hill.* How can one know which of the three core prototypes outlined above is the appropriate schema without specifying the method of selection. Additionally, when one begins to consider the use of selection rules that are needed, the advantage of a prototype account over full specification begins to disappear.

More recently researchers have started to bridge the gap between specifications of lexical entries of words and visual attention (Hayward & Tarr, 1995; Logan & Sadler, 1996). Typically, it has been assumed that the located and reference objects in the scene can be of any form yet still have their position in that scene specified by the same

preposition. Any object can be *above*, *in front of* and *beside* any other object; what those objects are has not been thought of to be important from this perspective. Such an approach to spatial language often makes a definite link between linguistic structure and spatial representation (Landau & Jackendoff, 1993).

From this approach to spatial language, the notion of a spatial template has been proposed. The concept of a spatial template suggests that for every spatial preposition, there is a good, acceptable and bad region of space that corresponds to that preposition (see Figure 1.5).

Figure 1.5. A Schematic Spatial Template for the Preposition *above* Based on all Three Frames of Reference Coinciding

A	A	A	G	A	A	A
A	A	A	G	A	A	A
A	A	A	G	A	A	A
B	B	B		B	B	B
B	B	B	B	B	B	B
B	B	B	B	B	B	B
B	B	B	B	B	B	B

Note: "G" = Good, "A" = Acceptable and "B" = Bad regions of space
Illustration adapted from Carlson-Radvansky & Logan (1997)

Such a concept is intuitively appealing if one believes that the nature of the reference and located objects themselves are irrelevant to how we talk about *where* those objects are in space. Moreover, the notion that similar prepositions have similar templates is the obvious next step from this premise. Therefore, it has been suggested that the words *above* and *over* both have spatial templates resembling the one illustrated schematically in Figure 1.5, and that likewise, the words *below* and *under* have the same converse spatial template to *above* and *over* (e.g., Hayward & Tarr, 1995; Logan & Sadler, 1996). Hayward and Tarr (1995) specifically tested this assertion of the spatial structure of spatial prepositions using located and reference objects with no particular relationship to each other (e.g., a circle and a square, a swimming fish and a raft). They presented adults with pictures containing a centralised reference object with a located object placed in any one of 48 positions around it. Using a seven-by-seven grid (similar to that seen in Figure 1.5) they placed the reference object in the central position. Forty-eight pictures for each set of reference and located objects were generated by placing the reference object in one of the surrounding cells until each cell had been used once. The grid was removed before any participant viewed the picture.

In their first experiment, they asked participants to generate a description of the located and reference objects. Hayward and Tarr then grouped the prepositions produced in the utterances into the two categories of *vertically oriented* prepositions (e.g., *above*, *below*, and *over*) and *horizontally oriented* prepositions (such as *left*, *right* and *beside*). The production of individual prepositions was not reported, instead the percentages of production for either horizontally or vertically oriented prepositions were then mapped onto the seven-by-seven grid they had previously used to construct the original pictures. They found that adults produced vertically oriented prepositions most frequently when the located object was positioned along the vertical axis as defined by the reference object; this represents the *good* region of space in a spatial template. Adults' production of such

prepositions was found to decrease as the located object moved away from the vertical axis; this represents the *acceptable* region of space in a spatial template. Finally, adults produced vertically oriented prepositions quite frequently in every position that was not located along the horizontal axis as defined by the reference object. Therefore, for vertical axis prepositions, the horizontal axis represents the *bad* region of space in a spatial template. A similar pattern of responses was found for the horizontally oriented prepositions, where the vertical axis represented the *bad* region of space.

In a second experiment, Hayward & Tarr (1995) took the two vertical and two horizontal prepositions that were most prevalent in their first experiment and asked adults to rate them against a set of pictures. The prepositions were *above*, *below*, *left* and *right*, and the pictures were broadly similar to those used in Experiment one. Once again, they found that each spatial term exhibited predominant regions of applicability along the salient axis as denoted by the individual term. Therefore, ratings were higher when the located object was positioned along the vertical axis to the reference object for the terms *above* and *below*, decreasing in acceptability as the located object moved away from it. Only when the located object lay across the horizontal axis from the reference object were the terms *above* and *below* deemed unacceptable. Similar findings were reported for the terms *left* and *right*.

Unsurprisingly these results were discussed in terms of regions of prototypicality for each spatial term. Such prototypical regions were quite narrowly defined; they were graded according to how the position of the located object varied away from the central axis of the reference object. Therefore, the prototypical region for *above* describes a located object situated in any position directly along the vertical axis as defined by the reference object, and becomes gradually less and less prototypical as the located object moves away from that axis (Figure 1.5 as seen on page 23). Further research investigating spatial templates has confirmed these findings and the assumption that similar prepositions

have comparable templates (Logan & Sadler, 1996). Using a similar methodology, Logan and Sadler (1996) found, for example, that the templates for *above* and *over* have analogous shapes and that they are opposite to those for *below* and *under*.

Moreover, Logan and Sadler provide reaction-time evidence to show that the distance between located object and reference object had little effect on the time it took participants to comprehend them, thus suggesting that these spatial templates are applied in parallel to the whole of the visual field (Experiment 4, Logan & Sadler, 1996).

As previously mentioned, projective prepositions such as *above* must be used with respect to a particular viewpoint, and this viewpoint has been called a *frame of reference*. Recall earlier that we briefly defined three frames of reference; the *intrinsic*, the *relative* and the *absolute* (see Figure 1.1 on page 8, above). Using a variety of tasks, including a sentence-picture verification task, it has been demonstrated that there is a simultaneous activation of multiple frames of reference during reference frame assignment and that they compete with each other for selection (Carlson-Radvansky & Irwin, 1994; Carlson-Radvansky & Logan, 1997). Moreover, it appears that multiple spatial templates are simultaneously constructed; one for each reference frame that is active (Carlson-Radvansky & Logan, 1997).

One further point regarding spatial template theory is that it has been suggested that spatial templates exist for each lexicalised *conceptual* representation, but in the case of polysemy, there is a different template for each conceptual representation of the word (Logan & Sadler, 1996). This is problematic for two main reasons. Firstly, as previously mentioned, if it is the case that spatial terms with similar conceptual representations have the same spatial template, then the prepositions *over* and *above* and the prepositions *under* and *below* have similar templates to each other (Hayward & Tarr, 1995; Logan & Sadler, 1996). However, as we shall see in the next section of this chapter, these prepositions behave very differently to each other when objects with functions are used rather than the

unrelated objects that feature in spatial template research (Coventry, Prat-Sala & Richards, 2001).

Secondly, consider the suggestion that there is a different spatial template for each polyseme. This is similar to the fully specified accounts of spatial language as discussed in the previous section. Take for example the case of *over* where it has been argued there are almost 100 different senses of the word centred around three core meanings (Brugman & Lakoff, 1988). Representing different spatial templates for each meaning of the word *over* may prove to be problematic, especially when we consider the selection of which spatial template is appropriate for any given context. When there are only a few templates to consider this may not be much of a problem. However, it becomes computationally expensive when there are a sizeable number of templates to consider. Moreover, a similar problem occurs to that mentioned above for Brugman and Lakoff; we have no way of knowing how the correct sense is selected from the numerous templates possible for each word.

Let us now stand back and summarise the situation when geometry is utilised to account for the meanings that underlie spatial prepositions. Researchers begin with the premise that the nature of the located and reference objects are immaterial to the way we comprehend and produce spatial language; *what* objects are does not influence *where* objects are in a scene. From this premise, research had shown that our comprehension and production of spatial prepositions are characterized according to quite narrowly defined spatial regions. These regions are graded according to how the position of the located object varies away from the particular axis of the reference object as defined by the preposition produced and are applied in parallel to the whole of the visual field. Spatial terms with similar conceptual representations have the same spatial template, and in the case of polysemy, each meaning has a separate, distinct spatial template. Let us now

consider the evidence that suggests that *extra-geometric* factors are needed in order to fully account for the semantics that underlie a range of spatial prepositions.

1.2.2. The Importance of Extra-Geometric Factors

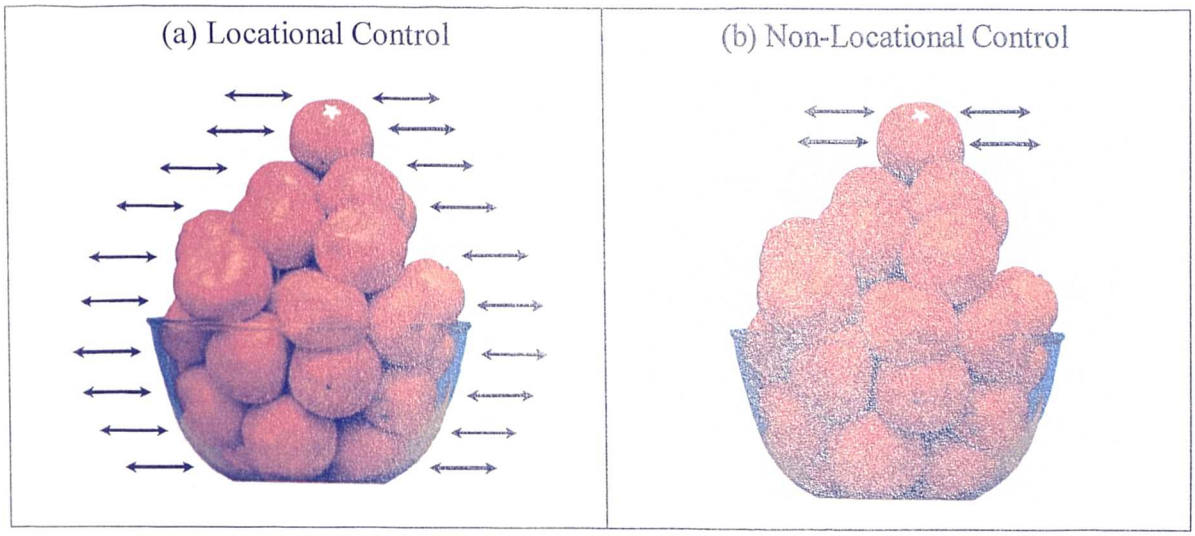
As mentioned previously, adult's production and comprehension of spatial prepositions are not only affected by geometric considerations of the event to be described, but also affected by the extra-geometric factors in the scene. The purpose of this review is to examine the various factors that can be grouped together under the banner of *extra-geometric* factors and to assess how each of these factors affect the way adults comprehend and produce spatial language. We have seen from earlier sections of this chapter that concepts such as enclosure and contiguity have been proposed to underlie adults' comprehension and production of the words *in* and *on*. However, we have also seen that these geometric factors are insufficient by themselves to specify the characteristics that underlie spatial prepositional comprehension and production. Other factors, which we will classify as *extra-geometric* factors, have been shown to influence adults' spatial language. These are a set of factors that are not to do with the geometry of the scene, at least, not in the way geometry has been characterised above. They include factors such as locational control, the nouns we use to describe objects, the context of the utterance and even the object specific properties of both located and reference objects. We will now examine the range of types of *extra-geometric* factors that have been found to date. Later in the thesis we will re-examine some of this research in more detail.

In and *on* are considered to be simple spatial prepositions that reflect the geometric notions of enclosure on the one hand and contiguity with a surface on the other. However, it has been argued that these constructs also involve a component that has been characterised as functional or locational control (Coventry, 1992, 1998; Garrod, Ferrier &

Campbell, 1999; Garrod & Sanford, 1989; Vandeloise, 1991, 1994). For an object to be a successful container, and likewise for a surface to be successful as a supporting surface, it must be able to constrain the location of objects over time.

Imagine a bowl of fruit such that the fruit is piled high above the rim of the container. When the container is so full, the only place that the other pieces of fruit can go is to be piled up higher and higher. Imagine further that someone is moving the container in such a way that all the fruit remains in the same relative position to the container over time. This illustration demonstrates how a container can afford *locational control* of its contents and has been used in video studies to test the functional element of *in*. In an experimental situation, for scenes such as these not only would you expect an effect for the height of pile where degrees of enclosure are changing, but you might also expect effects of locational control. When the bowl is shown to be constraining the location of the contents over time, one might expect *in* to be appropriate. As dynamic manipulations such as this will be discussed throughout this thesis, for the illustrations that follow we will use arrows to represent motion. When an object is moving a double-sided arrow will be pointing on either side of that object, as in Figure 1.6 below. Therefore, locational control is depicted in Figure 1.6 (a). The converse of this is non-locational control and is illustrated in Figure 1.6 (b). Consider the bowl mentioned earlier with the fruit piled up high. Imagine that the object on the very top of the pile is an orange and that it is depicted moving from side to side of its own accord as if it has a life of its own, thereby strongly suggesting that there is no locational control being exerted by the bowl (as denoted by the arrows in the illustration). The comparison scenes for both the locational and the non-locational control scenes is a scene with the same geometric manipulation where there is no movement involved.

Figure 1.6. Relative Movement of Fruit and Bowl used to Assess the Notion of Locational and Non-Locational Control



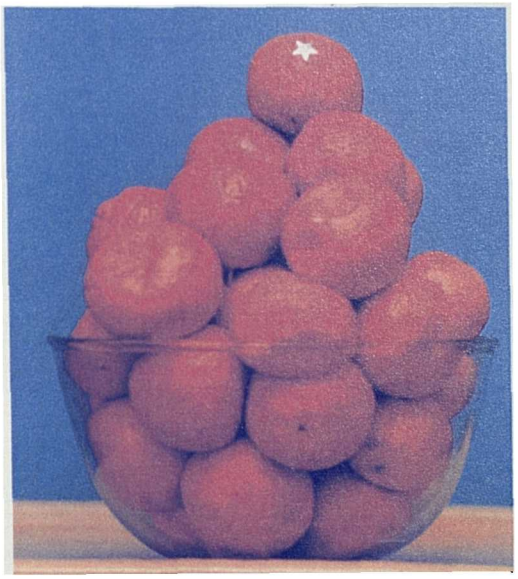
A number of studies have shown that these movement factors do indeed influence adults' production and comprehension of *in* (e.g., Coventry 1992, 1998; Garrod et. al., 1999). Both geometry and locational control were systematically manipulated and displayed to participants by means of a video. The geometry of the scene was assessed by showing various scenes of a bowl with fruit in it depicted at different heights. Locational control was determined by the use of the relative movement of bowl and target object (either together or target object alone as depicted in Figure 1.6 above) and static scenes as described above. When identifying the location of a target object, *in* was produced significantly less (in a sentence completion study) and rated as less appropriate when the pile of objects was high than when it was low. Moreover, when the bowl demonstrated locational control, *in* was produced more and rated as more appropriate than when it was static (Coventry, 1992, 1998). Additionally, *in* was produced less and was rated as less appropriate when the scene depicted a non-locational control situation compared to the static scenes. Furthermore, it has also been shown that if the container is tilted, suggesting

that its contents will fall out, adult's production and comprehension of *in* is reduced (Coventry, 1992, 1998).

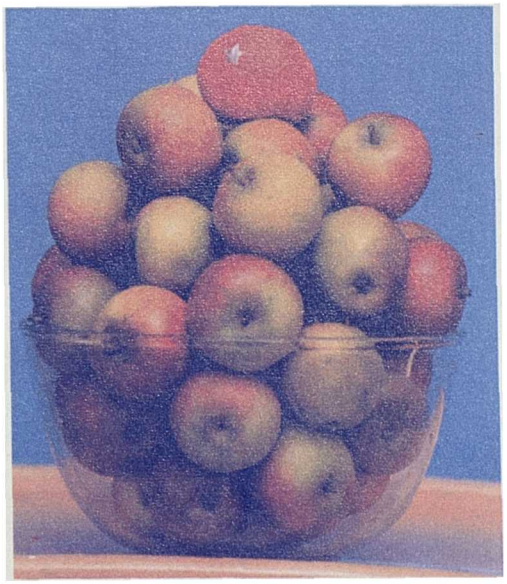
However, locational control is not the only extra-geometric factor that has been demonstrated to influence adult's production and comprehension of *in*. Figure 1.7 (a) below illustrates a *continuous* scene whereby the objects in the container are all the same as the target object (marked with a star), whereas (b) depicts a *discontinuous* scene as the objects in the container are different to the target object at the top of the pile. It has been shown that when adults are asked to locate the position of a target object, they produce the preposition *in* with the reference object (e.g., *in the bowl*) more when the contents are continuous than when they are discontinuous (Coventry, 1992, 1998).

Figure 1.7. An Example of Continuous and Discontinuous Scenes of Fruit and Bowl

(a) Continuous Scene



(b) Discontinuous Scene

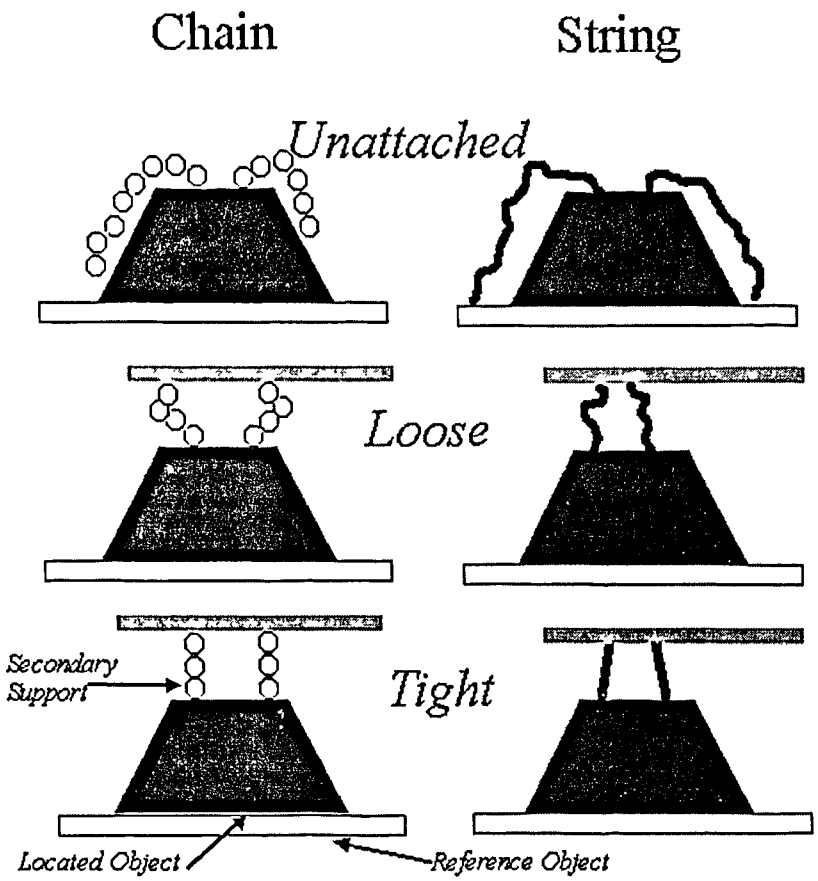


Another method of manipulating locational control involves the *alternative* control of objects. Consider a number of scenes in which there is a bowl with a target ball on top of other balls positioned at various heights, we shall call these the *contact* scenes. Now

imagine the target ball positioned at those same heights *without* the other balls being present; these will be known as the *no contact* scenes. Such scenes were shown to adults where the target ball was either clearly attached to a wire (thereby demonstrating an *alternative control*), or no wire was visible (demonstrating *no alternative control*). When an alternative source of control was depicted, adults' confidence of *in* descriptions was significantly reduced for the contact scenes with no difference for the no contact scenes. Following this, a second group of adults were shown the same scenes and requested to make a choice between one of two outcomes if the bowl was moved sideways. They were to asked predict that there would either be *no change* in the relative positions of the bowl and target ball following such movement, or that there would be a *change*. A significant positive correlation was found between predictions of *no change* and confidence judgements of the sentence that located the ball *in the bowl* (Garrod et. al., 1999).

Another aspect of alternative control that has been examined relates to the nature of the located object itself and whether it is animate or inanimate. Illustrations of containers varying in concavity were shown to adults along with either a coin or a firefly. Now a firefly obviously has alternative control, in that at any given time, it can fly away thereby making it less likely that the container itself is fulfilling the function of locational control. In situations such as this, adults have been found to use *in* more when the located object was a coin rather than when it was a firefly (Feist & Gentner, 1998).

Figure 1.8. The Secondary Support Manipulations used by Garrod, Ferrier & Campbell (1999) for the Preposition *on*.



Note: Illustration adapted from Garrod et. al. (1999).

Garrod et. al. (1999) used alternative control as a means of manipulating locational control for the preposition *on*. Consider a heavy weight on a plank of wood (see Figure 1.8 above), with a strong metal chain attached. Figure 1.8 depicts three scenes; in the first scene, the chain hangs loosely around the weight (*unattached* scenes). In the second scene, the weight is attached loosely to a secondary support suspended above it indicating the possibility of alternative control. Finally, in the third scene, the chain attached to the secondary support is taut thereby strongly suggesting the presence of alternative control over the weight. Three similar scenes involving string instead of a chain were also used

(see Figure 1.8 above). When scenes such as these were shown to adults, ratings of *on* to describe the position of the weight to the plank reduced significantly when the alternative control was strong, i.e., when the string/chain was taut (Garrod et. al., 1999). Once again, there was a strong positive correlation between the ratings of *on* for these adults and the degree to which a second group of adults judged the relation between the weight and the plank to be stable.

Now consider the sentence *the ring is on the finger* and what it means to be *on* in this example. In a canonical situation, it is the finger that determines the location of the ring; when the hand is moved, the ring moves with it. Such locational control might well be one factor in deciding whether or not the ring is indeed *on*. Let us take the situation where there is a normal sized ring on a finger, and a situation where there is a much larger ring on a finger where the fit of the ring is so loose that it can move up and down the finger with great ease. When adults were shown videos of both the large and the small ring either stationary or moving up and down a finger, they rated *on* to be significantly more appropriate to describe the small ring than to describe the large ring. Additionally, they rated *on* as being more appropriate when the small ring was static than when it was depicted as moving up and down the finger (Coventry, 1992). Locational control asserts that the supporting surface should control the location of the figure over time. As the ring was depicted moving, this violated such control and therefore *on* was less appropriate even though the ring was of normal size.

The picture is now becoming clear; comprehension and production of the prepositions *in* and *on* are not only affected by the geometry of the scene, but also by extra-geometric factors. Locational control has been demonstrated to affect adult's production and comprehension of *in* and *on*. Additionally, the extra-geometric factor of continuity/discontinuity similarly affects the preposition *in*. Let us now turn our attention further to other aspects of the world that might affect the way adults produce and

comprehend topological prepositions. Consider the knowledge we have of objects in the world and of our understanding of the canonical use of such objects. Now suppose those objects are put to a different use. The question of whether this would affect the language we produce when describing the location of those objects has been investigated.

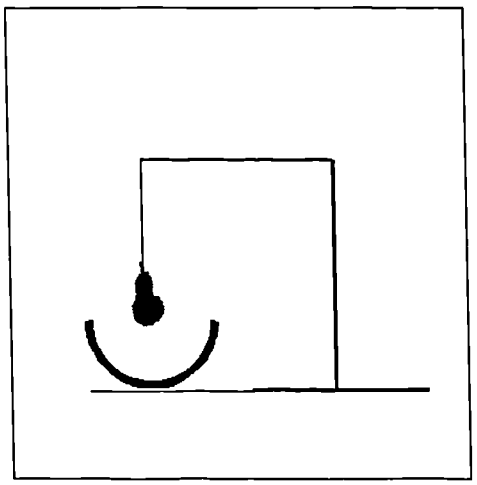
Bowls are canonically used as containers of solids whereas jugs usually contain liquids. Recall the bowl piled high with fruit. Now imagine a jug of similar proportions as the bowl with a similar pile of fruit. When adults were shown scenes such as these, *in* was produced more to describe the location of the target object when the bowl was used as the container of solids rather than when it was the jug, thereby suggesting that the specific function of objects can affect the production of a preposition (Coventry, 1992). Now imagine that liquid is poured into both the jug and the bowl (both of which still contain the fruit). This has the effect of highlighting the specific function of the jug (i.e., to contain liquids). When adults viewed both sets of scenes, with and without liquid added, the appropriateness rating for *in* was reduced when liquid was added to the jug, but adding liquid to the bowl had no similar effect (Coventry, Carmichael & Garrod, 1994). Object specific effects for both prepositions *in* and *on* have since been found over an even greater range of materials (Coventry & Prat-Sala, in press).

Furthermore, not only can the specific function of an object affect the prepositions *in* and *on*, but also whether that same object is labelled a *dish* or a *plate*. Adults have been shown to produce *in* more and rate it as more appropriate when the same reference object was labelled *a dish*, whereas *on* was produced more and rated as more appropriate when it was labelled *a plate* (Coventry et. al., 1994; Feist & Gentner, 1998). Such a finding suggests that different nouns can evoke differing object specific properties.

One further extra-geometric factor that has been shown to influence the production and rating of *in* has been that of context. Consider the scene depicted in Figure 1.9 below, in the context of a game. The object of the game is to move the frame such that the pear

and bowl are positioned as depicted. At the end of the game, David shouts *I have won; the pear is _____ the bowl.* In the context of this game, adults produced the preposition *in* significantly more to describe the location between the pear and the bowl than when no context was presented (Coventry, 1999). Moreover, in a second task where the string was further shortened thereby ensuring that it was clearly not occupying the space of the bowl, *in* was still produced and also rated as being significantly more appropriate in the presence of a context than when no context was given.

Figure 1.9. The Pear is *in* the Bowl; How Context Affects the Production of *in*



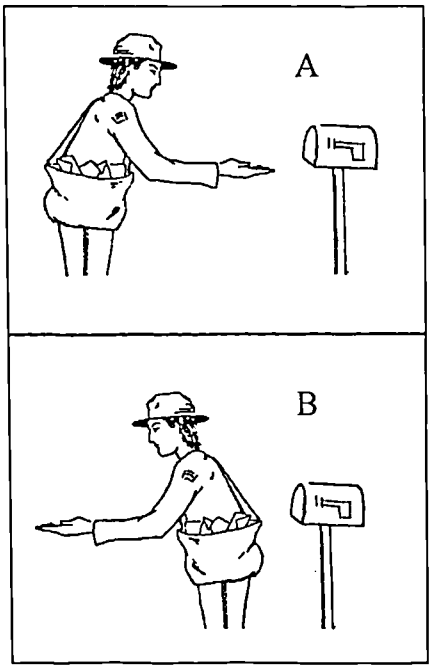
Note: Illustration Adapted from Coventry (1999).

By now is should be apparent that the geometric constructs that have been proposed to underlie the prepositions *in* and *on* are by themselves insufficient to account for the way adults produce and comprehend these prepositions. Other extra-geometric factors such as locational control, continuity/discontinuity, object specific associations and context all contribute to the way adults comprehend and produce *in* and *on*.

Let us now consider the situation for projective prepositions. Recall that projective prepositions such as *above* and *in front of* are often used with a particular frame of

reference. Carlson-Radvansky and Radvansky (1996) investigated functional influences on adults' reference frame selection using both a sentence rating and a fixed-choice sentence completion task. They showed adults a series of pictures that depicted functional and non-functional scenes. Function was assessed by depicting the located object in a typical interaction with the reference object; see Figure 1.10 (A) below for an example. The located object was reflected so that it did not typically interact with the reference object for the non-functional scenes (Figure 1.10 (B)).

Figure 1.10. An Example of the Functional and Non-function Pictures used in Carlson-Radvansky and Radvansky's (1996) Study.



Note: Illustration taken from Carlson-Radvansky & Radvansky, 1996.

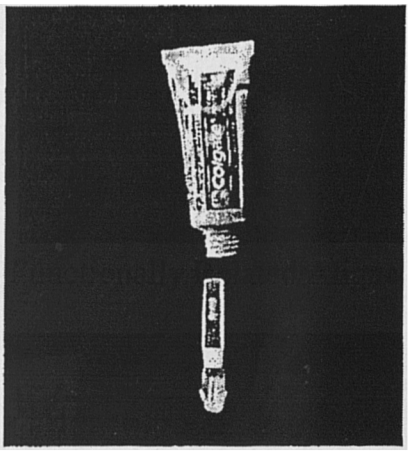
We can see from the pictures above, that there is more than one way of describing the scenes. For example, if we adopt an intrinsic reference frame (where we co-ordinate the position of the located object with reference to the inherent features of the reference object) we would say *the postman is in front of the mailbox.* Alternatively, we can adopt a *relative/absolute* frame of reference by co-ordinating the position of the located object with reference to ourselves, other viewers or to the environment and in doing so would say *the postman is to the left of the mailbox.* It was found that participants selected the *intrinsic* descriptions significantly more and rated them as significantly more acceptable than *relative/absolute* descriptions for the functional than the non-functional pictures. Additionally, they selected the *relative/absolute* descriptions and rated them as significantly more acceptable than *intrinsic* descriptions for the non-functional pictures (Carlson-Radvansky & Radvansky, 1996). This suggests that what objects are can affect where they are in terms of the prepositions that we use when we are describing them.

Recall that spatial template theory maintains that our comprehension and production of spatial prepositions is characterized according to quite narrowly defined spatial regions (see illustration on page 23 above). These regions are graded according to how the position of the located object varies away from the particular axis of the reference object as defined by the preposition used. Moreover, similar spatial terms have the same spatial template. Such a theory presupposes that *what* objects are is immaterial to *where* objects are.

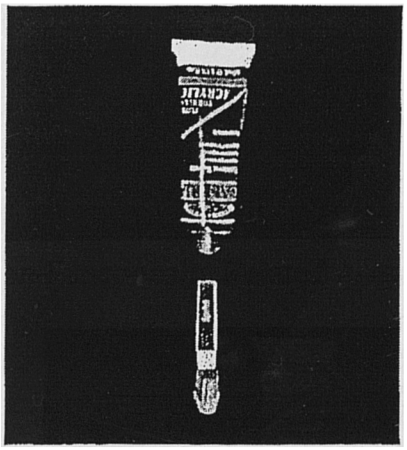
Other researchers have investigated spatial language using objects that are associated with one other (often in a functional manner) and have seen that extra-geometric factors of the spatial scene can also affect our comprehension of prepositions such as *above* (e.g., Carlson-Radvansky, Covey & Lattanzi, 1999; Carlson-Radvansky & Radvansky 1996; Coventry, Carmichael & Garrod, 1994). For example, Carlson-Radvansky et. al. (1999) found that the function of an object affected the way adults

comprehended the prepositions *above* and *below*. They gave people pictures of various located objects and asked them to place the located object "above" or "below" a reference object. The located and reference objects were either functionally related (e.g., a tube of toothpaste and a toothbrush, see Figure 1.11 below) or they were functionally unrelated (e.g., a tube of oil paint and a toothbrush).

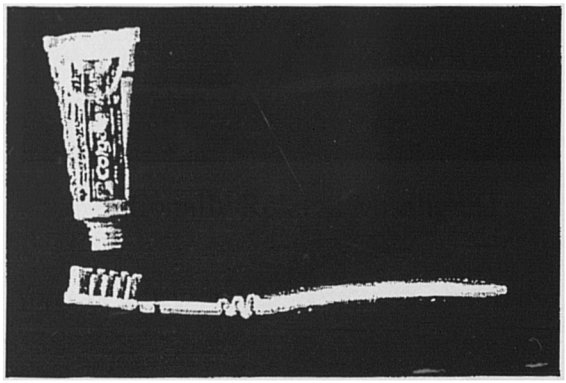
Figure 1.11. Examples of The Related and Unrelated Located and Reference Objects used in the Carlson-Radvansky, Covey & Lattanzi (1999) Placement Task.



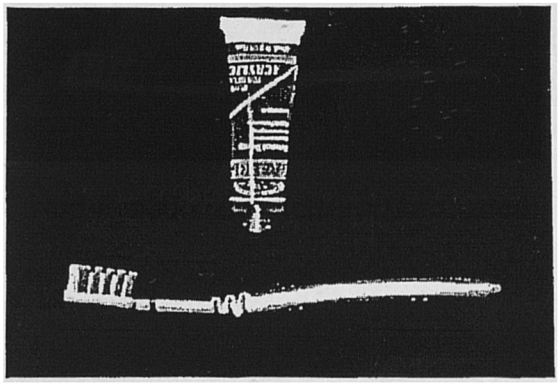
Functionally Related/Aligned



Non-Functionally Related/Aligned



Functionally Related/Misaligned



Non-Functionally Related/Misaligned

Note: Illustration taken from Carlson-Radvansky et. al. (1999).

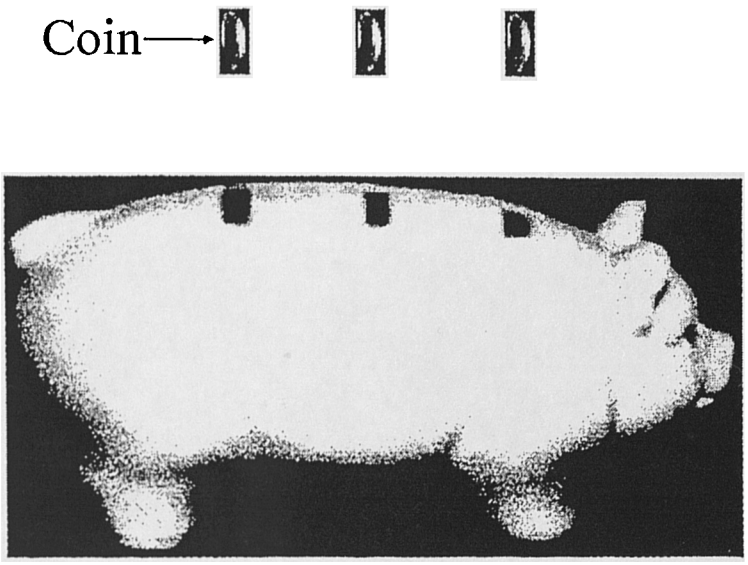
Not only was the normal interaction with the functional part of each reference object from "above" or "below" it, the functional part of each reference object could be dissociated from the centre-of-mass of the object (e.g., the bristles of a toothbrush are located at one end of the object).

Participants placed the located object towards the functional part of the reference object (and away from the reference object's centre-of-mass) significantly more when the located object was functionally related than when it was unrelated. It is therefore clear from this study, that the prepositions *above* and *below* are more than just geometric terms, they also have an extra-geometric component to them.

Carlson-Radvansky et. al. (1999) also used a sentence rating task to look at whether the region of acceptability for *above* would change according to where the functional part of an object is. Consider the picture of the piggy bank in Figure 1.12 below. The slot on the top of the piggy bank is a functionally important part as it is where the money is deposited. Participants were shown sentence-picture pairs and asked to rate how acceptable the sentence *the coin is above the piggy bank* was to describe the picture - that accompanied it. In each picture there was a coin and a piggy bank, and the position of the slot was manipulated across three different groups of participants with each group seeing the coin in all three different positions.

Carlson et. al. (1999) found that all participants rated the sentence *the coin is above the piggy bank* significantly more appropriate when the coin was depicted directly above the slot they saw (irrespective of where the slot was positioned) than when the coin was in either of the other two positions. Therefore, the most acceptable region for *above* changed according to the functional information in the scene.

Figure 1.12. The Piggy-Bank and Slots Picture that was used in the Carlson-Radvansky, Covey & Lattanzi (1999) Study.

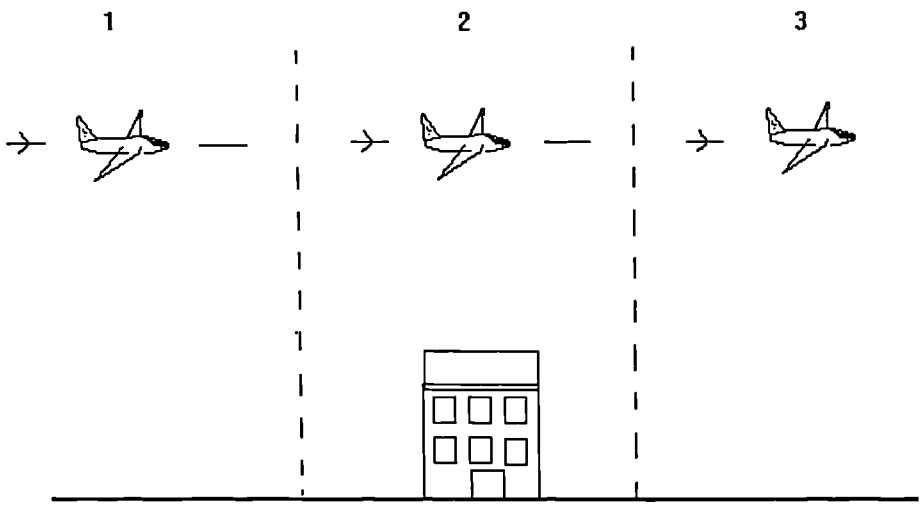


Note: Illustration taken from Carlson-Radvansky et. al. (1999).

Coventry and Mather (in press) have illustrated how the preposition *over* can be affected by object-specific knowledge and that relations between objects includes knowledge of (naïve) physics. In one experiment, adults were presented with a line drawing partitioned into three segments with each segment containing a plane in flight (facing right). The middle segment had the addition of a building in it (see Figure 1.13 below). The participants were required to indicate where the plane should be positioned for the expression *the plane is over the building* to be appropriate. Participants were allocated into three conditions; they were either in the *no context* group where they were merely informed that the building lay on the flight-path of an aeroplane, or they were in one of the two *context* groups. Both *context* groups were told that the plane was on a mission to bomb a building. However, for one group, the building was referred to as *the building*, whereas for the other group it was referred to as *the target*.

The production and ratings for the three segments were found to be significantly different between conditions. In the context conditions, segment one was given higher ratings than the control condition. Conversely, segments two and three were given higher ratings in the control condition than in the context conditions.. In addition to these it was found that both the ratings in the two context groups significantly correlated with judgements of where they thought the bomb should be dropped for it to successfully hit the building. One further experiment found that, unlike *over*, the preposition *above* showed no such relationship with world knowledge.

Figure 1.13. The Plane and Building Picture Used in Coventry and Mather (in press).



Note: Illustration taken from Coventry and Mather (in press).

Following from this, it has recently been demonstrated for the first time that adults comprehension of the spatial prepositions *over*, *under*, *above* and *below* are differentially affected by functional and geometric relations (Coventry, Prat-Sala & Richards, 2001),

adding to the evidence that terms such as *over* and *above* are not synonymous (as suggested by spatial template theory).

Consider the sentences *the umbrella is over the man* and *the man is under the umbrella* and think about what it means to be *over* and *under* in such contexts. The spatial prepositions of *over* and *under* when used in this way suggest more than just *where* the objects are positioned in the scene, but whether or not a particular function is being fulfilled. For an umbrella to be *over* a man, and conversely, for a man to be *under* an umbrella, in both cases implies that the man is being protected from the rain by the umbrella.

In a direct attempt to test these intuitions Coventry et. al. (2001) showed adults pictures such as those in Figure 1.14 below. Four object pairs were used in each of two picture sets, all depicting objects with particular functions. Geometry was manipulated by rotating the position of the located object (e.g. an umbrella) by 45° or 90° from its vertical position.

Additionally, function was systematically manipulated along with the geometry of the scene whereby the umbrella was depicted as either protecting the man from the rain (*functional* scenes), not protecting him (*non-functional* scenes) or there was no rain present (*control* scenes). According to spatial template theory, the only manipulation that would affect adults ratings of *over*, *above*, *under* and *below* would be the position of the umbrella in relation to the man. However, if functional relations are important, whether the umbrella is depicted as protecting the man from getting wet should also influence ratings.

Figure 1.14. Examples of Manipulations, Experiment 1, Picture Set 1, Coventry, Prat-Sala & Richards (2001)

Note: Illustration taken from Coventry et. al. (2001).

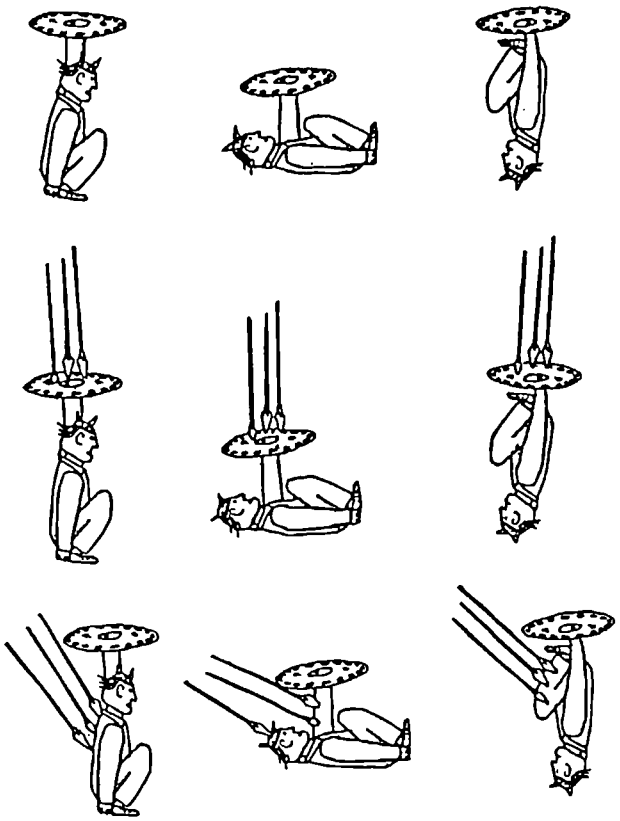
Coventry et. al. (2001) found that, in line with spatial template theory, higher ratings were indeed given to the prepositions when the canonical vertical orientation was depicted, and ratings reduced proportionately the further the object moved away from the vertical axis. However, ratings were also significantly lower when the object was depicted as not fulfilling its function, than when it was shown as successfully fulfilling its function or for the control at all three levels of geometry. The functional scenes were also rated significantly higher than the control and non-functional scenes for both the 45° and 90° angles, and significantly higher than the non-functional scenes for the canonical angle.

Moreover, although all four prepositions were affected by both function and geometry, the prepositions *over* and *under* were more affected by the functional aspects of the scene whereas the prepositions *above* and *below* were mainly affected by geometric aspects. Therefore, the spatial template theory would need to be modified in order to account for effects such as these especially as these functional effects were found even when the umbrella was positioned directly above the reference object in what is deemed to be the *good* prototypical region of space for *above*. This evidence also questions the argument put forward by Landau and Munnich (1998) that suggested extra-geometric factors only come into play when the prototypical geometric relation does not hold.

From here we can see that purely geometric approaches to spatial prepositions are by themselves insufficient; both functional relations and geometric relations are needed to fully specify spatial language. We can also see that although some prepositions may appear to be quite similar to each other, they are not. The prepositions *over* and *above* may have identical spatial templates when unrelated objects are positioned in a spatial scene, but when there is a functional relationship between objects in the scene and when functional information is present, they appear to be differentially affected by function and geometry.

In another experiment, Coventry et. al. (2001) rotated the reference object such that there was a conflict between frames of reference (See Figure 1.15 below). For example, when the man is depicted standing in an upright, vertical position holding a shield the *intrinsic* and *absolute* frames of reference coincide. However, when the man is rotated such that he is depicted in a horizontal position (rotated by 90°), or when he is rotated further still (by 180°) such that he is orientated upside-down in a vertical position, the *intrinsic* and *absolute* reference frames conflict with each other. Using these scenes,

Figure 1.15. Examples of Manipulations, Experiment 3, Coventry, Prat-Sala & Richards (2001)



Note: Illustration taken from Coventry et. al. (2001)

Coventry et. al. (2001) found that *above* and *below* were highly influenced by the conflict between reference frames whereby the greater the conflict between *intrinsic* and *absolute* frames of reference, the lower the ratings. Additionally, no effects of function were found in this experiment for the prepositions *above* and *below*. However, for the prepositions *over* and *under* the effect of function was similar to that found in the previous experiment (reported above). Moreover, the manipulation of reference frame conflict (i.e., rotation of the reference object) had no effect on ratings for *over* and *under*.

Recall earlier the claim that the activation of multiple reference frames during reference frame selection results in the simultaneous construction of multiple spatial templates, one for each reference frame that is active (Carlson-Radvansky & Logan, 1997). Given the results from Coventry et. al. (2001) this suggests that this may only be so for the prepositions *above* and *below*. The results for *over* and *under* suggest that there is no need for the construction of multiple frames of reference as early processing of information in the scene (e.g., the rain or spears) makes the absolute frame of reference salient.

1.3. The Interplay between Geometric and Extra-Geometric Factors

It is clear that both geometric and extra-geometric factors are important for adults' comprehension and production of spatial prepositions. What remains to be seen, however,- is whether or not children attend to such factors when they produce these prepositions. To date, there has been no research that has investigated both geometric and extra-geometric factors with children. As mentioned earlier, such an investigation might shed some light on the issue of whether extra-geometric factors are merely *add-ons* to the geometric representation (Landau & Munnich, 1998) or conversely whether these extra-geometric factors are the central factors that underlie the meaning of spatial prepositions. Indeed, Vandeloise (1991, 1994) proposes that the container/contained relationship and the bearer/burden relationship are the main concepts that form the basis of the prepositions *in* and *on* respectively. Landau and Munnich (1998) have suggested that one way to assess this claim would be to look at it from a developmental perspective. Establishing whether

geometric or extra-geometric factors have the initial influence on children's spatial language might clarify the situation concerning the question of centrality of these factors.

One further point regarding the experiments described in this chapter concerns the paucity of research that has investigated spatial language *production*. The majority of the research conducted with adults (as outlined above) has investigated spatial language *comprehension*. Moreover, even when production has been assessed, the methodologies used have often been too restrictive to assess the true production of spatial expressions. For example, as reviewed earlier, Carlson-Radvansky and Radvansky (1996) used a sentence completion study to investigate functional influences on adults' reference frame selection. However, rather than giving participants the freedom to complete the pre-formed sentence in their own words, they were required to select a completion from a choice of six expressions. Therefore, this fixed-choice sentence completion task is a *comprehension* rather than a production task (see Chapter 5 for a more detailed discussion of this).

The experiments to be reported in Chapters 3 - 5 aim to examine the production of spatial expressions developmentally for the first time by manipulating both geometric and extra-geometric variables. Given the paucity of production work with adults, some of the studies reported also include an adult group for comparison.

Furthermore, as we shall see in Chapter 2 of this thesis that outlines children's spatial language development, a similar pattern emerges. Much of the research has focussed on children's *comprehension* rather than their *production* of spatial terms. It is for this reason that investigating children's spatial language production will be interesting and informative in its own right.

1.4. Précis of the Thesis

It should apparent by now that the focus of this thesis concerns the relative influence of geometric and extra-geometric factors on children's production of English locative expressions. In order to set the scene, Chapter 2 examines the main research to date that has investigated children's acquisition and development of spatial prepositions during the first ten years of life. We will see that there is a general order of acquisition, beginning with words such *in*, *on* and *under*. Children then go on to develop projective terms, for example, *in front of* and *above*. Later on in this chapter we consider whether perceptual and conceptual aspects influence prepositional learning. For example, H. Clark (1973) and Mandler (1992) have both argued that the perceptual aspects of the child's experiences determine a child's acquisition of spatial language whereas others have suggested that it is the language that the child is exposed to that determines how children will learn to talk about objects in space (e.g., Choi & Bowerman, 1991). Chapter 2 will also review some of the evidence regarding children's acquisition of nouns where the question of whether it is knowledge of an object's form or its function that influences children's naming of novel objects will be considered.

In Chapter 3, we will focus in on the simple topological prepositions *in* and *on*. Two experiments that directly manipulate both geometric and extra-geometric factors for the first time with children of different age groups will be reported. The first experiment uses a free-response game playing paradigm whereas the second utilises a sentence completion paradigm. It will become clear in Chapter 3, that for topological prepositions, extra-geometric factors do actually play a role in the production of locative expressions, even in the very youngest children examined (from the age of 3;4).

The question of whether this is the case for all prepositions is considered in Chapter 4 when we go on to examine for the first time whether geometric and extra-geometric factors influence the way adults and children describe the whereabouts of objects that are positioned along the vertical axis. Two experiments are reported in this chapter that focus on superior (i.e., higher-than) and inferior (i.e., lower-than) relations using a free-response sentence completion paradigm. Here we will see that both adults' and children's production of locative terms are similarly affected by how successfully objects are interacting with each other.

Adults' and children's use of spatial frames of reference is the focus of Chapter 5 of this thesis. Following on from research demonstrating that adults select an *intrinsic* description in the presence of a functional relation (Carlson-Radvansky & Radvansky, 1996), two experiments are reported that evaluate this for the first time using a free-response sentence completion paradigm. Here we find that adults prefer to produce *intrinsic* descriptions of spatial scenes according to both geometric and extra-geometric factors of the scenes. However, this is not apparent in children's descriptions where a different method of distinguishing between scenes is found.

Finally, Chapter 6 discusses the findings of this research in the context of current debates on lexical semantics and language use. We will also address the limitations of the research described in this thesis and make some suggestions for further research.

2. Chapter 2: Children's Spatial Language Development: What, When and How.

We have seen in Chapter 1 of this thesis how both geometric and extra-geometric factors are important for adults' production and comprehension of spatial language. The purpose of the present chapter is to examine the developmental literature. In order to understand the relative influences of geometric and extra-geometric factors for children we need to examine how this fits in to what we already know about the acquisition and development of spatial prepositions. As there has been no specific research which has examined both geometric and extra-geometric factors in children's spatial language, this chapter will examine what we know about the spatial prepositions children learn, the age at which they learn them and the factors that might influence how they are learned.

We will begin with a review of some of the research that has investigated children's development of English spatial prepositions. The aim of this review is to cover the major milestones in children's prepositional development. Here we will see that there is a general order of acquisition for spatial terms. We will also discover how the context and the nouns used to describe objects and aspects of the located and reference objects themselves can all affect children's performance when demonstrating their production and comprehension of spatial language. When we look at the factors that might affect spatial language development we will see that the order of acquisition of spatial terms appear to be affected by three main factors. These factors are the linguistic complexity of the term, its conceptual complexity and frequency of its production in the child's environment, although in reality they are often confounded (in that all three factors interact with one another).

2.1 The Development of Children's Comprehension and Production of Spatial Locatives

2.1.1. Problems of Attributing Children with Full Comprehension and Production of Spatial Terms

The aim of this section is to look at children's development of spatial prepositions with an emphasis on when they learn them. In order to do so, we will look at the age at which children are likely to produce and comprehend certain English prepositions and whether or not there is a consistent order of acquisition of these prepositions. One of the problems in assessing the development of children's spatial language is that they tend to produce and demonstrate a comprehension of spatial prepositions before they fully understand the meaning of the terms. For example, imagine a child is given an apple and a bowl and is asked to *put the apple in the bowl.* When the child places the apple appropriately *in* the bowl, that child might have fully understood the preposition used in the request. Alternatively, the response might be made according to some non-linguistic strategy such as "if X is a container, put Y *in* it" (E. Clark, 1973). Indeed, we will see that children in their second year of life produce a range of prepositions (Tomasello, 1987). However, we will also see that the production of these terms begins with non-prepositional uses of them before they are used spatially. The point at which children gain full comprehension and production of spatial terms differs according to the criteria that are adopted by the individual researchers concerned. We will therefore need to consider these

problems as we proceed and assess how different researchers have measured children's performance with spatial prepositions.

Several diary studies, reviewed by Durkin (1978), show that an extensive range of spatial terms has appeared in the child's repertoire by the time they reach their third birthday. Children continue to build up a sizeable lexicon of terms during pre-school and early school years. Nevertheless, such 'frequency' studies do not necessarily tell us *how* children are using the terms and the mere occurrence of a term does not mean that it is being produced in an adult-like manner. For example, it could be that the production and comprehension of these terms are context specific.

It has also been demonstrated that children produce spatial prepositions initially when non-spatial meanings are intended (Tomasello, 1987). Documenting the production of prepositions during his daughter Travis's second year, Tomasello (1987) found that she initially learned 'spatial oppositions'; *up - down* (aged 1;6), *on - off* (1;6-1;7), *in - out* (1;6-1;7) and *over - under* (1;7-1;8). All of these terms were produced primarily in a non-prepositional way. For example, she would use *down* in a verb-like way to describe her own activities (*kitty down* or *towel down* at 1;6), only later did she begin to produce the words spatially (*pillow down here* at 1;7.23). This pattern of non-prepositional use for locatives, followed later by prepositional use, was prevalent for all but the preposition *over*. *Over* was never produced spatially during her second year. Prepositional uses of *in* and *on* occurred almost simultaneously; Travis produced *on* as a spatial preposition at 1;7.20 when she said *bug on monkey bars*. Two days later (1;7.22) she produced *in* spatially when she uttered *bug in there*. Her first production of *at* was around 1;8 and 1;9 where she would produce it in *look at* expressions. However, *at* was produced as a locative expression from around 1;10 when she uttered the sentences *Linda at home* and *Play at the playground*. One interesting finding was that Travis produced *under* as a locative at an extremely early age (we will see later in this chapter that *under* is not fully understood

until at least the age of 3;0). For example, at 1;8 Travis said *here it is under the balloon.* We can see from here, that even before children reach their second birthday they may well be able to produce simple locative words such as *in*, *on*, *at* and *under* appropriately in some situations.

One problem with this type of study is that it may serve to over-simplify the order of acquisition and any claims that a child might *fully* understand a certain preposition on the basis that a child has demonstrated the production of it in context would surely be premature. Many uses of words in the early stages can be imitative, unstable and often contextually bound. For instance, Travis might say *under the balloon* when an object is in contact with the under side of the balloon and occluded by it, but we cannot conclude from this that she would say *under the balloon* when there is no contact or occlusion present. Other studies have shown that *under* is infrequently produced and that when measures of frequency of production are taken into account, *in* and *on* do not become stable members of a child's spatial lexicon until well into their third year (Sinha, Thorseng, Hayashi & Plunkett, 1994). It appears, therefore, that during a child's second year of life, their spatial world is beginning to be lexicalised. Words emerge that denote locations of objects and people, irrespective of whether those words are fully understood by the children that utter them.

When assessing whether or not a child fully understands a spatial term, researchers have used different criteria. Some use adults in their studies and score children on their ability to comprehend terms according to their adult-like response (ALR, e.g., Abkarian, 1983) while others use their own intuition as the ALR (e.g., E. Clark, 1980). It has also been suggested that sometimes a child can appear to understand something in an adult-like manner, but in reality they are responding according to some kind of strategy (e.g., E. Clark, 1973). Imagine a large box on its side with the opening toward you and a supporting surface at the top. If a child demonstrates the ability to put a small box *in* that

large box when asked to, Clark would argue that this does not necessarily mean that the child fully understands the preposition *in*. The child might be responding according to a non-linguistic strategy, for example, "if the reference object is a container, put the located object *in* it". Only when that child can place an object *in* the box and *on* the box appropriately, can we say that the child understands these prepositions.

In summary, we have seen that children in their second year of life begin to lexicalise their spatial world. However, the words they produce are often unstable in that they can be contextually bound or imitative. Children's comprehension of spatial prepositions can also be subject to contextual factors that may be partly reflected in the strategies they employ when responding to spatial requests. Additionally, the point at which different researchers have attributed a full understanding of certain prepositions to children may also differ according to the criteria they use. With all this in mind, we will now take a look at children's first seven or eight years of life and the way in which they develop both comprehension and production of a variety of spatial prepositions.

2.1.2. The Development of the Spatial Lexicon; the Early Years

2.1.2.1. The First Three Years of Childhood

The first spatial prepositions that are typically developed by children have been shown to be *in*, *on* and *under*. Children begin to produce *in* and *on* from around the age of 2;0. Later they produce other prepositions. However, children sometimes make mistakes, often over-extending these simple spatial prepositions and producing them in place of prepositions that are more complex. For example, producing *in* rather than *between* or *over*, or *on* rather than *above* (Brown, 1973; E. Clark, 1972; Durkin, 1980; Grimm, 1975).

Nevertheless, experimental studies looking at the comprehension of *in*, *on* and *under* suggest that *in* and *on* are not fully comprehended until children are well into their third year (around 2;3-2;9) and that *under* is not fully understood until children are at least 3;0 (E. Clark, 1973; Sinha, 1982; Weist, 1991;Wilcox & Palermo, 1975). Most of these studies required a child to place one object in relation to another object using a simple spatial request (e.g., *put the X preposition Y*).

Figure 2.1. The Reference Objects Used in E. Clark's (1973) Study.

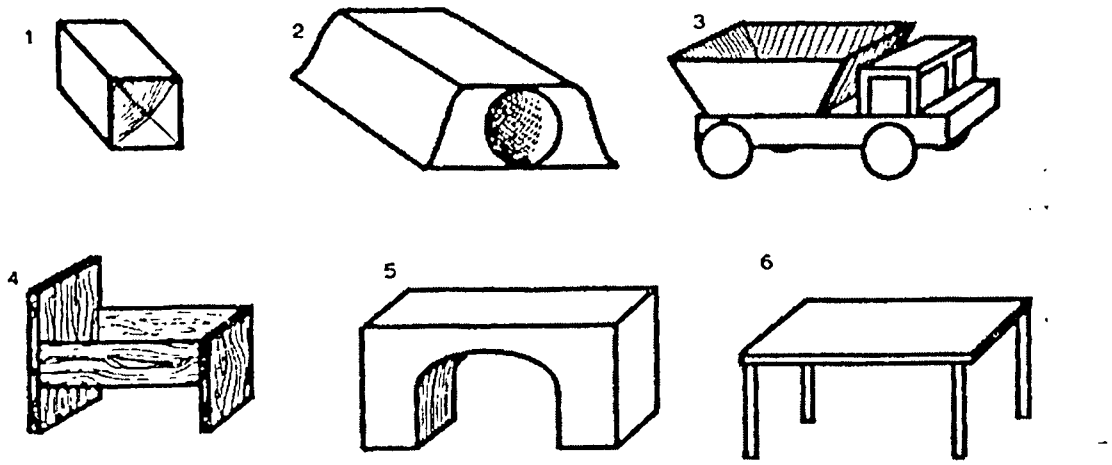


Illustration taken from Clark (1973).

For example, E. Clark (1973) demonstrated how children use their pre-linguistic knowledge of objects, and the canonical use of them, in forming their first hypotheses about the meanings of spatial prepositions. She suggested that, when asked to place one object in relation to another, children would use one of two "rules" about the spatial relations that hold between objects and containers or surfaces. Looking at children between 1;6 and 5;0, Clark instructed them to place a toy animal either *in*, *on* or *under* one of six reference objects (see Figure 2.1 above). Each reference object afforded two types of spatial relations; a box on its side and a tunnel allowed an object to be placed both *in*

and *on* them, a dump truck and a crib allowed *in* or *under* placements, with a table and bridge affording both *on* and *under* placements. Children below 2;0 produced *in* placements correctly all the time, *on* placements some of the time, and *under* placements none of the time. Older children's placements showed an improved understanding of *on* and *under*. An examination of the error data revealed that children begin by interpreting the instructions according to two ordered rules:

Rule 1: If B is a container, A belongs inside it.

Rule 2: If B has a supporting surface, A belongs on it.

As a consequence of this, children appeared to understand *in* all the time, *on* with surfaces but not containers, and *under* none of the time. By the time children reached the age of 3;0, E. Clark found that most of them had full comprehension of all three prepositions. In further studies of this nature, E. Clark (1975, 1977) found that three and four year-old children revert to their original strategies when faced with instructions that contained more complex prepositions such as *above*, *below*, *in front of*, or *at the bottom of*. For example, when asked to place one toy *in front of* another that had a supporting surface, they would place it *on* instead (as reported in Clark & Clark, 1977). E. Clark (1973) proposed the partial semantic hypothesis, whereby children's early understanding of a word contains a single feature, for spatial prepositions this would be [+Locative], at which point they use non-linguistic knowledge (e.g., the two rules set out above) in order to interpret the words.

Subsequent studies investigating the comprehension of *in*, *on* and *under* have cast some doubt upon the adequacy of the partial semantic hypothesis. Although children's understanding of *under* develops much later than *in* and *on* (as predicted by the hypothesis), rather than relying on the features of a reference object, children's strategies

appear to be more contextually based (Grieve, Hoogenraad & Murray, 1977; Wilcox & Palermo, 1974). As we shall see later on in this section, Grieve et. al. (1977) found that children's ability to place one box relative to another was hampered when they were instructed to think of the boxes as a bath and a baby and when the placement required was incongruent with their canonical spatial arrangement (e.g., *put the baby under the bath*).

However, even younger children have been shown to be able to associate the prepositions *on* and *under* with types of spatial relations (Meints, Plunkett, Harris & Dimmock, in press). Children who understand a verbal request to look at a target stimulus, will look at that stimulus more than the distracter (Golinkoff, Hirsh-Paseck, Cauley & Gordon, 1987). Meints et. al. (in press) used this kind of preferential looking task with children aged 1;3, 1;6 and 2;0. Such a task measures the amount of time, relative to a pre-verbal baseline, a child looks at one of two visual stimuli that are displayed simultaneously. Meints et. al. (in press) began by asking adults to rate the typicality of a variety of *on* and *under* pictures using both animate and inanimate located objects (see Figure 2.2 below). The typical *on* pictures depicted the located object in the centre of the supporting surface whereas atypical *on* pictures illustrated them positioned to the edge. Similarly, typical *under* pictures had the located object directly under the reference object with atypical *under* pictures depicting them indirectly beneath the reference object.

They then showed children those images rated as typical and atypical *on* and *under* pictures, along with a distracter. The target-distracter pairs were created by displaying the target picture using one spatial arrangement (e.g., typical *on* arrangement) along with a similar distracter picture using the other spatial arrangement (e.g., typical *under* arrangement). Therefore, typical *on* pictures were paired with typical *under* pictures and atypical *on* pictures were paired with atypical *under* pictures. A verbal request accompanied the pictures whereby the children were asked *look at the X on/under the Y.*

Figure 2.2. An Example of the Typical and Atypical *On* and *Under* Pictures used in Meints Plunkett, Harris & Dimmock (in press) Study.

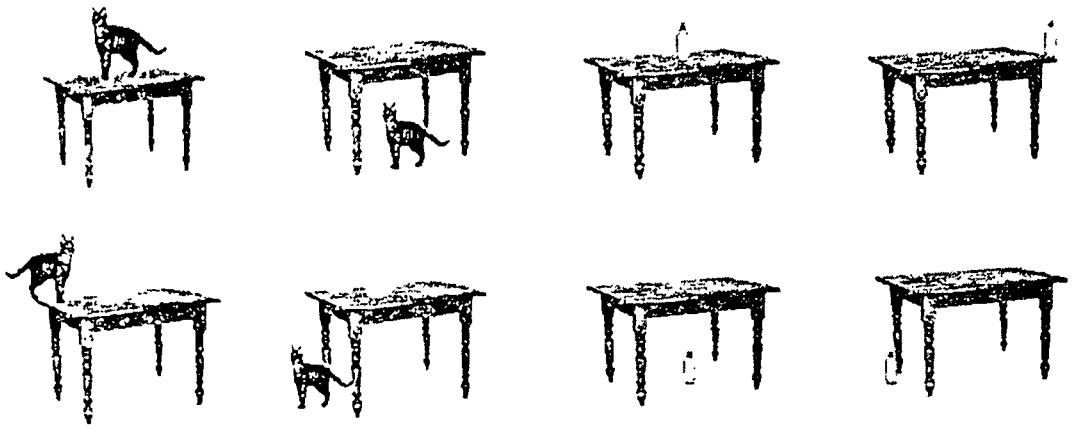


Illustration Taken from Meints et. al. (in press).

Meints et. al. (in press) found that at 1;3, children looked longer at the typical than the atypical targets therefore suggesting that at this age children associate the prepositions *on* and *under* with typical situations only. By the age of 1;6, children looked longer at the atypical situations, suggesting that they are beginning to recognize that these, too, can be examples of *on* and *under* prepositions. However, this finding was only robust for the animate scenes.

Although *under* appears to be learned later than *in* and *on*, it has been argued that the comprehension of *under* requires two types of spatial understanding (Halpern, Corrigan & Aviezer, 1983). The first type of 'under' ($under_1$) is where the structure of the reference object is such that it allows another object to be placed under it without moving the reference object (e.g., a train under a bridge). The second type of 'under' ($under_2$) necessitates the movement of the reference object in an upward direction so that a space is created beneath it for the located object to be placed (e.g., one box under another). It has been argued that $under_2$ is more difficult for the child as a space has to be mentally created before the located object can be positioned 'under' the reference object as this space is not automatically visible to the child (Halpern et. al., 1983; Sinha, 1982). Using free play, an

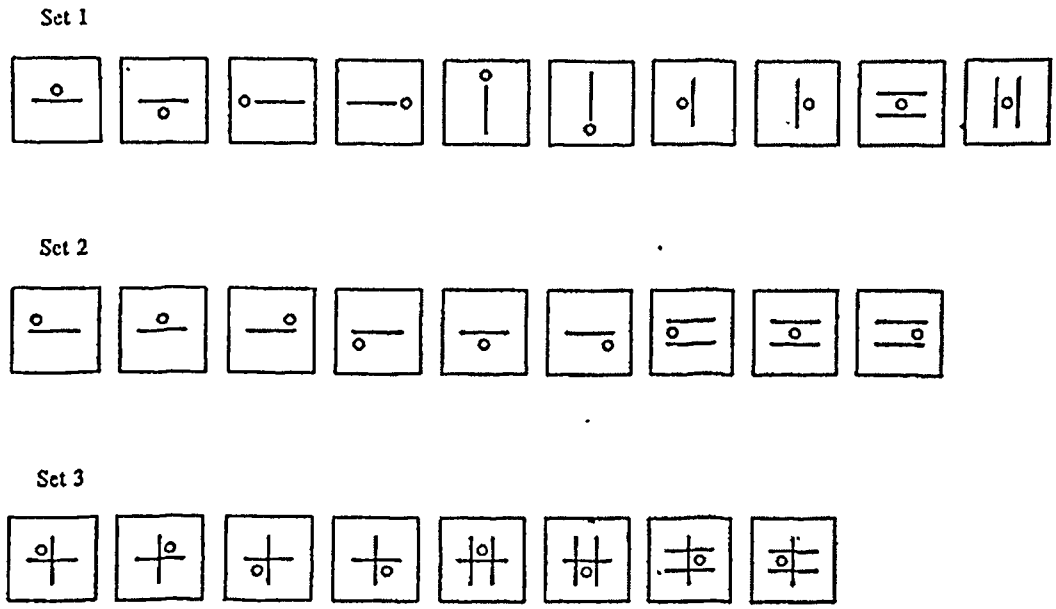
object placement task and a production methodology Halpern et. al. (1983) demonstrated that under$_2$ developed much later than under$_1$. Out of the 75 children tested between the ages of 1;2 and 2;6, only four participants could construct an under$_2$ placement when asked to (14 could construct under$_1$), with three children producing the term *under* to describe under$_2$ (seven produced *under* to describe under$_1$). However, as Halpern et. al. (1983) only looked at children up to the age of 2;6, no conclusion can be drawn from their data as to when children typically understand the meaning of under$_2$.

Other research has demonstrated that a similar placement task with boxes can be reliably performed at the age of 3;0, but when asked to imagine that those same boxes are objects such as a table, a chair, a baby and a bath, even children of 3;9 cannot successfully complete the task if it violates the canonical arrangement of those objects (Grieve, Hoogenrad & Murray, 1977). Therefore, when asked to *put the table under the cup* or to *put the bath under the baby*, children up to 3;9 could not stack the boxes accordingly, even though they had previously demonstrated an ability to do so when the boxes were referred to simply as boxes. It is obvious from this that the ability of a child to understand spatial instructions can be strongly affected by the nouns used to describe those objects. It might also be possible that, just as children comprehend spatial prepositions differently according to the objects that they are placing in relation to each other, when children produce spatial locatives they might produce them differently according to the objects located in the scene.

One final comment regarding the preposition *under* is that unlike *in* and *on* which appear to be prolific in children's language, *under* is infrequently produced by children at this age (Asso & Wyke, 1973; Halpern et. al., 1983; Sinha et. al., 1994). Additionally, when it is produced, it can often be produced incorrectly (e.g., *under* for 'back' and 'front' configurations, Johnston, 1982). Asso and Wyke (1975) report a systematic increase in the production of *under* with age. They showed sixty children across three age groups (mean

ages 5;1, 6;1 & 7;2) a variety of lines and circles displayed separately on pieces of card (see Figure 2.3 below). When they asked these children to describe the location of the circle in relation to the line, children's production of *under* increased across age groups; the 5-year-old group of children produced the preposition *under* a total of 11 times compared to the 7-year-old group who produced it 38 times during the same task.

Figure 2.3. The Circle and Line Drawings used by Asso and Wyke (1975)



Note: Illustration taken from Asso & Wyke, 1975

Given that children typically comprehend the preposition *under* between three and four years of age, and that the materials the children saw could have elicited an inferior relational preposition (e.g., *under*, *underneath*, *below* or *beneath*) around 100 times per age group, the production of *under* was relatively infrequent. Moreover, *underneath* was produced only 5 or 6 times per age group, *beneath* was uttered a total of eight times in the experiment and *below* was never produced.

We can see from the above that by the time children reach their third birthday they can already comprehend a variety of spatial prepositions, although their production of spatial prepositions does not always fully reflect their comprehension of such terms. We will also see later on in this section, that children's spatial language development continues throughout their pre-school years and continues to develop during their primary school years.

2.1.2.2. From Pre-School Years to Early Primary Years (3;0 to 6;0).

One prepositional phrase that is usually comprehended and produced by children during their pre-school years is *next to* (Johnston, 1984; Sowden & Blades, 1996; Wilcox and Palermo, 1982). Johnston (1984) gives evidence to suggest that children learn to produce *next to* to express a spatial location at around 3;4, shortly after learning *under*. However, at this age, children might equally produce *next to* when describing an *in front of* or a *behind* relationship as these terms are typically acquired later (Johnston, 1984).

Looking at children's comprehension of *next to*, Wilcox and Palermo (1982) found that children have problems with some tasks more than other tasks when requested to make a *next to* placement. When children were given a train station and a section of track and asked to *put the station next to the tracks*, the number of errors in placement reduced as the age group of children increased. Seventy-five percent of the placements made by the two-year old children were errors, but this reduced to 44% for the three-year old group and 25% for the four-year old group. The placements made by the five and six-year old groups were error free. Yet, when they were given a block and asked to *put the block next to you*, errors were still being made even in the 6-year-old group. However, Wilcox and Palermo

did not give any details of these errors or how such errors were measured. For example, there were no adults tested with which to make comparisons and no information was given about where the objects were placed. In addition to this, the experiment was not designed to assess the age of acquisition, rather it was designed to look at the types of information children use when comprehending adults' requests to place two objects in relation to one another. Therefore it is difficult to infer from this study the typical age at which children display an adult-like comprehension of *next to*.

One study that was designed with both of these factors in mind suggests that children demonstrate an adult-like comprehension of *next to* much earlier than six years of age (Sowden & Blades, 1996). Looking at children's comprehension of *next to* and *near to* using a placement task, Sowden and Blades (1996) found no significant differences between the responses of children (mean ages 3;7, 4;5 & 6;7) and those made by adults undertaking the same placement task using the preposition *next to*. This was not found to be so for *near to* placements where children in the youngest age group (mean age 3;7) made 62% of contact placements (i.e., where the located and reference objects were touching) compared to 18% of contact placements made in the adult group. It was not until children reached around 6-years of age that they responded in a similar manner to adults when undertaking a *near to* placement task. Although it is not possible to directly compare the results regarding *next to* with those found in the Wilcox & Palermo (1982) study as no placements were made using the children themselves as the reference point, it is likely that by the end of a child's fourth year they can both comprehend and produce *next to* using reference points other than themselves in an adult-like manner.

Looking at children's production of *near to*, it has been shown that children between the ages of 4 and 8 years old produce the term *near to* quite liberally (Durkin, 1980). Durkin (1980) asked five age groups of children (means 4;6, 5;0, 5;7, 6;5 and 7;6) to describe the location of a brick as he positioned it around a board with various different

objects placed on it. When he lifted the brick above the board, all groups of children produced the term *near to* when they described this no-contact vertical location (e.g., above) between 19% and 36% of the time, with the youngest group of children (mean 4;6) using it in 29% of their descriptions. Although these four-year-old children quite readily produce the term *near to*, as mentioned earlier, they do not fully comprehend it in an adult-like manner until around 6-years of age (Sowden & Blades, 1996). One final note regarding children's comprehension of distance terms is that it has been shown that children are able to make the distinction between *closer to* and *further from* in both production and comprehension by the earlier age of five (Donaldson & Laing, 1993).

Between the ages of four and five, children are beginning to comprehend and produce the spatial terms *in front of*, *behind/in back of*[1] and *beside*. Because the terms *in front of* and *behind/in back of* have been extensively studied using various methods and methodologies there are some large inconsistencies regarding the exact age of acquisition. Some research has offered evidence to suggest that children have an adult-like comprehension of these terms as young as 3;3 (Clark, 1980) whereas others suggest it is not until a child reaches the age of 7 or 8 that they fully comprehend the term *in front of* (Cox, 1979). Again, most studies do not include an adult group in their analysis and use only the author's own intuition (or the intuition of a handful of other adults) with which to decide upon correct or incorrect responses.

One of the main interesting issues regarding a child's comprehension and production of *in front of*, *behind/in back of* and *beside* is how a child decides what is the front, the back and the side of an object. Some objects have obvious features, and although there is no exact principle that sets out where *the front* is, it has been suggested that the

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[1] The American English term for *behind* is *in back of*, and as much research in this area has been undertaken looking at the term *in back of* rather than the English expression *behind*, such research will be included in this review.

front of an object is usually the side that is prominent in some way; others have suggested this prominence is related to the usual way in which we interact with that object (H. Clark, 1973; Miller & Johnson-Laird, 1975). However, this is only so for objects that have features, for example, cars, cookers, animals, people and buildings etc. Objects like a drinking glass, a block or a ball do not possess intrinsic features, yet it is still possible to place an object *in front* of them. We shall see that children's understanding of learning how to assign fronts, backs and sides to both featured and non-featured objects is a protracted affair with a general order of development. For example, children have much greater difficulty in producing *in front of* utterances to describe one object placed *in front of* another when the reference object contains no inherent features. We will now take a look at how children develop an understanding of identifying and assigning fronts, backs and sides for both featured and non-featured reference objects.

By the middle to end of their fourth year children can reliably indicate where their own 'front' and 'back' are, with 'side' being a later acquisition; this appears to be the first step towards the development of the spatial terms *in front of*, *behind/in back of* and *beside* (Kuczaj & Maratos, 1975). Children then appear to learn to extend this knowledge to assign *fronts* and *backs* to other objects. They can do so in an adult-like way with few errors by around 4-years of age, with some objects being easier than others (Kuczaj & Maratos, 1975). The next stage appears to be that children comprehend *in front of* and *behind* for objects that possess intrinsic fronts and backs, and slightly later they comprehend *beside*, displaying full comprehension of all three terms by the end of their fifth year (Harris & Strommen, 1972; Kuczaj & Maratos, 1975). This agrees with evidence from production studies demonstrating that children begin to produce the term *beside* from around five-years of age (e.g., Durkin, 1980).

There is also some evidence to suggest that children's comprehension of *behind* is acquired before their comprehension of *in front of* (Abkarian, 1982; Cox, 1979). Indeed,

when looking at the production of spatial terms with children between the ages of 2;7 and 4;7, Johnston (1984) found that children produced *in back of* first in cases where the located object was placed behind a non-featured tall object (thereby being obscured from view); 11% of children in the youngest age group (mean 2;11) could do this, as could 40% of children in the middle age group (3;5), and 67% of children in the oldest age group (4;2). Fewer children produced *in back of* when the reference object was a featured, same-sized object (with none in the youngest group doing so). Both of these uses of *in back of* generally occurred before any production of *in front of*, which was uttered by 13% of children in the middle age group (mean 3;5) and 56% of those in the older group (mean 4;2). None of the children in Johnston's (1984) study produced *in front of* to describe the location of an object that was positioned at the front (i.e., between the child and the reference object) of a non-featured reference object.

The final task for children in their acquisition of *in front of*, *behind/in back of* and *beside*, therefore, is knowing where to place or how to describe the location of an object when the reference object has no inherent features (Kuczaj & Maratos, 1975). As we cannot use the intrinsic features of a featureless object, it has been suggested that we project fronts, backs and side features onto it ourselves (H. Clark, 1973). Clark proposed the notion of the *canonical encounter* which suggests that, since the typical context of language use involves a speaker and an addressee in face-to-face contact a short distance apart, we impose a canonical relationship upon that featureless object by treating it as if it were another person facing towards us. Therefore, if a speaker is looking at a scene and says *the bat is in front of the ball*, the bat will be between the ball and the speaker. Likewise, if the speaker says *the bat is behind the ball*, the bat will be on the opposite side of the ball to the speaker (see Pattern "A" in Figure 2.4 below). However, it has been demonstrated that adults have problems with comprehension studies that use a placement task with non-featured reference objects. Their responses tend to conform to the notion of

a canonical encounter a little over half the time. For example, Abkarian (1982) found that thirty-one percent of placements were to the far side of the reference object for *in front of*

Figure 2.4. Patterns of Placements Made by Adults and Children When Asked to Place a Located Object *in front of, in back of/behind* and *beside* Featured and Non-featured Reference objects.

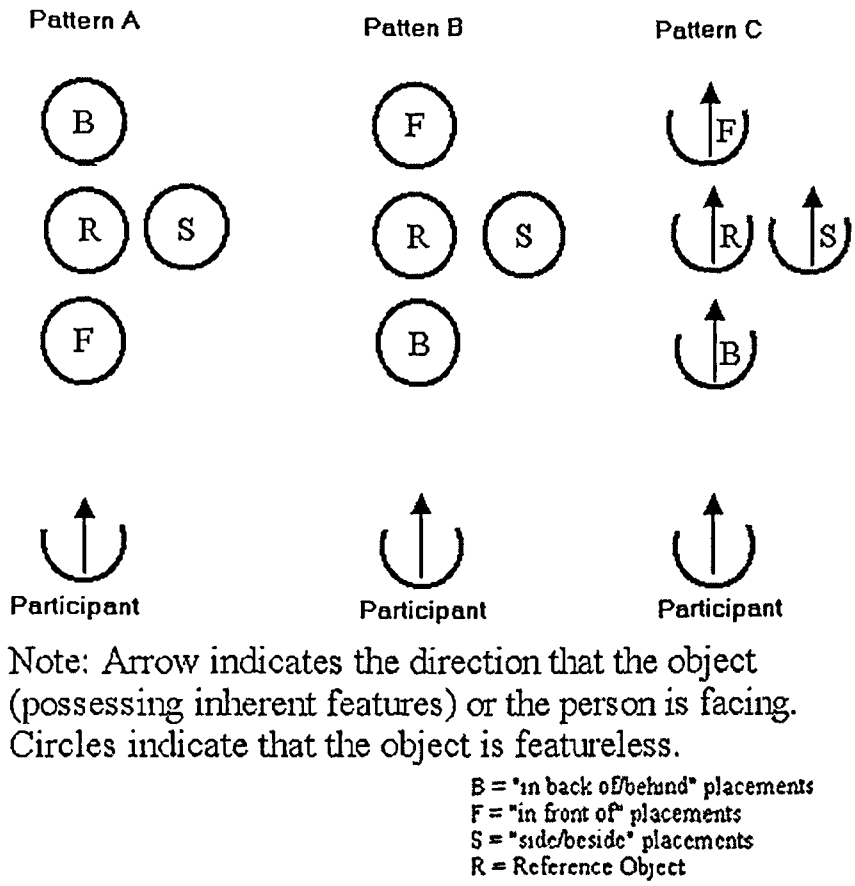


Illustration Adapted from Harris and Strommen (1972).

requests (as in Pattern "B" in Figure 2.4 above). Additionally, Abkarian noted that the consistency with which adults made their placements was poor, with only 48% of them choosing the same location for the same spatial term each time. Children, too, appear to struggle with this placement task with different studies suggesting different ages at which they perform to an adult level. In fact, early research did not actually look at adults'

performance and therefore assumed a level for adults well above that which actually exists (e.g., Kuczaj & Maratos, 1975).

On the basis that adults place objects between featureless reference object and themselves around 62% of the time for *in front of* requests and place it on the far side of the featureless reference object around 75% of the time for *behind* requests (Abkarian, 1982), children have been shown to reach adult competence as young as 3;11 (68% & 73%, Kuczaj & Maratos, 1975) and as old as 7;2-8;10 (c. 80% for both terms, Cox, 1979). The late acquisition in Cox's study appears to be due to children's problems with *in front of*; children as young as 5-6 years old were placing the located object to the far side of the reference object for *behind* requests c. 70% of the time.

To sum up the research on *in front of* and *in back of/behind* so far, we can see that the comprehension of these terms typically begins when children extend the knowledge of their own fronts, backs and sides to identifying those components for featured objects. This is usually toward the end of their fourth year. Later, they begin to use a system similar to Clark's canonical encounter whereby they assign fronts, backs and sides to featureless objects. Children typically demonstrate an adult-like performance with their comprehension of this using placement tasks at around 4-5 years of age, with *in front of* placements sometimes being acquired later. The production of these terms appears to follow a similar course, only slightly later in their development. One further aspect to note is that the terms *in front of* and *in back of/behind* are not always the easiest of terms to elicit. When Durkin (1980) asked children to describe various positions of objects he found that for the children in his study (4;6 to 7;6), *in front of* and *behind* were infrequently produced, with prepositions such as *near* being a more common term with which to describe the locations. It seems from this, that although children know the terms, they can be reluctant to produce them in an experimental setting.

One final point to be made regarding the comprehension of *in front of* and *in back of/behind* is that it has been shown that the orientation of the located object is also considered by children when making their placements. When children placed a featured object *in front of* and *in back of/behind* another featured object they had a strong tendency to match the face orientation of the placed object to that of the reference object (see Pattern "C" in Figure 2.4 above; Harris & Strommen, 1972; Wanska, 1984). Indeed, Harris and Strommen report this to be so for 86% of placements with children between the ages of 4;9 and 7;9 (looking at them as a single age group) with Wanska finding a tendency for older children to do so more than younger children (69% for the 3 and 4-year old children and 84% for the 6-year old children). This aspect of spatial placement has not been looked at with adults.

2.1.2.3. Further Developments in the Early School Years; from 6;0 to 10;0

We will now look at children's understanding and production of terms that describe objects positioned along the vertical axis. As we have seen, children between the ages of three and four typically comprehend the preposition *under*. However, their comprehension and production of the prepositions *over*, *above* and *below* appear to develop much later. Children appear to find the vertical dimension more salient than the other dimensions (Clark, 1980) and in spatial language production, some researchers have commented, "in the vertical dimension, spatial terms were dominant even among the youngest children. *At the top*, *up*, *at the bottom*, *down* and *under* were the actual terms used most frequently" (Cox & Richardson, 1985, p.618). However, they later comment that the terms *above* and *below* were produced by very few children (aged 3-10 years) and were mainly adult terms.

From here we can see that although children notice the vertical dimension and talk quite freely about it, they do not always produce the same terms as adults produce to denote the vertical axis. As we have seen already, there have been a number of studies conducted that have looked at the preposition *under* with children (e.g., Clark, 1973; Halpern et., al., 1983; Wilcox & Palermo, 1975), although far fewer have looked at its inferior relational counterpart *below*. Most studies into the production of vertical axis prepositions by children make no mention of the word *below* implying that children produce the terms *under* or *underneath* as a preference to describe an inferior spatial relationship between two objects. Indeed, Durkin has suggested that *below* is one of the many prepositions that are still developing during children's early school years (Durkin, 1980).

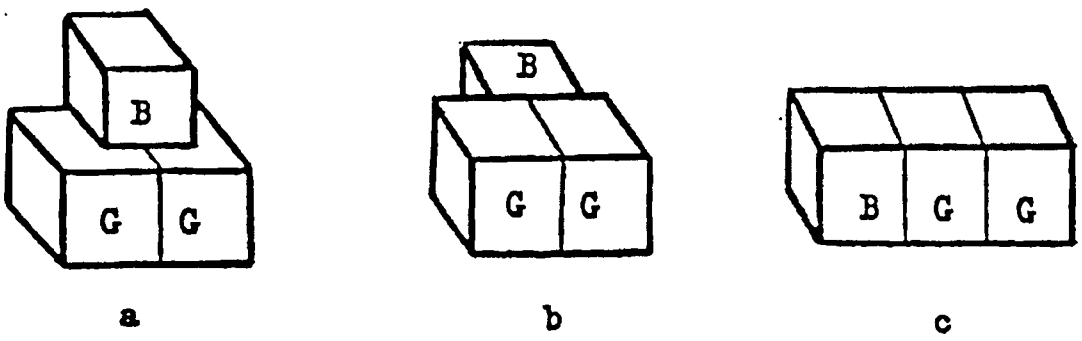
Over and *above* are the superior counterparts to *under* and *below* and they also appear to be learned by children during their early school years. It has been shown that children do not freely utter these words to describe a no-contact vertically higher relationship when they are clearly the most appropriate. As mentioned earlier, Durkin (1980) found that children up to the age of about five used the term *near* more than *over* or *above* to describe the position of a cube in relation to a cup when he raised it into the air. They also preferred the term *on top of* to describe this spatial relation. Thirty three percent of the productions from the 5-year old children were *on top of* compared to 4% of *above* responses. None of these children produced the preposition *over*. He also found that only 29% of responses from his oldest age group (mean 7;6) produced the term *above* with no children producing *over* at this age (although 5% of the 6-year olds responses did produce *over*).

Asso and Wyke (1973) showed three groups of twenty children between the ages 4;6 and 7;6 a circle and lines drawn on various cards (see Figure 2.3 on page 61 above). None of the children in the Asso and Wyke study produced the preposition *above* when describing a vertical axis spatial arrangement. Additionally, although the five-year-old

group never produced the preposition *over*, it was still only rarely produced by the six and seven-year-old groups (18 and 22 utterances respectively). As each child described at least five cards where *over* or *above* were the most appropriate prepositions, the infrequency with which these prepositions are produced suggests that even at the age of seven, some children either had not fully mastered these terms or were reluctant to produce them in this context.

It has been found that children's development of the spatial preposition *between* is a protracted affair. Although children as young as 2;2 are reported to produce this term, and certainly by three years of age it appears to be a relatively commonly produced preposition, it has been demonstrated that even seven-year olds can have problems with certain types of *between* placement tasks (Durkin, 1978, 1981). However, the task that appears to cause the most problems is one where it was necessary for the children to move the reference objects apart so that the located object could be placed *between* them (other tasks had reference objects a distance apart from each other).

Figure 2.5. Errors Children Made in the Durkin (1981) Study for the *between* Placements.



Note: "B" = blue block, "G" = green block; Placement request was *put the blue blocks between the green blocks. (Illustration taken from Durkin, 1981).*

Figure 2.5 above illustrates the three main types of errors that the children made, of which, responses (a) and (b) suggest a partial understanding of the task. Children may

have problems with this specific task for one of two reasons. Firstly, it could be that children felt, for some reason, that they were not allowed to move the blocks. Therefore, they may have possessed full knowledge of *between*, but in the experimental situation they were unsure whether they could move the blocks in order to complete the task. Alternatively, it could also be that they had not yet developed the cognitive ability to mentally create the space needed for a 'between' placement (cf. Halpern et. al., 1983). Due to the paucity of research into the comprehension of *between*, no firm conclusion about the age at which children typically develop a full adult-like comprehension of *between* can be drawn here. In relation to children's production of *between*, we can see that different tasks, again, elicit different results. Durkin (1980) found that no children below the age of around 5;7 uttered the preposition *between* in his task, even though opportunities for a *between* description were numerous. Even when *between* was uttered, it was in such low proportions (0.1% mean age 5;7 and 1.2% mean age 6;5) that Durkin concluded that it was not the readiest of productions for children between 4;6 and 7;6. Indeed, Asso and Wyke (1973) found that most of the instances of *between* in their youngest group (22 correct uses from 24 at mean age 5;0) came from two children, production of *between* systematically increased for the older age groups with it being produced in age group three (mean 7;0) correctly for around 90% of their 84 *between* descriptions.

Finally, let us look at children's development of the terms *left* and *right*. Asso and Wyke (1973) found that the production of these terms systematically increased both in number and in correctness of use with the age groups of children they tested. The five-year old group produced *left* and *right* in their spatial descriptions 22 and 32 times respectively with only around 50% of their utterances being a correct use of the term. However, the oldest group (seven-year olds) produced *left* and *right* 100 and 98 times respectively when viewing the same scenes, representing around 80% correct usage of the terms. Other research has shown that it is not until children reach the age of seven that they readily

begin to produce *left* and *right* in their spatial descriptions (Cox & Richardson, 1985). Interestingly, it has been shown that although children of about five and six years of age have considerable problems with *left/right* instructions when retrieving objects, those same children are able to accurately produce the *left/right* labels when giving the directions themselves (Waller, 1986). Additionally, Waller found that the 7-year-old group who performed very well on the *left/right* retrieval task appeared to realise the restrictions of the younger children and gave them fewer *left/right* directions than they did for the children who were the same age as themselves. This was not so for the younger children who gave the same *left/right* directions to all age groups of children.

As we can see from all of the above, children begin to produce spatial terms very early on in life and their production and comprehension continue to develop throughout the first eight or nine years of life. Table 2.1 summarises the main findings outlined above. Additionally, following on from their research, both Johnston and Slobin (1979) and Johnston (1984) have proposed an order of acquisition for the production of spatial prepositions that a typically developing child will follow and are broadly consistent with the developmental pattern described in this chapter. Although Johnston and Slobin believe this order of acquisition to be in part a reflection of conceptual universals present in spatial language, we will see later on in this chapter that this view has been more recently challenged (e.g., Bowerman, 1996). Additionally, other researchers have speculated on the order in which prepositions will be learned (e.g., H. Clark, 1973), but this has generally not been borne out by the data. We will therefore consider the orders of acquisition proposed by Johnston and Slobin (1979) and Johnston (1984) to be the most appropriate in as much as they are driven by empirical observation and have been generally supported by other research in the area. We will reserve discussion of why the pattern of acquisition is as it is in a later section of this chapter, considering factors such as word frequency, conceptual complexity and linguistic complexity.

Table 2.1. Summary of Spatial Term Production and Comprehension

Spatial Term	Age of Comprehension	Age of Production	Researchers
In	2;3 - 2;9	1;7 - 2;6	4, 6, 8, 9, 11, 12, 14, 15, 17, 20, 21,
On	2;3 - 2;9	1;7 - 2;3	4, 6, 8, 9, 11, 12, 14, 15, 17, 20, 21,
Under	3;0* - 3;9	‡ 1;8 +	4, 2, 8, 9, 11, 12, 14, 17, 21,
Next to	3;7* - 4;0	3;4 +	11, 16, 22
behind/in back of (featured objects)	4;5* - 5;0	3;6 -	1, 6, 10, 11, 12, 13, 19, 20, 22
In front of (featured objects)	4;5* - 5;0	3;11 -	1, 3, 6, 10, 11, 12, 13, 19, 20, 22
Beside	4;0 - 5;0	5;0 +	2, 6, 10, 12, 13,
behind/in back of (non-featured objects)	3;11* - 6;6	3;6 -	5, 10, 11, 12, 13, 19, 20
In front of (non-featured objects)	3;11* - 7;2	5;0 +	5, 10, 11, 12, 13, 19, 20
Between	5;0* - 7;0+	‡3;0 - 3;6	2, 6, 7, 12, 20
Over/Above	6;0 - 7;0	‡3;0 + (low frequencies)	2, 6, 15
Left - Right	6;0 - 7;0+	‡5;0 - 7;0+	2, 18

‡ = Systematic increase of use reported with age over extended period

* = Earliest comprehension, highly task dependent

Researchers

1. Abkarian, G.G. (1983).
2. Asso, D., & Wyke, M. (1973).
3. Bialystok, E., & Codd, J. (1987).
4. Clark, E.V. (1973)
5. Cox, M.V. (1979).
6. Durkin, K. (1980).
7. Durkin, K. (1981).
8. Grieve, R., Hoogenrad, R., & Murray, D. (1977).
9. Halpern, E., Corrigan, R., & Aviezer, O. (1983
10. Harris, L.J., & Strommen, E.A. (1972).
11. Johnston, J.R. (1984).
12. Johnston, J.R., & Slobin, D.I. (1979).
13. Kuczaj, S.A., & Maratsos, M.P. (1975).
14. Sinha, C. (1983)
15. Sinha, C., Thorseng, L.A., Hayashi, M., & Plunkett, K. (1994).
16. Sowden, S., & Blades, M. (1996).
17. Tomasello, M. (1987).
18. Waller, G. (1986).
19. Wanska, S. (1984).
20. Weist, R.M. (1991).
21. Wilcox, S., & Palermo, D.S. (1975).
22. Wilcox, S., & Palermo, D.S. (1982).

2.1.2.4. Methodological Issues

Now that some of the research that has been undertaken to investigate children's production and comprehension of spatial language has been outlined, we will consider the difficulty that we have in reaching firm conclusions regarding the exact point at which children possess full comprehension and production of specific spatial terms. As much of the research outlined above has looked into children's comprehension of spatial language, this cannot be taken as an indicator of how children produce such prepositions. Indeed, children very often appear to produce prepositions well before they demonstrate any firm understanding of them (e.g., the prepositions *in* and *on*) and are reluctant to produce some prepositions that they probably comprehend rather well (e.g., the preposition *under*). There are few studies that detail the correctness or accuracy of prepositional production by children. One reason is that many researchers have had difficulties when attempting to elicit *specific* prepositions. As we shall see later on in this thesis, most spatial relations can be described in a variety of ways, all of them correct. For example, imagine a boy who is about to post a letter into a post box. As his outstretched hand reaches towards the opening slot, the following descriptions might be used, all of them correctly describing the boy in relation to the post box:

The boy is in front of the post box

The boy is beside the post box

The boy is near the post box

In fact, many other prepositions including *by*, *next to* and *close to* can also be produced to correctly describe the spatial relationship between the boy and the post box. This has been problematic for researchers looking into both children's and adults' spatial language production (e.g., Durkin, 1978; Carlson-Radvansky & Radvansky, 1996).

One further point to bear in mind, is that the evidence drawn upon to suggest the approximate ages and order in which children acquire and develop spatial terms comes from a variety of sources. Some of these are observational studies and whilst they might report children's production of a spatial term, it is difficult to ascertain what a child is actually doing or looking at when he or she utters the word (e.g., Sinha et. al., 1994). Other research is experimental, looking at either the comprehension or the production of specific words. However, experimental data from production tasks, for example, are not always representative of how prepositions are actually produced in spontaneous speech. Additionally, the experimental studies themselves are not directly comparable; many of the studies used different tasks, different measures of competence and were originally designed to assess different theoretical viewpoints. It has been shown that children's performance on spatial tasks can be highly dependent upon the task requirements, the objects used in the task, or even the names used for the objects in the task (e.g., Durkin, 1981; Grieve et. al., 1977; Wilcox & Palermo, 1975, 1982). Children know that adults are likely to ask them to place something according to the normal relationship between those objects, that the repetition of a placement request by an adult is likely to indicate that the child's first response was incorrect, that different words have different meanings and that only certain words go in certain linguistic contexts. Children also have a tendency to make the simplest motor response needed in order to execute a placement request (Wilcox & Palermo, 1975).

Task demands and the type of paradigm used might alter children's understanding of the task or willingness to co-operate. Johnston (1988) noted that discrepancies in

reports on children's understanding and acquisition of *behind* and *in front of* might have resulted from differing context effects across studies. Different paradigms can also elicit different numbers of prepositions. For example, the simple *where* questions asked by an adult experimenter have been shown to elicit fewer responses from young children than situations where children interact in a game with a puppet via the experimenter (e.g., Johnston, 1984; Johnston & Slobin, 1979).

It is impossible to get a complete picture of the age at which children develop an adult like production and comprehension of individual prepositions in the absence of any long term longitudinal studies. Therefore all we have are "snapshots" of children's abilities which leaves us with some degree of inference in our description. Durkin (1980, 1981) suggests that children's acquisition of prepositions is not complete at the time of their individual appearance; development appears to be a complex process that goes on for many years (a view echoed more recently by Leikin (1998) for spatial prepositions in Russian). This view also concords with Holzman (1981) who believes that verbal concept development in children is a three-stage process, beginning with a set of memories as instances and going on until that concept is understood as an abstraction. Therefore, if a child is asked *what does 'in' mean* and the response is *inside the house*, this suggests that an abstract concept has not yet been formed. It is at the age at which an abstract concept of each spatial word has formed that we can then say that the child has an adult understanding of that word.

We will now consider some of the factors that might affect the development of the spatial lexicon, beginning with children's perceptual understanding of space and their conceptual understanding of the factors of containment, support, and gravity; all of which develop before children's linguistic understanding of spatial relations. We will then go on to address the opposing issues of whether it is linguistic or non-linguistic experience that affects the way we conceptualise and talk about space.

2.2. Factors Affecting the Development of the Spatial Lexicon

It is certainly true that when babies are born they do not have a single word in their heads, yet by the time they mature as an adult speaker of English, for example, they typically possess a vocabulary of anything between 20,000 and 50,000 words with which to formulate their utterances, and a comprehension vocabulary that is invariably larger (Clark, 1993). There have been estimates that suggest that typically developing children of around six-years of age have a vocabulary of approximately 14,000 words. Therefore, from around two-years of age a child would need to master, on average, 10 new words a day (Carey, 1978). This is no mean feat when one considers that in order to learn a single new word a child needs to go through a complex series of steps; identifying individual word forms and sorting out numerous ambiguities before mapping the meaning onto the form. For example, sometimes the word form will relate to a tangible object in the environment (e.g., a dog, a car or a toy), sometimes not (e.g., happiness or sadness). Mapping the meaning onto the form is one of the first problems for children learning a lexicon; therefore looking into the factors that influence this mapping is an important aspect of developmental research.

As we shall see later on in this chapter, mapping meaning onto form can necessitate that a child identifies possible meanings by drawing on their conceptual categories, by attending to the input language for possible word forms and how they are used, or even by some kind of pre-wired biological constraint (e.g., Bowerman, 1996; Clark, 1973,1980; Landau, 1994). There are many suggestions (and counter-suggestions) regarding how children learn the words that form their lexicon, all of which are far beyond

the scope of this thesis. Therefore, the intricacies of lexical development *per se* will not be discussed here in full. Rather, we will look generally at the factors that have been posited regarding the foundations that a typically developing child needs in order to develop their lexicon with an emphasis on whether functional aspects or aspects of geometric form are involved in the development of a *spatial* lexicon. Essentially we will address the question of what aspects of the world it is that children attend to when attempting to map meaning on to word forms such as *in*, *on*, *under*, *in front of*, *over* and *above*. First, let us look at what children might already know before they begin to develop their spatial lexicon.

2.2.1. The Starting Blocks of a Spatial Lexicon

As we have seen, children typically begin to utter their first words at the age of about one and spatial prepositions begin to enter their lexicon with the words *in* and *on* at around the middle to end of their second year, although they might not comprehend these words completely until they are well into their third year. Well before they do this, their general understanding of the world is already quite sophisticated. In the spatial world, for example, children under the age of 1;0 can represent abstract geometric spatial relations independently of the specific objects used and have a rudimentary understanding of support and containment relations (e.g., Kolstad, 1991, as reported in Mandler, 1992; Needham & Baillargeon, 1993; Quinn, Cummins, Kase, Martin & Weissman, 1996). How children develop such sophistication and what impact this knowledge might have on the development of a spatial lexicon will be explored further in this section.

Perceptual categorisation involves the organisation of an infants' perceptual experience into some kind of order thereby allowing them to discriminate between different objects and their relations as members of the same or a different category based on some internalised representation of that category. The ability to categorically represent

spatial relations such as *above*, *below*, *in*, *on*, *left*, *right* and *between* is the tool by which infants experience objects in relation to one another, rather than as items in spatially unrelated locations (Quinn, 1994). It has been argued that such categorisation, along with interaction with the world, then forms the foundation for the conceptual, knowledge-based categories of adults and children. This in turn may generate the geometric conceptual primitives that support the lexical learning of spatial terms and the prototypical regions that apply to them.

It has been shown that infants' categorical representations of objects in space begin by initially being rather concrete and specific and are limited to the objects that are used to depict the relations (Quinn, 1994). For example, in a preferential looking task, 3 to 4 month olds were habituated to images of a diamond in either an *above* or a *below* position relative to a horizontal bar. They were then shown novel *above* and *below* diamond and bar pictures. Those infants that had been habituated to *above* exemplars looked longer at the *below* pictures whereas those who had been habituated to the *below* exemplars looked longer at the *above* pictures, thus demonstrating an ability to categorise *above* and *below* spatial layouts. However, when different objects were used to depict the spatial layouts of *above* and *below* (e.g., a heart shape rather than a diamond shape), infants of 3 to 4 months did not show a preference for the novel spatial layout (Quinn et. al., 1996). This suggests that the representations made by infants at this age were specific to the objects originally used (i.e., the diamond and the horizontal bar). It is not until infants reach 6 or 7 months of age that they have the ability to categorically represent abstract geometric spatial relations (e.g., *above*, *below* and *between*) independently of the specific objects used to present these relations (Quinn, 1999; Quinn et. al., 1996).

In the realm of object perception,[2] it has been demonstrated that 3-month old infants perceive objects as a single unit if they are static (Kestenbaum, Termine, and Spelke, 1987). At this age, they do not use colour, texture or size differences in order to segregate objects, although when there is an actual depth distance, infants of this age do use this information to infer separation between objects. It has also been demonstrated that 4-month old infants perceive objects as a single unit if they move rigidly together (Kellman and Spelke, 1983). However, the same infants perceive objects as separate from one another if they move relative to each other. It is interesting to note that, perceptually, objects moving separately are doing so in a similar manner to the way in which the objects moved in the non-locational control fruit and bowl scenes as described in Chapter 1 of this thesis. Additionally, the former description (objects moving together) resembled the locational control scenes, whereby the contents of the container moved along with the container itself. Indeed, this factor of cohesion (objects move as connected, bounded units) has been highlighted as one of the principles that appears to guide the reasoning of young infants in order to make inferences about the physical world around them (Spelke, 1994). Moreover, Spelke (1994) argued that this set of principles remain central to the common-sense knowledge systems of older children and adults. Therefore, these principles are used when adults infer the necessary properties of material objects, people and places. For example, adults recognise that an object coheres as a unit. As such, a collection of particles floating around in a room is seen as a collection, and therefore it is not considered to be one material object. If this is so, then it is possible that the principle of cohesion forms the origins of what Garrod and Sanford (1989) originally called locational control.

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[2] Although research investigating infants' perceptual development of object recognition is an interesting and potentially relevant area, due to constraints of space, this thesis will only briefly touch on the subject. The interested reader is directed toward Slater (1998) for an up to date review of this literature.

The research described above suggests that infants do have a good perceptual understanding of objects and spatial relations very early on in their development. However, we will argue that what is important about the world is how objects interact with each other, what the function of the objects in the spatial scene is, and how those objects fulfil their functions, rather than abstractly where they are positioned in isolation.

In order for a child to become familiar with functional information about objects, the child will invariably need to experience that function in some way. Take for example the concepts of containment and support that have been posited to underlie the meanings of the prepositions *in* and *on* as discussed in Chapter 1 of this thesis (e.g., Vandeloise, 1991, 1994). It is only by interacting and experiencing interaction with containers and surfaces that one might fully understand these concepts. It has been noted that even very young children enjoy putting things into and taking things out of containers, and certainly by the end of their first year children have had much experience of drinking from cups and will have experienced numerous instances of situations where containment or support fails (Bowerman, 1996). Even before children typically demonstrate an adult-like understanding of the preposition *in* (between 2;6 and 3;0 according to E. Clark, 1973), it has been shown that they have some understanding of the concept of containment and know the canonical use of containers (Freeman, Lloyd, & Sinha, 1980). Freeman et. al. (1980) looked at the retrieval strategies of three age groups of children (mean ages 0;10, 1;0 and 1;3). They used upright and inverted cups as hiding places for objects. All three age groups of children made significantly less place errors (i.e., searching for the objects at the initial hiding place) with upright than inverted cups. Thus at around 10 months to 1-year-of-age it appears that young children understand that the position of the container determines the position of its contents, although this only held for instances where objects that usually fulfil the containment function (cups) were used. Children's understanding in this study did not extend to unusual objects fulfilling a containment function. Therefore,

when Freeman et. al. (1980) used an object that is not normally utilized as a container (e.g., an inverted toy house with its cavity pointing up), children did not demonstrate such knowledge.

It has since been demonstrated that children do not fully comprehend the basis of containment until around 1;5 (Caron, Caron, & Antell, 1988). Up to this point children appear to understand that openings on the surface of an object afford the insertion of something into the opening, but it is not until they reach around 1;5 of age that they understand that these openings need to have supporting bottoms in order for them to contain. Using a preferential looking task, Caron et. al. (1988) showed four groups of children (mean ages 0;11, 1;2, 1;5 and 1;8) videotapes of a bright red, hand-held cylinder being tilted forward and backward. The tilting revealed the cylinder to either be container-like (e.g., *a can*, open at the top with a closed bottom) or not (e.g., *a tube*, open at both ends). Sand was then poured into the upright cylinder from a bottle and was either contained or not contained; in the contained condition, the sand rose above the rim of the cylinder whereas in the non-contained condition it fell through the bottom. The tapes depicted four types of events; *can containing* (non-violation event), *can failing to contain* (violation event), *tube containing* (violation event) and *tube failing to contain* (non-violation event). Children in the oldest two age groups (means 1;5 and 1;8) looked more at the violation episodes than at the non-violation episodes.

It is therefore evident that children appear to be preoccupied by containers and even appear to have an understanding of the functional notion of containment by the middle of their second year. Indeed a number of the younger children in E. Clark's (1973) study looking at the prepositions *in*, *on*, and *under* (mean ages 1;9 and 2;3) demonstrated this preoccupation. When asked to *put the X on [or under] the Y*, "many of the younger children manipulated the box so its opening faced upwards (Experiment 1); they often righted the upside-down glass in Experiment 2 *[where they were required to copy the*

experimenters configuration], and three children subsequently righted the experimenter's as well; and they showed a general preference for putting objects *in* the crib rather than under it." (E. Clark, 1973 p.178).

Focusing on children's understanding of support relations, a similar, gradual understanding of the concept of support has been demonstrated (Baillargeon, Needham & DeVos, 1992; Needham & Baillargeon, 1993). Infants begin by demonstrating an initial concept of support; at the age of 4.5 months, they demonstrate surprise if an object remains suspended when the visible form of support is removed (Needham & Baillargeon, 1993). At the age of 5.5 months, they believe that an object can be fully supported when only its corner is in contact with a platform. However, by the age of 6.5 months, infants recognize that a box can fall even when partially supported (Baillargeon et. al., 1992).

It appears, therefore, that well before the age at which children demonstrate an adult-like comprehension of the prepositions *in* and *on*, they have firstly experienced the purely geometric, visual form of objects in a spatial array and exhibit behaviour suggesting that they have developed an understanding of the functional notion of the concepts of containment and support.

The question of what it is that a child notices about the world, and what is it that they map onto spatial linguistic forms when they are developing their spatial lexicon has long been considered. Some theorists would argue that it is the function of the objects in space that forms the complex concepts which guide children throughout their acquisition of spatial terms such as *in* (Vandeloise, 1987) whereas others would argue that it is the geometry of the scene that specifies what children map onto their prepositional linguistic forms (Landau, 1994).

There is no research to date that has investigated the development of lexical acquisition with reference to functionality and spatial prepositions. Therefore, later on in this chapter, we will take a look at the factors that children notice when learning nouns to

see whether we can find any evidence of children's attendance to function or form (geometry) in order to address this question. When we do so, we shall see that there is much evidence to suggest that children notice both form and function when naming novel objects. In general, it appears to be mainly older children (over 5-years-old) and adults that utilise functional knowledge in their naming whereas younger children attend to form rather than function. However, when given the opportunity to interact with objects and assess them according to their functionality, it has been demonstrated that children as young as 2-years-old extend nouns based on their functional knowledge. Before we consider this evidence, we briefly return to consider the relative influence of perceptual and language inputs on spatial language development.

2.2.2. The Influence of Perceptual and Language Inputs on Spatial Language Development

How much the language we are exposed to shapes the way we conceptualise the spatial world and to what extent our concepts are determined non-linguistically will be the main focus of this section. We will begin by looking at the view that spatial language development is derived from non-linguistic, perceptual information. It begins with the development of relatively simple topological concepts of space (e.g., *in* and *on*) before forming more sophisticated, projective, conceptualisations of space (e.g., *in front of* and *above*). We will see, however, that theorists who have demonstrated language-specific influences upon children's production and comprehension of spatial language have come to challenge this view more recently.

As we saw in the previous section, pre-linguistic infants know a great deal about their spatial world before they begin to produce words with which to express this knowledge (e.g., Baillargeon et. al., 1992; Caron et. al., 1988; Needham & Baillargeon,

1993; Quinn et. al., 1996; Quinn, 1999). We have also seen that children use factors such as context and non-linguistic concepts when inferring meaning for spatial terms (e.g., E. Clark, 1973; Grieve et. al., 1977). It has been suggested by some theorists that children's semantic categories of words such as *under*, *over*, *in* and *on* are driven by perceptual categorisation (e.g., H. Clark, 1973). If our own biology (e.g., we stand upright, we have eyes, ears, etc.) and the environment we live in (e.g., gravity) determine the way we perceive space, and if this in turn is then mapped onto the linguistic forms that we know in English as spatial prepositions, then native learners of other languages (who stand upright, live in a world with gravity and have eyes and ears, etc.) will similarly map those same perceptual concepts onto the spatial words in their own language. Therefore, meanings for words like *in* and *on* will be mapped directly from a universally held, spatial concept that has been perceptually derived from the environment (e.g., H. Clark, 1973; Johnston & Slobin, 1979; Piaget & Inhelder, 1956).

H. Clark (1973) strongly suggests that our semantic categories of spatial words are developed from non-linguistic perceptual knowledge. This in turn informs the way children understand spatial language, in that children map their perceptual understanding of space ("*P*-space"), onto English spatial terms ("*L*-space"). Therefore, children must first possess *P*-space before they can ever acquire the actual word that describes that concept. For Clark, the manner in which *P*-space is developed reflects our own biology and the natural forces that surround us. Because we are born into a world with gravity, we have eyes and stand upright; we develop a *P*-space with distinctive properties. The more complex the spatial concept is, the longer it takes us to develop a *P*-space and therefore the later that the *L*-space is acquired. H. Clark (1973) argued that due to the perceptual apparatus we possess (i.e., our eyes, ears, nose etc) our bodies define positive and negative features of space. For example, as we have an asymmetrical vertical plane running through our bodies that separates our fronts from our backs; forward is the positive and backward

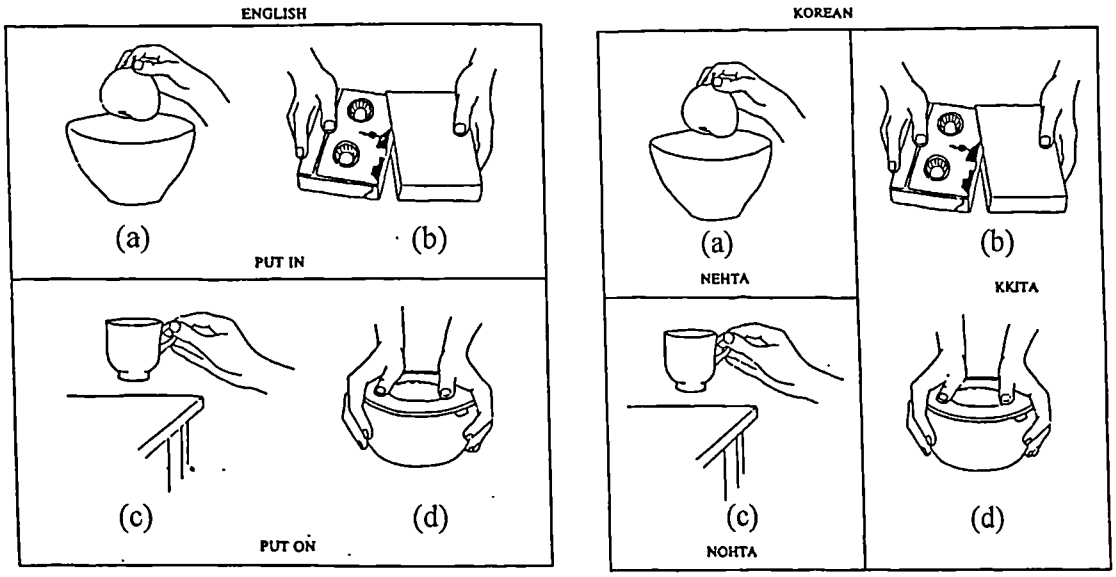
is the negative feature. In his complexity hypothesis, Clark asserted that the order of acquisition of spatial terms will be constrained by certain rules of application whereby conditions must be met before a word can be applied to a perceptual event. The central rule here is that given an antonym pair of words (e.g., above/below, in front of/behind, more/less), the positive one of the pair will be acquired first. He also highlighted complexity concerning the positioning of objects in space. The properties of the location (in terms of one-dimensional, two-dimensional and three-dimensional space) add to the conceptual complexity of the associated term. The point of reference in one-dimensional space (e.g., *distance* and *length*) is simple, getting more complex when more than one dimension is present (e.g., *tallness*, *height* and *depth*).

Given this analysis, the order of acquisition of the spatial prepositions *in*, *on* and *at* should be *at* (one-dimensional) followed by *on* (two-dimensional), with *in* (three-dimensional) being last. One would also expect *in front of* to be acquired before *behind.* However, this has not been borne out by the data, where *in* is usually acquired before *on*, and both of these are often acquired before *at*. Moreover, as we saw earlier on in this chapter, *in back of/behind* often precedes *in front of* for both fronted and non-fronted objects.

More recently, Mandler (1988; 1992) proposed that a pre-linguistic infant's conceptualisation of space is derived from a *perceptual analysis* of incoming stimuli. She suggests that perceptual analysis is the process that takes new information from perceptual experience and recodes it into a non-perceptual form that represents a meaning. This can be contrasted with *perceptual processing* which is automatic and not under the control of the perceiver. Therefore, perceptual analysis involves the active recoding of a subset of perceptual features into meanings that form the foundation of available concepts (image-schemas). These image-schemas make up the meanings that infants use in their concept formation; this includes relational concepts such as containment and support. Mandler

(1992) believes that this process begins when a child is as young as 3-4 months old, although at that stage it might be rudimentary and primitive in form. If this is so, then this fits in with what we know of children's basic intuitions of the concepts of containment and support as set out in the previous section of this chapter (e.g., Baillargeon, et. al, 1992; Needham & Baillargeon, 1993). Mandler suggests that these image-schemas provide a facilitatory level of representation that is intermediate between perception and language and thus aids the process of language acquisition.

Figure 2.6. Semantic Classification of Four Actions in English (left) and Korean (right)



Note: *nehta (put something into a loose container), nohta (put something loosely onto a surface), kkita (cause one 3-dimensional object to 'fit' another). (Illustration taken from Choi & Bowerman, 1991)*

On the other hand, Choi and Bowerman (1991) have found evidence to suggest that the specific language that they are exposed to can affect the way children conceptualise and categorise space. When children embark on the process of learning new words in their lexicon, they typically begin to extend those words to other situations and contexts according to their own conceptual understanding of the word itself. Consider the

pictures in Figure 2.6 above, along with the spatial words needed to describe them. If a child understands that (*put*) *in* leads to the end-state of containment and (*put*) *on* leads to the end-state of support, then that child will extend *in* to both (a) apple-bowl and (b) video-case, and will extend *on* to both (c) cup-table and (d) lid-bowl. However, if a child's conceptual notion of words also contains strong information regarding whether or not there is a loose-fit between container and contained (e.g., toy-toy box, apple-bowl) or a tight-fit (e.g., top-pen, video-case), then that child should not extend their words in a similar manner to the first child.

Looking at Korean and English languages, Choi and Bowerman (1991) found differences in the way that both languages express spatial information. When focusing on how the respective languages express the notion of Path, they note that Korean Path verbs and English prepositions often carve out different categories of Path meanings. There are no Korean verbs directly equivalent to the English *put in* or *put on*, rather there is a set of verbs that specify joining located and reference objects depending on the properties of those objects. Some of these verbs relate to whether the objects 'fit' together. Therefore, for a child learning Korean as his or her first language, the terms they use will determine whether or not the two objects represent a loose (*nehta*) or tight (*kkita*) fit (See Figure 2.6 above). If children derive their pre-linguistic concepts from non-linguistic information (as proposed by H. Clark, 1973 and E. Clark, 1973), when hearing the words *nehta* (for Korean children) and *in* (for English children), both sets of children would conceptualise the event as a containment event and would extend their understanding and production of the terms accordingly. Only later in development, would Korean children begin to correct their understanding of the term.

However, looking at spontaneous speech samples from a limited number of children (two English and eight Korean) Choi and Bowerman (1991) found that children's extensions when learning these terms were closely related to the semantic structure of their

input language. Therefore, English children produced *in* for Paths into both tight and loose containers and extended their use of *in* accordingly (for example, when trying to put a piece of toy furniture into a dolls house). On the other hand, Korean children produced *kkita* for putting objects into tight spaces, produced *nehta* for putting objects into loose containers, and extended their use accordingly (for example, *kkita* when putting a doll into the tight-fitting seat of a toy horse).

In a more recent study using the preferential looking task with children between 1;6 and 2;0 years, Choi, McDonough, Bowerman and Mandler (1999) assessed 20 English children's comprehension of *in* and 10 Korean children's comprehension of *kkita* to assess whether they made similar, language specific, generalisations. The main finding from this study was that by the age of around 1;6 to 1;11, children learning both languages spent more time looking at the language appropriate aspects of spatial relations. Therefore, on hearing *in*, English children looked more at containment scenes than not, and on hearing *kkita*, Korean children looked more at scenes involving a tight-fit relationship than not.

This contemporary perspective on the influences of language on infants' mapping of meaning onto form might at first appear to be at odds with the previous research that asserts the role of perceptual information for this process (H. Clark, 1973; Mandler, 1992). Although reconciling this research with Clark's conceptual complexity hypothesis is difficult, as far as Mandler's work is concerned, it might be plausible that language input to the child may influence what it is that a child perceptually attends to, or possibly the image-schemas (as described on page 88) selected by the child when forming their less basic conceptual knowledge (Choi et. al., 1999; Mandler, 1992).

We will now briefly consider other factors which have been shown to influence the order of acquisition of spatial prepositions.

2.2.3. Frequency, Complexity and Spatial Language Development

It has been suggested that the frequency with which a child hears a particular word can affect the development of that word in the child's lexicon. However, few studies have been undertaken that look into the frequency of words in a child's own environment. Many studies assume that because certain words appear in a word-frequency corpus, those words will also be either frequent or infrequent in a child's own experience (e.g., Asso & Wyke, 1973; Weist, Lymburner, Piotrowski & Stoddard, 2000). For example, looking at spatial complexity and spatial language acquisition, Weist et. al. (2000) used the Francis and Kučera (1982) frequency norms for written English and correlated them with children's understanding of spatial prepositions in different age groups in order to determine whether the order of acquisition for such terms was associated with their word frequency. They concluded that while the order of acquisition of spatial terms was associated with word frequency, this association was not significant. In contrast, longitudinal research measuring early vocabulary growth (including, but not exclusive to spatial prepositional production) found a significant correlation between the actual speech input from mothers to children and the age of acquisition of those words (Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991).

However, in order to fully address the issue of how word frequency affects spatial language development one would need to establish whether the specific words uttered by the adults were addressing aspects of the child's current focus of attention (e.g., Harris, 1992; Tomasello & Farrar, 1986). One further problem with evaluating the order of prepositional learning according to the relative frequency with which the child hears a word is that it can be correlated or confounded with other aspects of the word itself (for example, conceptual complexity, E. Clark, 1972), and adults have been shown to adjust

their vocabulary according to their estimation of a child's ability to understand them (see Snow, 1986 for a review of child directed speech).

As mentioned earlier, it has been suggested that non-linguistic spatial knowledge occurs first with children building up concepts of primitive topological relationships such as proximity and enclosure. Only later are they able to relate these objects to one another and to a viewpoint; either the child's own or other objects on which they are projected (Piaget & Inhelder, 1956). From this widely held perspective, it has been suggested that the conceptual complexity of space will be greater for projective terms than for simple topological terms and that this will be reflected in the order that a child acquires spatial terms (e.g., Johnston & Slobin, 1979). Indeed, this has generally been shown to be so. As we have already seen, children do begin to develop *in/on* first; such concepts require the located object to be contained/supported by the reference object. Next come the prepositions that require co-ordination specific reference to another object such as *in front of/behind* that are initially used with featured objects. All of these concepts (*in/on/in front of*(f)/*behind*(f)) can be termed "mono-referential" as a single object is required for location. The cognitively more complex *between* and *in front of/behind* for non-featured objects, however, require two reference objects and a coordinated projective relationship. These can be termed "bi-referential" relationships. Research has shown that the more cognitively simple mono-referential terms are acquired before the more complex bi-referential terms (Johnston & Slobin, 1979; Weist, 1991; Weist, Lymburner, Piotrowski & Stoddard, 2000). It should be noted, however, that the cognitive complexity of mono- and bi-referential terms is different from H. Clark's (1973) cognitive complexity hypothesis. H. Clark maintained that the features of the reference object itself (in terms of the number of dimensions required for each spatial term) determined how complex a preposition is. However, here, it is the number of reference objects required that determines prepositional complexity.

One further issue of complexity that has been posited to affect how easily a term is learned is linguistic complexity (e.g., Durkin, 1981; Johnston & Slobin, 1979). As words are rarely produced in isolation, their semantic interpretations can often be affected by syntactic components of the sentence (Durkin, 1981). For example, it has been demonstrated that the preposition *between* is normally found in non-singular noun phrases, such as *the apple is between the orange and the pear*. Durkin (1978) found that children had most problems when dealing with *between* sentences that contained complex underlying structures. For instance, *between* sentences that contained both an *and*-conjoined noun-phrase and where the conjuncts were also plural, such as *put the apple between the oranges and the pears* were found to be the most difficult of structures to comprehend.

In their cross-linguistic study, Johnston and Slobin (1979) suggested that the order of acquisition they found across languages could be fully accounted for based on conceptual development and linguistic complexity. However, for prepositions such as *between*, it has been argued that conceptual complexity is confounded with linguistic complexity and therefore it is impossible to know which is the exact factor that contributes to its late arrival in the child's spatial lexicon (Durkin, 1981).

One further factor that might affect the order in which prepositions are acquired is that of polysemy. Polysemy occurs when a word form has more than one meaning. Although almost all words have more than one sense, this is more obvious for some words (e.g., *over*) than for others (e.g. *above*). As we have described in section 2.1.2. of this chapter (on page 55), children's development of the basic meanings of spatial prepositions[3]

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[3] It has been shown that people generally perceive the spatial sense of prepositions as *basic* (e.g., Crowther & Durkin, 1982; Durkin, Crowther, Shire, Riem & Nash, 1985). Moreover, it has been demonstrated that the spatial sense of a preposition is acquired before the temporal sense (e.g., Weist, 1991), although see Friedman and Seeley (1976) for a different perspective on this.

continue over their first few years of life. However, research in the areas of music and mathematics education suggests that children have problems with those same words when they are presented in musical and mathematical contexts (see Durkin et. al., 1985 for a review). However, the extent to which polysemy hinders children's acquisition of the basic spatial meaning of prepositions, if indeed it does, is not yet known.

We have seen so far in this section that infants begin to recognize spatial relations at a very early age. Even before words such as *in* and *on* have become stable members of a child's lexicon, they have developed a conceptual understanding of containment and support. Additionally, we have seen that the specific language to which the child is exposed, and the way that that specific language carves up space, might well influence this conceptual understanding. When attempting to understand the order of acquisition for spatial terms, we have looked at the factors of frequency of input, conceptual and linguistic complexity. We will now go on to look at children's development of naming in the context of nouns. The main question that we will address is whether children's generalisation of a word to a novel object is influenced by either the functional information or the perceptual (form) information associated with that object. In general, we will see that children from around the age of 5-years-old and adults generalise on the basis of functional information, whereas younger children generalise according to form. However, we will also see that, when given more time in which to interact with the novel objects, children as young as 2-years-old will generalise on the basis of function. The apparent differences between these findings will be discussed in terms of their relevance to children's acquisition of spatial prepositions.

2.3. The Development of Object Naming: Influences of Form and Function

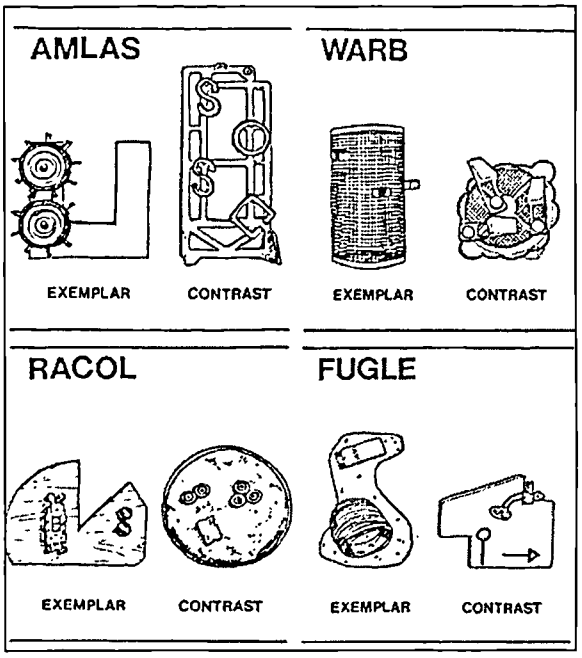
The question of whether children's lexical learning is influenced by form or function was debated quite fiercely in the 1970's and 1980's with regard to children's acquisition of nouns (E. Clark, 1973b; Nelson, 1978). It had been argued that children are more likely to label two objects with the same name if they share *perceptual similarities*, for example shape (E. Clark, 1973b). However, an equally strong assertion was made claiming that the initial categorisation and naming of objects will be on the basis of some *shared function*, for example, actions that an object is capable of making or actions that children can perform on an object (Nelson, 1974, 1982). Nelson maintains that the child's semantic development (i.e., organisation of word meaning) cannot be considered separate from the acquisition of real world knowledge. The object of this review is to assess whether children ever attend to function when mapping meaning onto linguistic form and if so, at what age this develops.

The following novel-object novel-noun paradigm has usually been employed in an attempt to assess the relative influence of form and function. Children are shown a novel object with a novel count noun (e.g., "stad") and they are encouraged to learn the name of the object. Next, the children are either given some functional information about the novel object (e.g., it can be used to mop up water), or are given no functional information at all. They are then shown additional novel objects. Some of these resemble the original in their form but not their function whereas others resemble the original in their function but not their form. The children are subsequently asked a question such as *is this a stad?*

Many studies using such a paradigm have demonstrated that young children, under 5 years of age, respond according to the perceptual characteristics of these novel objects rather than their functional abilities (e.g., Gathercole, Cramer, Somerville & op de Haar,

1995; Gentner, 1978; Landau, Smith & Jones, 1998; Merriman, Scott & Marazita, 1993; Smith, Jones & Landau, 1996; Tomikawa & Dodd, 1980). Moreover, much of this research has suggested that function is more salient for older children (over 5;0) and adults (e.g., Gathercole et. al., 1995; Landau et al., 1998; Merriman et. al., 1993).

Figure 2.7. A Selection of The Novel Objects and Their Appendages used by Smith, Jones and Landau (1996).



Note: Illustration taken from Smith et. al. (1996).

For example, in an attempt to assess whether children are sensitive to the functional or perceptual properties of an object when naming that object, Smith et. al. (1996) conducted a series of four experiments where they showed three-year-olds and adults novel objects. The objects were in the form of a distinctive base object with appended parts such as moveable knobs, gears or gadgets (see Figure 2.7 above for examples). For each novel object, there were four 'test' objects; one was the *contrast object*

(as in Figure 2.7), one was *identical* to the original novel object in every respect and the remaining two were constructed by crossing the bases and parts of the exemplar and its contrast object. These two objects either had the *parts* of the exemplar on the base of the contrast, or the *base* of the exemplar with the parts of the contrast. Each exemplar was given its own novel name; *amlas*, *warb*, *racol* and *fugle*. The participants were presented with one of the exemplars and were then asked two questions about each of the four test objects; the *contrast*, *identical*, *parts* and *base* objects. For the Similarity task, the experimenter asked the participants *is this like that? Are these two alike?* For this task, no names were used for the objects presented. On the other hand, for the Naming task, all the exemplars were named from the outset with the experimenter asking the participant to repeat the objects' name (e.g., *amlas*). The experimenter then said, *we need to find some more amlases. Is this an amlas?* In some experiments functional information was made salient where for half the exemplars the functional part was the base, for the other half the functional parts were the appendages. Base functions were things such as *a toy dog sits in it* and *it makes grooves in sand or clay*. Part functions were things like *holds a pen* and *the tone comes on when the switch is flipped*. Prior to the presentation of any test object, the participant was encouraged to use the exemplar to perform its function and when the test objects were presented, they were also allowed to attempt the function (although at this point they were not specifically asked to). Smith et. al. (1996) found that whereas adults' judgments in both naming and categorising tasks were significantly influenced by function, only the categorising task for the three-year olds was influenced in this way. Three-year old children were not influenced by function in the naming task. Smith et. al. (1996) suggested that early object naming might be closely linked to perception in such a way that it is cut off from the other influences of world knowledge that the child has.

One further study looking into functionality and children's object naming that is particularly interesting and relevant to the current research was undertaken by Anderson

and Prawat (1983) as a follow-up to previous research (Prawat & Wildfong, 1980). Their study looked at whether functional information for containers would affect the nouns used for individual containers, or whether this was due to purely perceptual features. They varied the functional context of containers with handles of various heights and widths, and employed a paradigm designed by Labov (1973) in order to test children's labelling of them. The paradigm and materials used in this study were suitable for young children because of the minimal verbal demands and because even the youngest of children were highly familiar with the items used, unlike the previous research that used highly novel objects and words. The suggestion was that if children attended to function then the labels they would use for containers that are ambiguous with respect to form should be strongly influenced by the functional context in which they are presented.

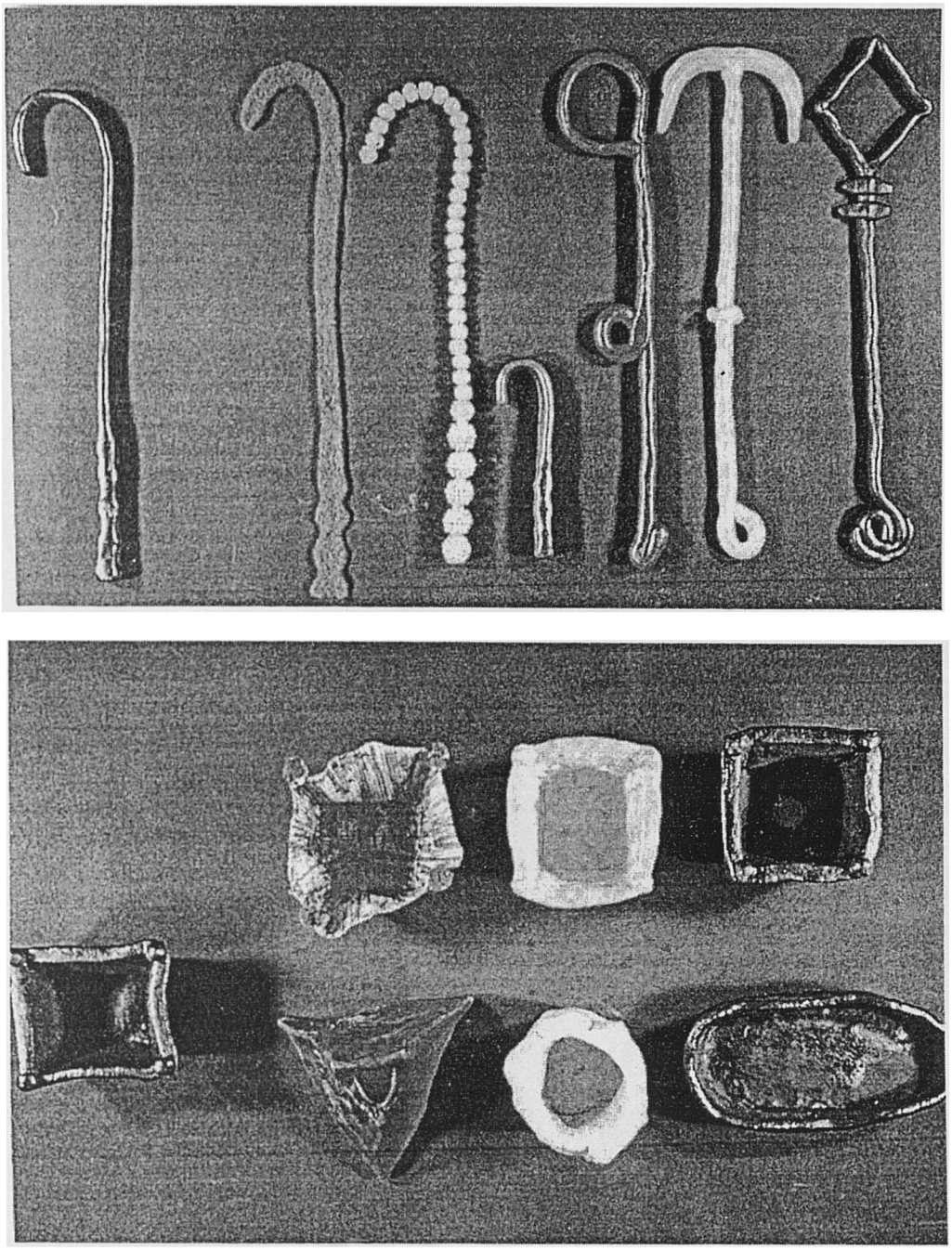
Three groups of children with mean ages of 4;11, 7;6 and 10;4 were either presented with pictures of containers in four different functional contexts (pictorial condition) or presented with pictures of the same containers with context being added verbally (verbal condition). Three of these contexts depicted substances being poured into the container from an appropriate vessel (these substances were coffee, cereal or water); the fourth was a neutral context with no substance depicted. Height and width ratios of handled containers were systematically varied in relation to a prototype form (either a cup, bowl or glass). As the focus of the experiment was to assess children's naming of ambiguous containers, the prototypical cup, bowl and glass were not used in the materials for each of the relevant contexts. Children in the verbal condition were asked to imagine the following scene, and were then told a story such as the following:

> *Pretend it is breakfast time and you go into the kitchen and see someone pouring dry crispy cereal into this (i.e., the ambiguous container) from a cereal box like the one I showed you. Would you call this a bowl, a cup or a glass?*

Those children in the pictorial condition were shown a picture of the cereal being poured into the ambiguous container and asked the question *Would you call this a bowl, a cup or a glass?*. Anderson and Prawat found that in the verbal condition, only older children used the functionally supporting term according to the context (e.g., used *bowl* in the cereal context). However, when the actual pictures were shown to the children (pictorial condition), even the youngest age group (mean 4;11) gave functionally appropriate labels to the containers. Therefore, the container was called a *bowl* more when cereal was depicted being poured into it, and it was called a *cup* more when coffee was being poured into it. This suggests that the salience of the functional context in which an ambiguous container is used can affect children's naming of that container. However, the children in this study were somewhat older than those in the Smith et. al. (1996) study (mean age 4;11 versus mean age 3;2) and it could be argued that the age of the children had a lot to do with their naming on the basis of function.

One experiment that combined both familiar objects (e.g., containers) and younger participants (mean ages 2;6, 3;7 & 5;5) was reported by Landau et. al. (1998). They showed children and adults two sets of objects (see Figure 2.8 below). The *standard* object of each set was ideal, both functionally and perceptually, whereas the other objects differed either functionally or perceptually. For example, the standard cane was 6" and made of hard clay, its function was to retrieve small toys from a distance by hooking and pulling them. Three of the test objects were the same shape as the standard object but could not be used to perform the same function (either too short or too flimsy), or they

Figure 2.8. The Canes and Containers used in the Landau, Smith and Jones (1998) study



Note: The "standard" is pictured on the left. (Pictures taken from Landau et. al., 1998)

could perform the same function, but had different shapes. Similarly, the standard container was four-sided and made of hard clay with a function to carry water. Of the

remaining six test objects, three had the same shape but were functionally useless (e.g., had holes) whereas three could perform the same function but were differently shaped (e.g., oval). Half of the participants were in the No Function group; the remainder were assigned to the Function group. During the experiment, the Function group were shown the standard object which was named *see this? This is a dax (rif)*. The experimenter then demonstrated how it performed its function (the No Function group were simply shown the object). Each participant was then shown each of the test objects in turn and asked *is this a dax (rif)?* (Naming task). Following from that, each participant was shown the object a second time and asked its function, for example, *can you carry water with this?* (Function task). Landau et. al. found that in the Naming task, only the adults in the Function group labelled the test objects according to whether or not the object could perform the same function. Only when they were explicitly asked whether or not each test object could perform the same function as the original, did the three and five-year olds (and adults) respond positively to same-function test objects. The two-year olds showed no evidence of being able to correctly judge whether or not objects could carry out particular functions.

However, it has recently been demonstrated that children as young as 2-years-old can generalise novel nouns on the basis of function if that function is salient and relevant to them (Kelmer Nelson, 1999). Two-year-olds saw novel artefacts in one of two conditions. In the first condition, children played with the object, it was named and its function was made salient. The children were then shown the test objects that differed in functionally relevant and/or irrelevant ways. They were then given an activity session in which they judged and tried out the test objects' functions. One week later, the same children participated in a naming session whereby they were asked to generalise the novel word to the set of test objects. The children in the second condition were also shown the target object, it was named whilst its function was demonstrated and they were given the

opportunity to try out the function of the target object. Finally, they were shown the test objects and were asked to generalise the novel name to them. At no time were these children given the opportunity to play with the test objects (although they did play with the original novel object). Kelmer Nelson (1999) found that, when generalising a novel category name, children were influenced exclusively by functionally relevant properties if they had prior experience of playing with the test objects. Without this direct experience, children largely generalized by global appearance.

A similar finding has been found for two-year-olds' classification of novel objects. It has been demonstrated that two-year-old children will classify novel objects according to function rather than form when they are encouraged to interact with those objects (Corrigan & Schommer, 1984). Using the novel-object novel-noun paradigm as described above, two-year-old children were divided into three groups. Those that were in the function group were shown a novel toy and its function was highlighted, for example the experimenter said *here is a zaf, see how the zaf comes apart.* In the form group the experimenter said *here is a zaf, see how the zaf is curvy*, and the toys' function was also demonstrated without comment. The children in the no context group were simply told *here is a toy.* All children were given the toy to play with for a while before the next toy was brought out (nine toys in all). Following this, the children were asked to group the toys with others. These toys either had the same form but different functions or had the same function but different forms. Corrigan & Schommer found that both neutral and form groups categorised according to perceptual features whereas the function group sorted equally on the basis of perceptual and functional features. In a second experiment the function of the toys were made even more salient for the children (e.g., they were encouraged to interact with them more). This resulted in a much greater degree of categorisation according to function.

We can see from the research described above, that even very young children can attend to functionality when naming and categorising objects. When children are encouraged to interact with the test objects before they are asked to name them, function becomes even more salient and the children can use that information in their naming (Kelmer Nelson, 1999).

It is interesting to see that both context (e.g., Anderson & Prawat, 1983) and interaction with objects (e.g., Corrigan & Schommer, 1984; Kelmer Nelson, 1999) can influence children's attention to functional characteristics, and in turn to their naming and categorising of objects. It is also possible that the "naming later" condition in the Kelmer Nelson study emulates spatial prepositional learning more than the other studies mentioned above; repeated experience with functional/non functional aspects, without the added demands of generalising a novel word, may serve to allow children to represent aspects of functionality and utilise those aspects more easily. As we saw in an earlier section of this chapter, children's functional and non-functional experiences with containers and containment are experienced long before they use the preposition *in*. However, in relation to nouns, where naming usually occurs concurrently with one's perceptual and functional experience of objects, it might well be the case that the perceptual aspects of the scene are primary for young children and that the importance of function is an aspect that only older children and adults consider.

2.4. Summary

This chapter began by reviewing the main literature that has investigated the order of acquisition and the development of spatial terms for children. We saw that there is indeed a broadly consistent order in which children begin to produce and comprehend a variety of prepositions, although research investigating children's production of spatial

terms covered a more limited range of terms than the comprehension studies. We also saw that the factors of conceptual complexity, linguistic complexity and frequency of production in the child's environment influence this pattern of development. Interestingly, when we looked at the research on children's development of projective prepositions (*over*, *above* and *in front of*), it appears that although children display an understanding and some degree of production of these terms from as young as four or five years of age, they appear reluctant to produce them readily until they are much older (around seven or eight years of age). Conversely, other terms such as distance terms (e.g., *near*) are freely produced from the age of four although children do not display a full adult-like understanding of them until they reach six years of age.

Looking at the influence of perception and language on children's development of spatial terms, it became apparent that the way different languages conceptualise space can affect even the very earliest of utterances. Moreover, using a preferential looking task, Choi et. al. (1999) found that children as young as 1;6 were sensitive to aspects of language specific conceptualisations of space such that when English children heard the preposition *in* they looked more at containment scenes than not, and when Korean children heard the word *kkita* they looked at more scenes depicting a tight-fit relationship than not.

Finally, the research that investigated functional influences on children's naming of objects generally agreed that, although function can be important for young children, it is usually older children and adults that consider functional aspects of objects in naming tasks.

The following chapter describes two experiments that were designed to investigate for the first time whether functional information of a scene is considered when children describe the relative positions of objects. The specific prepositions that we focus on are the "simple" topological terms of *in* and *on* (cf. Piaget & Inhelder, 1956) testing children from the age of 3;4.

function of containing the location of the located object over time by moving the container and the contents at the same rate (locational control, Figure 3.1 (a)) positively influences the appropriateness rating and use of *in* by adults. Showing this is not the case through movement of the located object independently of the reference object (non-locational control, Figure 3.1 (b)) decreased the ratings and use of *in*. Furthermore, factors such as object-specific function (e.g., a bowl versus a jug as a container of solids), the nature of other objects in the scene (e.g., whether they are different or the same) and how the reference object is labelled (e.g., a plate versus a dish) have all been shown to affect the way in which these prepositions are comprehended and produced by adults, in addition to locational control (Coventry 1992, 1998; Coventry et. al., 1994; Coventry & Prat-Sala, in press; Feist & Gentner, 1998).

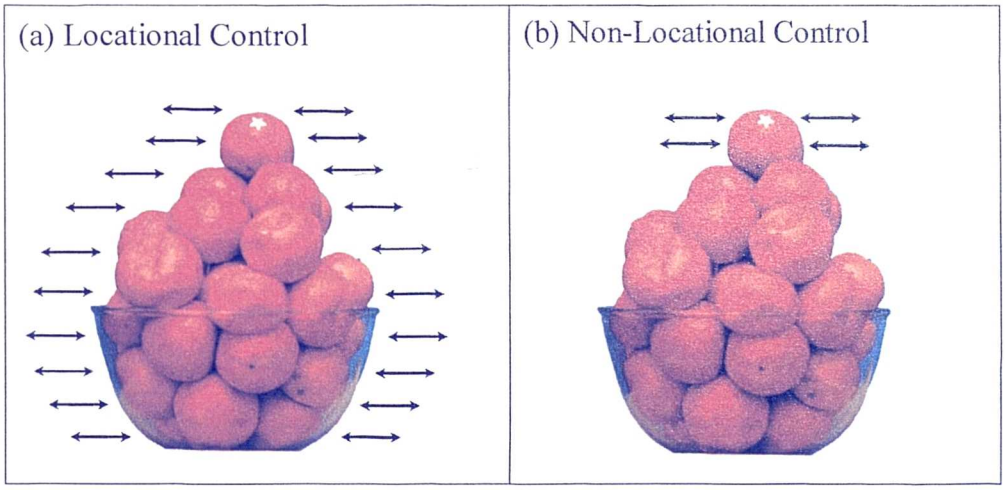
Two experiments are reported. Experiment 1 was designed to follow on from the video experiments conducted by Coventry (1992, 1998) and Garrod et. al. (1999) that investigated the prepositions *in* and *on* with adults. The experiment reported here primarily explores how the extra-geometric factors of locational control and continuity of other objects in the scene (e.g., whether they are the same, or different) affect the way children describe where a target object is in that scene. We shall see from this experiment that children as young as 3;4 highlight both locational control and continuity in their responses. The second experiment follows that of Coventry and Prat-Sala (in press). This experiment investigates the role of geometry, object-association and locational support for the production of the preposition *on* with both adults and children.

Before presenting the experiments, we need to outline an account of the semantics of spatial prepositions that takes into account the functional aspect of locational control. We will then examine the studies of Coventry (1992, 1998) and Garrod et. al. (1999) in greater detail as they formed the basis for the first experiment.

3. Chapter 3: "Simple" Spatial Prepositions; Two Experiments

This chapter primarily explores how geometric and extra-geometric factors affect children's production of the prepositions *in* and *on*. Although research has investigated these factors for adult's comprehension and production of spatial prepositions, there has been no research to date looking into these factors with children. We have seen in the previous chapters that *in* can be geometrically specified by the notion of enclosure and *on* is specified as contiguity with a surface, and that ratings of these terms are affected by height of pile, for example. However, we have also seen how the constructs of *in* and *on* involve a component that has been described as locational (or functional) control (Coventry, 1998; Garrod et. al., 1999). Demonstrating that a container is fulfilling its

Figure 3.1. The Relative Movement of the Fruit and the Bowl That Has Been Used To Assess the Notion of Locational and Non-Locational Control



Note: Double-headed arrows denote movement

3.1. Locational control and the Semantics of *in* and *on*

As we saw in Chapter 1 of this thesis, specifying the nature of the semantic representations for prepositions such as *in* and *on* has often been approached by expressing them as geometric relations (e.g., Bennett, 1972; Cooper, 1968; Miller & Johnson-Laird, 1976). However, we also saw that geometry, by itself, was inadequate in that it could not account for a wide range of geometrically under-determined relations. More recently, theorists have suggested that the semantic representations of words such as *in* and *on* is actually *functional* in nature (e.g., Garrod & Sanford, 1989; Vandeloise, 1991, 1994). For example, Vandeloise (1991, 1994) has proposed that the container/contained and bearer/burden relationships underlie the representations of the prepositions *dans* (*in*) and *sur* (*on*) in French. Indeed, Vandeloise (1991, 1994) has suggested that locational control is one of the factors that underlie the meaning for the preposition *dans*.

In a similar vein to Vandeloise, Garrod and Sanford (1989) have proposed that the meaning of prepositions such as *in* and *on* is related to the physical/functional relationship between the located and reference object and they, too, suggest that locational control is an important factor. As such they highlight functional containment as being a core element to the meaning of *in* whereby *functional containment* is defined in the following manner: If Y *fcontains* X, then Y's location controls X's location by virtue of *some degree* of spatial enclosure. Likewise, a similar functional account has been suggested for the preposition *on* that has been called *fsupport* and is defined as: If Y *fsupports* X, then Y's location controls the location of X with respect to a unidirectional force (by default gravity) by virtue of *some degree* of contact between X and Y. The meanings of the prepositions *in* and *on* as proposed by Garrod and Sanford (1989) are set out in Table 3.1 below

Table 3.1. The Functional Account for the Prepositions *in* and *on* as Proposed by Garrod and Sanford (1989).

If X is *in* Y	then a one-, two- or three-dimentional object Y *fcontains* another a one-, two- or three-dimentional object X
If X is *on* Y	Then the object Y *fsupports* the object X

According to this account, for example, for a person to be *in a queue* means that the queue, and its movement, predicts the location of the person, and for a pear to be *in a bowl* means that when the bowl is moved, the pear should move with it. Additionally, if a picture is *on the wall*, the wall prevents the picture from falling and if a kite is *on a string* the string *fsupports* the kite against the force of the wind.

Therefore, this functional account contains two elements: both a functional representation (concerned with locational control) and a geometric representation (concerned with the geometric relationship that determines how that control can take effect). As such it can be viewed as a hybrid account that specifies both geometric and functional aspects of the prepositions *in* and *on*. One of the main differences between the geometric accounts outlined in Chapter 1 and the more functional account suggested by Garrod and Sanford (1989) is that the concepts relate to inherently dynamic mental representations (Freyd, 1987). This suggests that even when viewing a static arrangement, the functional geometry reflects *inferred* dynamic forces between the objects in the scene. Such an account is in a similar vein to Talmy (1988) who highlights the role of force-dynamics between language and cognition. He proposes that we directly sense interactions between objects in relation to opposing forces such as an object's intrinsic tendency toward motion or rest, or another object's resistance to these forces and so on.

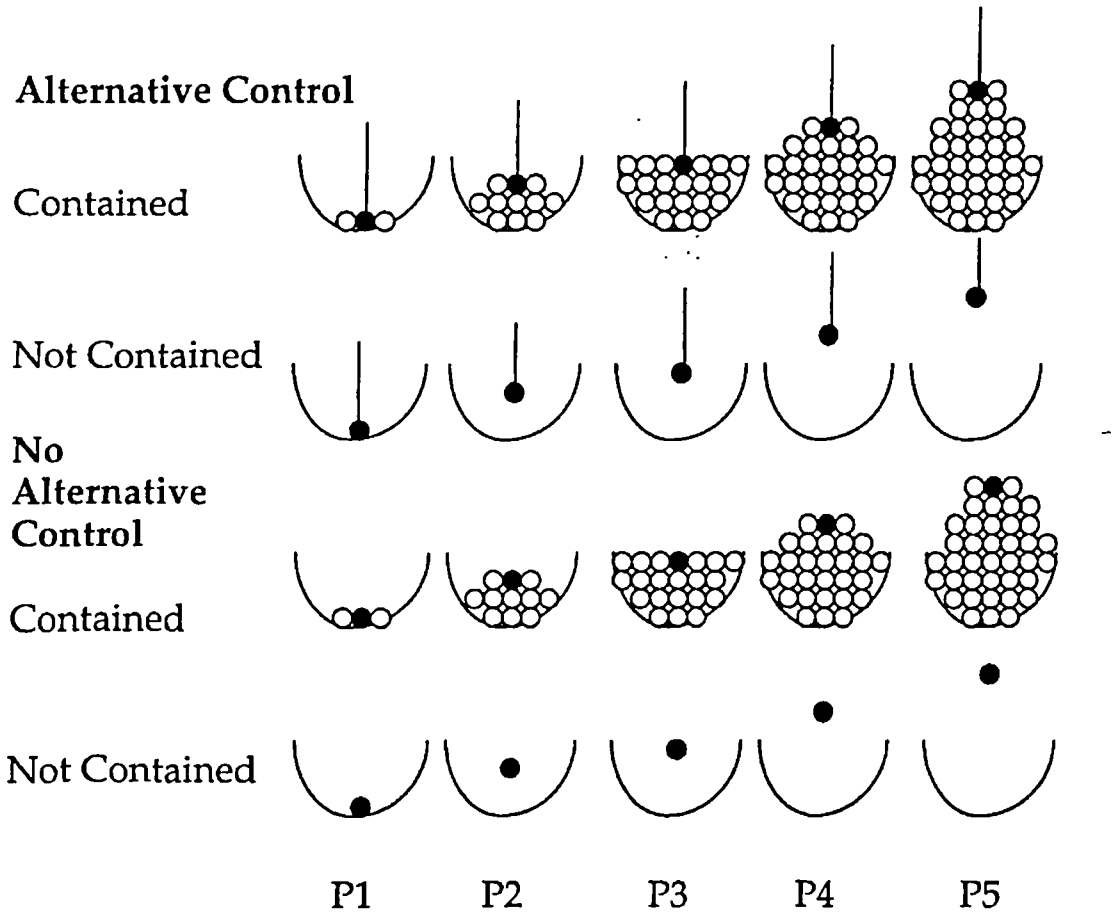
3.1.1. Examining the influence of Locational control, continuity and geometry for the preposition *in* with adults

As briefly reviewed in Chapter 1, the factor of locational control has been assessed for the prepositions *in* and *on* (Coventry, 1992, 1998; Garrod et. al., 1999). Here we will concentrate on the preposition *in* and will begin by outlining in more detail some of the experiments carried out by Garrod et. al. (1999) that were briefly discussed in Chapter 1, before detailing the main experiment undertaken by Coventry (1992, 1998) that formed the basis of the first experiment set out in this chapter.

Using video scenes of various scenes of ping-pong balls and bowls, Garrod et. al. (1999) asked one group of adults to rate the sentence *the ball is in the bowl* according to how appropriate it was to describe the various scenes displayed. They then asked another group of adults to judge whether dynamic changes in the same scenes would affect the geometric relation of the ball and the bowl. According to the functional account of *in* as set out above, the scenes where a *change* in the geometric relation is predicted between the ball and bowl following movement of the bowl (thereby suggesting no locational control) should correspond with lower ratings of *in*, conversely a *no change* prediction should correspond with higher ratings of *in*. Garrod et. al. (1999) systematically manipulated the factors of geometry and locational control. They showed participants video scenes of a bowl and some ping-pong balls. The geometry of the scenes was manipulated by varying the height of the pile. Five heights of pile were used (see Figure 3.2 below). Locational control was manipulated in two ways. Firstly, the presence and absence of other balls in the bowl was manipulated (we shall call these the *contained* scenes, see Figure 3.2 below). Secondly, the target object was depicted as having an *alternative support* (in the form of a wire attached from above) or no support was present. For the sentence rating task adults were asked to rate on a scale of 1 to 5 how appropriate each sentence was to describe the

scene (1 = highly unlikely, 5 = highly likely). Participants were given six sentences to rate for each scene in the form of *the ball is* _____ *the bowl.* The prepositions used for each of the sentences were *in*, *above*, *on*, *under*, *over* and *below*, although only the results for the preposition *in* was reported.

Figure 3.2. The Manipulations of Height of Pile, Alternative Support and Containment Made by Garrod, Ferrier and Campbell (1999).



Note: Illustration taken from Garrod et. al. (1999).

Garrod et. al. (1999) found that the manipulations of containment and alternative control had no effect on adults rating of the preposition *in* at heights 1 and 2 (where the ball was located below the rim of the bowl, see Figure 3.2 above). However, when the target ball was positioned at or above the rim, adults rated the preposition *in* higher for the contained scenes where other objects were positioned directly below the target ball than for the not contained scenes where no such objects were present. There was also a difference between the alternative control scenes and the contained scenes at heights 3 and 4 whereby *in* was rated lower for the alternative control-contained scenes than for the contained scenes with no alternative control, although both sets of not contained scenes (either with or without alternative control) were rated similarly. A second group of adults were shown the same video scenes and asked to make a judgement concerning the possible outcome should the bowl be moved sideways. They were asked whether there would be *no change* in the arrangement of the bowl and the target ball following such a movement, or whether there would be a *change* in this arrangement. A positive correlation was found between the ratings of *in* and the judgements that there would be *no change* in the relative positions of the ball and bowl following movement of the bowl.

In a larger-scale production experiment, Coventry (1992, 1998) manipulated the geometric factor of height, the functional constraint of locational control and continuity (or discontinuity) of the target object with other objects in a bowl. He used video scenes of real objects (e.g., bananas, apples, oranges and balls) under the pretext of a memory experiment in order to elicit natural language production. Adults were required to complete a sentence in the form of *the located object is* _____ *the bowl*, such that it described the scene as accurately as possible. In addition, they were asked to keep the fill-ins as brief as possible without losing information.

As a geometric manipulation, Coventry (1992, 1998) used four heights of pile of objects. The target object was placed inside the bowl below the rim, just above the level of

the rim, well above the rim or very high above the rim (similar to heights 2 to 5 in Figure 3.2 above). Three levels of locational control were used as an extra-geometric manipulation. Locational control was depicted as the target object moving with the bowl (and all its contents where present, similar to that illustrated in Figure 3.1 (a)). Movement of the target object independently of the reference object demonstrated that no locational control was present (similar to the illustration in Figure 3.1 (b)). Finally, the same scenes were presented statically. One further extra-geometric manipulation was made, that of continuity/discontinuity of other objects in the scene. Continuity of objects was so when the target object was the same as the other objects in the scene, for example, an orange on top of other oranges (as previously illustrated in Figure 1.7 (a) on page 31 above). The manipulation of discontinuity depicted the target object as being different to the other objects in the scene, for example, an orange on top of apples (Figure 1.7 (b)).

Coventry (1992, 1998) found that adults' produced *in* to describe the position of the target object less as the height of the pile increased, thereby demonstrating that the geometry of the scene did indeed affect adults' production of this preposition. Furthermore, the manipulation of locational control also affected adults' production of *in*. There was no effect of either locational control or non-locational control at height 1 (where the target object was below the rim of the bowl). However, when the pile of objects in the container was high, *in* was produced significantly more for the scenes that illustrated the bowl demonstrating locational control over the target object than in the static scenes. Moreover, *in* was produced significantly less for the non-locational control scenes than for the static scenes. In a similar vein, when the pile of objects in the container was high, continuity of other objects in the scene with the target object elicited significantly greater production of *in* than when the other objects were different.

In addition to the main manipulations described above, Coventry also made subsidiary manipulations. The effect of presence and absence of other objects between the

target object and the bowl was assessed by depicting the target object suspended over the bowl at all four heights (as described above) with no other objects present (similar to the contained and not contained scenes illustrated in Figure 3.2 above). These scenes were then compared with the scenes where the target object was present along with other objects underneath it. If locational control is important, the bowl is likely to control the location of the target object when it is in contact with other objects in the bowl whereas this is not possible when these objects are absent. As predicted by locational control, Coventry found that *in* was produced significantly less when there was an absence of other objects than when other objects were presence. Moreover, the greater the height, the less *in* was produced for the absence condition compared to when other objects were present.

However, when we look at the Garrod and Coventry studies more closely, we can see that they both have methodological limitations. For example, the experiments undertaken by Garrod et. al. (1999) asked adults to rate several sentences at once for each manipulation. As such, the participants may have artificially differentiated between the prepositions whereby a negative rating for *in* may have been a function of a more appropriate rating of another preposition. Moreover, the participants in the study undertaken by Coventry were allowed to differentiate between scenes in a limited way. The reference object was pre-specified in the sentence to be completed (even though there was the potential for adults to use other objects as the reference object). In addition to this, Coventry's instructions contained the request that participants kept their completions short thereby deterring them from lengthy completions that refer to more than one reference object. As such this can only be seen as a quasi-production study.

Nevertheless, we can see from this detailed review of the Garrod and Coventry studies (and the broader review of other research for *in* and *on* described in Chapter 1) that contextual, perceptual, object-specific and functional factors of objects in a spatial scene can all influence the way adult's comprehend and talk about *where* those objects are in that

scene. However, as previously mentioned, there has been no research to date that has specifically examined the influence of these geometric and extra-geometric factors on children's spatial language. There is also a paucity of research that has examined children's *production* of spatial language. Examining the influence of extra-geometric factors on children's production of prepositions is in itself interesting to our knowledge of both spatial language development and spatial cognition. Moreover, it has recently been argued that these extra-geometric factors are mere *add-ons* and that their role is to *define* the geometry of the scene (Landau & Munnich, 1998). Landau and Munnich (1998) suggest that when a reference object is moving along with its contents (i.e., locational control), the motion of the reference object has the effect of expanding the geometrical region that is acceptable. Therefore, Landau and Munnich have argued that adults' production of *in* can be modulated by both the force-dynamic properties of objects, for example, how they interact with each other, as well as the functions carried out by objects. Therefore, the geometric region of *in* that is acceptable is extended upward to include any stable item that is being functionally contained by the container (similar to Herskovits' (1996) *tolerance* mentioned in Chapter 1).

One interesting issue that arises from this debate, however, is whether extra-geometric factors (e.g., locational control) affect the representation of spatial terms later in development than geometric knowledge, or whether geometric and extra-geometric factors interact from the beginning (Landau & Munnich, 1998). Understanding the answer to this question might enable us to address the issue of whether it is geometric or extra-geometric relations that are central to spatial language or whether neither is central. Indeed, Wallace, Klahr and Bluff (1987) point out that it is only by adopting a process-oriented account of word meaning and concept formation that we can form an adequate understanding of the meaning of that word. Such an account emphasises the perspective of word meaning and concept formation from the point of view of their existence on a continuum; therefore, one

can only define a concept in relation to how it has developed. Certainly, as we have seen in Chapter 2 of this thesis, infants as young as 6 months of age have the ability to categorically represent abstract geometric spatial relations independently of the specific objects used to present them (e.g., Quinn, Cummins, Kase, Martin & Weissman, 1996). We have also seen that it is not until children reach around 1;5 of age that they fully understand the nature of containment such that openings need to have supporting bottoms (rather than be hollow openings) in order for them to contain (Caron et. al., 1988).

Therefore, by way of addressing all these issues mentioned above, the first experiment in this thesis will examine the effects of the extra-geometric factors of locational control and continuity/discontinuity in addition to geometry on children's production of spatial expressions.

3.2. Experiment One

3.2.1. Introduction

This experiment was designed to explore the effects of both geometric and extra-geometric factors on children's production of *in* and *on*, using manipulations similar to those used with adults by Coventry (1992, 1998) and Garrod et. al. (1999) as described above and in Chapter 1. However, some changes were made to the design of the study and the type of data collected bearing in mind very young children were participating rather than adults. As we saw in Chapter 2, different paradigms have been shown to elicit different quantities of prepositions; the simple *where* questions asked by an adult experimenter has been shown to elicit fewer responses from young children than situations where children interact in a game with a puppet via the experimenter (e.g., Johnston, 1984;

Johnston & Slobin, 1979). Therefore, in an attempt to elicit natural language production, a series of video scenes depicting two puppets hiding real objects was shown to the children. Each video clip involved a 'game' for the children to play with the puppets that were also present for the duration of the experiment. The child's role was to tell a puppet wearing a blindfold where another puppet had 'hidden' the target object (a free response paradigm). The dependent variable was the utterance given by the child for each spatial scene.

3.2.2. The Selection of Participants

Before we describe the experiment in full, some discussion is merited regarding the age group of children used in the study. The youngest group of children in this experiment had a mean age of 4;1 (n=20, range 3;4 to 4;6). Children of this age were used as the youngest age group because preliminary investigations showed that younger children had problems with the production task. This is not uncommon. For example, Halpern et. al. (1983) found that in their group of 75 children between the ages 1;2 to 2;6 only 10 managed to produce both *in* and *on*, and Johnston (1984) suggests that the production of *in* and *on* does not reliably occur until a child reaches around 3;2. As discussed in Chapter 2, many uses of words in the early stages can be imitative, unstable and often they are contextually bound. For this task, the children needed to be able to produce both *in* and *on* in reasonably large quantities in order for their utterances to be usefully categorised and analysed.

3.2.3. Method

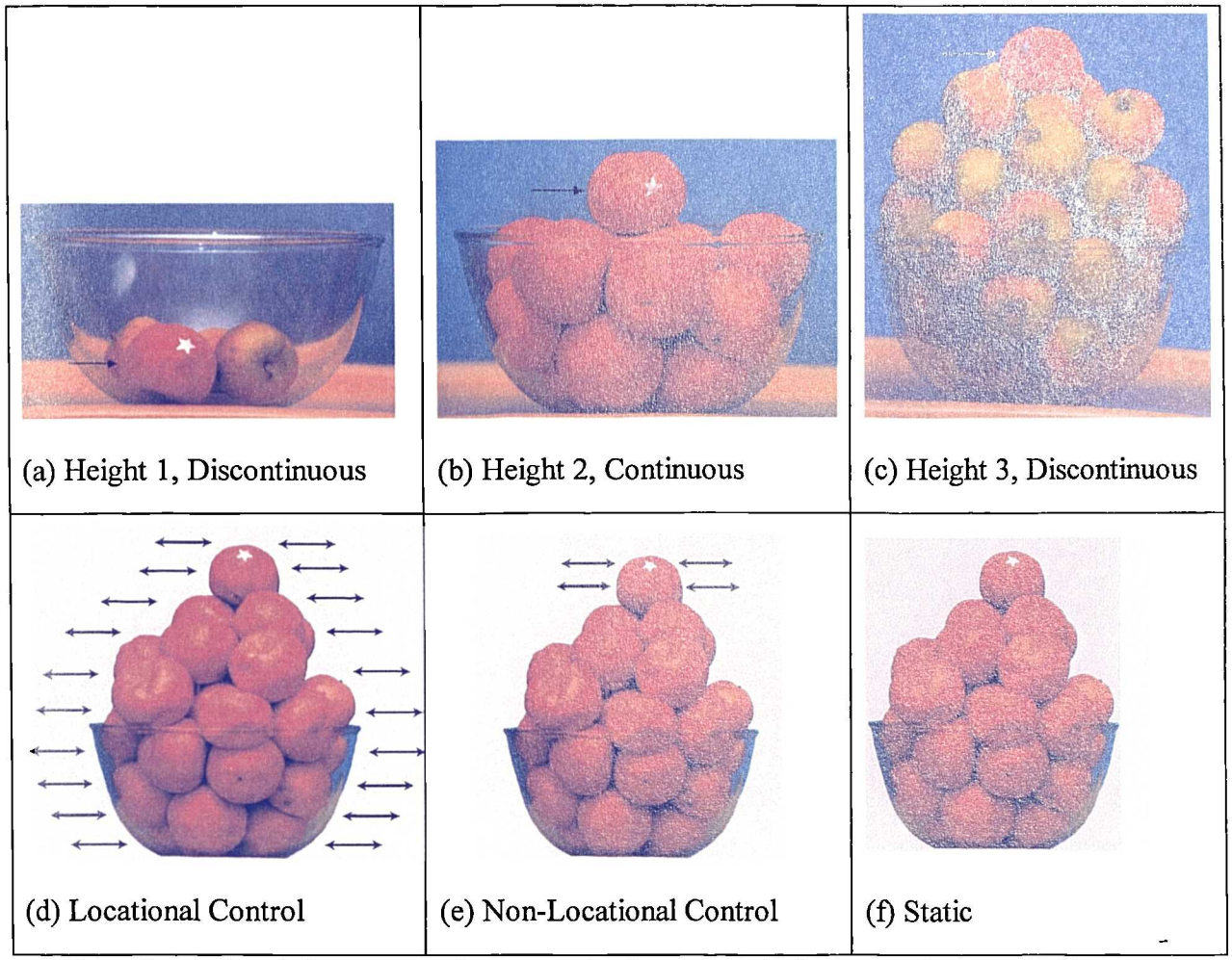
3.2.3.1. Design

A 4 (age group) x 3 (height) x 3 (locational control) x 2 (continuity) partial within-participants design was used for the main manipulations. Age group was the between participants variable with height, locational control and continuity as the within-group variables.

3.2.3.2. Main Manipulations

The main part of the experiment used four target objects and four bowls. The main variables manipulated were height of pile, locational control and continuity of target object with other objects in the scene. Examples of the scenes used can be seen in Figure 3.3 below and the main manipulations are characterised as follows:

Figure 3.3. The Main Bowl Manipulations of Experiment 1



Note: Single headed arrows and stars on the fruit identify the target objects; double-headed arrows denote movement.

Variable 1: Height of pile (geometric manipulation).

Three levels of height were used (see Figure 3.3 (a), (b), and (c), where the target object is indicated by an arrow). The located (target) object was either touching the base of the bowl, level with the rim of the bowl (approximately 13 cm above the base) in contact with other objects touching the base of the bowl, or high above the rim of the bowl (approximately 26 cm above the base) in contact with other objects touching the base of the bowl.

Variable 2: Locational control of the bowl (extra-geometric manipulation).

Three levels of relative movement of the target object and reference object were manipulated: *locational control, non-locational control* and *static.* Locational control depicted the bowl fulfilling its function over time. Here, the target object moved directly with the bowl and its contents (from side-to-side) thereby highlighting the locational control of the bowl (see Figure 3.3 (d)). By contrast, non-locational condition showed the target object moving from side-to-side, independently of the bowl and other objects inside the bowl, whilst at all times remaining in contact with the objects directly beneath it (see Figure 3.3 (e)). The static condition involved no movement of either the target object or the bowl (see Figure 3.3 (f)).

Variable 3: Continuity of target object with other objects in the bowl.

Two levels were manipulated: continuity and discontinuity. *Continuity* was the case when the target object was identical to the other objects in the bowl (see Figure 3.3 (b), (d), (e) and (f)). For example, a yellow ball (target object) on top of other yellow balls or an orange on top of other oranges. *Discontinuity* was the case when the target object was different to the other objects in the bowl (see Figure 3.3 (a) and (c)). For example, a yellow ball on top of red balls or an orange on top of apples.

A total of 72 scenes were filmed across the three main variables in this experiment. These consisted of four target objects being filmed once for each level of the manipulation

(4 target objects x 3 levels of height x 2 levels of continuity x 3 levels of locational control).

In addition to the main manipulations outlined above, other manipulations of extra-geometric factors were also used in a more exploratory fashion. These scenes were interleaved with scenes from the main experiment. These subsidiary aspects of the experiment involved the use of a target object and a *bowl* as before, but also the use of a target object and a *plate.*

3.2.3.3. Subsidiary manipulation with the bowl

In order to address the aspect of locational control in a similar manner to Garrod et. al. (1999) and Coventry (1992, 1998) the absence of other objects between the target and reference objects was manipulated. The following scenes would be compared with the original scenes where the target object was resting on other similar objects at heights two and three:

1. Absence of other objects between target object and the bowl.

These scenes had no other objects present apart from the target object and the bowl. Additionally, only two levels of height were used which were identical to heights two and three for the main manipulations.

3.2.3.4. Subsidiary manipulations with the plate

The manipulations involving the plate were designed to assess whether any effects found with the bowl might also be found with a plate or whether they were object specific. Therefore, the two factors of height and continuity were manipulated using a plate as the reference object in a similar fashion to the bowl scenes. Additionally, the absence of other objects between the target and reference objects was manipulated; the target object was suspended at two heights (heights 2 and 3 from the main manipulation) with no other objects being present apart from the plate. These scenes would be compared with the original scenes where the target object was resting on other similar objects at heights 2 and 3:

1. Height of pile.

The three levels of height manipulated were the same as for the bowl scenes (see Figure 3.4 below (c)).

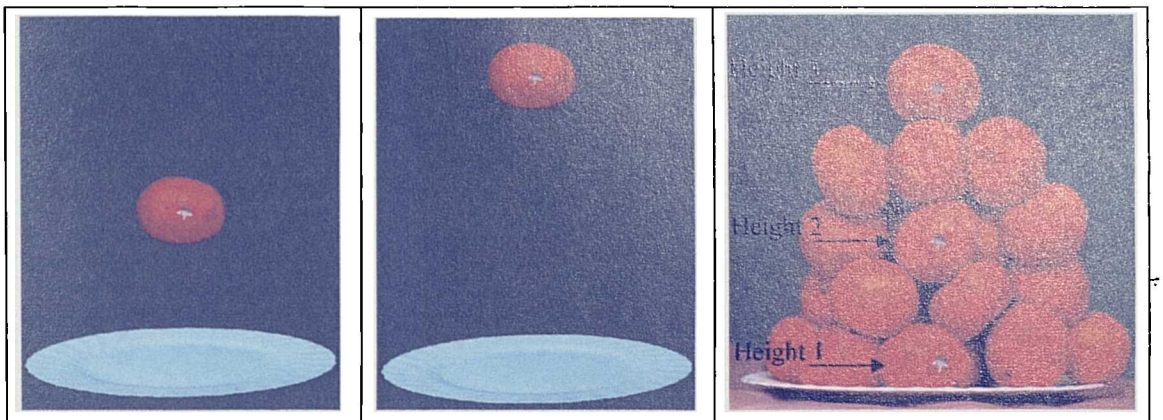
2. Continuity of target object.

The two levels of continuity and discontinuity were the same as for the bowl scenes (see Figure 3.4 below for an example of continuity).

3. Absence of other objects between target object and the bowl or plate.

These scenes had no other objects present apart from the target and reference objects. Therefore, only the target object and the plate were present. Additionally, only two levels of height were used which were identical to heights two and three below (see Figure 3.4 below (a) and (b) for examples of the plate scenes).

Figure 3.4. Examples of the Subsidiary Plate Manipulations of Experiment 1



(a) Plate, other objects absent, height 2	(b) Plate, other objects absent, height 3	(c) Plate, other objects present (continuity), heights 1, 2, & 3

Note: For each of the heights in (c) the target object was on top of the pile (in a similar manner to the bowl scenes) with no other objects above it.

These subsidiary manipulations yielded a further 40 separate scenes (the four target objects being filmed once for each manipulation). A further 16 scenes (distracter scenes) were then produced which were designed to elicit different prepositions and were subsequently interleaved with the experimental scenes.

Therefore, a total of 128 scenes were shown to the children: Seventy-two scenes from the main bowl experiment, forty from the subsidiary manipulations and sixteen that were not analysed.

3.2.3.5. Participants

Eighty children from four age groups participated in the experiment. All participants came from the same town. The youngest group of children attended a small Nursery School, and had a mean age of 4;1 (n=20, range 3;4 to 4;6). However, in a pre-test (not reported in full here), two children from this age group failed to display any production of the prepositions *on*, *over*, or *above*, preferring to use the preposition *in* for all spatial locations. These children were subsequently not used in the experiment. The older groups of children attended a single Infants school in the same town. These groups had mean ages of 5;5 (n=20, range 4;8 to 5;7), 6;1 (n=20, range 5;8 to 6;8) and 7;1 (n=20, range 6;9 to 7;8). All participants were native speakers of English and had normal, or corrected to normal, eyesight and hearing. However, one child from the second age group became unwell during testing, and did not complete all the testing sessions. As a consequence, the data from this participant was eliminated from the analysis.

3.2.3.6. Materials

Video scenes of two natural and two synthetic, three-dimensional, target objects were created. The target objects were an apple, an orange, a ball and a child's building brick (called 'a block' in the experiment). Each of these was identified as the target object

by the prominent display of a star stuck to each object which was orientated toward the camera. The reference objects used were transparent bowls (of comparable dimensions to one another) and a white plate. Two hand puppets (a teddy bear and a lion) were filmed between spatial scenes to involve the children in the 'game' (see Figure 3 5 below for an illustration of the puppets and the four target objects that were used).

Each spatial scene manipulation was filmed four times (once with each of the four target objects). All scenes were filmed using a Panasonic VHS camera. The scenes involving the puppets were filmed in a natural setting (a child's playroom). The spatial scenes were filmed against a plain background that varied between blue, pink, red and black.

Figure 3.5. The Puppets and Four Target Objects used in Experiment 1

Note: Target objects (L to R) a block, an apple, an orange and a ball.

This resulted in 128 individual spatial scenes that were alternated with a similar number of puppet scenes. Due to the large number of scenes that the children were to view

and in light of the expected concentration span of the children to be tested, the scenes were divided into four sets; each set contained one of the four scenes from each manipulation. The video footage was later digitized and edited into four separate video sessions (named video A to video D). Each session contained two hand puppets 'hiding' the four different target objects in 32 spatial scenes. A narrator's voice was added during editing. Each video session lasted approximately 5 minutes, 30 seconds. Each spatial scene clip lasted 5 seconds.

The spatial scenes were ordered to minimize priming effects, and to prevent participants from giving the same response throughout the experiment (see Appendix 1 for full details of the order of scenes in each video). No scene involved the same level of manipulation as the previous scene unless a 'change-over' scene preceded it. Such a scene involved the puppets changing roles from being the blindfolded puppet to being the puppet that hid the objects. This acted as a short break from the game and a distracter from the previous spatial scene.

3.2.3.7. Procedure

Each child was tested individually in the morning sessions at school on four separate occasions (with no more than 10 days between the first and last meeting). Each child sat at a table with the experimenter holding the puppets to their right. These puppets were the same ones used in the videos; the children were requested to tell the blindfolded puppet that was held by the experimenter where the objects were in the scenes. All responses for the experiment were recorded onto an audiotape in addition to the experimenter's written notes.

Using the hand puppets from the main video experiment, the first session included a brief pre-test of each child's comprehension and production for the prepositions *in*, *on*, *over*, and *under*. This pre-test also acted as an introduction to the puppets and the 'game' they were about to play, although the objects used in the pre-test were different to those used in the main experiment itself.

Pre-tests for Comprehension and Production

The first session included a brief pre-test of the child's comprehension and production for the prepositions *in*, *on*, *over* and *under*. The aim of this test was to ensure that each child had the preposition in their lexicon, and could produce them appropriately. As the main experiment was a production task, children needed to minimally produce *in* and *on* for their responses to be categorised and analysed fully. Each child was introduced to the two puppets. They were then told that Teddy was not very clever and that he wanted them to teach him how to do certain things (the comprehension test). Four items were then produced; a toy duck, a cup, a toy car and a solid cube. The youngest groups (mean ages 4;1 and 5;5) were asked to name the items and these names were subsequently used by the experimenter. The child was then briefly tested for their comprehension of the prepositions by the experimenter who said *can you show Teddy how to put the car [duck/box/cup]* <u>*on*</u> *[in/over/above] the box [cup/car/duck]*? When the child had performed an action (correct or incorrect), the experimenter said, *Look, Teddy, did you see that?* and moved on to the next preposition.

If the child was successful in performing the action, the experimenter continued on until all four prepositions had been executed. If the child had not been successful in performing a correct action, the experimenter continued on to the next preposition before returning to the unsuccessful preposition one more time (using different objects). A

maximum of two requests were made for each preposition. If a child made a placement error appropriate to the reference object (e.g., putting the object *in* the cup or *on* the cube), the reference object was switched for the second testing of that preposition. If a child had not performed the action correctly after two requests, that child was not assumed to have full comprehension of the preposition used.

A production test was then performed. The child's attention was drawn to the blindfold being put over the eyes of the puppet. The child was then introduced to another game. In this game, the experimenter was going to join in and move the objects, and the child had to tell the puppet where the objects had been moved. As in the comprehension test, the experimenter attempted to elicit a response for each preposition. A maximum of two attempts were made for each preposition. If a child did not respond using the desired preposition, a record was made of this.

As mentioned above, the aim of this pre-test was to assess whether the children could minimally produce both prepositions *in* and *on*, this was needed so that their data could be meaningfully analysed. Two children in the youngest age group could not do this. These children were subsequently not used in the main video experiment.

The Video Experiment

The child was then shown a 15" screen and asked to watch a short introductory video whilst the experimenter explained the game. The video contained pictures of the target objects (orange, apple, ball, and block) with stars prominently displayed on them. The puppet held by the experimenter then invited the children to 'play the game of hide and find'. The children were asked by the experimenter to name the objects and their attention was drawn to the stars. When the experimenter was sure the child knew what to

do, the video session was displayed on the screen. For sessions 2-4 this was the only task required of the children.

The four video tapes were all of a similar structure: A narrator's voice was heard throughout the video session describing the actions of the puppets on the screen and asking the children questions. One puppet on the screen was blindfolded whilst the other puppet 'hid' each of the four objects in turn. After the puppet had taken away each object, the screen faded to black for one second before revealing the spatial scene. Whilst the screen was black, the narrator's voice asked the question *where's the orange [apple/ball/ block]*? in order for the children to tell the blindfolded puppet where the object was located. After all four objects had been hidden and shown in the spatial scene twice, the puppets changed roles. There were four blocks of eight spatial scenes in each video session. The video clips were counterbalanced to ensure that no two children in one age group saw them in the same order (see Appendix 2 for order of video scenes for each participant).

During testing, when the children were requested to respond, the experimenter waited briefly for the utterance. If the child did not respond quickly, the experimenter repeated the narrator's question, *where's the orange [apple/ball/block]?*. If a response was given in the form of 'preposition-reference object', the experimenter recorded it and continued with the game. If no response was given, the experimenter paused the video clip and asked the child if they wanted to see it again. If an invalid response was given, such as *there*...[pointing], the child was reminded that the puppet could not see because it was wearing a blindfold and that they had to *tell* the puppet where the object had been hidden. One further attempt was made to elicit a response before the next scene was shown.

3.2.4 Coding the Data

The tape-recorded responses from each child were transcribed and entered into a spreadsheet for later coding. The experimenter's notes were also used for clarification of any ambiguous utterances. The data contained an abundance of fine-grained differences within the utterances given by the children, much of which was irrelevant to the purposes of this study. Had they been coded individually such coding would give hundreds of unnecessary categories. Therefore, utterances were grouped together in categories using less fine-grained detail. For example, utterances such as *in the glass bowl*, *in that bowl*, *in a bowl*, and *in the apple bowl* were essentially variations of *in the bowl* and were all coded under the same category although an additional code was used beside them to denote any differences that may have been of potential interest. Additionally, responses such as *in the dish* or *in the pot* were also variations of *in the bowl* where the child was simply referring to the bowl using a different noun, but always that of a container. These utterances were classified initially as examples of the *in the bowl* but again, an additional code was used alongside such utterances denoting that the noun *bowl* was not used.

Some children used the word *plate* for a scene in which the bowl was present and *dish* or *bowl* for scenes containing a plate. In these instances, a simple check was made to ensure that they were not responding in a similar manner throughout the experiment (or for that section of the experiment). Therefore, if the child's previous response was different (e.g., *on the blocks*), the use of *plate* (for a bowl) and *bowl* (for a plate) was assumed to be a simple naming error and was coded as if they were referring to the containment/support object in the spatial scene. This final coding resulted in 52 categories.

The coding was checked for internal consistency. This was done by the same person re-coding one quarter of the utterances a second time. This second attempt was then compared with the first attempt to check for any discrepancies in coding. Such discrepancies were minimal (less than 0.2% differences, any errors found were corrected). From this basic categorization scheme, some categories were further collapsed or taken apart for the analyses reported below.

3.2.5 Results

An alpha level of .05 was used for all statistical tests in this thesis. Tukey (HSD) was used for all follow-up analyses unless age group was included in the analyses when Tukey (HSD) for unequal Ns was used. Again, this will be the case for all follow-up analyses reported in this thesis.

Initially it was of interest to look at the range and complexity of the types of completions produced by age group for all the spatial scenes.

3.2.5.1. Length of Utterances

The responses (excluding errors) fell into one of two categories. The first category of responses comprised single phrase utterances, minimally containing a preposition and a noun phrase, for example, *in the bowl*, and *on top of the oranges* (see Table 3.2 for further examples). The second category of responses was comprised of utterances containing two single prepositional phrases combined together in a single utterance. This category included responses such as *with the blue blocks in a plastic bowl* and *in a bowl with some*

balls. The production of two prepositional phrases increased with age; 10% of the utterances from children in age group 1 (mean age 4;1) contained two prepositional phrases, rising to 11% of the utterances for age group 2 (mean age 5;5), 15% of age group 3 utterances (mean age 6;1) and 27% of age group 4 utterances (mean age 7;1). As the differences between means of age groups one and two and the mean of age group 4 appeared to be large, two t-tests were performed on the data. The results showed that the difference between age group one and age group four was significant, $t_{.05}(36) = 2.12$, $p<.05$. However, the difference between age group two and age group four did not quite reach significance, $t_{.05}(37) = 1.92$, $p=.06$. A similar developmental difference in the length of utterances has also been found in other studies using a free response paradigm (e.g., Plumert, Ewert, & Spear, 1995).

Table 3.2. Examples of the One and Two Prepositional Phrases that were Produced by the Children in Experiment 1.

One Prepositional Phrases	Two Prepositional Phrases
Over the plate	*On top of blue blocks in a glass bowl*
On the plastic bowl	*With the oranges in the bowl*
On top of the bowl	*On a plate on top of other blocks*
On top the oranges	*In a bowl on top of apples*
In the block bowl	*Up above all the other oranges on a plate*
Above the plate	*In the other oranges in the bowl*

3.2.5.2. Errors, Unusual and Ambiguous Responses

This section aims to set out the manner by which errors, unusual and ambiguous responses were defined. The majority of the responses in this category occurred for the no contact scenes (278 utterances; 2.8% of the data collected), the remaining 50 responses in this category occurred when children were describing scenes from the main manipulations.

Looking at these responses for the no-contact scenes first, the youngest age group (mean 4;1) was responsible for 40% (111 utterances) of such responses in the no contact scenes, Group 2 for 26% (72), Group 3 for 21% (57), and Group 4 for 14% (38). It appears that the unusual responses were an attempt to describe a no contact scene when a child did not produce either *over* or *above*. Often, in a situation like this, the prepositions *on* or *on top of* were produced (and they were coded as such). However, utterances such as *in the ceiling*, *up in the air*, *on the wall*, and *in the sky* were commonplace and diminished with age. These utterances are similar to those described in Durkin (1980) from children of a similar age in response to similar arrangements of located and reference objects. One participant in the youngest age group in this experiment knew that he did not have a word for the no contact spatial scenes. He consistently responded with utterances such as *I don't quite know that one*, he finally responded with *I don't know where that is. I don't know that all the time.*

The ambiguous responses for the no contact scenes were fewer and consisted of utterances like *up there*, or prepositions without reference objects. Errors were minimal, usually mentioning an object that was not in the spatial scene. For example, *on the apples* when only the target object and a bowl or plate were in the scene.

The remaining errors, unusual or ambiguous responses were for contact scenes involving the plate and the bowl. These were mainly ambiguous comments, for example,

on the top, *in between*, and *in the middle*. Again, they diminished with age. Of the 50 responses in this category for the contact scenes, 44% (22 utterances) were from the youngest age group, 50% (25) from age group 2 and 6% (3) from age group 3. The oldest children made no such responses.

3.2.5.3. Naming of the Bowl and Plate

Not all children used the noun *bowl* to describe the bowls in the scene or the noun *plate* to describe the plate. Looking firstly at the bowl scenes, some children called the bowl a *ball bowl,* an *apple bowl*, an *orange bowl* and a *block bowl* depending upon the target object used. Six percent (81) of age group 1 (mean 4;1) utterances were of this nature, with 7% (95) of age group 2 (mean 5;5) utterances, 18% (243) of age group 3 (mean 6;1) utterances and 5% (73) of the utterances from age group 4 (mean 7;1) were of this type. A similar occurrence of such naming was found for the plate; *ball plate*, *apple plate*, *orange plate* and *block plate* were all produced by children in all age groups (again, more common with age group three).

It is interesting to note that the noun used along with bowl and plate was that of the located object (rather than the other objects in the scene), and that children used this labelling not only for the scenes where other objects were present, but also for the no contact (other objects absent) scenes. As such this rules out the possibility that when they said *in the apple bowl* they were trying to say *in the bowl of apples*.

Some children made what might be regarded as errors in their naming of the reference objects in the scene. The bowl was called a *pot, saucepan*, *dish* and occasionally *plate*. Likewise, the plate was referred to as a *dish* and sometimes the term *bowl* was used.

These were all relatively uncommon and were not peculiar to any one age group of children.

3.2.5.4. Analysis of the Main Manipulations

All the utterances produced from the main bowl manipulations were separated out from the rest of the data. Table 3.3 below contains the main completions (>2% of the data in any one age group[4]) along with percentage and number of utterances in each category for all age groups. We can see from Table 3.3 that the most common response from children of all age groups was *in the bowl*; between 43% and 60% of utterances in each age group fell into this category. Of the single prepositional phrases, *On top of the oranges [apples/blocks/balls]* was the next most frequently produced phrase across age groups (between 9% and 25% of utterances for each age group). *On the oranges [apples/blocks/balls]* was also popular for age groups three (mean 6;1) and two (mean 5;5). Of the two prepositional phrases, *On top of the oranges [apples/blocks/balls] in the bowl* was popular for age groups three and four (mean 7;1) consisting of 5% and 13% of their utterances respectively. Additionally, *in the bowl with the oranges [apples/blocks/balls]* was relatively popular for age groups three and four (7% and 11% of utterances). It is interesting to note that *over the bowl* and *above the bowl* were only produced by some children in age group four. Bearing in mind that there was always some contact between the located object and the other reference objects in the scene a more natural description might be *on* or *on top of* these other objects rather than *over the bowl.*

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[4] Note: As Table 3.3 contains only data that comprises >2% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 3 for full breakdown.

Table 3.3. The Percentage (and Number) of Utterances Produced by Each Age Group for the Main Bowl Manipulations, Experiment 1.

Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
Inside the bowl	62	2%(21)	1%(18)	1%(10)	1%(13)
In the bowl	2823	50%(652)	64%(882)	47%(673)	43%(616)
On the bowl	112	3%(36)	2%(27)	3%(44)	0%(5)
On top of the bowl	139	2%(21)	2%(30)	3%(36)	4%(52)
Above the bowl	40	0	0%(2)	0%(2)	3%(36)
Over the bowl	36	0	0	0%(4)	2%(32)
In the oranges [apples/blocks/balls]	34	1%(12)	1%(10)	1%(11)	0%(1)
On the oranges [apples/blocks/balls]	378	5%(64)	8%(105)	14%(201)	1%(8)
On top of the oranges [apples/blocks/balls]	933	25%(319)	9%(120)	16%(231)	18%(263)
In the bowl with the oranges [apples/blocks/balls]	313	3%(42)	1%(19)	7%(97)	11%(155)
On the oranges [apples /blocks/balls] in the bowl	49	0	2%(34)	0%(7)	1%(8)
On top of the oranges [apples /blocks/balls] in the bowl	303	0%(4)	3%(35)	5%(77)	13%(187)
With the oranges [apples /blocks/balls] in the bowl	169	6%(77)	4%(51)	1%(14)	2%(27)
Ambiguous/Errors/Non responses	56	3%(34)	1%(18)	0%(4)	0

Looking at the main variables involving the *bowl*, the first question to be answered from the data was whether children's prepositional production changed according to the manipulations in this study for the main manipulations involving the bowl. As discussed earlier, research into adults' prepositional production with similar geometric and extra-geometric manipulations showed that adults' production of *in* with the reference object *bowl* was affected by all three factors of geometry, continuity/discontinuity and locational control. Coventry (1992, 1998) used a sentence completion paradigm where the sentence to be completed was in the form of "the target object is _____ the bowl". The productions were examined to see whether an identical analysis would be possible, given the different task undertaken by the children in this experiment. Therefore, the frequency of production of the preposition *in* co-occurring with the noun phrase *the bowl* was considered. Bearing in mind that previous research has demonstrated that different nouns can elicit different prepositions (Coventry et. al., 1994; Feist & Gentner, 1998) any utterances that referred to the bowl using a different noun (e.g., dish, plate, pot, jar) were not looked at.

As can be seen in Table 3.4 below, children in all age groups produced the preposition *in* the majority of times when they mentioned the word *bowl*. Additionally, there was a large proportion of utterances that did not mention the word *bowl* (e.g., single prepositional phrases such as *on the apples* or used a different noun with which to refer to the bowl); giving a total of 40%, 36%, 43% and 27% for age groups one to four respectively. One of the reasons for the lower occurrence of references to the bowl for the youngest age groups, and conversely the high occurrence of bowl references for age group four, is due to the number of two prepositional phrases produced by the children. When a child produces a two prepositional phrase, they will always refer to the bowl whereas single prepositional phrases referred either to the bowl or to the other objects in the scene. Given that *in* co-occurred with *bowl* to such an extent, and that there were numerous

instances where children did not mention the noun *bowl* at all, it was apparent that an alternative method of analysis would be necessary.

Table 3.4. The Number of Responses (and Percentages) for Each Preposition Co-occurring with the Noun *Bowl* for Each Age Group for the Main Bowl Manipulations, Experiment 1.

	Number (and Percentage) of Bowl Utterances			
Preposition	Group 1 (4;1)	Group 2 (5;5)	Group 3 (6;1)	Group 4 (7;1)
In	716 (90%)	807 (92%)	719 (88%)	936 (89%)
Inside	22 (3%)	17 (2%)	14 (2%)	13 (1%)
On	36 (5%)	20 (2%)	41 (5%)	5 (<1%)
On top of	17 (2%)	27 (3%)	35 (4%)	52 (5%)
Above	0 (0%)	2 (<1%)	1 (<1%)	35 (3%)
Over	0 (0%)	0 (0%)	3 (<1%)	7 (<1%)

Note: Total number of utterances in data set: Group 1 = 1296; Group 2 = 1368; Group 3 = 1440; Group 4 = 1440.

Further Considerations for the Analysis

The analysis undertaken in the adult studies looked at when adults produced the preposition *in* for the sentence completion task. As we have seen above, this was not possible with children, due to the use of a free-response task. The question to be answered from the children's data was when did the children consider the target object to be *in the bowl*. Therefore, the use of other nouns with which to describe the scene (e.g., *pot* or *dish*) would not be a problem.

Single prepositional phrases were also not a problem for an analysis of this kind as the children firmly located the target object either *in the bowl* or *on the oranges [apple /block/ball]*. However, when children produced two prepositional phrases, such as, *on the apples in the bowl*, it is not clear whether they were firmly locating the target object 'in the bowl', or whether this was merely additional information with 'on the apples' being the primary location of the target object. This is also a potentially ambiguous situation as they might even mean *on the apples* <u>*that are*</u> *in the bowl.* Indeed, some children were more sophisticated than others when describing the locations, using for example, *on top of a whole pile of apples that are in a glass bowl* and *On top of oranges but the oranges are on a plate* (child from age group 4). On the other hand, others were very basic, such as, *on top apples* and *in bowl* (child from age group 1). Obviously, as we have seen, the general trend was that the older children gave more information in their descriptions. Therefore, two alternative methods of categorisation were considered:

1. Put together all the single prepositional phrase utterances in the form of *in the bowl* into a single category. This way we will know that the child has firmly located the target object *in the bowl.* The other category would consist of all cases where the *oranges [apples, blocks, balls]* were referred to *irrespective* of when they were mentioned in the utterance. For example, either as a single prepositional phrase (such as *on the oranges*) or as part of a two prepositional phrase (such as *on the oranges in the bowl* and *in the bowl on the oranges*).

2. Categorise all the utterances on a *first mention* basis. Therefore, every utterance that used the preposition *in* with the reference object *bowl* as either the first (or only) prepositional phrase would be put into one category. Likewise, every utterance that mentioned the *oranges [apples, blocks, balls]* as the first (or only)

prepositional phrase would be put into a second category. Both of these categories could potentially contain utterances that consisted of one or two prepositional phrases.

As significantly more of the children in age group four produced utterances containing two prepositional phrases, the first option could introduce a confound. It could force an age difference when otherwise there might not be one. Additionally, if one puts together the utterances *on top of the oranges in the bowl* and *in the bowl on top of the oranges* assuming they both mean the same thing, one may reduce the sensitivity of the measurement.

Looking at the second option, one could argue that by selecting the first prepositional phrase mentioned, one may actually be ignoring valuable data. For example, *why* mention the oranges [apples, blocks, balls] at all, if not because the relationship between them and the target object is important and/or salient? Perhaps the utterances *on top of the oranges in the bowl* and *in the bowl on top of the oranges* do mean the same thing, the word order being irrelevant.

However, there is evidence in the literature that word order is important. Looking at where sentences come from and in particular *starting points*, MacWhinney (1977) proposed that starting points could serve four functions[5]. For the purpose of this research, the most important of these functions is *attentional focus*. It has been argued that first mention may serve to draw the listener's attention to an important factor or component. It is believed that the starting point *must* fulfil the function of attentional focus, but may or

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[5] The details of all of these functions will not be reported here, the reader is referred to MacWhinney (1977) for further information.

may not fulfil the other three functions (MacWhinney 1977). Indeed, research has shown that aspects such as perceptual factors do affect the order of words in a sentence (e.g., Clark & Chase, 1974; Flores d'Arcais, 1987). For example, Flores d'Arcais (1987) investigated how elements of a situation are conceptually organised and how this affects the word order adults' produce when describing those events. Over a series of studies, he found an effect of first mention for many situations. These included the first mention of large objects and of objects that *lead* the way in dynamic scenes (e.g., when there is movement of a series of objects, the one that is leading is mentioned first). Moreover, word order has been shown to be important for children also. Plumert et. al. (1995) asked children aged 3 and 4-years-old to describe the location of an object in a model room that contained pairs of primary landmarks (e.g., two identical hats). The target object was placed with the target primary landmark (e.g., *under a hat*); therefore, in order for children to disambiguate one primary landmark from another they needed to refer to a secondary landmark (e.g., *under the hat next to the bed*). Children's single prepositional responses in both age groups invariably used the primary landmark as the reference object, with more two prepositional phrases given by the older children. Additionally, when producing two prepositional phrases, both age groups of children invariably mentioned the primary landmark *before* the secondary landmark. This indicates that the first place mentioned in these children's utterances was the main *locational focus of attention*, with the secondary landmark being mentioned as additional information. Finally, research into spatial language production in adults reports a tendency for participants to produce more than one spatial term (e.g., Hayward & Tarr 1995). Where they did so, the first preposition mentioned was the one that was used in the analysis.

Therefore, there is evidence to believe that the children in this study altered the starting point of their utterances according to the perceived relative importance of either containment or support. It was decided to analyse the data in terms of whether *in the bowl*

was produced as the first (or only) prepositional phrase. In this way, we could get at whether the focus of description changed as a function of the manipulated factors in the present study. For example, *the orange is on top of other oranges in the bowl* would be considered a use of *on top of oranges* as first mention, while *the orange is in the bowl on top of other oranges* would be considered as a use of *in the bowl* as first mention. This method of analysis was also considered to be more appropriate given that a significant proportion of the older children's utterances were two prepositional phrase utterances.

Given that the free response task resulted in great variation within the data, it was necessary to make some assumptions during categorization. As it was no longer the aim of this particular analysis to draw exact parallels to the adult study by Coventry, it was not necessary to exclude all the instances where a child did not call the container a *bowl.* Consequently, whenever a child used a different word for the bowl (such as *dish*, *pot*, or *saucepan*) they were assumed to have been referring to the container in the spatial scene (as there was only a *bowl* in the scene). Therefore, although these were few in number, the production of words such as *pot* or *dish* were considered to be the child's own word for the specific container in the scene rather than errors.

Similarly, if a child mentioned objects such as *eggs* or *lemons*, they were assumed to have been referring to the supporting objects in the spatial scene (i.e., oranges, apples, blocks or balls). Such naming errors were highly infrequent (less than 5 per noun). In order to simplify the analyses that follow, we will refer to whether or not *bowl* was used as the reference object, although (as set out above) occasionally children may have called the bowl by a different name.

Table 3.5. Examples of Utterances Coded in Each of the Three Categories for the Main Bowl Manipulations, Experiment 1.

Category 1 (*in-bowl*)	Category 2 (*other preposition-bowl*, other reference object)	Category 3 (errors, unusual responses, etc)
In the apple bowl with all the apples.	*On top of the blocks.*	*Inside.*
In the block bowl.	*On the apples.*	*In the other ones.*
In a glass bowl on top of all the other oranges.	*On the eggs.*	*In with the other blocks.*
In the dish with the other pink blocks.	*On the bowl.*	*On.*
In the pan.	*With the red blocks in the bowl.*	*In there.*
	Inside the apple bowl.	*On top.*
	On top of a tower of blocks in a moving glass bowl.	*Outside.*
	Above the bowl.	*Don't know.*
		Up there.

All 5544 of the utterances from the main *bowl* manipulations were grouped into three categories on a 'first (or only) mention' basis (see Table 3.5 above for examples). Every utterance that mentioned *in the bowl* first (or only) was put into Category 1 (giving 3,144 responses across all age groups). Every utterance that mentioned other objects as reference objects [*oranges, apples, blocks, balls*] first (or only), or used a preposition other than *in* with *bowl* was put into Category 2 (2,281 responses). Errors, unusual responses, etc., were placed into a third category (119 responses). These were categorised according to the criteria set out in the relevant section on page 133. The data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances

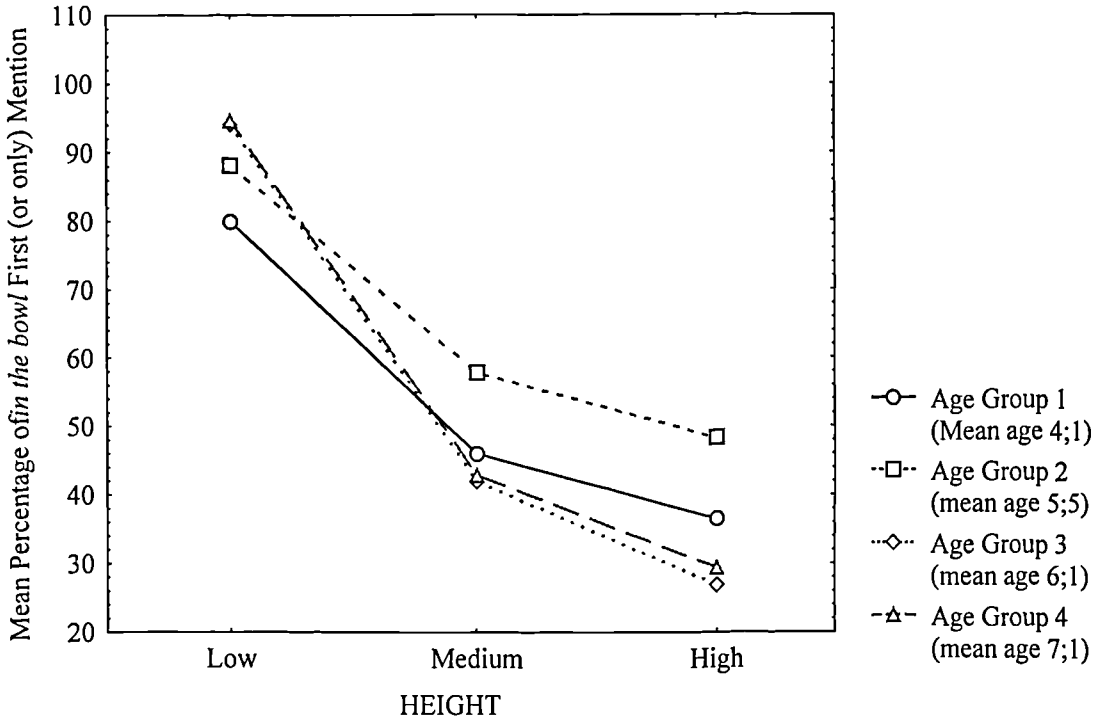
(ignoring Category 3 responses) for each cell of the design and expressing it as a percentage. A four-way, partial-within-participant, analysis of variance was performed on the data. The between-group variable was age (4 groups: Mean ages 4;1, 5;5, 6;1 and 7;1). The within-group variables were height (3 levels: low, medium, and high) locational control (3 levels: static, non-locational, and locational control) and continuity (2 levels: continuity and discontinuity), as outlined on page 118. Table 3.6 below displays the mean percentage of *in-bowl* first (or only) utterances for each age group, and the results from the analysis of variance are displayed in Table 3.7 on page 146 below. As can be seen from Table 3.7, a significant main effect of height was found. Follow-up analysis revealed a significant difference between all three levels of height. Children produced *in the bowl* as the first (or only) prepositional phrase most when the target object was at the lowest height (mean 89%), and least when the target was at height three (mean 35%). However, a significant interaction between height and age was also present. Although all age groups produced *in the bowl* more as the first (or only) prepositional phrase with lower heights, the differences between levels of height were more dramatic with the older two age groups (see Figure 3.6 on page 147 below).

Table 3.6. Mean Percentage of *In-Bowl* First (or Only) Utterances across Age Groups, N = 77, for the Main Manipulations of Experiment 1.

	Height 1 (Low)						Height 2 (Medium)						Height 3 (High)					
	Continuity			Discontinuity			Continuity			Discontinuity			Continuity			Discontinuity		
Age Group	*ST*	*NLC*	*LC*	*ST*	*NLC*	*LC*	*ST*	*NLC*	*LC*	*ST*	*NLC*	*LC*	*ST*	*NLC*	*LC*	*ST*	*NLC*	*LC*
1 (mean 4;1)	81	84	80	81	78	76	43	47	59	43	35	50	35	39	47	35	31	32
2 (mean 5;5)	89	89	93	86	84	88	61	59	62	55	51	58	46	50	57	50	39	49
3 (mean 6;1)	94	93	95	95	95	94	39	41	50	41	34	46	28	24	28	30	25	28
4 (mean 7;1)	95	95	95	95	93	95	48	41	47	41	36	45	36	25	31	30	25	29
All Ages	90	90	91	90	88	88	48	47	54	45	39	50	36	34	40	36	30	34

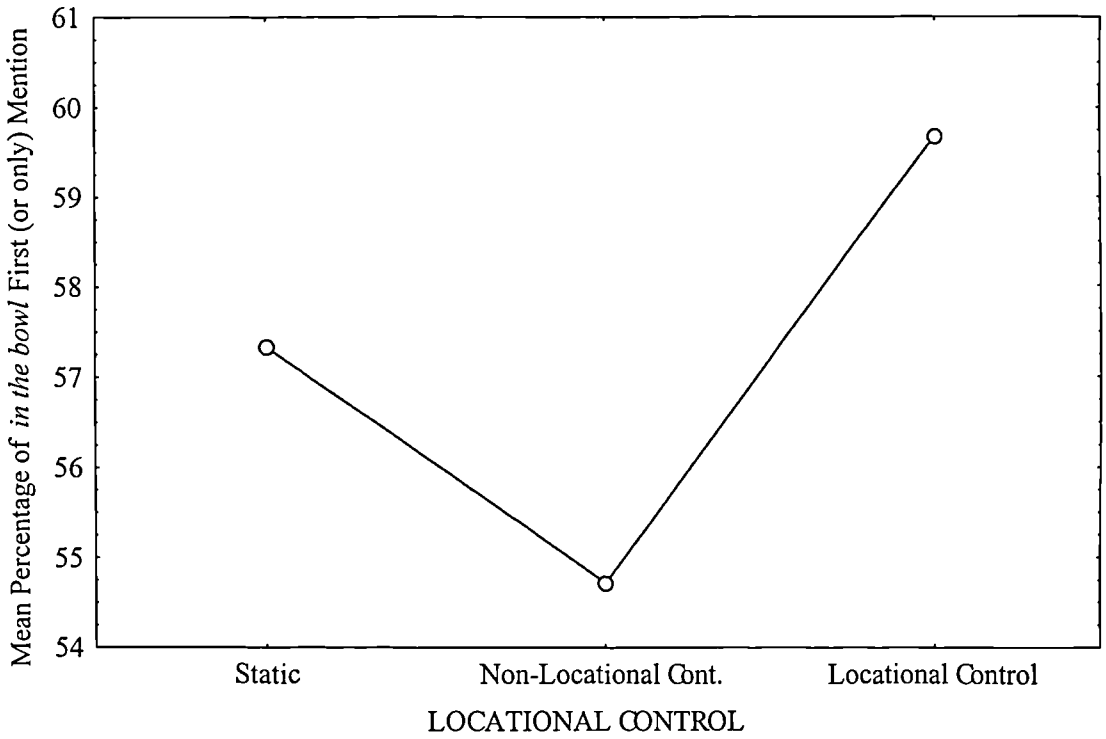
Note: Locational control abbreviations: ST = Static, NLC = Non-Locational Control, LC = Locational Control.

Figure 3.6. The Significant Interaction between Age Group and Height of Pile for the Main Bowl Manipulations, Experiment 1.



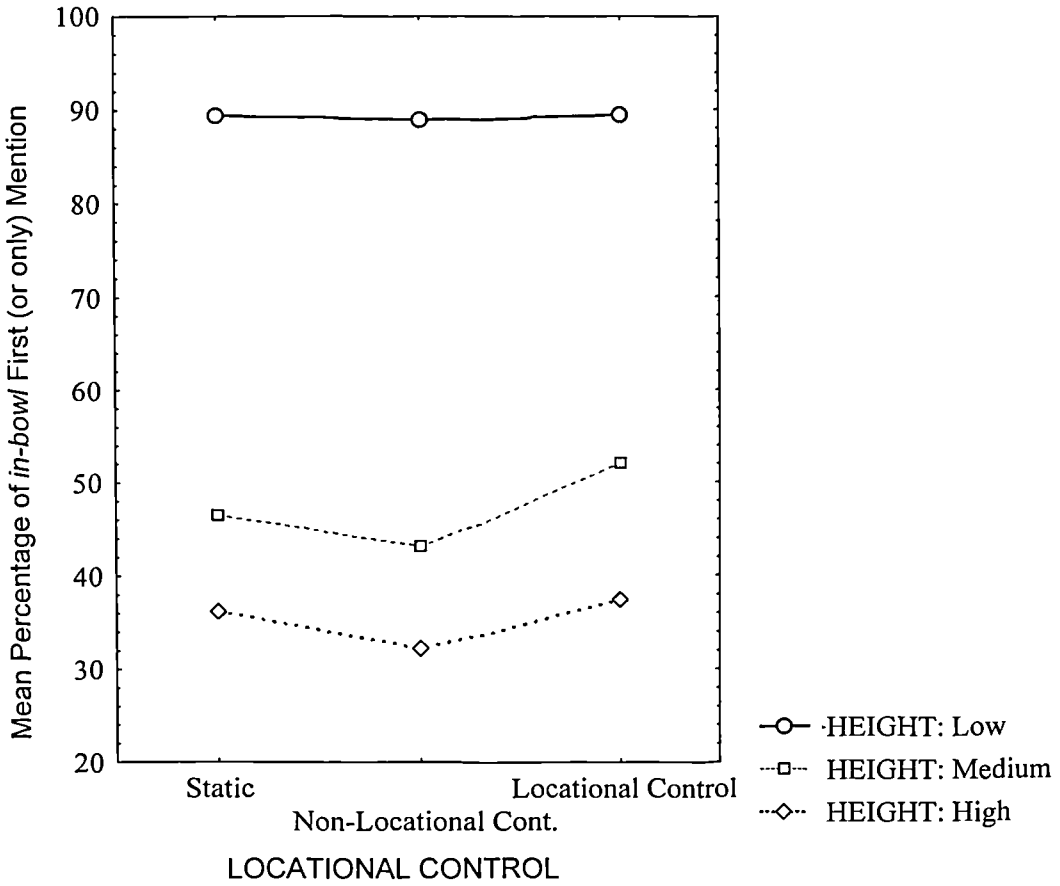
A significant main effect of locational control was found, and is displayed in Figure 3.7 below. Follow-up analyses showed all three levels to be significantly different from one another. Children produced *in the bowl* most as the first (or only) prepositional phrase for the locational control (mean 60%), and least for the non-locational control scenes (mean 55%). The mean for the static scenes was 57%.

Figure 3.7. The Significant Main Effect of Locational Control for the Main Bowl Manipulations, Experiment 1.



There was a significant interaction between height and locational control. This is displayed in Figure 3.8 below. Children showed no significant differences in their production of *in the bowl* for the manipulations of locational control at height one (low). They did, however, show significant differences between the manipulations of locational control and non-locational control and between static and locational control at height two and between the non-locational control condition and the locational control condition at height three.

Figure 3.8. The Significant Interaction between Height and Locational Control for the Main Bowl Manipulations in Experiment 1.

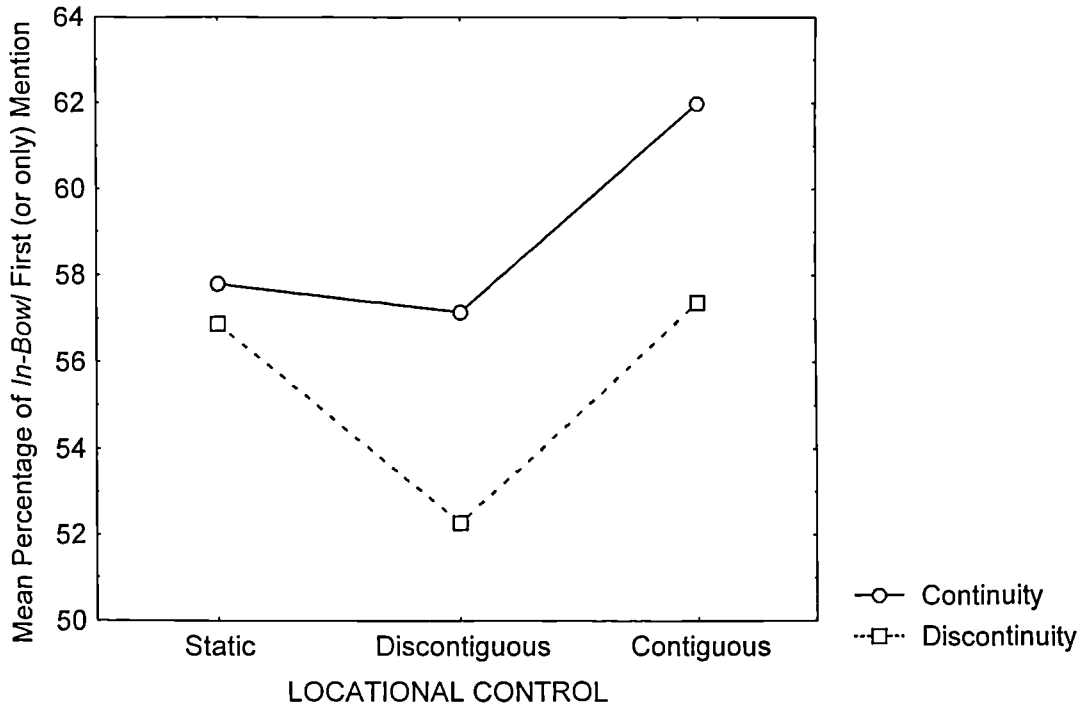


A significant main effect of continuity was also found. Children produced the phrase *in the bowl* as the first (or only) prepositional phrase more when the other objects in the scene were the same (mean 59%) than when they were different (mean 56%).

Finally, a significant interaction between locational control and continuity was also found. For the continuity scenes children produced the phrase *in the bowl* as the first (or only) prepositional phrase significantly more for the locational control scenes than for either the static or non-locational control scenes. There was no significant difference between the static and non-locational control scenes (see Figure 3.9 below). However, for the discontinuity scenes, children produced *in the bowl* significantly less as the first (or

only) prepositional phrase for the non-locational control than for both the locational control and static scenes, and no difference was found between the locational control and static scenes[6].

Figure 3.9. The Significant Interaction between Continuity and Locational Control for the Main Bowl Manipulations in Experiment 1.



[6] For completeness, a further analysis was undertaken with age groups one to three looking at whether or not the children mentioned a reference object other than the bowl irrespective of *where* it was mentioned in the utterance. It was not possible to undertake such analysis for age group four due to the large number of two prepositional phrases produced. The results of this analysis were very similar to the findings outlined above, and are therefore not reported here (See Appendix 4. for ANOVA table).

3.2.5.5. Subsidiary Manipulations; Analysis of Scenes with the Bowl

We now turn to look at the subsidiary manipulations involving the *bowl* where there was an absence of other objects in the scene. For these scenes, therefore, there was no contact between the located and reference objects (these manipulations are described in full on page 123). The data associated with these scenes were separated out from the remaining data. Table 3.8 below contains all the utterances in the data along with percentage and number of utterances in each category for all age groups.

We can see from Table 3.8 below that children still produced the preposition *in* with the reference object bowl even when there was no contact between the target and reference objects (i.e., when other objects were absent). However, the tendency to do so dramatically reduced with age. It was therefore of interest to establish to what extent children produced the same preposition when the target object was touching other objects in the bowl as they did when there were no other objects present. While children's production of the words *dish*, *pot*, *plate*, etc., were treated in a similar manner to the previous analysis, the utterances were categorized differently. For the scenes where there were no other objects present, all the utterances children produced (except errors) referred to the bowl in a single prepositional phrase. The prepositions used were *inside, in*, *on*, *on top*, *above*, and *over*. Utterances using these prepositions were placed into five separate categories (with *inside* and *in* being collapsed due to the small number of *inside* utterances). One final category was created for errors, unusual responses, non-bowl responses, etc., and contained mainly ambiguous utterances made by children who did not

produce the prepositions *above* or *over* (examples of utterances in this category are *in the air*, *in the ceiling* and *up there*).

Table 3.8. Percentages (and Number) of Utterances Produced by Each Age Group in Each Category for the No Contact Bowl Scenes (Heights 2 and 3) from the Subsidiary Manipulations of Experiment 1.

Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
Inside the bowl	2	1%(2)	0	0	0
In the bowl	73	23%(33)	16%(25)	4%(7)	5%(8)
On the bowl	74	15%(21)	16%(25)	13%(21)	4%(7)
On top of the bowl	174	36%(52)	26%(39)	28%(44)	24%(39)
Above the bowl	164	8%(11)	18%(28)	34%(54)	44%(71)
Up above the bowl	14	0	5%(7)	3%(4)	2%(3)
Over the bowl	60	4%(6)	8%(12)	11%(18)	15%(24)
Ambiguous/Errors /Non responses	55	13%(19)	10%(16)	8%(12)	5%(8)
Total:	616	100%(144)	100%(152)	100%(160)	100%(160)

The data that were used as a comparison were taken from the main experiment for the static, continuous scenes at heights two and three (the same heights as the no contact scenes). This follows from a similar analysis undertaken by Coventry (1992, 1998). The

single prepositional phrases that mentioned the *bowl* were placed into the same categories as the no-contact data according to the preposition mentioned. Those single prepositional phrases that mentioned the *oranges* [*apples, blocks, balls*] were placed in the seventh (errors, non-bowl response) category. For the responses that contained two prepositional phrases, the preposition paired with the *bowl* was classified in a similar manner to the single prepositional phrase utterances, irrespective of where it occurred in the response. For example, the utterance *on top of the oranges in a plastic bowl* was classified as an instance of *in* as was the utterance *in the bowl on all the other oranges*. Due to the large range of prepositions produced and the high proportion of *in* - *bowl* pairings, inferential analysis was not undertaken. The descriptive statistics are nonetheless informative.

We can see from Table 3.9 below, children did not produce the same preposition when other objects were absent as they did when they were present. When referring to the bowl, children in all age groups, and at both heights, produced the preposition *in* when other objects were present at least 80% of the time. The production of *in* for the scenes where other objects were absent reduced across the age groups. The youngest age group produced *in* 28% of the time at both heights, reducing to 8% and 3% at heights two and three for age group four. This kind of responding has been found by previous researchers investigating the development of the production of spatial prepositions whereby children over-extend simple spatial prepositions and produce them in place of prepositions that are more complex, for example, producing *in* rather than *between* or *over* (Brown, 1973; E. Clark, 1972; Durkin, 1980; Grimm, 1975).

Children in all age groups produced the prepositional phrase *on top of* mainly for the no-contact scenes where other objects were absent. However, its production declined with age for these scenes at height three with the youngest age-group producing *on top* 35% of the time, dropping to 5% for the oldest age-group.

Table 3.9. The Percentage of Utterances of Prepositions Occurring with the Reference Object Bowl for Presence and Absence of Other Objects Scenes, from the Subsidiary Manipulations, Experiment 1.

	In (413 utterances)				On (91 utterances)				On top (201 utterances)				Above (185 utterances)				Over (65 utterances)			
Age Group:	4;1	5;5	6;1	7;1	4;1	5;5	6;1	7;1	4;1	5;5	6;1	7;1	4;1	5;5	6;1	7;1	4;1	5;5	6;1	7;1
Presence (H2)	81	93	80	84	9	3	13	0	9	3	7	6	0	0	0	5	0	0	0	5
Absence (H2)	28	22	9	8	24	26	25	9	46	38	38	44	1	8	20	33	0	5	8	6
Presence (H3)	85	92	83	84	10	2	3	0	5	6	11	7	0	0	3	5	0	0	0	4
Absence (H3)	28	14	0	3	7	8	1	0	35	19	20	5	19	46	61	66	11	13	17	26

Total number of bowl utterances for each age group:

Group 1, height 2: presence = 43, absence = 71; height 3: presence = 39, absence = 54

Group 2, height 2: presence = 58, absence = 73; height 3: presence = 52, absence = 63

Group 3, height 2: presence = 46, absence = 79; height 3: presence = 36, absence = 69

Group 4, height 2: presence = 63, absence = 79; height 3: presence = 57, absence = 73

The production of *above* and *over* increased with age, with *above* generally being produced more than *over*. These prepositions were produced almost exclusively for scenes where the other objects were absent by children of all ages, and were produced more for height three than for height two (where *on top of* was more commonly produced). Looking at the pattern of the data for the prepositions *on top of*, *above* and *over* at height three, a clear developmental progression emerges with the youngest children (mean age 4;1) producing *on top of* as a preference for no-contact scenes (35% of the time) rather than the prepositions *above* or *over* (19% and 11% respectively). However, this is no longer apparent with older children who display a preference for *above* for no-contact scenes by age group two (46% versus 19%, mean age 5;5) that gradually increases as children get older (66% versus 5% for age group 4). The production of *over* is also preferred to *on top of* for the oldest age-group (26% versus 5%). This trend is not so apparent at height two where the scenes are more ambiguous. Here, the rim of the bowl is level with the base of the located object therefore possibly suggesting there may be some degree of support afforded by the bowl.

3.2.5.6. Subsidiary Manipulations; Analyses of Scenes with the Plate

Contact Scenes

Looking now at the manipulations for the *plate*, all the data for the contact scenes were placed into a separate Table for further analysis (See Appendix 5 for categories along with a breakdown of percentages and numbers of utterances across age groups). These scenes involved the manipulations of height (three levels) and continuity/discontinuity (as

described in full on page 122). Recall that children's use of the word *dish* was treated as the child's own word for plate and coded as such. Children's use of the word *bowl* was classified in a similar manner to the word *plate* for the *bowl* categorisation (as set out on page 130). Table 3.10 below displays the main categories (>2% of the data in any one age group[7]) along with the percentages and number of utterances across age groups. We can see from Table 3.10 that children produced the single prepositional phrase *on the plate* between 27% and 45% of the time. *On top of the oranges [apples/blocks/balls]* was also produced relatively frequently; 26%, 10%, 20% and 20% across age groups one to four respectively. It is also interesting to see that children produced the preposition *in* with the reference object *plate*. This was especially so in the younger age groups with age groups one and two producing *in* for 18% and 16% of utterances whereas age groups three and four produced *in* for 7% and 5% of their utterances. Forty-six of these uses of *in* were probably due to the nouns the children used for the plate (e.g., *dish* and *bowl*). Taking this into consideration, children produced *in* with the noun *plate* 14%, 12%, 4% and 5% for age groups one to four respectively. As mentioned earlier in this chapter (and reviewed more extensively in Chapter 1), adults prefer to produce the preposition *on* when an object is labelled *plate* and the preposition *in* when it is labelled a *bowl* or *dish* (Coventry et. al., 1994; Feist & Gentner, 1998). Certainly, when viewing the bowl scenes, the children in this study showed a marked preference for producing the preposition *in* with the nouns *bowl* and *dish* (and also containers in general, e.g., *pot*). It could be that the association of *on* with *plate* is a slightly later development as the pairing of *in* with *plate* appears to reduce with age.

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[7] Note: As Table 3.10 contains only data that comprises >2% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 5 for full breakdown.

Table 3.10. The Main Categories for the Plate Scenes (>2% of the data in any one age group) With the Percentages and Number of Utterances Produced across Age Groups, Subsidiary Manipulations, Experiment 1.

Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
On the oranges [apples/blocks/balls]	145	4%(18)	9%(40)	18%(84)	1%(3)
On top of the oranges [apples/blocks/balls]	352	26%(114)	10%(46)	20%(95)	20%(97)
*In[side] the plate *only 1 participant used 'Inside'*	203	18%(76)	16%(71)	7%(33)	5%(23)
On the plate	632	27%(117)	45%(205)	34%(161)	31%(149)
On top of the plate	132	8%(36)	5%(22)	5%(23)	11%(51)
Above the plate	16	0	0	0%(2)	3% (14)
On the plate with the oranges [apples/blocks/balls]	81	3%(15)	1%(4)	6%(27)	7%(35)
Over the plate	20	0	0	0	4%(20)
On top of the oranges [apples /blocks/balls] on the plate	111	1%(3)	4%(16)	6%(29)	13%(63)
With the oranges [apples /blocks/balls] on the plate	65	7%(29)	4%(16)	3%(12)	2%(8)
On the bottom of the plate & Underneath the plate	35	4%(17)	4%(17)	0%(1)	0
Ambiguous/Errors/Non responses	12	0	2%(10)	0%(1)	0%(1)

Similar questions were looked at here, to those for the *bowl* scenes; namely, whether children altered their responses according to the geometric and extra-geometric factors of the study. As the children appeared to produce the preposition *in* relatively freely when they referred to the plate, especially the youngest two age groups, we looked at whether the children said *on/in the plate* first (or only) according to the geometric and extra-geometric factors manipulated in this study. When categorizing the data for this analysis, all the utterances that mentioned *on/in the plate* first (or only) were put into category 1 (922 utterances). All responses that mentioned *oranges* [*apples, blocks, balls*] first (or only) were put into the second category along with responses that mentioned other prepositions with the plate (910 utterances). The third category contained errors, unusual responses or ambiguous responses (16 utterances). Table 3.11 below shows examples of the responses that were placed in each of the three categories.

Table 3.11. The Examples of Utterances Coded in Each of the Three 'First Response' Categories for the Plate Data from the Subsidiary Manipulations, Experiment 1.

Category 1 (*in/on-plate*)	Category 2 (*other prepositions-plate, other reference objects*)	Category 3 (*errors, unusual responses,* etc)
On a plate with two more blue bricks.	*On top the plate.*	*Beyond the apples.*
In the plate.	*Above the plate.*	*With the other...*
On the plate.	*In the other blocks in a plate.*	*On the top.*
On the orange plate.	*With the other oranges on a plate.*	*On there.*
On a plate on top of balls.	*On the other apples.*	*In between.*
On a plate with some other blocks.	*On top of the balls on top of the plate.*	*In the bottom with the apples.*
	On top of oranges but the oranges are on a plate.	

The percentage of Category 1 utterances was calculated against those in Category 2 (ignoring Category 3 responses) for each cell of the design, thus standardizing the responses. Table 3.12 below displays the means for the plate manipulation for all age groups. A three-way partial-within participants ANOVA was then performed on the data. The between-group variable was age (4 groups as before). The within-group variables were continuity (2 levels: continuity and discontinuity) and height (3 levels: low, medium, and high).

Table 3.12. Mean Percentages of *On/In-Plate* First (or Only) Utterances for all Age Groups, N = 77, from the Subsidiary Manipulations, Experiment 1.

	Height 1 (Low)		Height 2 (Medium)		Height 3 (High)	
Age Group	Continuity	Discontinuity	Continuity	Discontinuity	Continuity	Discontinuity
1 (mean 4;1)	63	60	47	37	47	37
2 (mean 5;5)	80	75	58	50	53	51
3 (mean 6;1)	83	84	31	29	28	25
4 (mean 7;1)	81	79	30	34	25	20
All Ages	77	75	41	37	38	33

The results of the analysis of variance are displayed in Table 3.13 below. We can see from Table 3.13 that a main effect of height was found. Children mentioned *on/in the plate* as the first (or only) prepositional phrase significantly more when the target object was directly in contact with the plate (height one) than when it was not (heights two and three; $p<.0001$). This effect of height replicates that found for the bowl scenes. There was also a significant interaction between height and age group that mirrors the one found

earlier with the bowl scenes (as reported on page 147). Again the differences between levels of height were more dramatic with the older age groups (see Figure 3.10 below).

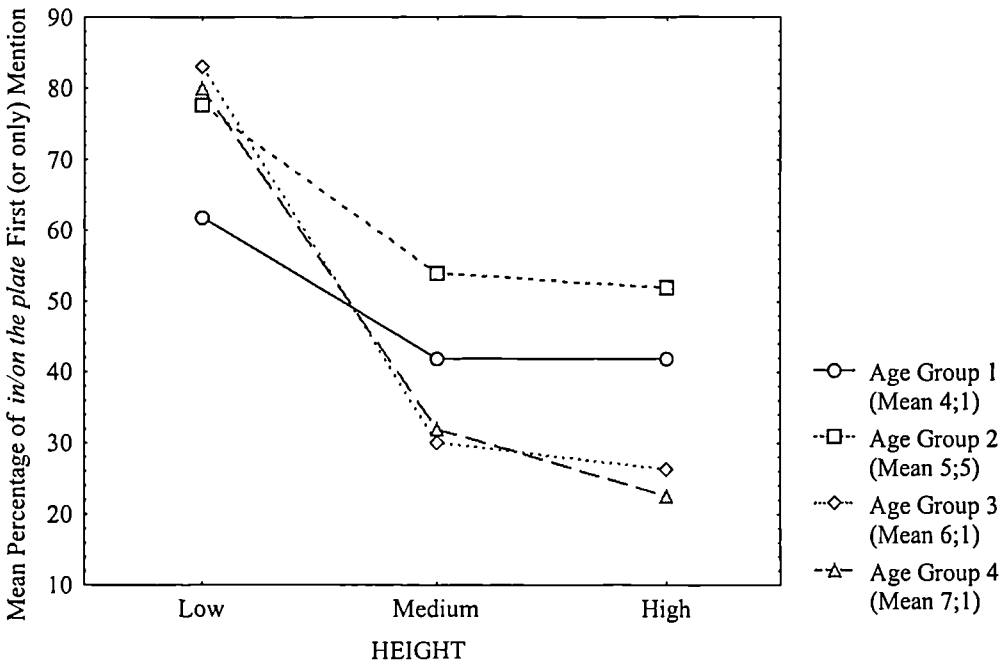
Finally, a significant main effect of continuity was found. Children in all age groups age groups produced *on/in the plate* as the first (or only) prepositional phrase more when the other objects on the plate were the same (with a mean of 52% of responses) than when they were different (48% of responses).

Table 3.13. The Results of the Analysis of Variance for the Main (Contact) Plate Manipulations (First Response) from the Subsidiary Manipulations of Experiment 1.

Source	df and F value	MS(error)	F
AGE (A)	F (3,73) = 0.94	6828.16	ns
HEIGHT (H)	F (2,146) = 97.53	768.14	****
CONTINUITY (C)	F (1,73) = 6.95	249.32	**
A x H	F (6,146) = 5.82	768.14	****
A x C	F (3,73) = 1.25	249.32	ns.
H x C	F (2,146) = 0.33	189.34	ns
A x H x C	F (6,146) = 0.81	189.34	ns

Note: $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

Figure 3.10. The Interaction between Age Group and Height of Pile for the (Contact) Plate Scenes from the Subsidiary Manipulations of Experiment 1.



The next analysis assessed the manipulations involving the *plate* for the scenes where other objects (except the target object) were absent (as originally described on page 121). Table 3.14 below displays the original categorisation of this data along with percentages and number of utterances produced across age groups.

Table 3.14. The Categories for the Plate (No Contact) Scenes with the Percentages and Number of Utterances Produced across Age Groups, from the Subsidiary Manipulations of Experiment 1.

Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
In the plate	12	6%(8)	1%(2)	1%(2)	0
On the plate	40	10%(15)	15%(23)	1%(2)	0
On top of the plate	119	33%(48)	18%(28)	19%(30)	8%(13)
Above the plate	235	15%(22)	32%(49)	43%(69)	59%(95)
Up above the plate	20	0	6%(9)	6%(9)	1%(2)
Over the plate	88	8%(12)	11%(16)	15%(24)	23%(36)
On the bottom of the plate & Underneath the plate	3	0	0	2%(3)	0
Ambiguous/Errors/Non responses	99	27%(39)	16%(25)	13%(21)	9%(14)
Total:	616	100%(144)	100%(152)	100%(160)	100%(160)

We can see from Table 3.14 above that a few of the younger children still produced the prepositional phrase *in the plate* even when the target object was suspended higher than the plate with no other objects present, with slightly more children producing the phrase *on the plate.* This is similar to the way children produced *in the bowl* for the no-contact scenes involving the bowl as described earlier on page 153. Twenty eight percent of the utterances produced from the children in age group one (mean 4;1) used the phrase

on top of the plate with only 16% of their utterances using *above the plate* to describe these scenes. However, the production of *above the plate* increased systematically with age, with 63% of age group four utterances using it. Likewise, the production of *over the plate* to describe these scenes also increased with age consisting of 24% of the utterances from age group four. Conversely, the production of the phrase *on top of the plate* to describe these scenes diminished with age. One further observation with this data is the relatively high rate (25%) of ambiguous/errors/non-responses from age group one for these scenes.

The main question to be answered for these scenes was when the children referred to the plate, whether they produced the same preposition when the other objects were absent as they did when they were present. The data were categorised in the following way: For the scenes where other objects were absent, all the utterances (except the errors) referred to the plate in a single prepositional phrase. The prepositions produced were the same as for the bowl (presence-absence) data (as seen in Table 3.9 on page 154 above) and therefore were all placed into the same five categories of *in*, *on*, *on top of*, *over* and *above*.

The data used to compare these scenes were taken from the static, continuous scenes for heights two and three from the previous (plate) data set. The data were re-categorized in an identical manner for all the single prepositional phrases that mentioned the *plate*. Those single prepositional phrases that mentioned the *oranges* [*apples, blocks, balls*] were placed in the errors, no-plate response category. For two prepositional phrase responses, the preposition paired with the word *plate* was classified according to the preposition produced, irrespective of where it occurred in the utterance. Again, due to the large range of prepositions produced, inferential analysis was not possible.

Table 3.15. The Percentage of Utterances of Prepositions Occurring with the Reference Object Plate for Scenes Involving the Presence or Absence of Other Objects, Subsidiary Manipulations from Experiment 1.

	In (84 utterances)				*On* (294 utterances)				*On top of* (136 utterances)				*Above* (280 utterances)				*Over* (99 utterances)			
Age Group:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Presence (H2)	38	31	14	4	55	62	75	72	7	7	8	12	0	0	3	7	0	0	0	5
Absence (H2)	9	1	0	0	18	25	3	0	36	15	22	5	23	47	58	68	14	12	17	26
Presence (H3)	29	23	16	10	71	65	75	69	0	12	6	12	0	0	3	6	0	0	0	4
Absence (H3)	8	0	1	0	17	18	0	0	40	23	23	5	19	47	59	70	15	13	17	25

Total number of plate utterances:

Group 1, height 2: presence = 42, absence = 56; height 3: presence = 38, absence = 52.

Group 2, height 2: presence = 55, absence = 68; height 3: presence = 52, absence = 62.

Group 3, height 2: presence = 36, absence = 72; height 3: presence = 32, absence = 71.

Group 4, height 2: presence = 57, absence = 76; height 3: presence = 51, absence = 73.

However, descriptive statistics were again revealing. By looking at Table 3.15 above we can see that children of all ages produced different prepositions to describe the scenes where there were other objects present than when the other objects were absent. The younger children mainly produced the prepositions *on* and *in* when other objects were present, with *on top of* largely being produced when they were absent in a similar manner to the bowl scenes. They also produced a wider range of prepositions for the scenes when the other objects were absent. The older age groups produced mainly *on* when other objects were present, with *above* and to a lesser extent *over* being produced for scenes where they were absent. There was little difference in the pattern of responding for heights two and three.

3.2.6. Discussion

It can be argued that the use of a video methodology involving puppets in a game task allowed children to produce utterances that are realistic and similar to the way they would normally produce language. The utterances produced were extremely varied both within and between age groups. Most notable was the developmental difference in the length of utterances produced. Older children produced longer utterances involving two prepositional phrases more of the time. This developmental difference in the length of utterances has been noted in previous studies using a free response paradigm (e.g., Plumert et. al., 1995). The range of prepositions produced by the children maps onto what is already known about acquisition, with *in* and *on* being produced by all children, while *above* and *over* were uttered more frequently by the older children. The data, therefore, suggest that the task is a reliable barometer of production, although we note that the scenes to be described were restricted to a limited range of objects.

As this study used a different methodology to the sentence completion and sentence rating studies of Coventry and Garrod et al., some comments in relation to the difference between these studies are merited. Children in this free response paradigm produced the preposition *in* with the reference object *bowl* between 88 and 92 percent of the time. This suggests that children do not naturally produce other prepositions to describe the relative position of an object and a bowl, therefore a different type of analysis to that used with adults was required for the children. The use of first mention as a means of analysis is supported by the differences reported by researchers such as MacWhinney (1977) and Flores d'Arcais (1987), and indicates that attentional focus is an important parameter to examine when children are describing visual scenes.

One of the aims of this experiment was to assess whether young children begin by using spatial language in a highly geometric manner with extra-geometric aspects developing later, or whether extra-geometric information has an early influence on children's utterances. Children in all age groups illustrated knowledge of geometric relations in that higher piles were associated with lower production of *in the bowl* as the first (or only) prepositional phrase, with older children displaying this to a greater extent than younger children. In itself, this finding could be evidence for a geometric component, or for a functional component. When the target object is enclosed in the container, locational control is also present; as mentioned previously the higher the pile, the more likely it is that the target object will fall out should the reference object be moved (as has been reported by Garrod et. al., 1999). We therefore need to examine the extra-geometric manipulations before we can assess what children are likely to be doing.

Even children in the very youngest age group (range 3;4 to 4;5, mean 4;1) not only produced *in the bowl* as their first (or only) prepositional phrase according to the geometric relationship depicted in the scene, but also depending upon whether or not a bowl was successfully fulfilling its containment function. This finding mirrors the effects

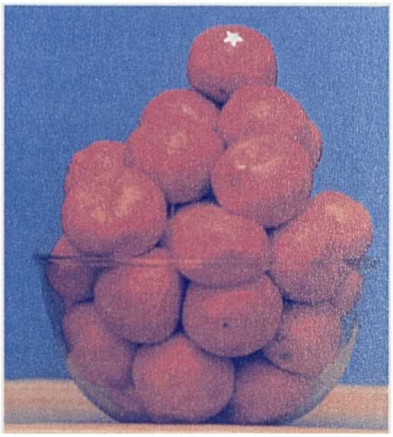
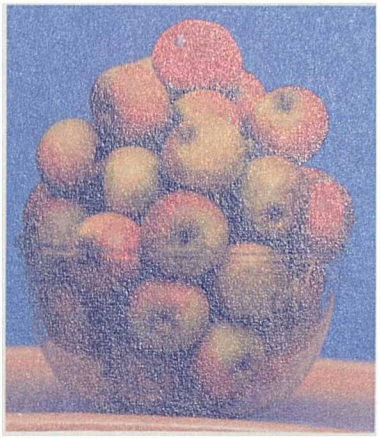
found for adults (Coventry, 1992, 1998; Garrod, Ferrier & Campbell, 1999), and strongly suggests that extra-geometric relations are important early on in learning how to produce prepositions appropriately. However, an interaction was also found between geometry and locational control such that effects of locational control were present only when the target was located outside the space that the bowl occupies (i.e., at heights 2 and 3). This pattern again fits with those reported for adults and could be interpreted as evidence that locational control only comes into play when the geometric construct of enclosure does not clearly hold (as has been suggested by Landau & Munnich, 1998). However, as already stated, when the target is contained inside the bowl locational control and the geometric constraint are both at their optimum, and therefore it is too early to conclude that locational control only comes into play when the geometric constraint does not clearly hold. Moreover, a significant interaction was also found between age group and height of pile. The higher the height, the less the children produced *in the bowl*; but this distinction became greater as the age group of children increased. If geometry was the primary construct, one would not expect this distinction to show an age trend.

However, other findings in the present study suggest that the Landau and Munnich position is unlikely to be the case. When other objects were present beneath the target object and in contact with the container or plate, *in* (for the *bowl*) and *in/on* (for the *plate*) were produced considerably more than when no objects were present. This finding occurred across all age groups. If geometry was primary for young children acquiring language, then one might expect that the production of *in* when the target object was located outside the space the container occupies would be less frequent than when the target object was directly enclosed, and that this would not be influenced by the presence of other objects in the container. The effect of presence/absence of other objects clearly implicates a locational control explanation. When other objects are present, the force of gravity allows the objects underneath to constrain the location of the target object, and as

some of these objects are directly constrained by the bowl, the target object is (transitively) constrained as well.

Reflecting the findings in the adult literature (Coventry 1998), the other objects in the spatial scene also influenced the children's choice of prepositional phrase. Children in all age groups produced the prepositional phrase *in the bowl* as the first (or only) phrase significantly more when the other objects in the scene were the same than when they were different. These findings can be explained in terms of perceptual salience in relation to the notion of tolerance (i.e., the permitted deviation of the use of a word from its ideal meaning; Herskovits, 1986). When the target object (e.g., an orange) is the same as the other objects in the bowl (e.g., more oranges), the perceptual salience of the other objects is low (see illustration in Figure 3.11 below). The target object perceptually "blends in" with the other objects *in the bowl* and *on the plate* due to the similarity of those objects (e.g., in colour, texture, shape etc). Therefore, the objects are naturally grouped together as *oranges in the bowl/on the plate*. However, when the target object (e.g., an orange) is different to the other objects in the bowl (e.g., apples), the perceptual salience of these other objects is highlighted and so, too, the support that they afford the target object is also highlighted. Therefore, the objects are not grouped together as being *in the bowl/on the plate* due to the highlighted support relationship.

Figure 3.11. The Relative Salience of the Located Object and Other Objects in the Bowl and on the Plate

Examples of Continuity Scenes	Examples of Discontinuity Scenes
	
	

Furthermore, the interaction between continuity and locational control provides evidence that the presence or absence of continuity is difficult to override. When continuity is present (i.e., an orange on top of other oranges), locational control of the bowl was found to increase the production of *in* as first (or only) mention and non-locational control had no effect. Conversely, when discontinuity was present (i.e., an orange on top of apples) non-locational control of the bowl decreased ratings while locational control had no effect. This pattern suggests that locational control associated with continuity is so strong that even when the target is moving of its own accord, it is still regarded as being controlled by the pile. On the other hand, when discontinuity is present locational control is so clearly absent that movement together of target object and the rest

of the pile is not enough to affect usage. This provides important evidence that, for children at least, perceptual salience and locational control are difficult to separate.

Overall, the results show that young children are aware of and use both geometric and functional constraints when describing the relative positions of objects to containers and supporting surfaces. The children selected for the youngest age group in the present study were selected to be able to produce relevant prepositions, but only just. Indeed, during a pre-test, two of the youngest children in age group one could not be used in the main study as they exclusively used the preposition *in* to describe all the spatial arrangements. The ideas that geometry is the primary determinant of spatial language production and comprehension in adults, and that extra-geometric factors extend geometric regions (Landau & Munnich, 1998) would not appear to be supported by this data. It might be expected that children would be sensitive only to the geometric properties of scenes when they begin to acquire a prepositional lexicon if geometry is primary. Indeed they are sensitive to geometric properties of scenes, but this sensitivity increases with age and they are also sensitive to manipulations of locational control and continuity. The data therefore support the idea that *in* and *on* both involve a geometric and a functional component. However, the results, as noted earlier, were found only for containers and supporting surfaces which have particular functions. There are many cases of *in* where geometry does seem to dominate and where locational control seems less applicable (e.g., the marble is in the circle), and conversely there are cases where functionality seems to dominate (see Coventry, 1999). Developmentally it is of interest to examine whether children begin to produce *in* in cases that involve both a geometric and a functional component, or just in cases which involve either component in isolation.

Before we go into a more general discussion about extra-geometric factors and topological prepositions it must be remembered that this experiment involved a limited range of scenes and manipulations. Moreover, the aspect of locational control for the

preposition *on* was only assessed by looking at the differences in children's utterances for scenes that involved contact via other objects on the plate and those that involved a no contact relation. As such, we need to consider a wider range of relations before any generalisations can be drawn. Therefore, Experiment 2 focuses on locational control and geometry for the preposition *on*, along with one further extra-geometric factor, that of object association.

3.3. Experiment Two; a More Detailed Examination of *on*

As we saw in Chapter 1 of this thesis, most approaches to the preposition *on* suggest that it is the contiguity of located and reference objects that underlies the preposition *on* along with the view that the reference object needs to be canonically horizontal in order for it to support the located object (e.g., Herskovits, 1986; Miller & Johnson-Laird, 1976). Looking at the concept of locational control for the preposition *on*, this suggests that support carries an important functional component such that when one object is on top of another, the object underneath serves the function of supporting the object on top. Additionally, objects tend to move with supporting surfaces when those surfaces are moved (e.g., Garrod & Sanford, 1989; Garrod et. al., 1999).

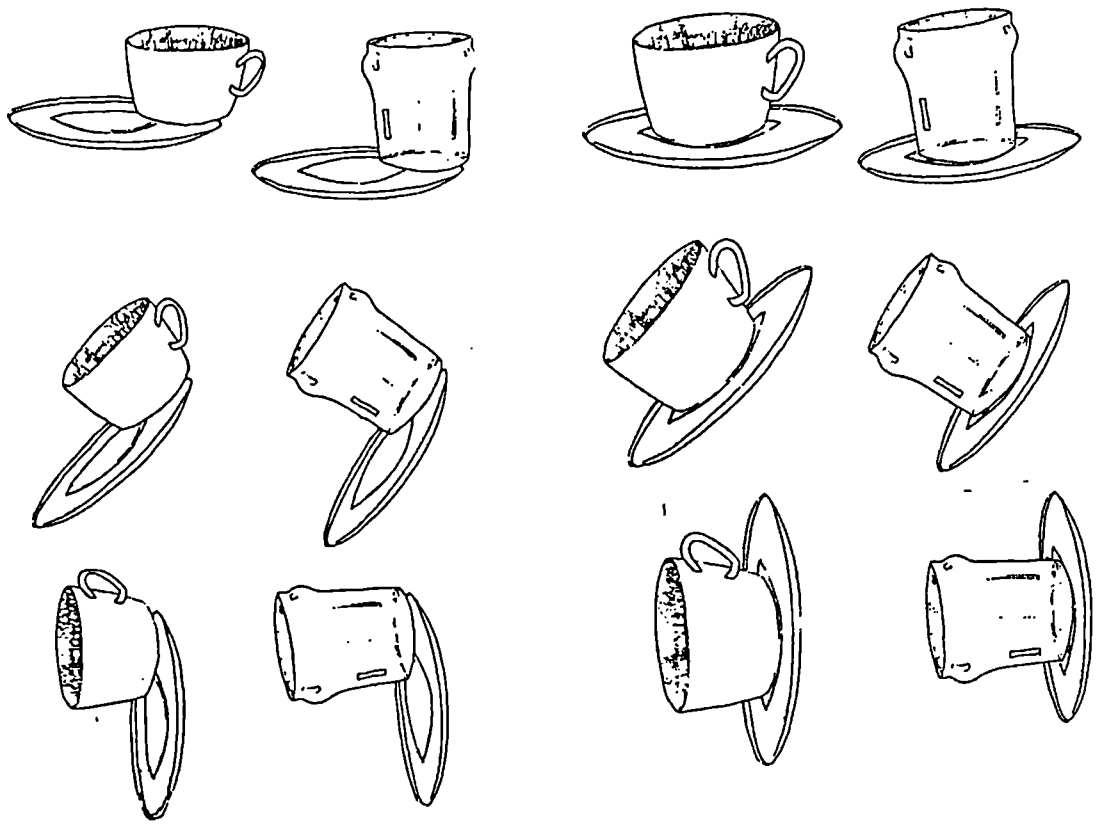
As reviewed earlier on in Chapter 1 and in the introductory section of this chapter, evidence for the functional support component for the comprehension of *on* with adults comes from a variety of sources (e.g., Coventry, 1992; Coventry & Prat-Sala, in press; Garrod et. al., 1999). For example, when Garrod et. al. (1999) showed adults scenes involving secondary support of a target object on a plank (e.g., a chain attached to the target object from a source above), their ratings of the use of *on* to describe the position of

the target object to the plank reduced significantly when the alternative control was strong, i.e., when the chain was taut. Additionally, there was a strong positive correlation between the ratings of *on* for these adults and the degree to which a second group of adults judged the relation between the weight and the plank to be stable.

Experiment 2 was designed to look further into the notion of locational support and to explore the extra geometric aspect of object association using a production methodology with both adults and children. Before we look further at Experiment 2, we will begin by reviewing the findings obtained by Coventry and Prat-Sala (in press) that assessed these factors for adults' comprehension of *on* and formed the basis of this experiment.

Recall that accounts that regard geometry as central often assert that it is the contiguity of located and reference objects and the fact that the reference object needs to be canonically horizontal to support it that underlies the preposition *on*. Therefore, if the located and reference objects are a cup and a saucer and if the saucer were to be tilted away from its canonical horizontal axis, then *on* would become less appropriate to describe the position of the cup to the saucer. However, according to accounts that emphasise geometry, it would not matter *where* on the saucer the cup is positioned, the very fact that the cup is contiguous with the saucer should be sufficient for it to be deemed *on*. The accounts that emphasise functional aspects of *on* would suggest differently; if the saucer were to be moved, the cup might fall off if it is positioned to the side rather than in the middle of it. Recall also that previous research has found that object association between located and reference objects can affect adults' comprehension of prepositions. For example, Coventry, et. al. (1994) found that *in* was rated as more appropriate to describe an object on the top of a high pile of other objects (solids) when the container was a bowl rather than when it was a jug and that the addition of liquid to both containers made this relationship more salient.

Figure 3.12. Examples of the Scenes Manipulating the Position of the Reference Object, the Position of the Located Object and Object Association between Located and Reference Objects.



Note: Illustration taken from Coventry and Prat-Sala (in Press).

Coventry and Prat-Sala (in press) showed adults scenes that systematically manipulated the position of the located object on the reference object (in the middle or the edge) and position of the reference object (horizontal, 45° and 90° rotations), see Figure 3.12 below. An additional manipulation of object association (e.g., fish and plate versus brick and plate) was made. Not only did the adults' produce the preposition *on*

significantly less when the reference object was tilted away from the horizontal axis, but also when the located object was positioned on the edge of the reference object.

Object association effects were also found. When the located object was positioned at the edge of a horizontally oriented reference object and object association was low (e.g., a brick and a plate), *on* was rated significantly higher than for a similarly positioned highly associated object (e.g., a fish and a plate). Therefore, when locational control is doubtful, the less appropriate figure appeared to highlight the support relationship while the appropriate figure made salient the possibility that locational control did not hold. Coventry and Prat-Sala (in press) also report identical findings with a different sense of *on* where no uniform horizontal plane and a part-enclosure relationship were present (e.g., a hat on a head versus a pan on a head).

Experiment 2 in this thesis aimed to look at whether the production of *on* is similarly affected. As no data for this have been collected with adults for the production of *on* with these specific manipulations, the utterances of both children and adults were examined. Although the free-response game-playing paradigm proved highly successful in Experiment 1 with children, it did produce a large amount of variation in the data that caused certain problems when coding that data for inferential statistical analysis. For example, children's use of different nouns with which to describe the objects (e.g., calling a plate *dish*) sometimes meant that *in* was used instead of *on* for a support relation. Additionally, there was the problem of the large difference in the sophistication of utterances across age group whereby the utterances *on top of a whole pile of apples that are in a glass bowl* (age group 4 child) and *on top apples* (age group 1 child) potentially meant the same thing, but extra considerations needed to be made. Additionally, the use of a game-playing scenario could not be used with older children and adults. Although the older children in Experiment 1 were happy to join in the game with the puppets, children of 9 or 10-years and adults would find this task patronising. Therefore, in order to

standardise the experiment across age groups and to make a close comparison with the comprehension study (Coventry and Prat-Sala, in press), a sentence completion paradigm was used. The task required participants to complete a sentence in the form of "the located object is _____ the reference object". A similar paradigm has proved highly successful with adults (e.g., Coventry, 1992, 1998) although it has not been used extensively to assess spatial language in children.

3.3.1. Selection of Materials

The materials used in this experiment were based on those used in the comprehension study by Coventry and Prat-Sala (in press), but alterations were made given that young children would be participating. For example, Table 3.16 below displays the original materials for the comprehension study. It was thought that young children would not know what a beer-glass, a record, or a turntable were. Therefore, alterations to the Coventry and Prat-Sala materials took into account the age groups of children that would be participating. For Experiment 2, the objects considered to be low-association objects were chosen to be as close in size and shape as those where object association was thought to be high. Additionally, in order to check that there was indeed a difference in association between the sets of materials, a pilot study was run.

Table 3.16. The Two Sets of Materials used by Coventry and Prat-Sala (in press)

High Object Association	Low Object Association
Cup and saucer	Beer-glass and saucer
Fish and plate	Brick and plate
Record and turntable	Pizza and turntable
Pan and cooker	Book and cooker

Pilot Study

Seventeen adults were given a list of object pairs and were instructed to rate how associated each pair of objects were. The sheet contained the following instructions:

> *Below you will see a variety of objects put together in pairs. Your task is to rate how associated you think each pair of objects is. That is, how much each object in the pair is usually associated with the other object in the pair. For example, a computer and a mouse can be considered as a high association pair whereas a television and a mouse may be considered as a low association pair. Please use the scale 1-7 on the right of each object pair to make your rating where 7 = high object association and 1 = low object association. Please feel free to use any number on the scale to grade each pair of objects*

The order of the object pairs was randomised with an additional check that no two pairs of objects containing the same reference object were presented sequentially. The data were analysed using a 2 (object association: high or low) x 4 (reference object: saucer, plate, breadboard and cooling rack) within participants analysis of variance. Table 3.17

below displays the materials and the means and standard deviations for each pair separately. Table 3.18 displays the ANOVA results.

Table 3.17. The Materials Proposed for Experiment 2 with the Means and Standard Deviations for Each Object Pair.

High Object Association	Low Object Association
Cup and saucer (Mean:6.9, SD:0.3)	Apple and saucer (Mean:2.4, SD:1.3)
Cheese and plate (Mean:5.2, SD:1.4)	Camera and plate (Mean:1.3, SD:0.8)
Bread and breadboard (Mean:6.8, SD:0.6)	Brick and breadboard (Mean:1.2, SD:0.7)
Cake and cooling rack (Mean:5.7, SD:1.4)	Plant pot and cooling rack (Mean:1.1, SD:0.3)

Table 3.18. The Results of the Analysis of Variance for the Rating of the Materials Proposed for Experiment 2.

Source	df and F value	MS(error)	F
OBJECT ASSOCIATION (O)	F (1,16) = 991.01	0.74	****
MATERIALS (M)	F (3,48) = 22.18	0.62	****
O x M	F (3,48) = 4.15	0.13	*

Note. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

As can be seen from Table 3.18, there was a main effect of object association. Independent ratings agreed that the pairs of materials selected for this experiment did indeed differ significantly in their association to one another (means were 6.13 for high associated objects and 1.50 for low associated objects). There was also a main effect of materials. The follow-up analysis showed a significant difference between the ratings for the material sets apart from the cooling-rack and the plate sets. There was also a significant interaction between materials and object association. Follow-up analysis showed that the differences between high associated object pairs and low associated object pairs were all significant; however, there were additional significant differences between some of the high associated object pairs, and between some of the low associated object pairs. As this would not affect the outcome of the study, all the materials rated were subsequently used in Experiment 2.

3.3.2. Method

3.3.2.1. Design

A 5 (age group) x 2 (angle of reference object: canonical or rotated) x 2 (position of located object: central or on the edge) x 2 (object association: low and high) partial within-participants design was used for the main manipulations. Age group was the between participants variable with angle of reference object, position of located object and object association as the within-group variables.

3.3.2.2. Manipulations

This experiment used eight target objects with four reference objects (see Figure 3.13 below). The variables manipulated were:

1. Object Association

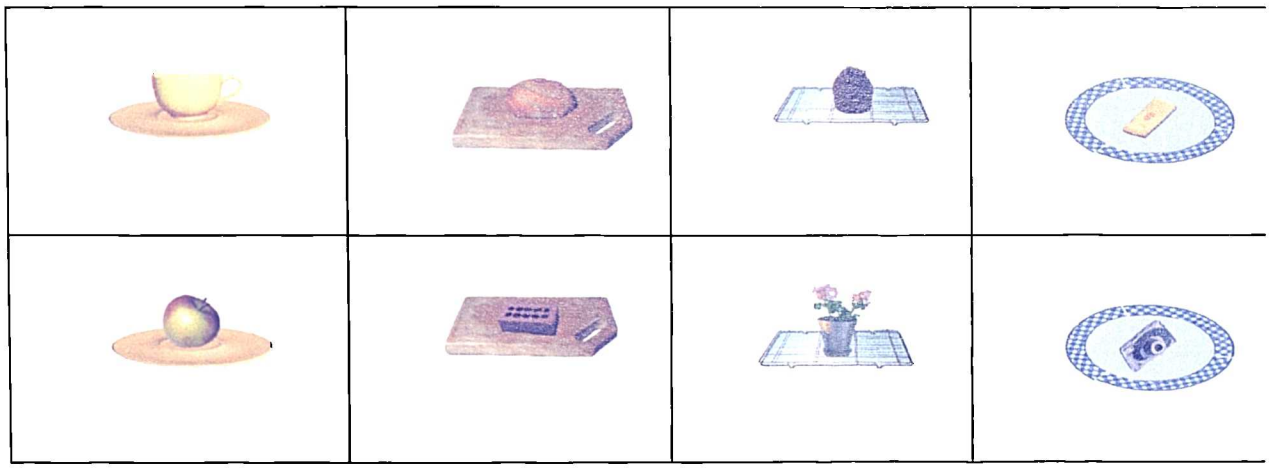
Two levels of object association were manipulated; pairs of objects were of either a high association or low association to each other.

In a similar manner to the comprehension study (Coventry and Prat-Sala, in press) four reference objects were chosen along with four associated located objects (see Figure 3.13 below for a full set of materials). These were chosen to be as similar as possible to those in the comprehension study while at the same time familiar to adults and young

children alike. These were a cup and saucer, bread and breadboard, a cake and cooling rack and a chunk of cheese and a plate.

A further four target objects were chosen that were considered to be of a low association to the reference objects. These were an apple, a brick, a plant pot and a camera and were chosen not only because they had a low association to the reference object, but also because they were of comparable size and shape to the more highly associated objects. Independent ratings of the pairs of objects agreed that they were significantly different to one another in terms of object association.

Figure 3.13. The Four High Associated Pairs and Low Associated Pairs of Objects Used in Experiment 2.



2. Angle of the Reference Object

Two levels of angle of the reference object were displayed; the first level was where the objects were presented in their canonical position (as in Figure 3.13 above), the second where the reference object was rotated from its central axis by 66° (for a full set of manipulations used see Figure 3.14 below).

3. Position of the Located Object

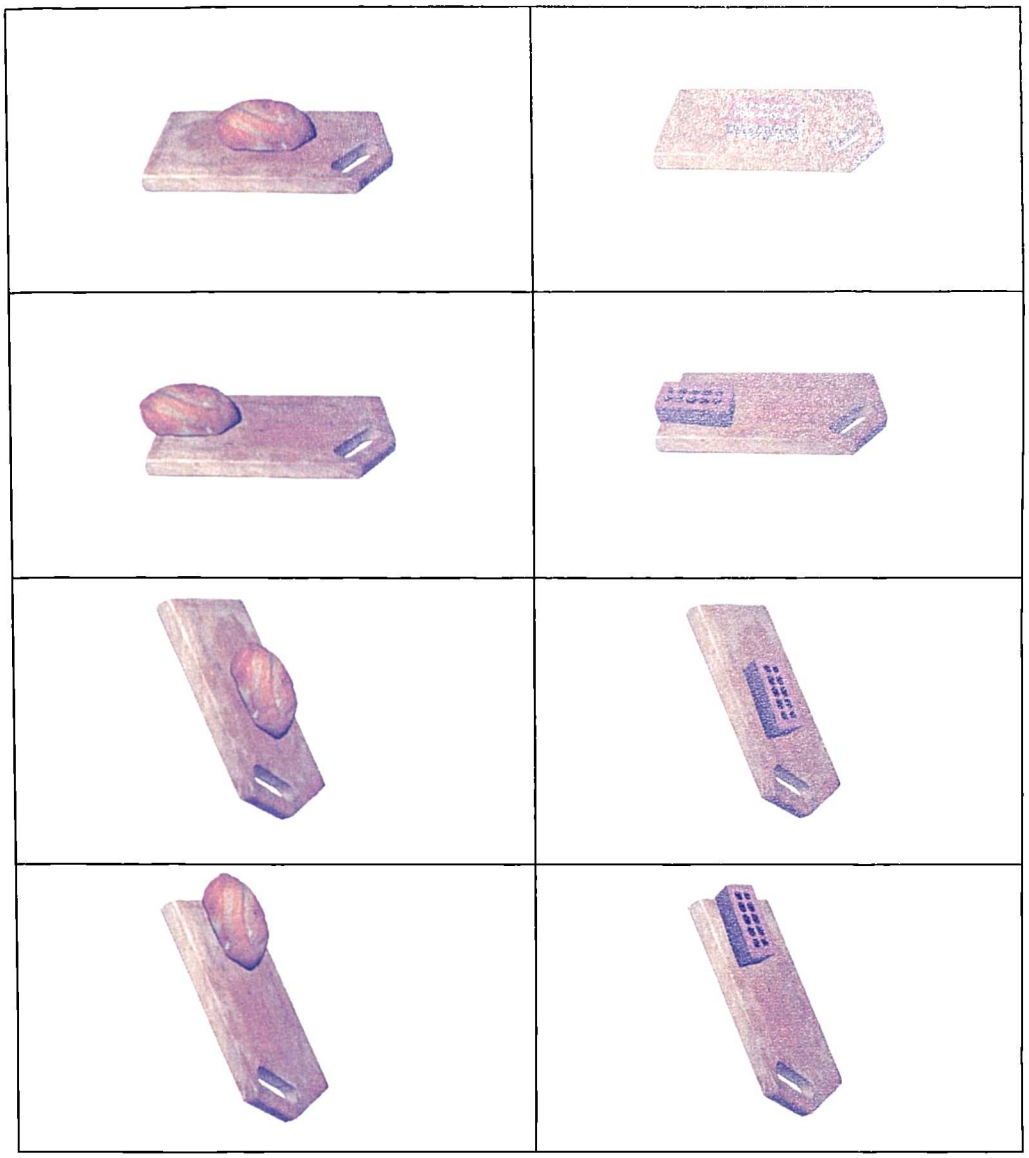
Two levels of position were made; the first where the located object was positioned centrally, the second where it was positioned on the edge of the reference object (see Figure 3.14 below).

3.3.2.3. Participants

One hundred and fifty two adults and children across five age groups participated in the experiment. All participants were native English speakers with normal, or corrected to normal, eyesight and hearing. None of the participants had previously taken part in any research of a similar nature.

The adults (n=38) were students, and the four groups of children came from a school located in a large town. The age groups were selected to begin at a similar age to those in Experiment 1. The youngest age group of children came from a nursery unit attached to the same school together with a few children from the reception class of that school. The mean age for the youngest group was 4;3 (n=26, range 3;5 to 5;1), for group 2 it was 6;7 (n=31, range 5;11 to 7;2), for group 3 it was 8;4 (n=30, range 7;11 to 8;10) and for group 4 it was 10;8 (n=31, range 10;0 to 11;1).

Figure 3.14. The Manipulations of Object Association, Angle of the Reference Object and Position of the Located Object in Experiment 2.



3.3.2.4. Materials

Individual colour photographs were taken of the four reference and eight located objects as previously described. The photographs were scanned individually into a

computer and placed onto a white background where they were subsequently edited together to form the pictures used in the experiment.

Each spatial scene manipulation was edited together four times (once with each of the four object pairs). This resulted in 32 individual spatial scenes (see Appendix 6 for the full set of pictures used in this experiment). The scenes were interleaved with scenes from another separate experiment[8] along with a variety of cartoon faces that appeared for one second after each picture to keep the children's attention and to act as a distracter from the previous spatial scene. The interest of the youngest two age groups was maintained by playing a guessing game using these cartoon faces; for example, the experimenter asked the child to guess the hair colour of the next cartoon face to appear.

The pictures were displayed on the screen with the aid of a computer program. The program was designed to use block randomisation to reduce carry-over effects; this comprised of four blocks of pictures each containing one picture of the eight spatial manipulations. As each participant's identification number was entered into the program, it automatically randomised the pictures within each block. It then changed the order that the blocks were displayed in[9]. This process was carried out for each participant until all the possible orders of the blocks were used for each age group before going back to the original order of blocks and starting again. All this took place before the participant began the experiment. If the participant was a child, the program stopped running after the first two blocks and subsequently began where it had left off when the participant's details were re-entered later. None of the participants were aware of the four blocks. The pictures were

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[8] Twenty-four scenes from Experiment 5 (reported in Chapter 4 of this thesis) were interleaved with these from Experiment 2 for the adults. The children viewed scenes from Experiment 6 (reported in Chapter 5 of this thesis). The scenes from the filler experiment were not expected to produce any carry-over effects that would affect this Experiment; a check was made afterwards that showed this to be so.

[9] This process was carried out by the computer program each time a participant was run until all the possible orders of the blocks were used for each age group, at which point the program went back to the original order of blocks and started again.

displayed in full colour along with the sentence to be completed on a 15" Dell Inspiron 7000 laptop computer screen. The experimenter recorded the participants' responses using a separate keyboard.

3.3.2.5. Procedure

As the remainder of the experiments reported in this thesis used the same procedure as described here for Experiment 2, we will explain it in detail here and refer back to it as necessary when reporting subsequent experiments.

Each participant was tested individually at his or her own school or university. The experiment was divided into two sessions for the children (lasting between 5 and 10 minutes each with no more than 7 days between sessions). Adults completed the experiment in a single 15-minute session. Each participant sat at a table with the experimenter to their right.

The first session began with an introduction. This introduction was used for all but the very youngest group of children. The introduction and procedure given to them was modified only slightly so as to reflect their lack of understanding of particular words used, such as the word *sentence*[10].

For the oldest four groups, each participant was shown the 15" computer screen as the experimenter explained the task. They were told that they would see a variety of pictures on the screen. They were shown a card with individual pictures of the objects used in the experiment printed on it in black and white and were asked to name each

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[10] Before testing, three children from the same school of a comparable age to the youngest age group participated in a small pilot study. It was discovered that a slight modification of the instructions and procedure was needed to enable these children to understand the task and respond with utterances fitting the sentence completion task.

object separately. All children were able to do this without hesitation. The experimenter then said;

> *With each picture, there will be a sentence that will have a gap in it (the experimenter showed them a card with example sentences). Above each sentence is a question. The question will ask you where something is in the picture and I want you to help me to fill in the gap the best way you can to describe the picture you see. In between each picture, there'll be a cartoon face on the screen, but you need to keep watching or you'll miss it! Shall we have a practice?*

The experimenter then showed the participant a card with a black and white picture printed on it (a can of beans in a cup, see Appendix 7) and a sentence to complete (the can is ____ the cup). The purpose of this was to check that each participant knew what was required of him or her before the task began. All of the participants were able to complete the sentence so that it described the picture.

As previously mentioned, the youngest group of children were unable to understand such sophisticated instructions. After discussions with their teachers and trying a few simple modifications to the instructions with three children of comparable age from the same school, the experimenter used the following instructions for each child from youngest age group after they had named the objects on the card:

> *We're going to look at some pictures now and I want you to help me find some words to SAY where things are in the picture. In between each picture, there'll be a cartoon face on the screen, but you need to keep watching or you'll miss it! Shall we have a practice?*

The experimenter then showed the participant the card with a black and white picture printed on it (a can of beans in a cup) and a sentence to complete (the can is ____ the cup) and said:

> *Look! There's a can of beans (pointing to can) and there's a cup (pointing to cup), can you TELL me where the can is?*

Usually, the child would respond with the simple sentence *the can is IN (INSIDE) the cup*. If the child had trouble with the task, the experimenter repeated the question. All of the children were able to construct the sentence so that it described the picture with ease.

For the oldest four age groups, during the experiment, each time a picture was displayed the experimenter pointed to the screen and read aloud the question and sentence. The experimenter then asked the participant for a word or words to put in the sentence to make it describe the picture. If a child did not respond after a few seconds, the experimenter encouraged the child to respond by asking, *what are you thinking*? If a child appeared to be struggling for an answer, the experimenter showed them the next picture. If a child continued to struggle with the task, the experimenter ended the session by thanking the child for their help.

For the youngest age group the experimenter repeated the original request, and for each picture displayed on the screen said, *Look! There's an X* (pointing to X) *and there's a Y* (pointing to Y), *can you TELL me where the X is?*. If a child struggled to give an appropriate answer, the question was asked again. If any child continued to struggle with the task, they were thanked and the session was ended.

Although all of the participants were able to complete the trial sentence "the can is _____ the cup", or in the case of the youngest age group produce an appropriate sentence to describe the scene, thirteen children failed to complete the main task. This consisted of

six (25%) from age group one (mean age 4;4), five (16%) from age group two (mean age 6;7) and two (7%) from age group three (mean age 8;4). None of the children in age group four (mean age 10;8) or any of the adults had a problem completing the task. The main reasons for failing the task were that either the children focussed upon what was happening in the picture rather than on where things were, despite being encouraged to concentrate on the latter, or that the child did not know a word to use in order to complete the sentence. In the youngest two age groups there was also a tendency for the children to merely point and say *there*, although completely failing the task because of this was relatively uncommon (two in the youngest age group and one from age group 2 produced too many of these responses for their data to be useful). As all the participants demonstrated an understanding of the nature of the task prior to the experiment, the sentence completion task itself was not considered to have been the problem.

3.3.3. Results

The responses for each of the participants were placed into a spreadsheet for later coding (see Appendix 8 for an exhaustive list of categories, percentage and number of utterances by age group). It is apparent looking at Appendix 8 that this free response sentence completion paradigm still led to a great degree of variation within the data, although to a much lesser extent than with the free response paradigm used in Experiment 1. Again, much of this variation was due to fine-grained differences within responses. A summary of the main responses (>1% in any one age group[11]) is displayed in Table 3.19 below. The majority of the completions comprised single prepositions or single

[11] Note: As Table 3.19 contains only data that comprises >1% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 8 for full breakdown.

Table 3.19. Percentages (and Number) of Utterances of Main Completions (>1% in Any One Age Group) For Experiment 2

Completions	Age Group 1 (mean 4;4, n=20)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=38)
On	58% (369)	81% (671)	74% (664)	67% (664)	60% (728)
Sitting on	0	0 (1)	0 (1)	2% (16)	0
On top of	10% (62)	9% (71)	4% (39)	3% (25)	5% (58)
On the top of	0 (3)	1% (7)	1% (6)	1% (6)	0 (4)
At the top of	0 (2)	0	0 (1)	1% (10)	2% (20)
At the edge of	0	1% (8)	5% (46)	11% (105)	6% (67)
On the left of	0	0	0	0 (3)	2% (29)
On the left side of	0	0	0	0 (2)	1% (7)
On the left hand side of	0	0	1% (5)	0 (3)	3% (35)
To the left of	0	0	0	0	1% (16)
On the end of	0	1% (7)	1% (12)	1% (5)	0
On the side of	3% (18)	3% (21)	3% (26)	3% (32)	2% (29)
To the side of	0	0	0	0	1% (8)
At the side of	2% (13)	0	0 (1)	0	0 (4)
In the middle of	7% (42)	3% (29)	7% (66)	9% (86)	9% (115)
On the middle of	0 (1)	0 (1)	1% (8)	0	0
In the centre of	0	0	0	1% (5)	4% (52)
Next to	5% (29)	0	0	0 (1)	0
On to	3% (21)	0	0	0	0
In	5% (31)	0 (1)	0	0 (1)	0
Lying on	0	0	0 (2)	1% (9)	0
At	1% (5)	0	0	0	0
Near	0 (3)	0 (1)	1% (5)	0	0
Errors	5% (35)	0 (3)	0 (2)	0	0

prepositional phrases; only 10 completions contained two prepositional phrase utterances, nine of which came from the adult group. Following from Experiment 1, and continuing throughout the thesis, any response containing more than one preposition or prepositional phrase will be categorised according to the first mention criteria for any inferential analysis. Perhaps unsurprisingly, as we can see from Table 3.19, *on* was the most common preposition produced to describe the relation between the target object and the reference object. Additionally, *on top of* was produced by all age groups, but especially by the youngest age groups. Very few children talked about the location of the reference object using the directional term *left*. This term was almost exclusively an adult term with 7% of adult's completions using it. Only 1% of the completions by the older two age groups (means 8;4 & 10;8) included the term *left*. Adults and children alike (although proportionally different) also talked about the relation of the located object and reference object by focussing on the position of the target object on the surface of the reference object. For example, *at the edge of* (for the older groups) and *at the side of* (for the youngest group) clearly defined the position of the target object in terms of its location on a plane, as does *in the middle of*. There were few errors. Those present came mainly from the youngest age group and consisted of utterances such as *there*, *up there* and *upside-down*. Any completion that did not form a true sentence was considered an error.

Looking at the data overall, as is clear from Table 3.19, a general pattern of responding became apparent. The position of the located object to the reference object was usually defined in one of two ways. The description either focussed on the contiguity/support relationship between located and reference objects, for example *the cup is <u>on</u> the saucer*, or concentrated on the location of the target object on the surface of the reference object, for example *the cup is <u>on the edge of</u> the saucer*. There were other types of completions that discussed the position of the target object using projective prepositions such as *next to* and *beside* or proximity terms such as *near*, but these were relatively few

in number (2% of the entire data collected). Although this was a different way of conceptualising the scene, participants were still describing the relationship between target object and reference object quite differently to simple *on* descriptions; this point will be considered later on in the chapter.

In order to discover whether the manipulations made in this experiment contributed to the main distinction adults and children made, this analysis looked at when children and adults produced simple *on* type completions versus when they produced descriptions indicating the target objects' *position* according to an area of the surface of the reference object. The data therefore needed to be classified into categories accordingly.

Classifying the data into such categories meant that certain decisions about the different completions needed to be made. As we saw in the first experiment, *on top of* can be used in various ways. It can be used where the located object is in direct contact with the reference object; but we have also seen how younger children produce it for no-contact scenes. In this experiment, perhaps participants were using *on top of* in the same manner as a simple *on* preposition would be used, or perhaps they were using it to describe the located object as being *on* the *top* of the reference object. Likewise, looking back to Table 3.19 above, we can see that completions where the definite article *the* is included usually referred to the located object being in a particular position on the surface of the reference object (e.g., *on the side of*). If it did, then the phrase *on the top of* should also be classified into this category. These important issues needed to be resolved as examples of such completions were relatively common and occurred across all age groups.

It has been suggested that, in adults, there is a tendency to interpret *on top* on the basis of environmental space, whereas *on the top* is interpreted on the basis of object space partly because of the use of the definite article in the latter (Olson & Bialystok, 1983). However, in a direct test of this assertion, comprehension tests did find that adults and children from around six-years of age onwards were sensitive to this distinction, whereas

younger children were not (Bialystok & Codd, 1987; Olson & Bialystok, 1983). Therefore, when asked to place one object *on the top of* another, more *intrinsic* responses were made than *relative/absolute* for children six-years of age and older. However, there has been no research that has investigated the difference between simple *on* utterances and *on top of* utterances. The term *on top of* can be considered ambiguous as it could mean a support relation, but it could also be used as a directional term (i.e., meaning the top; Clark, 1980) and it is quite possible that it might even have different meanings for different age groups. It was therefore decided that the data would be categorised for the analysis by including *on top of* with simple *on* completions, with *on the top of* as a *positional* completion[12].

Table 3.20. Examples of the Utterances that were Coded in Each of the Three Categories for Experiment 2.

Category 1 (*On*)	Category 2 (*Positional*)	Category 3 (*Errors, unusual responses, other*, etc)
On	*Standing on the left hand side of*	*Beside*
Sitting on	*In the centre of*	*Up in the sky*
Standing on	*On the side of*	*Above*
On top of	*In the middle of*	*Up there*
Balancing on	*On the top of*	*By*
Rolling on		*At*

[12] A check was made, by means of a second analysis, which placed *on top of* in the *positional* category. The results were broadly similar (see Appendix 4). The only difference between the two analyses was that there was no main effect of age.

Therefore, the data were categorised as follows. Simple *on* type completions were placed into category one (3,393 utterances), completions indicating an area of the reference objects surface were placed into the second category (1,029 utterances), with errors, ambiguous and non-responses being put into a third category (154 utterances; see Table 3.20 above for examples). For those completions that contained more than one preposition, the preposition mentioned first was used in the analysis. Having undertaken this process for all the participants it was discovered that the data from two children in the youngest age group could not be used as they contained too many category three responses that resulted in there being no useful data for more than one cell of the design.

Table 3.21. The Mean Percentage of *On* Completions for all Five Age Groups, N = 141, Experiment 2.

	High Object Association				Low Object Association			
	Canonical		66° Rotation		Canonical		66° Rotation	
Age Group	*Centre*	*Edge*	*Centre*	*Edge*	*Centre*	*Edge*	*Centre*	*Edge*
1 (mean 4;4)	85	84	83	82	80	87	83	83
2 (mean 6;7)	91	87	94	90	93	87	90	89
3 (mean 8;4)	86	78	82	76	83	79	83	76
4 (mean 10;8)	82	62	78	67	81	64	80	67
Adults	70	57	72	61	70	60	68	62
All Ages	82	71	81	74	81	73	80	74

The data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances (ignoring Category 3 responses) for each cell of the design and expressing it as a percentage. A four-way partial within group analysis of variance was performed on this data. The between-group variable was age (five groups

with mean ages 4;4, 6;7, 8;4 10;8 and adults). The within-group variables were object association (two levels: high association and low association), angle of reference object (two levels: canonical and 66° rotation) and position of located object (two levels: centrally positioned or positioned on the edge of the reference object). The means for the production of *on* completions are displayed in Table 3.21 above. The results from the ANOVA are displayed in Table 3.22 below.

Table 3.22. The Results from the Analysis of Variance for *on* versus *positional* Completions, Experiment 2.

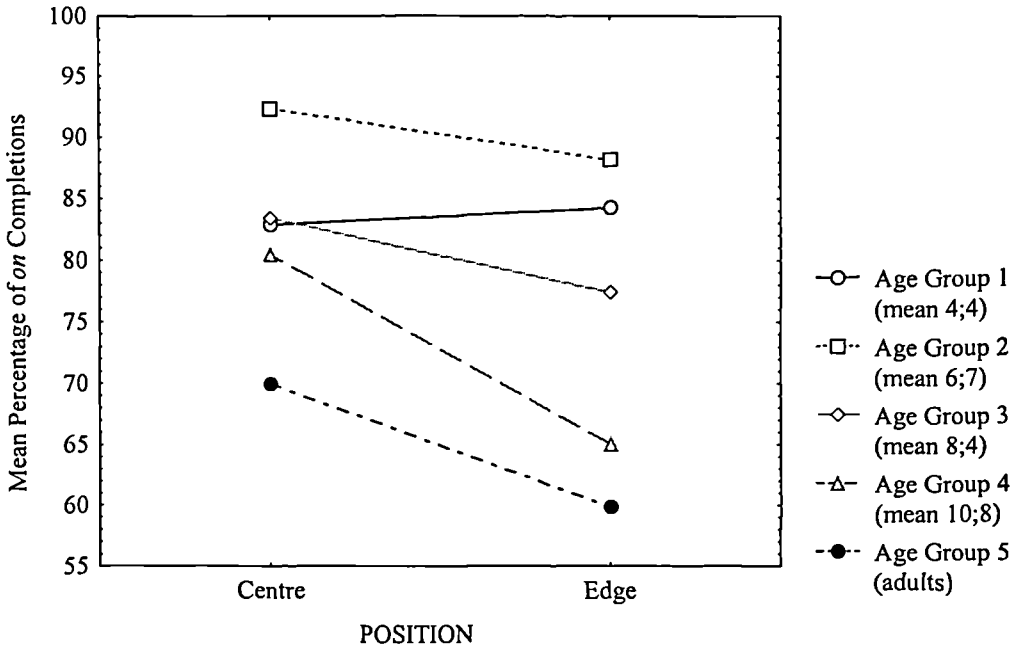
Source	df and F value	MS(error)	F
AGE GROUP (G)	F (4,136) = 2.82	8340.32	*
OBJECT ASSOCIATION (O)	F (1,136) = 0.09	80.91	ns.
ANGLE (A)	F (1,136) = 0.08	115.19	ns.
POSITION (P)	F (1,136) = 17.30	718.19	****
G x O	F (4,136) = 0.13	80.91	ns.
G x A	F (4,136) = 1.22	115.19	ns.
G x P	F (4,136) = 2.75	718.19	*
O x A	F (1,136) = 0.45	102.15	ns.
O x P	F (1,136) = 3.12	95.25	ns.
A x P	F (1,136) = 1.98	128.16	ns.
G x O x A	F (4,136) = 0.66	102.15	ns.
G x O x P	F (4,136) = 0.57	95.25	ns.
G x A x P	F (4,136) = 1.68	128.16	ns.
O x A x P	F (1,136) = 1.17	76.34	ns.
G x O x A x P	F (4,146) = 1.06	76.34	ns.

Note: $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

As we can see from Table 3.22 above, there was a main effect of age group. The mean production of *on* for each age group was 84% for age group 1 (mean 4;4), 90% for age group 2 (mean 6;7), 80% for age group 3 (mean 8;4), 73% for age group 4 (mean 10;8) and 65% for the adults. Follow-up analysis showed that although adults produced *on* completions less than the children this was only significant for age group two. However, this finding in itself can tell us little about the meaning of the preposition *on* when it was produced. As mentioned previously in Chapter 1, it has been argued that the lexical entry for *on* is specified in a geometric manner suggesting contiguity of one surface with another (e.g. Bennett, 1972; Leech, 1969). However, others argue that it is specified in a functional manner suggesting support relations and locational or functional control of the located object by the reference object (e.g., Vandeloise, 1991). The question here is whether the children and adults in this study produced the preposition *on* functionally or geometrically. This will be considered later.

No main effect of object association or angle was found. Additionally, there were no interactions involving either angle or object association. The main effect of position was significant with *on* completions being produced significantly more when the located object was situated in a central position on the reference object (means 82% versus 75%). This finding suggests that *on* was used in a prototypical manner, where an object is considered *on* more if it is placed centrally on the reference object than if it is placed to the edge of it. Additionally, a significant interaction between age group and position was found. Follow-up analysis showed that there was no significant difference between the two positions (edge or centre placements) for the youngest three age groups. However, significant differences were found for the oldest group of children (10;8) and for the adults (see Figure 3.15 below). Both adults and older children produced *on* significantly more when the target object was positioned centrally (means 70% and 80% respectively) than when it was positioned on the edge of the surface (60% and 65%).

Figure 3.15. The Significant Interaction between Age Group and Position of the Located Object, Experiment 2.



Looking at the interaction displayed in Figure 3.15, this strongly suggests that the youngest age groups of children do not make any linguistic distinction between scenes when the located object is positioned on the edge and when it is placed in the centre of the reference object, whereas adults and older children (10;8) do. However, although one interpretation is that older children and adults make a linguistic distinction according to the prototypical position of the located object to the reference object, no distinctions were made when the reference object was rotated by 66° from its canonical position. This disparity seems rather odd as one would expect that if prototypical relations are being noticed, then depicting the supporting surface at an angle should also be noticed as this is

an infringement on the typical arrangements of where objects such as these are usually located.

3.3.4. Discussion

This experiment was designed to further explore the effects of the angle of a supporting surface (either canonical or rotated by 66°), the position of a located object (either central to or on the edge of a supporting surface) and object association (high association or low association between supporting surface and located object) for the production of the preposition *on*. It was found that both adults and children usually defined the position of the located object to the reference object in two main ways. One of these ways was to focus on the contiguity/support relationship between located and reference objects, for example *cup is on the saucer* and *the cheese is sitting on the plate*. The second way was to concentrate on the location of the target object on the surface of the reference object, for example *the plant pot is on the edge of the cooling rack* and *the bread is in the middle of the breadboard*. However, occasionally they produced projective prepositions such as *next to* and *beside* or proximity terms such as *near*. These were relatively few in number (2% of the entire data collected) and were excluded from the final analysis[13].

The most surprising finding was that there was no difference in the way adults and children produced *on* when the supporting surface was canonically orientated and when it

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[13] There was a concern that by ignoring these utterances important data might be discarded. Although they only made up 2% of the data set, two children used them the majority of the time. Therefore, one further analysis was undertaken that included all of these types of completions in the second category broadening it to include *other* ways of talking about the spatial scene. The results were similar to those reported above and therefore will not be reported here.

was rotated from its central axis by 66°. Previous research investigating the comprehension of *on* found that adults rated *on* as being less appropriate for the rotated scenes than for the scenes depicting the support surface in a canonical horizontal orientation. No difference was found regarding the object association between located and reference objects for adult's and children's production of *on*. Once again, differences have been found in previous studies looking at this factor using both production and comprehension tasks (e.g., Coventry et. al., 1994; Coventry & Prat-Sala, in press).

The only significant finding in this study suggested that older children (10;8) and adults produced the preposition *on* significantly more when the located object was depicted centrally on the supporting surface than when it was depicted towards the edge of it. However, when the located object was depicted on the edge of the supporting surface, adults and older children highlighted its position on the surface of the reference object by using terms such as *at the edge of* and *on the side of*. Therefore, it could be said that in this study the older children and adults used the preposition *on* in a prototypical manner, similar to the way Meints et. al. (in press) found that 13 month old infants initially understand *on*. As we saw in Chapter 2 of this thesis (see illustration on page 58), Meints et. al. (in press) found that at the age of 1;3, children looked longer at typical *on* situations (where the located object was positioned in the middle of the supporting surface) than the atypical *on* situations (where the located object was positioned to the edge of it). However, by the age of 1;6, children looked longer at the atypical situations. This suggested that children of around 1;3 do not consider atypical *on* situations as being *on* whereas children of 1;6 do. However, if adults and older children are producing *on* in a prototypical manner, they should also have made a distinction between scenes that depicted the canonical orientation of the supporting surface and scenes that depict the supporting surface rotated by 66°. This is because the typical *on* arrangement for these types of objects is where the supporting surface is positioned horizontally. When the supporting surface is rotated,

however, this could be considered as being an atypical *on* relationship for the objects depicted.

It is interesting to note that it was the older children and adults who made the distinction (described above), rather than the younger children in this study, bearing in mind that children are sensitive to such prototypical spatial relations during their second and third years of life (e.g., Meints et. al., in press; Sinha, 1982). As we saw in Experiment 1, children as young as 3;4 made verbal distinctions according to the manipulation of continuity/discontinuity with *on*. Recall that the children in Experiment 1 produced the description *on the plate* as the first (or only) prepositional phrase when asked to describe the location of a target object to a plate more when the other objects in the scene were the same rather than when they were different. However, there were two main differences between Experiment 1 and Experiment 2. Firstly, Experiment 1 used a free-response methodology and therefore gave the children more freedom to make distinctions in their utterances whereas this experiment required them to fill in a gap in a pre-formed sentence. Secondly, the scenes depicted other objects in addition to the plate, therefore the children could conceptualise the scenes in terms of whether the located object was *on the plate* or *on the other objects* and were free to respond by referring to either one. In this experiment, only the located and reference objects were depicted and the children were required to complete a pre-formed sentence. Such restrictions might have made it more difficult for the younger children to make distinctions between the scenes. Although, as we have seen in Table 3.19 on page 188 above, even children in the youngest age groups conceptualised and talked about the scenes both in terms of support or contiguity relations with simple *on* completions and in terms of where things were positioned on the surface of the reference object (e.g., *at the side of*, *in the middle of*). However, although young children used both simple *on* completions and positional completions; they did not utilise these terms in order to distinguish between the scenes. It might be that using different phrases in order to

differentiate between scenes could therefore be a later development, occurring sometime around ten years of age. One problem with this explanation is that, as we shall see in Chapter 4 of this thesis, when talking about objects positioned along the vertical axis, children as young as 6;6 make distinctions between the scenes either by highlighting the vertical axis, or by producing words that are neutral with regards to an axis. It is therefore possible that the children in the youngest age group in this experiment did not think it necessary to make any such distinction.

We turn now to consider why no difference in responding was found between the scenes where the reference object was positioned canonically and where it was rotated by 66°. One reason why adults and children were not making a distinction between these scenes might be that they had little choice. As previously mentioned, they talked about the whereabouts of the located object in the scenes using two main distinctions; they described it in terms of a support or contiguity relationship or in terms of its position on the supporting surface. When the supporting surface was rotated, however, it could be argued that in a production study there is no alternative way of saying *on*. The preposition *on* can be rated in terms of appropriateness for comprehension, but when it comes to production, there is no other way you can describe the scenes apart from positional which is not wholly appropriate for the rotation where it might fall off. Indeed, some children in the youngest two age groups used the completions *off*, *half off*, *falling off* and *half on* on single occasions. However, such completions were very rare and never uttered by older children or adults. This might be because the scenes were static scenes depicting contiguity between the two objects. Perhaps if dynamic scenes were used depicting movement of the located object such responses might have been more prolific. For example, the located object could be depicted as sliding across the reference object thereby highlighting possible problems of locational support especially for the rotated scenes. It was also

interesting to note that neither adults nor children made use of modifiers in their verbal description (e.g., *almost on* or *nearly on*).

It could be argued that the reason no differentiation was made between the canonical and rotated scenes in this study and no object association effect found, whereas Coventry and Prat-Sala (in press) did find a rating differentiation, is down to purely methodological differences between the two studies. Coventry and Prat-Sala (in press) used two levels of rotation; 45° and 90°, whereas Experiment 2 of this thesis used only one level of rotation (66°). In addition, different materials were used in both studies. However, neither of these possibilities appears to be plausible. The angle used in this experiment was such that the support relation is quite clearly questionable. Moreover, it has been demonstrated that children as young as 2 or 3 years of age are sensitive to the forces of gravity (Hood, Santos, & Fieselman, 2000; Kim & Spelke, 1999). Looking at the question of the materials used, these were based on the materials previously used by Coventry and Prat-Sala. Adults also independently rated them as significantly different from each other in terms of object association, therefore the studies are equivalent materials-wise.

The main methodological difference between the two studies is that Coventry and Prat-Sala used a sentence rating task, whereas Experiment 2 of this thesis used a sentence completion task. Comprehension studies using appropriateness rating of prepositions are arguably more sensitive to differences that may not be found in production tasks. For example, an adult might rate the sentence, *the cup is on the saucer* as less appropriate to describe the scene where the saucer is rotated by 66° than when it is depicted in its canonical horizontal orientation, but when asked to describe those scenes that same adult might produce *on* both times. Additionally, the effect sizes found by Coventry and Prat-Sala were relatively small. For example, using a scale from 1 to 7, the mean ratings for the sentence describing the located object as *on* the reference object differed by approximately 1 point on the scale for ratings of the canonical and rotated positions. This is an important

point and may have implications for the final interpretation of the results found in Experiment 2.

3.4. Summary and General Discussion

Chapter 3 began by outlining the hybrid account for the semantic representation of *in* and *on* before looking in more detail at the Garrod et. al. (1999) and Coventry (1992, 1998) studies that examined the relative influences of geometric and extra-geometric factors on adults' comprehension and production of the prepositions *in*. Two experiments were then reported that were designed primarily to examine whether these factors also affect children's spatial language production. The first experiment began by exploring whether the geometric factor of height of pile and the extra-geometric factors of locational control of a bowl and continuity/discontinuity of other objects in a bowl affected the way children (3;4 to 7;8) described the location of a target object in a scene that depicted a bowl with other objects inside it. Unlike previous studies with adults, a free-response game-playing scenario was used whereby the children freely described to a puppet the location of target objects they saw on a screen. It was discovered that children altered their responses according to both the geometric and extra-geometric information of the scene. They produced the expression *in the bowl* as their first (or only) prepositional phrase significantly more when the height of the pile in the bowl was low rather than when it was high, with older children showing greater sensitivity to this factor than the younger children. Children also produced *in the bowl* significantly more when the bowl demonstrated locational control over the target object than when non-locational control was demonstrated. Additionally, they produced *in the bowl* significantly more when the other objects in the scene were the same rather than when they were different.

When the factors of continuity and height of pile were further assessed by the use of a plate rather than a bowl, similar results were found suggesting the results from the bowl scenes were not object specific. Children produced *in/on the plate* as their first (or only) prepositional phrase significantly more when the target object and other objects were the same rather than when they were different. They also produced it significantly less, the higher the pile was on the plate (again, older children were more sensitive to this).

The final manipulations assessed the factor of locational control of the bowl by comparing the preposition that was paired with the reference object *bowl* in the children's utterances when other objects in the scene (e.g. apples) were present with those utterances when they were absent. It was found that children produced the preposition *in* (for the bowl scenes) and *in/on* (for the plate scenes) less when describing the location of the target object at heights 2 and 3 (both heights outside the space occupied by the bowl) when the other objects were absent than when they were present.

Taken together the results from Experiment 1 clearly demonstrated that both geometric and extra-geometric factors are important aspects of children's spatial language production. Although adults appear to alter the preposition they produce when describing the position of a target object in relation to a bowl (e.g., Coventry, 1992; 1998), children use word order as a means of highlighting important and salient aspects of a scene. This is not to say that adults would not do the same, given an equivalent task. However, this is the first time that the effects of geometric and extra-geometric aspects has been demonstrated on children's spatial language production.

The second experiment reported in this chapter examined whether the angle of a supporting surface (either canonical or rotated by 66°), the position of a located object (either central or on the edge of a surface) and object association (high or low association between objects) affected both adults and children's production of the preposition *on*. Using a sentence completion paradigm, it was found that adults and children defined the

position of the located object to the reference object in two main ways. They either highlighted the contiguity/support relationship (e.g., *cake is on the cooling rack*) or they highlighted the position of the target object on the surface of the reference object (e.g., *the cake is on the edge of the cooling rack*). However, in this experiment, only the older age groups of children (10;8) and adults made any distinctions between scenes in their completions. Here, they highlighted the prototypical support relationship of the located and reference objects by producing *on* more when the located object was centrally positioned than when it was toward the edge of the surface.

From the two experiments described in this chapter, we are beginning to get an idea of how geometry and extra geometric factors might influence children's spatial language production. They can affect the word-order children use when describing the location of an object in a scene whereby children have been shown to highlight an important aspect of the scene by mentioning it first in their utterances. The factors can also influence the way older children distinguish between spatial scenes; for example, whether they highlight the support relationship or the positional aspect of location in their utterances.

In relation to the development of a spatial lexicon, it is clear that both geometric and extra-geometric variables are important factors influencing the production of *in* and *on* from a young age, although it appears that both factors continue to develop long after the relevant prepositions are stable members of a child's lexicon. However, Experiment 1 did not discover the exact age at which these factors develop. It might be the case that a different type of task would be needed for this (see Chapter 6 for a further discussion of this point). Therefore, it remains to be seen exactly how children acquire spatial prepositions. Certainly, both early spatial relations and early exposure to utterances and situations involving spatial prepositions are important factors in the acquisition of spatial terms. Additionally, the influence of extra-geometric variables gives us a clue to a further

factor that may be an important element in acquiring a prepositional lexicon. Learning nouns involves information not only about their shape, colour, etc., but also information about function (e.g., Kelmer Nelson, 1999; Landau, et. al., 1998; Prawat & Wildfong, 1980). During early interactions with the world, the functional properties of containers and supporting surfaces are salient. It is therefore unsurprising that the production of these spatial prepositions is influenced by the nature of the reference object early on. Learning spatial language involves more than learning spatial relations and co-occurrence relations between words – it also involves knowledge of how objects are able to interact with one another.

The experiments in this chapter have only looked at what Piaget called "simple" spatial prepositions (Piaget & Inhelder, 1956). As we have seen earlier on in this chapter and throughout the thesis so far, these "simple" prepositions can be conceptualised functionally according to the container/contained and bearer/burden relationships (e.g., Garrod et. al., 1999; Vandeloise, 1991). However, in order to gain a more complete picture of the influence of geometry and extra-geometric factors we need to consider other prepositions also. Therefore, Chapter 4 of this thesis will address the relative influence of these factors on the production of children's and adults' spatial expressions when describing objects that are located along the vertical axis.

4. Chapter 4: Superior and Inferior Relations; the Role of Function in Adults' and Children's Locative Expressions

4.1 Introduction

Words such as *over*, *above*, *under* and *below* are used to describe inferior and superior relations between objects and people. As we saw in Chapter 1, there has been much research into the comprehension of these words with adults focussing on the various geometric and extra-geometric factors that may underlie them, with much less research into their production (e.g., Carlson-Radvansky & Logan, 1993; Coventry, Prat-Sala & Richards, 2001; Hayward & Tarr, 1995; Logan & Sadler, 1996). Chapter 2 looked at the development of these prepositions in children and found that they were much later acquired than terms such as *in* and *on* and are amongst the terms that continue to be developed well into a child's early school years (e.g., Durkin, 1980).

This chapter will begin by very briefly outlining the evidence for functional influences on adult's comprehension and production of superior and inferior prepositions before reporting in detail the Coventry et. al. (2001) experiment that demonstrated the differential effects of function and geometry on the comprehension of the prepositions *over*, *under*, *above* and *below*. This study formed the basis of the production experiments reported in this chapter. In a later section, we will briefly outline relevant research that has investigated the development of prepositions such as *over, under*, *above* and *below*.

Two experiments will be reported in this chapter. The first experiment (Experiment 3) investigated adults' and children's verbal descriptions of scenes that depicted a superior relation between a located and a reference object using a sentence completion methodology similar to that used in Experiment 2 of this thesis. It was found that both adults and children made distinctions between the functional and the non-functional scenes in a similar manner to each other. Experiment 4 used the same materials and methodology as Experiment 3, this time investigating adults and children's descriptions of an inferior relation between located and reference objects positioned along the vertical axis. Similar results to Experiment 3 were found.

4.1.1. Adult's Comprehension and Production of the Prepositions *Over*, *Above*, *Under* and *Below*

In the following section we will see that the emergence of superior and inferior prepositions in children's speech is a prolonged event, often not being fully complete until well into the child's early school years (e.g., Cox & Richardson, 1985; Durkin, 1980;). Although there has been much research looking at *when* comprehension and production of prepositions develop in children, there has been little research to date investigating *how* children use them. The same cannot be said for adults where there is a great deal of research into the factors that underlie the meaning of the prepositions *over*, *above*, *under* and *below*. This section will briefly review some of the literature (a more extensive coverage was undertaken in Chapter 1 of this thesis), paying particular attention to the research by Coventry et. al. (in press) that demonstrated for the first time how adults' comprehension of the prepositions *over*, *under*, *above* and *below* is differentially affected by function and geometry.

We know much about the comprehension of superior and inferior prepositions in adults. For example, we know that the comprehension of the prepositions *over*, *under*, *above* and *below* has both a geometric and a functional component (Carlson-Radvansky & Radvansky, 1996; Carlson-Radvansky, Covey & Lattanzi, 1999; Coventry, Carmichael & Garrod, 1994; Coventry & Mather, in press) and that they are differentially affected by these factors (Coventry, Prat-Sala & Richards, 2001). However, our understanding of prepositional *production* is less detailed. This is not an uncommon situation and has been acknowledged more widely in all areas of language production (see Bock, 1996). As previously mentioned, when researching a particular aspect of language, it is often quite difficult to elicit the specific terms that are of interest and consequently, studies into the comprehension of specific terms are more prolific.

Looking at the geometric factors that underlie both inferior and superior prepositions, researchers have assumed that the located and reference objects in the scene themselves are unimportant; any object can be said to be *above* or *below* any other object irrespective of what those objects are or what they are doing. Spatial prepositions specify *where* objects are located regardless of any other factors. Therefore, the notion of spatial templates, or prototypical regions of space, for each preposition have been proposed to underlie our comprehension and production of spatial relations (Hayward & Tarr, 1995; Logan & Sadler, 1996[14]). Here, the space surrounding the reference object is carved into good, acceptable and bad regions of space for each spatial term (see Figure 1.5 on page 23 in Chapter 1). For example, a good region of space for the preposition *above* would be any object that is aligned directly upward from the vertical axis as defined by the centre-of-mass of the reference object. If the same object were aligned directly downward, this

[14] Although Logan and Sadler (1996) only investigated adults' comprehension of spatial prepositions, Hayward and Tarr (1995) included a production experiment in their investigation of prototypical regions of space.

would be a bad region of space for the preposition *above*, although it would be a good region of space for *below*. However, in general, research into spatial templates has over-simplified our understanding of the factors that affect spatial language comprehension and production. As a possible consequence of only depicting unrelated objects as stimuli and using mainly comprehension studies, researchers have grouped together prepositions suggesting that they are synonymous with one another. For example, from this geometric perspective, the prepositions *over* and *above* are deemed to have the same regions of acceptability as each other and therefore it is assumed that they are comprehended and produced similarly (Hayward & Tarr, 1995; Logan & Sadler, 1996).

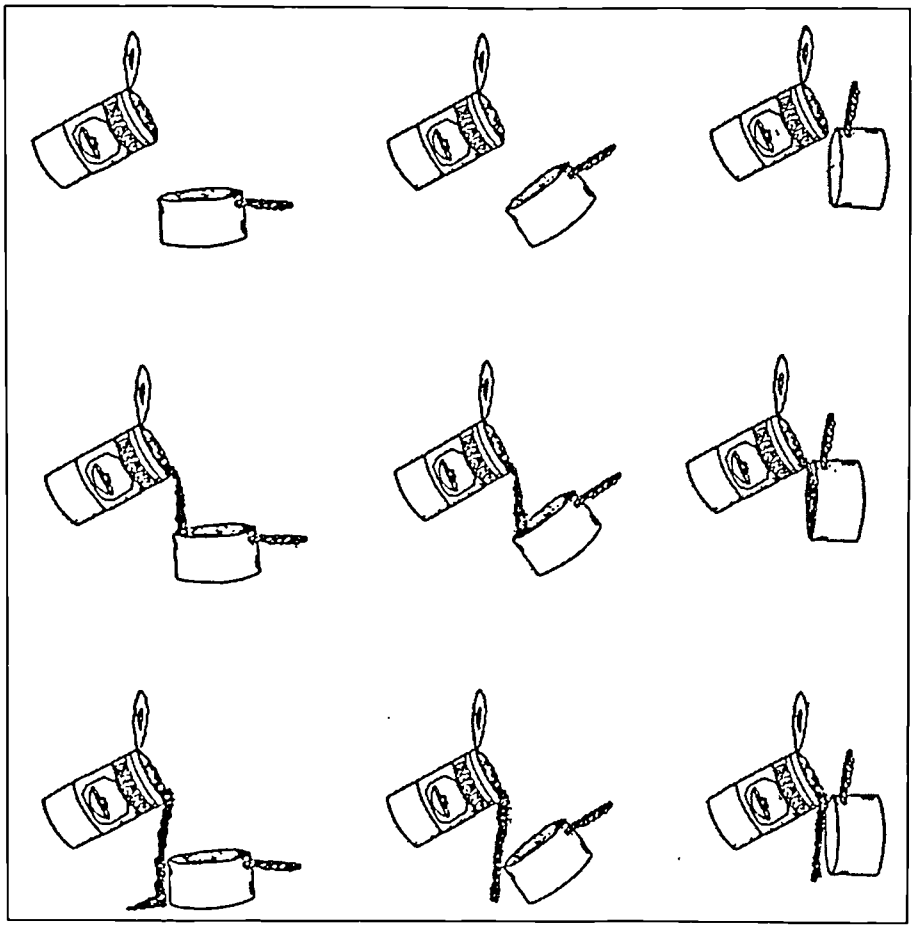
Other researchers have investigated spatial language using objects that are associated with one other (often in a functional manner) and have seen that extra-geometric factors of the spatial scene can also affect our comprehension of prepositions such as *above* (e.g., Carlson-Radvansky, Covey & Lattanzi, 1999; Carlson-Radvansky & Radvansky 1996; Coventry, Carmichael & Garrod, 1994;). For example, Carlson-Radvansky et. al. (1999) found that the function of an object affected the way adults comprehended the prepositions *above* and *below*. Using a placement task, they found that participants placed the located object towards the *functional part* of the reference object (e.g., the bristles of a toothbrush), and away from the reference object's centre-of-mass significantly more when the located object was functionally related (e.g., toothpaste tube) than when it was unrelated (e.g., paint tube). Similarly, in a sentence-rating task, they found that the region of acceptability for *above* changed according to where the functional part of the object was (recall the piggy bank and coin illustration on page 41). Participants rated the sentence *the coin is above the piggy bank* significantly higher when the coin was depicted directly above the slot they saw (irrespective of where the slot was positioned) than when the coin was depicted away from the slot. It is therefore clear from this study

that the prepositions *above* and *below* are more than just geometric terms, they also have an extra-geometric component to them.

Moreover, it has recently been demonstrated for the first time that adult's comprehension of the spatial prepositions *over*, *under*, *above* and *below* are differentially affected by both functional and geometric relations (Coventry et. al., 2001); clearly demonstrating that terms such as *over* and *above* are not synonymous. Coventry et. al. (2001) systematically manipulated both function and geometry in a variety of scenes to look specifically at the prepositions *over*, *under*, *above* and *below*. The scenes depicted either a person using an object to protect himself from falling objects (e.g., a man using an umbrella to protect himself from the rain, see Figure 1.14 on page 44 in Chapter 1), or two related objects, one of which was a container (e.g., a bottle and a glass, see Figure 4.1 below) with four object pairs (or object/people pairs) in each picture set.

Three levels of geometry were manipulated whereby the protecting object (e.g., an umbrella) was rotated away from its canonical upright position (directly above the reference object), by either 45° or 90° from the reference object. For the scenes depicting two interrelating objects, the container was rotated by 45° and 90° from its central axis towards the reference object (see Figure 4.1 below). Functionality was manipulated by depicting a *functional* context (e.g., rain falling on the umbrella keeping the man dry, or beans pouring into a pan from a can), a *non-functional* context (e.g., rain falling on the man rather than the umbrella, or liquid missing the glass) and a *neutral* context where no rain, liquid, etc., was present. Each picture was presented along with two sentences, e.g., either *the man is under/below the umbrella* or *the umbrella is over/above the man*. Using this sentence-rating task, they found evidence for the differential weighting of geometric and functional information. Geometry affected the ratings of the prepositions in a similar manner to that which had been found in previous research (e.g., Hayward & Tarr, 1995;

Figure 4.1. Examples of the Manipulations Made with the Second Set of Materials used by Coventry, Prat-Sala and Richards (2001).



Note: Illustration taken from Coventry et. al. (2001)

Logan & Sadler, 1996). When the located object was located away from the central axis of the reference object, the appropriateness rating for the prepositions was reduced. Additionally, functional relations between located and reference objects similarly affected ratings of the prepositions. Scenes that depicted a functional context were associated with significantly higher ratings than neutral scenes, conversely non-functional scenes were given significantly lower ratings than neutral scenes. However, the most interesting finding in this study was that although all four prepositions were affected by both factors of geometry and function, the prepositions *over* and *under* were more influenced by

function than geometry, whereas the prepositions *above* and *below* were more influenced by geometry than function.

We have now reviewed the main evidence for adult's production and comprehension of superior and inferior prepositions. It should be clear by now that not only are these prepositions affected by the influence of both function and geometry, but also that the comprehension of these prepositions are *differentially* affected by these two factors. However, as we will see in the following section, these terms are not always in the lexicon of young children and can take a while to develop. Additionally, the production of the terms to describe vertical axis spatial layouts (e.g., *over*, *above*, *under* and *below*) cannot always be relied on, as other terms, for example, *near* and *by*, may serve equally as well as descriptions of objects located along the vertical axis (e.g., Asso & Wyke, 1973; Durkin, 1980; Hayward & Tarr, 1995).

4.1.2. Children's Production of Superior and Inferior Prepositions

The aim of this section is to highlight the ages at which children comprehend and produce superior and inferior spatial terms (a more detailed review of the literature was presented in Chapter 1). When we look at children's development of these prepositions we will see that the recurring theme throughout this section is that although children can *comprehend* a spatial term at a certain point in their development, there appears to be a reluctance to *produce* that same term reliably in appropriate situations.

Experimental studies into spatial language development generally agree that correct comprehension and production of *under* is usually attained by the end of the child's third year, although *under* is produced and comprehended in certain contexts much earlier than this (e.g., Clark, 1973; Grieve et. al., 1977; Johnston & Slobin, 1979; Tomasello, 1986; Wilcox & Palermo, 1974). However, it has also been noted that children's

production of *under* continues to develop over the years. For example, research has found that children's production of *under* increases systematically between the ages of 4;6 and 7;6 (Asso & Wyke, 1973).

Although there have been studies specifically looking at the preposition *under* with children, none have looked specifically at its inferior relational counterpart *below*. Most studies into the production of inferior locative prepositions by children make no mention of the word *below* suggesting that children produce the term *under* or *underneath* as a preference to describe an inferior spatial relationship between two objects. Moreover, Cox and Richardson (1985) and Durkin (1980) highlight the preposition *below* as being mainly an adult term that is produced by very few children.

Interestingly, both Cox and Richardson (1985) and Durkin (1980) make similar remarks about the preposition *above*. Research looking at the utterances of school aged children has suggested that the description of locations on a vertical axis is difficult. For example, Asso and Wyke (1973) found that no children in their study (between 4;6 and 7;6) produced the preposition *above* to describe a vertical axis spatial arrangement. Moreover, the preposition *over* was never produced by 5-year-old children and only sparsely produced by the 6 and 7-year-olds (18 and 22 utterances respectively out of a possible 100 *over/above* scenes). The relative infrequency of their production suggests that even at the age of 7, some children had not fully mastered their use.

This suggestion is echoed by Durkin (1980) who looked at children of similar ages to those studied by Asso and Wyke (1973). He found that the prepositions most appropriate to describe an *above no-contact* position were produced less often than other types of words. For example, even children in the oldest two age groups (mean ages 6;6 and 7;4) produced *over* and *above* less than 30% of the time. Words such as *on top of*, *up*, *near*, *in*, *at*, and *on* formed the majority of the utterances produced to describe the spatial relation. Developmentally, Durkin (1980) found an overall low occurrence of the

preposition *over* for all age groups but a progressive increase of the preposition *above* from the age of 5;7. He also noted a high occurrence of children below the age of 6;5 that failed to respond when asked to describe a no-contact vertical axis spatial relation with several children giving the answer *nowhere* or *don't know*.

One final point that is of importance here is that previous investigators have experienced particular difficulties when attempting to elicit *specific* prepositions as most spatial relations can be described in a variety of ways, all of them correct. Imagine a cup and a teapot where the teapot is positioned higher than the cup on the vertical axis; such a scene might be described with the phrase *the teapot is over the cup*. However, one might equally use the prepositions *above*, *near*, *close to* or *by* to describe the scene, none of which are incorrect uses of the terms and all of which adequately describe the scene. This has been problematic for researchers studying both children's and adult's spatial language production (e.g., Durkin, 1978; Carlson-Radvansky & Radvansky, 1996)

It is possible to see from here that the development of the production of locative expressions that specify the vertical axis is a protracted affair with some researchers singling this out as a specific problem for children (e.g., Asso & Wyke, 1973; Durkin, 1980). Undoubtedly by the age of around 3;0 the comprehension of the preposition *under* has typically been mastered (e.g., Clark, 1973; Sinha, 1983), although children appear to be reluctant to produce it in speech until much later. Likewise *below* appears to be a term produced mainly by older children and adults (e.g., Asso & Wyke, 1973; Cox & Richardson, 1985). Superior prepositions are acquired later. In a similar manner to inferior prepositions, their production also appears to be delayed with many children being reluctant to produce them until they are well into their primary school years. Additionally, it has been shown that children do not always produce vertical axis words to describe vertical axis spatial arrangements; words such as *near* which do not involve the use of axes can also be correctly produced for such a scene (Durkin, 1980).

4.2. Comprehension versus Production: Rationale for Experiments 3 and 4

We can see from the research described in the previous section of this chapter, that both geometric and extra-geometric factors play an important part in the way both superior and inferior prepositions are comprehended. How adults actually produce these prepositions when describing spatial relations, however, is less clear.

In Hayward and Tarr's (1995) production experiment (reviewed in greater detail in Chapter 1) adults did tend to produce inferior and superior prepositions most of all when the located object was positioned directly upward (for superior prepositions) and directly downward (for inferior prepositions) along the vertical axis as defined by the centre-of-mass of the reference object. Nevertheless, they also produced other prepositions (e.g., *near*) in addition to superior and inferior prepositions when describing 'above' and 'below' type spatial relations. Moreover, Hayward and Tarr (1995) used only unrelated objects in their studies; but we have seen in other research that how objects interact with one another in context can affect the way we comprehend the prepositions *over*, *under*, *above* and *below* (e.g., Coventry et. al., 2001). This factor might also affect the *production* of these prepositions, and this is the main question to be explored in the experiments in this chapter.

Additionally, although Coventry et. al. (2001) found evidence for the differential weighting of geometry and functional information for *over* and *under* versus *above* and *below*, they found this by getting participants to rate the appropriateness of these prepositions against each other. The artificiality of restricting the choice between one of the two prepositions to denote a superior relationship might be misleading to theories of

spatial language production as this does not truly reflect the alternative expressions available to us. In natural language, when choosing a spatial expression to describe a scene, we can select from a number of different prepositions that might equally describe that scene. For example, although an umbrella may be positioned higher than a person on the gravitational (vertical) axis, the choice of a preposition that specifies this axis is not necessary. In many situations, proximity terms, such as *near*, still serve to locate the object.

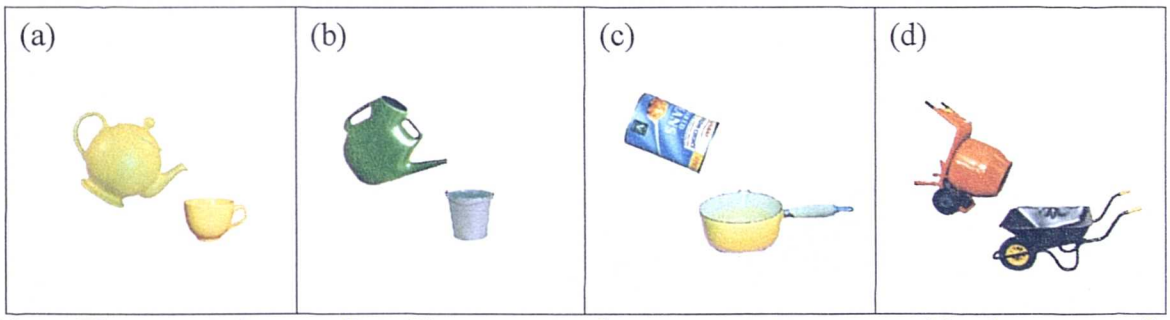
The two experiments reported in this chapter used a sentence completion task, similar to that used in Experiment 2, to look at how adults and children describe superior (Experiment 3) and inferior (Experiment 4) relations between two related objects where both the geometric and the functional relationship between the objects were systematically manipulated. The materials consisted of pairs of related objects (similar to items used in Coventry et al., 2001) where the located object's relationship with the reference object involved the function of containment of a related substance. The manipulation of function was achieved by depicting either a successful or unsuccessful containment situation, with the addition of a neutral containment situation (no related substance present) acting as a control condition. The geometric manipulation was achieved by rotating the container towards the reference object by 45° from its central axis.

4.3. Experiment 3: The Effect of Function and Geometry on Children's and Adults' Production of Superior Prepositions

The main aim of Experiment 3 was to examine how adults and children talk about functional and non-functional scenes across the vertical axis. While we do know that

adults are sensitive to aspects of functionality in their comprehension of prepositions that denote the vertical axis (Coventry et al., 2001), we do not know whether this is so for their production of such prepositions. Additionally, while research looking at the production of the topological prepositions *in* and *on* has shown children as young as 3;4 to be sensitive to the functions of containment and support (Experiment 1 reported in Chapter 3 of this thesis), there has been no research to date looking at aspects of functionality for the production of projective prepositions with children. Additionally, as this is the first time this has been investigated with children, one further aim of this study is to see whether there is a developmental trend between children and adults in their production of spatial expressions. For example, although the youngest children participating in this experiment have a mean age of 7;1 (range 6;7 to 7;5), given that children are still developing their understanding and especially their production of words such as *over* and *above* at this age (e.g., Durkin, 1980; Leikin, 1998), we expect to see an increase in the production of these terms for the older children and adults participating in this study.

Figure 4.2. The Four Sets of Materials Used in Experiment 3.



Note: The materials were (L to R) a teapot and cup, a watering can and bucket, a can of beans and pan and a cement mixer and wheelbarrow.

This experiment systematically manipulated geometry and function in order to assess these aspects of the spatial scene on children's and adults' spatial language

production. The materials were comprised of pairs of related objects (similar to items used in Coventry et al., 2001; see Figure 4.1 above for the full set of object pairs and Appendix 9 for a full set of pictures used in this experiment). The relationship of the located object to the reference object involved the function of containment of a related substance. The manipulation of function was made by depicting either a successful or unsuccessful containment situation, with the addition of a neutral containment situation (no related substance present) acting as a control condition. In order to elicit natural language production, a series of colour photographs was displayed above an incomplete sentence in the form of *the located object is* _____ *the reference object.* For this experiment, the located object was always the higher of the two objects, e.g., *the teapot is* _____ *the cup.* The pictures were shown to the adults and children who then told the experimenter the word(s) to put in the sentence so that it would best describe the picture (a free response sentence completion paradigm). The utterance given by the participant for each sentence accompanying the spatial scene was analysed.

4.3.1. Method

4.3.1.1. *Design*

A 4 (age group) x 3 (functional interaction between located and reference objects) x 2 (angle of reference object) partial within-participants design was used for the main manipulations. Age group was the between participants variable with functional interaction and angle of reference object as the within-group variables.

4.3.1.2. *Manipulations*

The experiment used a series of colour photographs of pairs of located and reference objects. The variables manipulated were:

1. Functional Interaction between Located and Reference Object

Three levels of functionality were manipulated. The objects were depicted as either successfully fulfilling their intended function (for example see Figure 4.3 below, b and e), unsuccessfully fulfilling their function (Figure 4.3, c and f), or they were depicted neutrally[15] (Figure 4.3, a and d).

2. Angle of Located Object (Geometric Manipulation)

Two levels of angle were manipulated. The reference objects were depicted in a canonical (vertical) orientation with the base of the object level with the ground and the top opening facing upward (see Figure 4.3, a, b, and c). For the second angle, the located object was rotated toward the reference object by 45° from its central axis. Here, the top opening of the located object faced toward the reference object (see Figure 4.3, d, e, and f).

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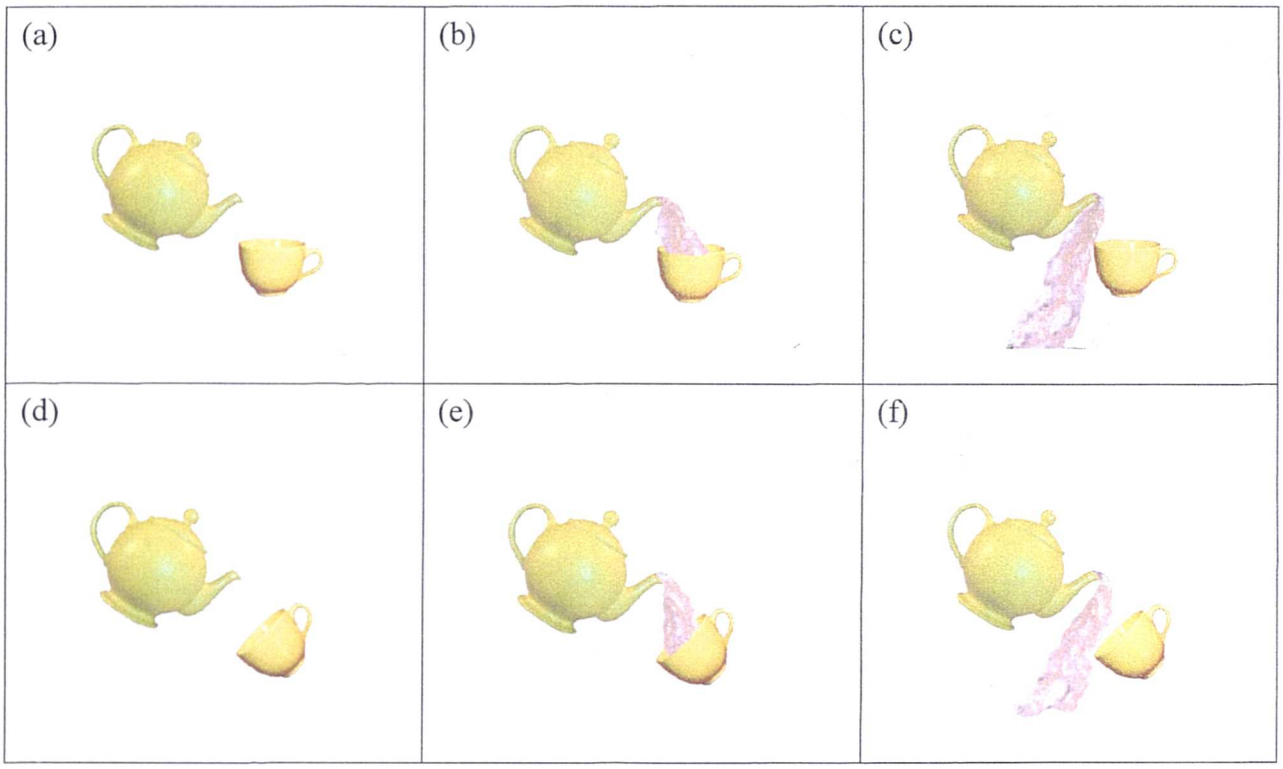
[15] Although we use the term *neutral* here, we acknowledge that, simply by positioning the objects in this manner implies an interaction irrespective of whether this is made explicit by the presence of the related substance. However, it has been demonstrated that the absence of a related substance in the scene can have the effect of reducing the salience of a functional interaction compared with the presence of such a substance in the scene (Coventry, et. al., 1994).

A total of 24 scenes were shown across the two main variables of functional interaction and angle of reference object. These consisted of four pictures for each level of the manipulation (4 object pairs x 3 levels of function x 2 levels of angle).

Figure 4.3. Examples of the Two Manipulations of Functional Interaction and Angle of Reference Object in Experiment 3.



4.3.1.3. *Participants*

One hundred and seventeen adults and children across four age groups participated in the experiment. All the participants were native English speakers with normal, or corrected to normal, eyesight and hearing. None of the participants had undertaken any experiments of this nature previously. The adults (n=33) consisted of undergraduates and postgraduates who received either course credit or payment for their participation. The

three groups of children came from a school located on the outskirts of a city. The mean age for group 1 was 7;1 (n=33, range 6;7 to 7;5), for group 2 was 9;01 (n=26, range 8;7 to 9;5) and for group 3 was 10;11 (n=25, range 10;6 to 11;5). Children below the age of 6;6 were not selected as research has shown that children have difficulties in their production of terms such as *over* and *above* even during their early school years (e.g., Asso & Wyke, 1973; Cox & Richardson, 1985; Durkin, 1980; Leikin, 1998).

4.3.1.4. *Materials*

Individual colour photographs were taken of the four reference and located objects. These were a teapot and cup, a can and saucepan, a watering can and bucket and a cement mixer and wheelbarrow (as displayed in Figures 4.2 & 4.3 above). Additionally, four related substances were photographed: tea, beans, water and cement. Each substance was only used with its related object pair (e.g., beans were only used with the can-saucepan objects). The photographs were scanned into a computer and placed onto a white background where they were edited together to form the pictures used in the experiment.

Each spatial scene manipulation was edited together four times (once with each of the four object pairs) with the located object situated to the right. This resulted in 24 individual spatial scenes. These scenes were then reflected so that the scenes depicted the located object to the left, which produced a further 24 pictures. The pictures were then divided into two picture sets. Each set contained all 24 experimental spatial scenes; 12 with the located object on the left and 12 with it on the right. Each participant saw only one picture set with (where possible) equal numbers of participants seeing each picture set in each of the age groups tested.

The scenes were interleaved with 32 scenes from another separate experiment[16] along with a variety of cartoon faces that appeared for one second after each picture to keep the children's attention and to act as a distracter from the previous spatial scene (in a similar manner to Experiment 2). The interest of the youngest two age groups was maintained by playing a guessing game using these cartoon faces; for example, the experimenter asked the child to guess the hair colour of the next cartoon face to appear.

The pictures were displayed on the screen with the aid of a computer program. This was set up in an identical manner to that used in Experiment 2 with the exception that in this experiment, each block contained one picture of the six spatial manipulations using a variety of object pairs, see the materials section on page 183 of Chapter 3 for the full details.

4.3.1.5. *Procedure*

Each participant was tested individually at his or her own school or university. The experiment was divided into two sessions for the children (lasting between 5 and 10 minutes each with no more than 7 days between sessions). Adults completed the experiment in a single 15-minute session. Each participant sat at a table with the experimenter to their right. The procedure was exactly the same as for Experiment 2; for full details of the experimental procedure, see the procedure section in Chapter 3 on page 184.

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[16] The scenes interleaved with this experiment came from Experiment 6, reported in Chapter 4 of this thesis. Both adults and children saw the same scenes.

Although all 117 of the participants were able to complete the trial sentence *the can is _____ the cup*, twenty-seven children failed to complete the main task. This consisted of sixteen (49%) from age group one (mean age 7;1), six (23%) from age group two (mean age 9;1) and four (16%) from age group three (mean age 10;11). Additionally, one participant from the youngest age group (mean age 7;1) produced *in* for all the scenes. As this completion was always classified as an error, the data from this participant did not contribute to the results of the study. None of the adults had any problem completing the task. The main reasons for failing the task were that either the children focussed upon what was happening in the picture rather than on where things were, despite being encouraged to concentrate on the latter, or that the child did not know a word to use in order to complete the sentence. Children in the youngest age-group found it particularly difficult to think of words with which to describe the superior relation depicted. As all the participants demonstrated an understanding of the nature of the task prior to the experiment, the sentence completion task itself was not considered to have been the problem.

4.3.2. Results

As previously mentioned in Chapter 3, an alpha level of .05 was used for all statistical tests. Tukey (HSD) tests were used for all follow-up analyses in this chapter unless age group was included in the analyses when Tukey (HSD) tests for unequal Ns were used.

The responses from each participant were placed into a spreadsheet for later coding (see Appendix 10 for an exhaustive list of categories, percentage and number of utterances by age group). As this study was a free response sentence completion task, the participants were at liberty to produce any completion they wished as long as it described *where* the

object was. This type of paradigm leads to great variation within the data. A summary of the main completions (>1% in any one age group[17]) are displayed in Table 4.1 (below). All but 62 of the responses contained single word, or single prepositional phrase completions. Of these longer completions, six came from age group one (mean age 7;1) and consisted of utterances such as *up high and a bit close to* and *near and close to*. The remaining 56 utterances all came from four adults (age group four) and were utterances such as *diagonally above, above and to the right/left of* and *to the right/left and above.* We can see from Table 4.1 (below) that *above* was by far the most common preposition produced to indicate a superior relation for age groups two to four. Age group one, however, produced words such as *on top of* and *higher than* equally as much. Such terms are produced by children who have not yet acquired the prepositions *above* or *over* and are often produced in place of these prepositions; hence age groups three and four did not produce these terms. This finding is similar to that of Durkin (1980) who found that children between the ages of 3;8 and 7;8 produced *on top of* more than *over* or *above* to describe vertical arrangements, with the younger children (3;8 to 5;3) using *on top of* more than *over*.

The preposition *over* was produced to a much lesser extent than *above* by adults and children of all ages. Again, this trend was found with children by Durkin (1980) who reported a low occurrence of *over* for all age groups, with a progressive increase in the production of *above* for children over 5-years-old.

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[17] Note: As Table 4.1 contains only data that comprises >1% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 10 for full breakdown.

Table 4.1. The Percentage (and Number of Utterances) of Main Completions for Superior Relations (>1% of Data in Any One Age Group) in Experiment 3.

Completions	Age Group 1 (Mean 7;1, n=17)	Age Group 2 (Mean 9;01, n=20)	Age Group 3 (Mean 10;11, n=21)	Age Group 4 (Adults, n=33)
Above	7% (28)	23% (110)	54% (274)	81% (641)
Up above	3% (13)	6% (31)	<1% (2)	0
Over	3% (14)	4% (19)	3% (16)	9% (75)
On top of	6% (24)	7% (32)	0	0
Higher than	6% (26)	7% (33)	0	0
By	11% (45)	1% (7)	4% (22)	<1% (1)
Next to	14% (58)	3% (15)	4% (22)	2% (12)
Close to	7% (27)	10% (46)	2% (12)	0
Near	8% (33)	14% (69)	8% (41)	2% (16)
In front of	7% (30)	3% (15)	4% (22)	<1% (1)
Opposite	3% (11)	3% (12)	9% (47)	0
Diagonal	0	0	3% (15)	1% (9)
On the side of	0	4% (18)	0	0
Far away from	2% (10)	1% (5)	0	0
Far from	<1% (1)	2% (10)	0	0
X feet away from	2% (8)	1% (4)	0	0
Away from	<1% (1)	2% (9)	<1% (2)	0
Errors/unusual responses	15% (62)	4% (21)	4% (19)	0

Generally, completions denoting a superior relation increased in frequency across age groups. However, although the photographs depicted a superior relationship between two objects, superior prepositions were not always produced to describe the pictures. Other prepositions denoting proximity or distance, for example, *next to, by, near* and *close to* were also produced. Looking more closely at the data it was found that thirteen children produced no superior prepositions in any of their responses. These consisted of six (35%) from age group one, four (20%) from age group two and three (14%) from age group three. All adults frequently produced superior prepositions during testing. Looking only at those participants that did produce a superior relational utterance it was found that the frequency of descriptions that included reference to the vertical axis increased with age. Therefore, 43% of completions from those children in age group 1 who demonstrated production of superior relational terms referred to the superior vertical axis. This rose to 61% for age group two children, 68% for age group three children and 91% for the adult group. Taken together this suggests that there an increase in the confidence of children to produce superior vertical axis descriptions with age.

Those completions that did not denote a superior relation varied across age group, with *next to* and *by* being most commonly produced by age group one (14% and 11% for each preposition respectively). Additionally, it should be noted that these prepositions were produced by children in this age group more than any of the superior prepositions individually. *Near* (14%) and *close to* (10%) were most commonly produced by the children in age group two (mean age 9;01), with children in age group three (mean age 10;11) producing *near* (8%) and *opposite* (9%) more frequently. *Near* (2%) and *next to* (2%) were produced by the adults in this study.

Given the variety of completions it was of interest to assess whether individuals changed the type of preposition they produced according to the geometric and functional

manipulations of the study. Therefore, the first analysis looked at when children and adults produced prepositions denoting a superior relation versus when they produced completions that did not specify such a relation.

When categorising the utterances for analysis, following on from Experiment 1, the first preposition mentioned was the preposition that was categorised. All the completions using words that denote a superior relation were placed into category one (1,363 utterances). This category not only included the prepositions *above* and *over*, but also included the completions such as *up high from*, *on top of, higher than*, and *vertical to* which were almost exclusively produced by the youngest two age groups (see Table 4.2 below for examples). Category two contained all the other completions produced by adults and children such as *by, next to, close to* and *near* (719 utterances). Errors, unusual and non-responses were placed into a third category (78 utterances). These were completions such as *in, down* and *half way* and were uttered mainly by children in age group one (mean 7;1), but also some from age groups two and three. Additionally, any response that did not form a complete sentence when it was placed in the gap of the pre-formed sentence displayed, were considered errors. No completions from age group four (adults) were in this category.

Table 4.2. Examples of Utterances that were Coded into Each of the Three Categories for Experiment 3.

Category 1 (vertical axis completions)	Category 2 (other completions)	Category 3 (errors, unusual responses, etc)
Above	*By*	*In*
Up above	*Next to*	*Half way*
Over	*Close to*	*A bit up*
High above	*Far away from*	*Very, very low*
Up high from	*Near*	*Tipping*
Very high from	*On the side of*	*A meter*
On top of	*Diagonal*	*Before*
Higher than	*To the left and above*	
Vertical to		
Above and to the left of		

The data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances (ignoring Category 3 responses) for each cell of the design and expressing it as a percentage. A three-way partial within group analysis of variance was performed on the data. The between groups variable was age (four groups, mean ages 7;1, 9;1, 10;11 and adults). The within group variables were functional interaction (three levels: functional, non-functional and neutral) and angle of reference object (two levels: vertical and 45° rotation). The means for this analysis are displayed in Table 4.3 below and the ANOVA results are presented in Table 4.4.

Table 4.3. Mean Percentage of Completions Denoting a Superior Relation across Age Groups in Experiment 3.

	Vertical Angle			45° Rotation		
Age Groups	Neutral	Functional	Non-Functional	Neutral	Functional	Non-Functional
Group 1 (Mean age 7;1, n=16)	37	28	28	38	36	27
Group 2 (Mean age 9;1, n=20)	58	60	33	51	54	40
Group 3 (Mean age 10;11, n=21)	64	64	53	61	61	60
Group 4 (Adults, n=33)	95	96	78	95	96	88
All Groups (n=90)	69	69	54	67	68	60

Table 4.4. The Results from the Analysis of Variance for Superior Relation Completions, Experiment 3.

Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (3,86) = 18.12	4941.07	****
ANGLE (A)	F (1,86) = .05	293.51	ns.
FUNCTIONAL INTERACTION (F)	F (2,172) = 17.37	414.34	****
G x A	F (3,86) = .44	293.51	ns.
G x F	F (6,172) = 1.15	414.34	ns.
A x F	F (2,172) = 3.06	227.79	*
G x A x F	F (6,172) = .68	227.79	ns.

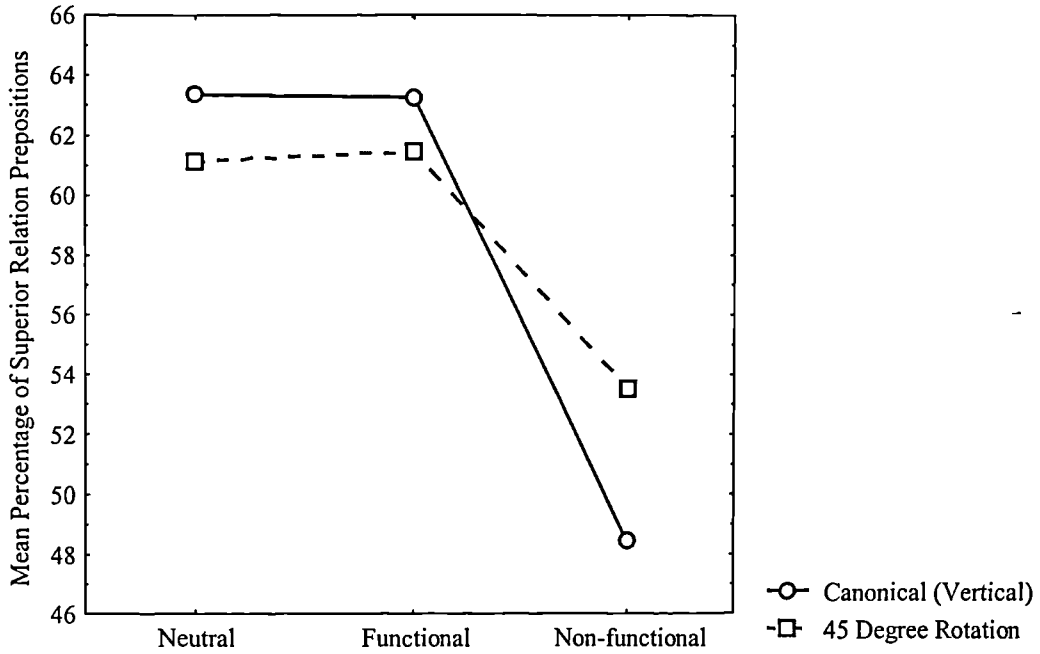
Note: $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

A main effect of age group was found. The mean percentage of the production of prepositions denoting a superior relation was 33% (age group one, mean age 7;1), 49% (age group two, mean age 9;1), 60% (age group three, mean age 10;11) and 91% (adults). Follow-up analyses found that adults produced prepositions to denote superior relations significantly more than all three age groups of children. In addition, children in age group three produced superior relation prepositions significantly more than children in age group one. Otherwise, there were no significant differences between the age groups of children.

A main effect of functional interaction was also found. Follow-up analysis showed that children and adults produced completions denoting a superior relation significantly more when they were describing functional or neutral scenes (means 62%) than when describing non-functional scenes (mean 51%). Although no main effect of angle was found, there was a significant interaction between angle of reference object and functional

interaction. We can see from Figure 4.4 below that although the effect of the functional manipulation was in the same direction for both angles, this effect was more marked when the reference object was positioned vertically than when it was rotated by 45°. Follow-up analysis showed the differences between the non-functional scenes and both neutral and functional scenes to be significant for both angles of the reference object. No other interactions were significant.

Figure 4.4. The Interaction between Angle of Reference Object and Functional Interaction between Located and Reference Objects, Experiment 3.



From this analysis we can see that when describing the scenes depicting a superior relation, adults produced prepositions denoting that relationship (e.g., *above* and *over*) more often than children, with older children producing such completions more than younger children. Both adults and children of all ages produced prepositions that denote

the vertical axis more often to describe a picture illustrating a functional interaction than when the interaction between the two objects was depicted as non-functional. This was more apparent when the reference object was displayed in its canonical (vertical) angle. However, as this analysis looked at all vertical axis completions together, and considering that most comprehension studies have assessed the impact of geometry and function on individual prepositions, it was of interest to establish the contribution made by each of these prepositions where possible.

Response styles differed between participants in that some produced the same superior preposition (sometimes with other types of completions) throughout the experiment, whereas others produced a variety of superior prepositions (see Table 4.5 below for a breakdown across age group). Thirteen children produced no superior prepositions in any of their responses. Six (35%) of these came from age group one, four (20%) from age group two and three (14%) from age group three. All adults frequently produced superior prepositions during testing.

Table 4.5 below gives a breakdown of participants who produced the completions *over, above, on top of* and *higher than*. As we can see, the production of *on top of* and *higher than* stopped at age group two (mean age 9;1). Additionally, it was not to possible to meaningfully analyse these utterances further as too few children produced them. This was also the case for *over*. One adult, and no children in this study, produced *over* as the only superior relational preposition in their descriptions. Although its production increased with age, only seven adults produced it along with *above* in their completions, therefore *over* could not be analysed separately. *Above* was the only preposition that could be meaningfully analysed on its own, except for the youngest age group (mean 7;1) where not enough participants produced it. As adults' comprehension of the preposition *over* has

Table 4.5. The Percentage (and Number) of Participants in each Age Group who Produced Each Vertical Axis Completion, either Solely or With Other Vertical Axis Completions, Experiment 3.

	Over		*Above*		*On Top Of*		*Higher Than*	
Age Group	Solely	With Other	Solely	With Other	Solely	With Other	Solely	With Other
Group 1 (mean 7; 1)	0	6% (1)	18% (3)	12% (2)	24% (4)	12% (2)	12% (2)	6% (1)
Group 2 (mean 9;1)	0	15% (3)	25% (5)	45% (9)	5% (1)	20% (4)	0	20% (4)
Group 3 (mean 10;11)	0	14% (3)	71% (15)	14% (3)	0	0	0	0
Group 4 (adults)	3% (1)	21% (7)	76% (25)	21% (7)	0	0	0	0

been shown to be highly affected by functional factors, ideally it would be desirable to analyse the utterances of only those participants who exclusively produced *above* to denote a superior relation. This way we can look at the production of *above* without any problems of participants switching between superior relational prepositions that may cause a potential confound in the analysis. However, this would have resulted in too few participants being used in the analysis. Therefore, no further analyses were undertaken.

4.3.3. Discussion

This experiment looked at the way adults and children produced superior spatial prepositions to describe the whereabouts of objects in functional and non-functional scenes along the vertical axis using a production task. The age groups selected for this study merit some discussion. It could be argued that younger age groups might have been included in this experiment. Certainly, as we found no effect of age for the manipulations of functional interaction or angle of reference object, younger children will need to be examined in order to assess at what point in a child's development these factors become important. As reviewed in Chapter 2 of this thesis, children begin to notice the function of objects and use this information when applying new names to those objects from between 2 and 5-years of age. We have also seen in Chapter 3 of this thesis how children as young as 3;4 notice when a container is functionally controlling its contents and use this information when describing such scenes. Additionally, although the utterances of all the age groups of children in Experiment 1 were affected by the manipulation of geometry (height of pile of objects) the older age groups were affected more than the younger age groups of children. However, it could be argued that children of a younger age would have had difficulty in completing the task in Experiment 3; not because the task itself was difficult (no-one failed the example sentence where the appropriate preposition was *in/inside*), but because children younger than 6;6 appear to have great difficulty generating the prepositions required to describe the scenes (e.g., Durkin, 1980). Indeed 49% of the youngest children in this experiment (mean age 7;1) did not complete the task, either

because they were struggling to find the words to use[18] or because they focussed on what was happening in the scenes. Additionally, 35% of the youngest group of children who did complete the task produced no superior prepositions in their responses. This reduced to 20% for age group two and 14% for group three. Although one cannot conclude from this that these children do not know superior prepositions or do not produce them to describe other scenes, in this study the production of superior prepositions did increase with age. Had children younger than 6;6 been used in this study they would have found it even more difficult to produce suitable prepositions.

An examination of the types of completions produced by children and adults pushes into sharp focus the limitations of rating studies that restrict the range of lexical items tested and calls into question the sufficiency of research that compares the comprehension of individual prepositions against each other (e.g., Coventry et. al., 2001). Such research might be misleading to theories of spatial language production; the way these words are produced and comprehended during conversations may be quite different to the way they are comprehended in isolation. This is not to claim, however, that the interaction between experimenter and participant in this experiment was the same as it would be during a natural conversation, but nonetheless they were participating in a verbal interaction with each other whereby the experimenter asked the question *where's the X?* for each scene and the participant was at liberty to respond by producing any locative term they so wished.

As mentioned earlier, in this experiment, the youngest age group produced relatively few vertical axis prepositions. *Over* and *above* utterances consisted of just 13% of the data set. This rose to 25% if we include the completions *on top of* and *higher than.* Thirteen children across the three age groups produced no superior prepositions at all. This

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[18] Many of these children, when asked *where's the X*, responded by saying that they didn't know.

reduced systematically with age, although there were still three children in age group 3 who never produced vertical axis descriptions in this study. All adults produced superior prepositions frequently, but not exclusively. Additionally, when only those participants that did produce a superior relational utterance were looked at, it was found that the frequency of descriptions that included reference to the vertical axis increased systematically with age (43%, 61%, 68% and 91% for age groups 1 to 4 respectively). However, it should be noted that generally, when children did produce superior prepositions, they did so in the same manner as the adults in this study. For superior prepositions, therefore, we have found quantitative evidence of a developmental trend, but not qualitative evidence. This suggests that one important factor in spatial language development might be gaining the confidence to produce prepositions that more closely define the vertical axis.

The other prepositions children (and adults) produced were generally less specific regarding an axis or direction, with *next to* and *by* being favoured by the youngest children. When they did produce completions denoting the vertical axis, however, both adults and children produced them significantly more when describing a functional scene than when describing a non-function scene. Additionally, *above* was produced more than *over* by all age groups.

In summary, this experiment suggests that both children and adults switch the types of prepositions they produced depending on the types of relations depicted. It has shown for the first time that when two objects are interacting in a functional way, they are more likely to be described by words that define their position according to the vertical axis of the reference object rather than terms which do not specify direction. Moreover, we have seen for the first time that both adult's and children's production of the preposition *above* is strongly influenced by the functional information in the scene. It can be argued that this finding may be due to the nature of the objects and functions portrayed in the

scenes that entail the instantiation of the gravitational plane; for an object to be successfully pouring something into a container it needs to be positioned higher than the container along the vertical axis. Therefore, that axis is highlighted as it plays an important functional role in the scene. However, when the interaction is portrayed as unsuccessful, the vertical axis is not emphasised in the words that are produced in order to describe where the objects are.

However, this experiment has only demonstrated this for scenes where adults and children describe superior relations between objects. Experiment 4 was designed to investigate whether this trend also happens when they are describing inferior relations between objects in a scene.

4.4. Experiment 4: The Effect of Function and Geometry on the Production of Children's and Adults' Inferior Prepositions

In Experiment 3, that looked at superior relations, evidence was presented that suggests both adults and children altered the type of preposition they produced depending on the types of relations depicted. When two objects interacted in a functional way, participants were more likely to talk about them using words that defined their position according to the vertical axis of the reference object (e.g., *above* or *over*) rather than terms which did not specify direction (e.g., *near* or *next to*). Experiment 4 was conducted in order to look at children's and adults' spatial language production for inferior relations. The pictures from Experiment 3 were used with a modification to the sentence underneath, whereby the lower of the two objects became the located object with the higher of the two objects being the reference object (e.g., *the cup is* _____ *the teapot*).

4.4.1. Method

4.4.1.1. *Design*

A 4 (age group) x 3 (functional interaction between located and reference objects) x 2 (angle of located object) partial within-participants design was used for the main manipulations. Age group was the between participants variable with functional interaction and angle of located object as the within-group variables.

4.4.1.2. *Manipulations*

The manipulation of functional interaction and angle of located object was the same as for Experiment 3 as set out on page 218 above.

4.4.1.3. *Participants*

One hundred and eighteen adults and children across four age groups participated in the experiment. All the participants were native English speakers with normal, or corrected to normal, eyesight and hearing. The adults (n=31) consisted of first year psychology undergraduates who received course credit of their participation. The three groups of children had mean ages of 7;0 (n=30, range 6;6 to 7;5), 8;11 (n=30, range 8;6 to 9;5), and 10;11 (n=27, range 10;6 to 11;5) and were chosen to be of a comparable age

range to those studied in Experiment 3. Each age group was comprised of children from the same school as each other, located in a small town. None of the children or adults had participated in Experiment 3.

4.4.1.4. *Materials*

The pictures from Experiment 3 were used with a sentence in the form of *the located object is* _____ *the reference object* displayed underneath. However, for this experiment, the located object was always the lower of the two objects, e.g., *the cup is* _____ *the teapot.* Again, the scenes were interleaved with 32 scenes from a separate experiment (not reported here) with all other aspects of the method as before,[19] the details of which can be found on page 220.

4.4.1.5. *Procedure*

The procedure for this experiment was the same as for the previous experiment which was set out in full on page 184 in Chapter 3. All 118 of the participants were able to complete the trial sentence *the can is* _____ *the cup*. Again, some children failed to complete the main task. These were a total of seventeen children; twelve (40%) of the children from age group one (mean age 7;0), four (13%) from age group two (mean age 8;11) and one (4%) from age group three (mean age 10;11). None of the adults had any

[19] The scenes interleaved with this Experiment came from Experiment 6, reported in Chapter 4 of this thesis. As mentioned in the previous section, scenes from Experiment 6 were also interleaved with Experiment 3. Both adults and children saw the same scenes.

problem completing the task. The reasons for failing the task were the same as for Experiment 3.

4.4.2. Results

The responses from each participant were placed into a spreadsheet for later coding (see Appendix 12 for an exhaustive list of categories, percentage and number of utterances by age group). A summary of the main completions (>1% in any one age group[20]) is displayed in Table 4.6 below. All but 20 of the responses contained single word, or single prepositional phrase completions. These 20 longer completions comprised of utterances such as *diagonally below, diagonally next to* and *underneath to the right.*

We can see from Table 4.6 below that the prepositions *under, underneath* and *below* were the most common of the completions indicating an inferior relation across all age groups, with *beneath* also being produced to a less extent. Unlike Experiment 3, where younger children produced the terms *higher than* and *on top of*, there were no utterances such as *lower than* or *on the bottom of.* However, in a similar way to the first experiment, not all participants produced inferior prepositions to denote an inferior relationship and some produced both inferior prepositions and prepositions that are more general in their completions. Unlike Experiment 3, all age groups of children appeared relatively confident in producing inferior prepositions. When only those participants who produced inferior prepositions were taken into consideration, the relative production of inferior prepositions did not differ dramatically with age. Eighty percent of utterances from age group 1 were

[20] Note: As Table 4.6 contains only data that comprises >2% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 12 for full breakdown.

inferior prepositions, with 71% for age group 2, 69% for age group 3 and 86% for the adults in this study.

Table 4.6. The Percentage (and Number of Utterances) of Main Completions (>1% of Data in Any One Age Group) for Experiment 4.

Completions	Age Group 1 (Mean 7;0, n=18)	Age Group 2 (Mean 9;0, n=26)	Age Group 3 (Mean 10;11, n=26)	Age Group 4 (Adults, n=31)
Under	13% (54)	31% (193)	26% (162)	25% (189)
Underneath	25% (106)	23% (145)	21% (132)	24% (175)
Below	21% (89)	13% (82)	12% (75)	35% (259)
Beneath	< 1% (1)	1% (6)	6% (37)	2% (16)
Near	15% (65)	8% (52)	8% (49)	3% (19)
Close to	9% (41)	1% (5)	2% (12)	0
Away	< 1% (2)	3% (20)	3% (18)	< 1% (3)
Next to	0	6% (40)	8% (53)	1% (6)
By	11% (47)	4% (23)	4% (27)	< 1% (1)
Beside	< 1% (1)	6% (40)	2% (15)	< 1% (2)
Diagonal to	0	< 1% (1)	3% (16)	< 1% (3)
In front of	1% (6)	< 1% (1)	2% (11)	1% (6)
To left/right of	1% (6)	0	< 1% (2)	7% (49)
Errors/unusual responses	3% (11)	1% (6)	1% (9)	0

The first analysis looked at when the participants in this study produced these inferior prepositions versus when they did not. For this analysis, all sentence completions containing inferior prepositions were placed into Category 1 (1,721 completions, see Table 4.7 below for examples of utterances in each category), with prepositions denoting proximity or distance being placed into Category 2 (677 completions, e.g., *near, next to,* and *close to*). Category 3 contained any errors, unusual and non-responses (26 completions). Responses that, when placed in the gap of the sentence, did not form a complete sentence were considered errors. For those completions that contained more than one preposition, the preposition mentioned first was the preposition coded in the analysis. The data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances (ignoring Category 3 responses) for each cell of the design and expressing it as a percentage.

Table 4.7. Examples of the Utterances that were Coded in Each of the Three Categories, Experiment 4.

Category 1 (vertical axis completions)	Category 2 (other completions)	Category 3 (errors, unusual responses, etc)
Under	*Near*	*Around*
Underneath	*Next to*	*Back*
Below	*Close to*	*Upon*
Beneath	*Away*	*In*
	Beside	
	Diagonal to	
	By	

A three-way partial within group analysis of variance was performed on the data. The between-group variable was age (four groups with mean ages 7;0, 8;11, 10;11 and adults). The within-group variables were functional interaction (three levels: functional, non-functional and neutral), and angle of located object (two levels: vertical and 45° rotation). The means for the production of inferior prepositions are displayed in Table 4.8 below, with Table 4.9 showing the results from the analysis of variance.

Table 4.8. Mean Percentage of the Completions Denoting an Inferior Relation across Age Groups for Experiment 4.

	Vertical Angle			45° Rotation		
Age Group	Neutral	Functional	Non-Functional	Neutral	Functional	Non-Functional
Group 1 (Mean age 7;0, n=18)	57	68	52	60	64	55
Group 2 (Mean age 8;11, n=26)	70	76	61	80	74	52
Group 3 (Mean age 10;11, n=26)	74	74	55	66	70	46
Group 4 (Adults, n=31)	91	95	74	89	93	73
All Groups (n=101)	74	81	62	75	77	57

Table 4.9. The Results from the Analysis of Variance for the Inferior Relation Completions, Experiment 4,

Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (3,97) = 3.97	5439.93	**
ANGLE (A)	F (1,97) = 2.07	356.26	ns.
FUNCTIONAL INTERACTION (F)	F (2,194) = 30.22	608.50	****
G x A	F (3,97) = 1.35	356.26	ns.
G x F	F (6,194) = .76	608.50	ns.
A x F	F (2,194) = 1.44	196.81	ns.
G x A x F	F (6,194) = 1.88	196.81	ns.

Note: $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

A main effect of age group was found. Mean percentages for the production of inferior prepositions were 59% for age group 1 (mean age 7;0), 69% for age group 2 (mean age 8;11), 64% for age group 3 (mean age 10;11) and 86% for adults. Follow up analysis showed that children in age groups 1 and 3 produced prepositions denoting an inferior relation significantly less than adults (both $p < .05$). This did not quite reach significance for age group two.

A main effect of functional interaction was also found. Mean percentages for the production of inferior prepositions were 73% for the neutral scenes, 77% for the functional scenes and 58% for the non-functional scenes. Follow up analysis revealed that all age groups produced prepositions denoting inferior relations significantly less when the objects depicted were not functionally interacting successfully than when they were interacting successfully or it was a neutral scene (both to $p < .0001$). The neutral and

functional conditions were not significantly different to one another. No significant effect of angle of located object, or interaction between variables were found.

From this analysis we can see that, in a similar manner to superior prepositions, prepositions denoting an inferior spatial arrangement (i.e., *under, underneath, below* and *beneath*) were produced more often to describe a picture depicting a functional interaction than when the interaction between the two objects was depicted as non-functional. Following on from this analysis it was of interest to ascertain whether we could establish the contribution made by each of these prepositions individually.

In a similar way to Experiment 3, participants displayed individual response styles. Some produced the same preposition (e.g., *below*) to denote an inferior relationship throughout the experiment (either with or without other terms). Other participants produced a variety of these prepositions to denote such a relationship (see Table 4.10 below for a breakdown across age group). Nine children produced no inferior relation prepositions in any of their responses in this study. Five (28%) of these came from age group one, one (4%) from age group two and three (12%) from age group three. All adults frequently produced inferior relational prepositions during testing.

Table 4.10. The Percentage (and Number) of Participants in each Age Group Producing Each Preposition either Solely or With Other Prepositions, Experiment 4.

	Under		*Underneath*		*Below*		*Beneath*	
Age Group	Solely	With Other	Solely	With Other	Solely	With Other	Solely	With Other
Group 1 (mean 7;1)	0	29% (5)	17% (3)	24% (4)	17% (3)	29% (5)	0	6% (1)
Group 2 (mean 9;1)	19% (5)	51% (13)	12% (3)	43% (11)	8% (2)	24% (7)	0	16% (4)
Group 3 (mean 10;11)	15% (4)	54% (14)	4% (1)	50% (13)	8% (2)	39% (10)	0	20% (5)
Group 4 (adults)	19% (6)	35% (11)	10% (3)	29% (9)	13% (4)	44% (14)	0	21% (7)

We can see from Table 4.10 that *Under, underneath*, and *below* were produced by similar numbers of children in age group one (5, 7 and 8 for each preposition respectively), although the number of participants who produced each of the prepositions were too few to analyse for this age group. Age groups two and three produced *under* and *underneath* more than *below*, whereas adults produced *below* slightly more than *under* and *underneath*. It appears from these results, that unlike the finding of Cox & Richardson (1985), the preposition *below* was not mainly an adult term; forty-six percent of children in the youngest age group (mean age 7;0) produced this term either on its own or with other inferior prepositions although its production did increase across age groups.

Looking at Table 4.10, we can also see that there was a greater tendency for adults and children to use more than one inferior relation preposition within their responses than was apparent in Experiment 3. This could be due to there being four suitable prepositions available (i.e., *under*, *underneath*, *below* and *beneath*) with which to describe an inferior relation between objects, rather than just two main prepositions when describing a superior relation between objects (i.e., *over* and *above*). As a consequence of this, it would be difficult to undertake any meaningful analysis that would not be confounded by the presence of another inferior preposition. Therefore, no further analysis was carried out.

4.4.3. Discussion

This experiment looked at the way adults and children produced inferior spatial prepositions to describe the position of objects depicted in functional and non-functional interactions along the vertical axis using a production task similar to that of Experiment 3. The main finding of Experiment 4 echoed that from the previous experiment that looked at the production of superior vertical axis prepositions. Both adults and children altered the type of preposition they produced to describe the location of one object in relation to another according to the functional information of the scene. Therefore, they produced inferior spatial prepositions that highlighted the vertical axis (e.g., *under, underneath*) significantly more when they described a scene that depicted a functional interaction between the located and reference objects than when they described the location of those objects in a non-functional interaction. The description of locations in non-functional scenes elicited prepositions that were more general in nature and neutral with respects to an axis (e.g., *near*, *by*). However, as too many participants produced a variety of inferior prepositions in their completions, rather than sticking to one, any analysis undertaken to look into the production of specific prepositions using this data would be confounded by

this factor. We could not, therefore, ascertain whether individual prepositions were more, or less, influenced than other prepositions by the factors of function and angle as was the case in the comprehension studies undertaken by Coventry et. al. (2001). Further research looking at specific prepositions may prove fruitful in discovering whether this is the case for children. However, this may need to be research into children's comprehension rather than their production of specific terms, for as we have seen, it is difficult to obtain specific prepositions in the latter.

Again, some children had difficulty in either finding the words with which to describe the scenes or in producing any inferior relational prepositions. Seventeen children who participated in this experiment (14%) failed to complete it. This was less than for Experiment 3 where 23% of the participants failed to complete the task. One possible reason for the lower attrition rate in this study can be attributed to the children's confidence in producing inferior prepositions compared to superior prepositions. As we have seen in an earlier section of this chapter, 23% of the children in Experiment 3 who completed the task produced no superior relational prepositions and for those children that did produce them, their relative production increased systematically across age groups (43%, 61%, 68% and 91% of all utterances for age groups 1-4 respectively). However, for this experiment investigating inferior relations, only 13% of the children who completed the task produced no inferior prepositions in their spatial descriptions. Moreover, the relative production of inferior prepositions was high for all four age groups, with between 69% and 86% of all utterances in each age group being inferior relational prepositions. The reason that children appeared more confident with producing inferior prepositions could be linked to the age at which these prepositions develop within the child's lexicon. Children begin to comprehend the inferior preposition *under*, for example, at around 3-4 years of age, and although its production is relatively sparse at this age, this does increase with age (Asso & Wyke, 1973). This can be compared to children's understanding and

production of terms such as *over* and *above* that are not typically developed until much later on with children still displaying some problems with these terms well into their early school years (e.g., Durkin, 1980; Leikin, 1998).

In order to assess further whether there was a difference between the production of superior prepositions and the production of inferior prepositions, the data from Experiments three and four were analysed together[21]. This analysis did indeed confirm that this was the case; the youngest two groups of children (mean ages 7;0 and 9;0) produced significantly more inferior than superior prepositions. It was not until age group three (mean age 10;11) that the children produced comparable amounts of superior and inferior relation prepositions.

4.5. General Discussion

This chapter has focussed on adults' and children's production of superior and inferior prepositions. The general findings were that both adults and children produced significantly more vertical axis prepositions (e.g., *above* and *under*) when they were describing scenes that depicted a successful functional interaction between two objects (or neutral scenes), with more general prepositions being produced to describe a non-functional interaction. One point that merits a mention is that although the vertical axis completions for the functional scenes were higher than for the control scenes, this did not reach significance in either experiment. This could be that, as mentioned earlier, the neutral scenes were not completely neutral. Simply by positioning them along the vertical axis in such a way suggests a possible interaction with one another. As no substance was

[21] The full details of this analysis will not be reported here. The results from the analysis of variance and any follow-up analyses made can be found in Appendix 11.

present there was no further information regarding how successful the interaction is, although the relative position of the two objects might suggest a positive interaction is possible, therefore it is likely that these scenes were more similar to the functional than the non-functional scenes and treated as such. Nevertheless, it is interesting to note that even children without a great range of prepositions to use in their lexicon make the same distinctions as adults in the spatial domain, although their absolute level of production for superior prepositions was lower.

Developmentally, it was found that young children (under 10-years old) generally have more problems with the production of words that denote a superior relation between objects than those that denote an inferior relation. Therefore, words such as *over* and *above* were not only produced by fewer children under the age of ten than words such as *under* and *underneath*, but also when children did produce them, they were less frequently produced. This difference had disappeared by the age of around ten or eleven years.

Looking at specific prepositions individually was somewhat problematic as relatively few participants produced some of the prepositions, and when they did produce superior/inferior prepositions, they frequently produced more than one. Therefore, it was not possible to analyse the production of individual prepositions meaningfully.

We will now consider what was happening when adults and children produced different types of completions in the two experiments reported in this chapter. As mentioned earlier in this chapter, the results of these production studies highlight the limitations of rating studies that restrict the range of lexical items tested and compares the comprehension of individual prepositions against one other (e.g., Coventry et. al., 2001). For example, although Coventry et. al. (2001) found differential effects of function and geometry for the comprehension of the preposition sets *over/under* and *above/below*, this information is meaningless when we look at the *production* of these prepositions. The individuals in these experiments did not alter the superior/inferior preposition they

produced when describing the scenes whereby *over/under* were produced more for the functional scenes; they altered the *type* of preposition they produced. Additionally, adults produced the preposition *over* between 8% and 9% of the time, whereas *above* was produced between 76% and 81% of the time. Therefore, comparing the preposition *above* with the preposition *over* is not comparing like with like.

The way spatial prepositions are produced and comprehended *during conversations* may be quite different to the way they are comprehended in isolation. As such, research that assesses the appropriateness of prepositions in isolation might be misleading to theories of spatial language production. Language operates in a predominantly social manner with usually more than one person participating (Clark, 1996). When people are talking together in a social context they make distinctions; we need to look at the whole process of interaction rather than just looking at what is specified in an individual's lexicon. How people make distinctions between different scenes when interacting is therefore an important aspect of spatial language.

Although no claim can be made regarding the naturalness of the conversations that occurred during the two experiments, both children and adults were participating in a *verbal interaction* with the experimenter. For each scene they were specifically asked to say aloud a word or words to complete a sentence so that it described where an object was in that scene. In order to make distinctions between the scenes, they altered the type of preposition they produced. Clark (1996) argues that language is a nonconventional method of communication. The conventions of English are insufficient for successful communication. They merely specify potential uses of words rather than their actual production. Words do not just have a small set of fixed conventional meanings that are specified in the lexicon. They potentially have a much greater set of nonconventional meanings and are dependent upon aspects such as context and joint salience for their solution. In this study, where both experimenter and participant were looking at the same

scene whilst the utterance was produced, the participant might produce the words *under* or *above* to describe functional scenes, but choose to produce *next to* or *near* for the non-functional scenes. This is not to say that *next to* or *near* has anything specified in the lexicon regarding non-functionality, but that this nonconventional use of the word was produced successfully as a distinction from the functional words uttered during a joint social interaction appealing to the interlocutors' current common ground. Common ground includes the aspect of joint perceptual salience that can be used as a co-ordination device in language (e.g., Clark & Marshall, 1981).

In the experiments described here, both participant and experimenter were looking at the same picture as the words were being uttered to describe it. Therefore, the production of a proximity preposition (which does not indicate directionality) allows the hearer to infer that functional relations are not present between objects, given the inherent vagueness of the preposition produced. In this sense, the speaker is deliberately breaking the principle of quantity (Grice, 1975) in order to differentiate between types of scenes in the common perceptual ground in a manner consistent with the model proposed by H. Clark (1996). How people make distinctions using language is an important area for further research. While comprehension studies are revealing about what words can mean, tasks involving interaction between a speaker and hearer are more likely to get at the distinctions people make in more real world situations. However, this chapter has only explored how adults and children make distinctions when objects are positioned along the vertical axis using a limited number of scenes. Chapter 5 investigates the way adults and children use frames of reference by utilising a free-response sentence completion paradigm similar to that used in Experiments 2, 3 and 4 in order to evaluate whether functional relations similarly influence frame of reference selection.

5. Chapter 5: The Effect of Functional Association, Blocking, Distance and Orientation of the Located Object on Adults' and Children's Frame of Reference Use

5.1. Reference Frames: Ambiguities and Definitions

Chapter 3 of this thesis examined geometric and extra-geometric influences for the production of simple topological prepositions such as *in* and *on*, whereas Chapter 4 addressed this issue for superior/inferior relational terms. This chapter will investigate spatial frames of reference and the factors that might influence how and when, adults and children use them. Although there has been limited research investigating how functional factors affect adults' comprehension and use of reference frame systems, this area has not yet been explored with children. Therefore, we will begin by giving a close definition of Levinson's (1996) classification of reference frames along with an indication of the age at which children might be able to comprehend them (a more detailed review of children's spatial language development was given in Chapter 2). Next we will look at what is known about children's production of the prepositions needed in order to use the different reference frames for the scenes in Experiments 5 and 6. Finally, before presenting Experiments 5 and 6 of this thesis, there will be a detailed review of the research that

investigated functional influences on adults' reference frame selection, which formed the basis of these two experiments.

Recall from Chapter 1 (on page 8 above) that projective prepositions allow the use of different reference frames when describing a spatial scene whereby each description takes a different reference point (*intrinsic*, *relative* and *absolute*) as its starting place. As we shall see later on in this chapter, the reference frame that we ultimately use may depend on various things including contextual aspects of the scene such as meaningful relations between objects (e.g., Carlson-Radvansky & Radvansky, 1996).

However, one complication that arises when talking about frames of reference and looking at the research conducted in the area is that we find that different researchers use different distinctions between various frames of reference and these distinctions do not directly map onto one another (Levinson, 1996)[22]. For example, some researchers use the terms *intrinsic* versus *deictic* (e.g., Abkarian, 1982) while others talk of *allocentric* versus *egocentric* (e.g., Cox & Isard, 1990) and even *object-centred/intrinsic* versus *viewer-centred/deictic* versus *environment-centred/extrinsic* (e.g., Carlson-Radvansky & Radvansky, 1996).

For the purpose of this thesis, and in order to simplify the situation, we will adopt Levinson's (1996) classification system of *intrinsic*, *relative* and *absolute* frames of reference that we will now set out in detail and that are illustrated in Figure 5.1 below. Therefore, to avoid confusion when discussing the research in this area, these terms, and only these terms will be used, mapping the original terms on to these where possible. According to Levinson's (1996) definition, the *intrinsic* frame of reference takes an object-centred perspective (see Figure 5.1 below for an example). The coordinates it uses are

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[22] Although reference frames have been investigated across many different areas of research including vision and imagery, for the purpose of expediency in this thesis we will only consider the terms used in psycholinguistics and linguistics.

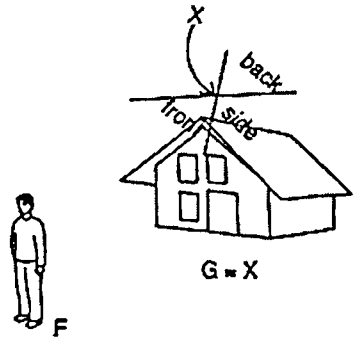
derived from the inherent features, or facets, of the reference object used. These facets are conceptually assigned, usually consistent with some kind of learning process. In English, it is often functional information that determines where *the front* of an object is (Miller & Johnson-Laird, 1976). For example, *the front* of a cooker is the side where the oven door is situated and *the front* of a post box is where the opening slot for the letters is located. Likewise, *the front* of a vehicle is the area that lies in the usual direction of motion. *The back* of an object is then taken to be the opposite side to the front of that object. Typically children can accurately assign an object's front and back by around four years of age (Kuczaj & Maratsos, 1975). However, learning where *the side* of an object is can be a more protracted affair, as can be learning where to place an object *in front* of another object that has no inherent front, back or side (e.g., a bowl or a ball). However it seems that children's understanding of *front*, *back* and *side* for featured objects is largely complete by the time they are 5-years-old (Harris & Strommen, 1972).

The *relative* frame of reference incorporates the notion of a viewer-centred description of the scene, but it is not restricted to that notion. It suggests a *viewpoint* of the scene that is quite separate from both located and reference objects. Such a viewpoint may be that of the speaker or some other perceiver (in any sensory modality) of the scene. Therefore, it can be conceived as having a triangulation of three points utilising the coordinates fixed on the viewpoint to assign the position of the located object to the reference object. Although the position of the body that is taken as the viewpoint can be used as the starting point for the coordinates, other things such as the direction of gaze might be equally used. Indeed, Levinson (1996) asserts that the *relative* frame of reference system is closely linked with visual criteria.

Figure 5.1. Canonical Examples of the Three Linguistic Frames of Reference.

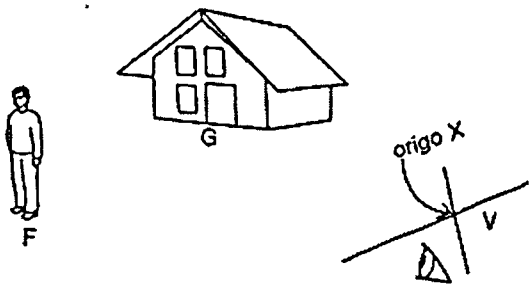
INTRINSIC

"He's in front of the house."



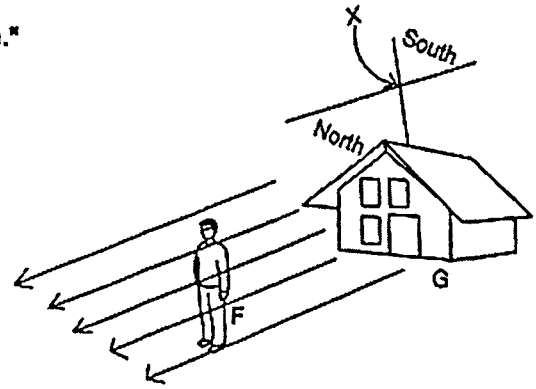
RELATIVE

"He's to the left of the house."



ABSOLUTE

"He's north of the house."



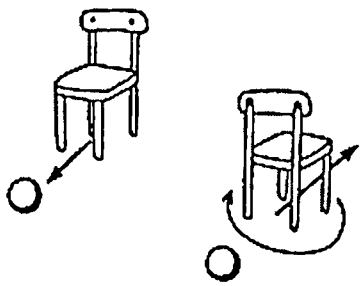
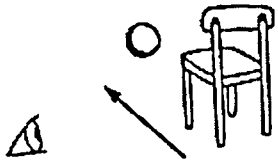
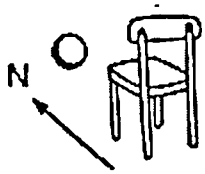
Note: Illustration taken from Levinson (1996).

Developmentally, the *relative* frame of reference is associated with the notion of the egocentricity of a child (although it does not directly map onto it). It has been suggested that children below the age of seven are locked into representations of space that are based on a purely egocentric perspective and therefore use only themselves as reference points rather than, for example, any intrinsic elements of reference objects (Piaget & Inhelder, 1956). However, research has shown that children are not always egocentric and even quite young children (mean 2;10) have been shown to find it easier to respond to placements of *in front of* when a reference object has intrinsic elements (e.g., a cooker) rather than when none are present (e.g., a ball; Kuczaj & Maratsos, 1975).

Finally, the *absolute* frame of reference mainly uses co-ordinations based on salient features of the environment. In English, gravity and canonical views of the visual horizon can be used and therefore the absolute reference frame often coincides with the canonical viewpoint of the speaker. Utterances such as *the church is to the north of the station* and *the picture is above the fireplace* are examples of using the *absolute* reference frame. It should be noted, however, that the scenes used in the experiments to be described later on in this chapter, the *relative* and *absolute* reference frames coincide.

Although this is a relatively brief introduction to the three different frames of reference that we will be discussing in this chapter, Figure 5.3 (below) gives us another aid with which to understand them. By looking at how each reference frame anchors its co-ordinates we can assess whether any given description fits with the *intrinsic*, *relative* and *absolute* frame of reference. For example, for the *intrinsic* frame of reference we can think of the reference object as the anchoring point whereas for the *absolute* frame of reference we can think of the viewpoint of an observer as the anchoring point (see Figure 5.2 for examples).

Figure 5.2. Properties of the Three Linguistic Frames of Reference Under Rotation.

	Rotation of: viewer	ground object	whole array
Intrinsic "ball in front of chair" 	same description? yes	same description? no	same description? yes
Relative "ball to left of chair" 	no	yes	no
Absolute "ball to north of chair" 	yes	yes	no

Note: Illustration taken from Levinson (1996).

Having set out the main classification scheme we will use in this thesis, let us now take a look at how objects themselves can influence which reference frame is used before going on to look at how children develop the prepositions required for using this referencing system. Finally, we shall review the evidence for functional influences on frames of reference use.

5.2. The Influence of Objects on Reference Frame Selection.

Some objects possess an inherent front (e.g., a television) others do not (e.g., a ball), and while some objects have obvious functional uses and we may interact with them (e.g., a chef and a cooker), others have no functional uses and our interaction with them is less obvious. When describing where objects are in relation to one another, we may decide to adopt any one of the previously described frames of reference, but sometimes this is contingent upon the reference object itself. For example, we might be restricted from using an intrinsic reference frame if the reference object possesses no fronts, backs or sides. It could therefore be said that the particular reference object we select has an influence on the reference frame we use to locate another object to it. Let us now take a look at the way adults use reference frames and how different objects might affect that use.

There are two types of fronts and backs; those that are derived from the inherent features, or facets, of a featured reference object (e.g., people, cars, cookers) and those that are projected onto featureless reference objects (e.g., a ball, a tree, or a flower). As we cannot use the *intrinsic* frame of reference on a featureless object, H. Clark (1973) invoked the notion of the "canonical encounter" to allow us to assign front, backs and

sides to that object. Recall from Chapter 2, H. Clark (1973) suggested that, since the typical context of language use involves a speaker and an addressee in face-to-face contact a short distance apart, an adult imposes a canonical relationship upon the featureless object treating it as if it were another person facing him or her. Therefore, if a speaker is looking at a tree and says *the flower is in front of the tree*, the flower will be between the tree and the speaker. However, it has been demonstrated that adults' responses to placing one object *in front of* a non-fronted object conforms to the notion of a canonical encounter a little over half the time, with 31% of placements being to the far side of the reference object (Abkarian, 1982). By doing this, they were adopting a *relative* frame of reference by taking their own viewpoint as the anchoring point for the coordinates rather than using the canonical encounter. Looking at simple comprehension tasks using objects with inherent fronts, backs and sides, it has been shown that adults have a strong preference for placing objects using an *intrinsic* frame of reference (98% of 1,728 responses; Abkarian, 1982) regardless of the orientation of the reference object itself. However, this study used a matchbox as the located object and a doll, a toy chair and a toy truck as the reference objects.

Using a fly as the located object and various unrelated reference objects (e.g., donkey, bottle, cake, boot), Carlson-Radvansky and Irwin (1993) investigated adult's understanding of the prepositions *above* and *below* with respect to each of the three reference frames. Over a series of experiments, they not only manipulated the orientation of the reference object but also the orientation of the participant in an attempt to separate all three reference frames. Carlson-Radvansky and Irwin found that *above* was usually interpreted with respect to the *absolute*, and sometimes *intrinsic*, frame of references. The *relative* frame of reference made no independent contribution to adult's interpretation of the preposition *above*. Consequently, they suggested that the use and meaning of *above* and *below* are determined after the reference frame has been selected rather than the terms

themselves constraining which reference frame is used. Individual differences in the way adults use reference frames have also been reported; some participants have been shown to use the *intrinsic* reference frame, some preferring the *relative/absolute*, while some participants switched between both (Carlson-Radvansky & Logan, 1997).

Given that there is some variation in the way adults use and comprehend *above* and *below* with reference to the reference frames they prefer, it could be that the type of objects depicted in a scene could influence adults' reference frame selection. Indeed, Carlson-Radvansky and Irwin (1993) found that making the reference object more salient positively influenced the ratings for the *intrinsic* uses of *above*.

As we have seen in Chapters 1, 3 and 4, *what* objects are and how they are interacting in the world can affect *where* they are in terms of the language we produce to describe them. Following on from this we might ask whether other factors, such as the presence of a functional relation between reference and located object, affect the way we talk about them in terms of the reference frame used. Before we address this important issue, we will briefly review the evidence on the development of children's spatial language and their subsequent use of reference frames.

5.3. The Development of a Referencing System in Children's Spatial Language

In the previous section we saw how adults comprehend both the *intrinsic* and *relative/absolute* frames of reference. We also saw how aspects of the reference object (i.e., whether or not it possessed inherent features) can affect reference frame comprehension in adults. The focus of this section is to ascertain how children learn to use

these referencing systems with an emphasis on the production of the terms required. However, in order to set the scene, we will briefly outline the development of children's comprehension of these terms. Once again, much of the research in this area concentrates upon children's comprehension of terms rather than the actual words children produce to describe spatial relations between objects, with object placement being used as the main measurement of comprehension. Most of this research was covered in greater depth in Chapter 2 of this thesis where we looked chronologically at children's development of spatial prepositions. Here, we will try to address the research of prepositional terms by way of looking at what this means in terms of children's use of frames of reference.

The question of children's egocentricity has been the focus of much of the research in this particular area (e.g., Abkarian, 1983; Cox & Isard, 1990). From an egocentric perspective the child is locked into interpretations based on the child's own position (Piaget & Inhelder 1956) and in this sense the child can only use a relative (rather than an *intrinsic*) based frame of reference. As mentioned earlier, the *relative* frame of reference is associated with the notion of egocentricity, although the terms are not synonymous with one another. The concept of egocentricity in the Piagetian sense can also mean not considering another's perspective, and in this way, it does not directly map onto the *relative* frame of reference. Although the notion of egocentricity asserts that children will use the *relative* frame of reference before they learn to use the *intrinsic* frame of reference, we shall see later on in this section that things are not so simple. Which frame of reference children use during their development can depend upon a number of factors including the located object, the reference object and the spatial term used.

5.3.1. The Development of Reference Frame Comprehension

Most of the research has looked at the comprehension of the terms *in front of* and *in back of/behind* and has shown them to be generally acquired earlier than terms such as *to the side of, on the top of, left of* and *right of.* However, the comprehension and production of the terms *in front of* and *in back of/behind* is acquired later if the reference object is featureless than if it possesses inherent front, back and sides.

Research has shown that children first learn that "front" and "back" are opposites before they acquire a specific understanding of either term. By the age of about 2;10 children can identify their own fronts and backs most of the time (83%) with children of around 3;11 displaying complete accuracy (Kuczaj & Maratsos, 1975). However, when asked to identify *the front* of a fronted object such as a cooker or a car, children are not so accurate. At around 2;10, children are correct only 64% of the time rising to 93% by the age of 3;11 (Kuczaj & Maratsos, 1975). Although children have mastered the understanding of their own "front" and "back" by around 4 years of age, they are still struggling to identify where the "side" of themselves and other objects are until they reach around 5 years of age (Kuczaj & Maratsos, 1975; Harris & Strommen, 1972).

Young children (2;10 to 3;5) have significant problems in knowing where to place one object (located object) *in front of/in back of* a reference object if the reference object has no intrinsic fronts, backs or sides (Kuczaj & Maratsos, 1975). Recall from an earlier section of this chapter H. Clark's (1973) notion of the *canonical encounter.* As we cannot use the *intrinsic* frame of reference on a featureless object, H. Clark suggests that we assign front, backs and sides to that object ourselves. He suggested that, since the typical context of language use involves a speaker and an addressee in face-to-face contact a short distance apart, we can impose a canonical relationship upon the featureless object by

treating it as if it were another person facing us (see Pattern A in Figure 2.4 on page 67 for an example of this configuration). It has been demonstrated that children as young as four-years of age, when instructed to place one object *in front of* a featureless object, do so conforming to the canonical encounter around 68% of the time (Kuczaj & Maratsos, 1975). This compares with 5 to 7 year olds who respond similarly 67% of the time, and adults who do so for 62% of responses (Abkarian, 1982; Harris & Strommen, 1972). The vast majority of adults' and children's placements that did not conform to the canonical encounter is represented in Pattern B of Figure 2.4 on page 67 (Abkarian, 1982; Harris & Strommen, 1972; Kuczaj & Maratsos, 1975). Therefore, by around four to five-years of age, children have attained a similar level of agreement to adults.

When the reference object possesses inherent front/back/side features, one question that has been asked is when do children begin to use these features as reference points for *in front of/behind* placements. It has been demonstrated that children as young as 2;10 can successfully place one object *in front of* another object's *intrinsic* front (and *in back of* its back) about half the time with 4-year old children responding *intrinsically* to *in front of* and *in back of* requests between 80% and 95% of the time (Abkarian, 1981; Bialystock & Codd, 1987; Clark, 1980; Harris & Strommen, 1972). Much of the research in this area has used located objects with no intrinsic fronts, backs and sides (e.g., a ball or cube). However, when children are given an object with inherent features (for example, a toy chair) and they are asked to place it *in front/back/side of* a similarly featured object it has been shown that not only do they place the located object in the appropriate spatial position according to the request, but they also place it so that both located and reference object are orientated identically (see Pattern C in Figure 2.4 on page 67 in Chapter 2). This has been shown to be so for children as young as 4;9 using a number of different located and reference object pairs including dolls, bugs and vehicles and across various different orientations of the reference object (Harris & Strommen, 1972; Wanska, 1984). It also

appears to be a predominant pattern; indeed, in the Harris and Strommen (1972) study of the 320 spatial placements made by 80 children between 4;9 to 7;5, 86% (275) of them were in this pattern. This suggests that the orientation of the located object can also affect children's interpretation of expressions such as *in front of*. This aspect of spatial placement has not been looked at with adults.

It has also been demonstrated that 5-year-old children can utilise the context of a situation when deciding whether or not the *intrinsic* frame of reference is appropriate in a placement task (Cox & Isard, 1989). For example, children were shown a toy car both facing sideways or away from them and were simply told to *put the man behind/in front of* the car. In this instance, the use of the *intrinsic* reference frame dominated their placements. However, in the context of a hide-and-seek game, when children were told *this man is going to hide from you. He's going to hide behind the car. Where?*, there was no difference between intrinsic and relative placements made by the children. This suggests that children as young as 5 years of age can use extra-linguistic cues in frame of reference selection.

As mentioned at the beginning of this section, comprehension of the terms *on the left of* and *on the right of* is relatively late acquired. Learning to comprehend and produce the terms *left* and *right* correctly require not only verbal and spatial ability but also the fundamental ability to tell "left" from "right". As with other terms, being able to identify the "left" and "right" of our own bodies precedes other aspects of "left"/"right" acquisition; this is usually achieved by the age of around five or six. From this point onwards, children begin to make the same differentiation regarding other bodies or objects. Finally, they are able to assign *left* and *right* verbal labels to the relative left-right relations among objects in space (Boon & Prescott, 1968; Corballis & Beale, 1976).

We can see from the above that developing the comprehension of the spatial terms required is a protracted affair. Children generally begin by learning how each spatial term

can be applied to themselves (e.g., front, back, side, left and right). They then extend this information and apply the terms to other objects. Additionally, young children are not wholly egocentric and are therefore able to use an *intrinsic* reference frame the majority of the time (with 80% or more correct placements) by the age of four.

5.3.2. Children's Use of Reference Frames: How Production Develops

The previous section looked at children's comprehension of reference frames, we will now outline some of the findings from two studies undertaken by Johnston that reported the order of production of some spatial terms and gave an indication of how they were used (Johnston, 1982; Johnston & Slobin, 1979).

Johnston and Slobin (1979) looked at (amongst other things) the utterances of children between the ages of 2;0 and 4;8 over two time intervals four months apart. They placed an object at the front and the back of both fronted and non-fronted objects. The order of acquisition for the production of locative expressions in English began at around the age of 3;9 with the production of *in front of* for a fronted object. Next, they produced *in back of/behind* for a fronted object (mean 4;4) and later children produced *in back of/behind* for non-fronted objects. *In front of* was only produced to describe the position of a located object to a non-fronted object by a few of the older children. Johnston and Slobin (1979) did not report mean ages for the last two uses of these terms.

In a later study, Johnston (1982)[23] found that children's earliest production of *in back of/behind* was to describe the location of an object that was placed out of sight

[23] Johnston (1982) looked at what she called *locative notions*. For example, the locative notion *in back of* could be expressed by a child as *back of X, back there, next back here to*

behind a tall, non-fronted reference object; 11% of the youngest children (mean age 2;11) did this. However, the age at which this becomes more reliable is around 3;6 with 40% of children producing *in back of/behind* to describe the location of an object placed behind tall, non-fronted reference objects. At roughly the same age, these children are also producing *in back of/behind* for fronted reference objects. By the age of around 4-years-old, children are producing *in front of* for fronted reference objects and *in back of/behind* for non-fronted reference objects. *In front of* was produced by 44% of the older children in Johnston's study (mean age 4;2) for tall, non-fronted objects, with none of the children producing *in front of* to describe the position of something placed in front of a same-size non-fronted reference object.

We can see from these two studies that children's development of the *intrinsic* reference frame use and the correct production of the terms *in front of* and *in back of/behind* is a complex affair. Children of around 4-years of age are able to comprehend the intrinsic frame of reference and they can also produce the terms appropriately most of the time. This finding is similar to research looking at the production of locatives in 115 pre-school German children's spontaneous speech; *in front of* and *behind* did not appear until around 4;4 (Grimm, 1975). However, Durkin (1980) found that for the children in his study (4;6 to 7;6), *in front of* and *behind* were infrequently produced, with prepositions such as *near* being more common.

Finally, prepositions that would denote an *absolute* or *relative* frame of reference for the scenes used in Experiments 5 and 6 are not always produced at such an early age. Children can produce the terms *left* and *right* from around 5 or 6 years of age, although their comprehension of these terms is not complete until they reach around 7-years of age (Asso and Wyke, 1973; Waller, 1986).

X or even *hind there*. Therefore, her study cannot be taken as evidence of the child using the correct production of these terms at all times.

We have seen in this section how aspects of both the located and reference objects can affect the way children use and comprehend reference frames. Whether an object is fronted or not appears to make a difference in children's placements of objects and their production of locations with which to describe the scenes. Following on from this we might ask whether other factors, in addition to whether objects have or do not have inherent features, affect the way we talk about them in terms of the reference frame used. The next section addresses this issue by looking at whether functional aspects of the scene affect reference frame use.

5.4. Functional Influences on Reference Frame Use

As discussed earlier, certain objects have inherent fronts, backs and sides with many of these objects being important to us in that we use them in a functional manner. Additionally, it has been suggested that the assignment of intrinsic sides to an object is often determined by the functional use of that object (Miller & Johnson-Laird, 1976). Therefore, one might assume that by depicting two objects interacting in a functional (or non-functional) manner, the use (or non-use) of the *intrinsic* reference frame would be influenced.

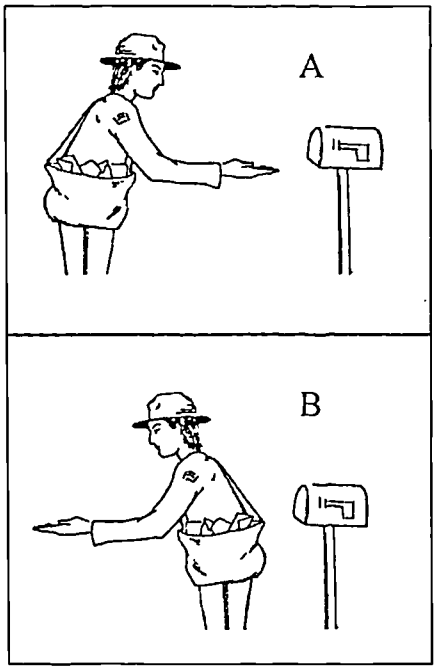
Although there has been no research to date investigating this with children, Carlson-Radvansky and Radvansky (1996) report two experiments looking at functional influences on adults reference frame selection. The first addressed adults' comprehension of reference frames; the second investigated adults' production of these systems. The pictures used by Carlson-Radvansky and Radvansky (1996) in both comprehension and production experiments were the same. Ten picture pairs were used, each containing a reference object and a located object that were related in some way (see Table 5.1 below for a full list of located and reference objects along with the spatial term classification and

Figure 5.3 below for an example). For each pair of pictures there was a functional and a non-functional version. The functional manipulation was made by depicting the located object in a typical interaction with the reference object (see Figure 5.3 (A) for an example). Reflecting the located object so that it did not typically interact with the reference object produced the non-functional manipulation (Figure 5.3, B).

Table 5.1. The Located and Reference Object Pairs with their Corresponding Reference Frame Classification as used in the Carlson-Radvansky and Radvansky (1996) Study

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

Figure 5.3 An Example of the Functional and Non-function Pictures used in Carlson-Radvansky and Radvansky's (1996) Study.



Note: Illustration taken from Carlson-Radvansky & Radvansky (1996).

For the comprehension study, each picture was produced twice and paired with a sentence to be rated (5-point scale) in the form "the located object is _____ the reference object". One sentence used the *intrinsic* reference frame, while the second sentence used the *relative/absolute* reference frame. Consider the pictures in Figure 5.4 above for example. The sentence *the mail carrier is in front of the mailbox* (an *intrinsic* description) and *the mail carrier is to the left of the mailbox* (a *relative/absolute* description) were each paired with the two pictures (giving a total of four picture-sentence pairings to rate). Participants rated *intrinsic* descriptions as significantly more acceptable than *relative/absolute* descriptions for the functional than the non-functional pictures. Additionally, they rated *relative/absolute* descriptions as significantly more acceptable than *intrinsic* descriptions for the non-functional pictures.

Carlson-Radvansky and Radvansky (1996) then wished to ascertain whether adults' *production* of reference frames would be similarly affected. They commented as follows, "Because subjects were provided with descriptions of pictures in Experiment 1, there was no indication whether these deictic-extrinsic [*relative/absolute*] and intrinsic terms would be used if subjects were asked to describe the pictures." (p. 58).

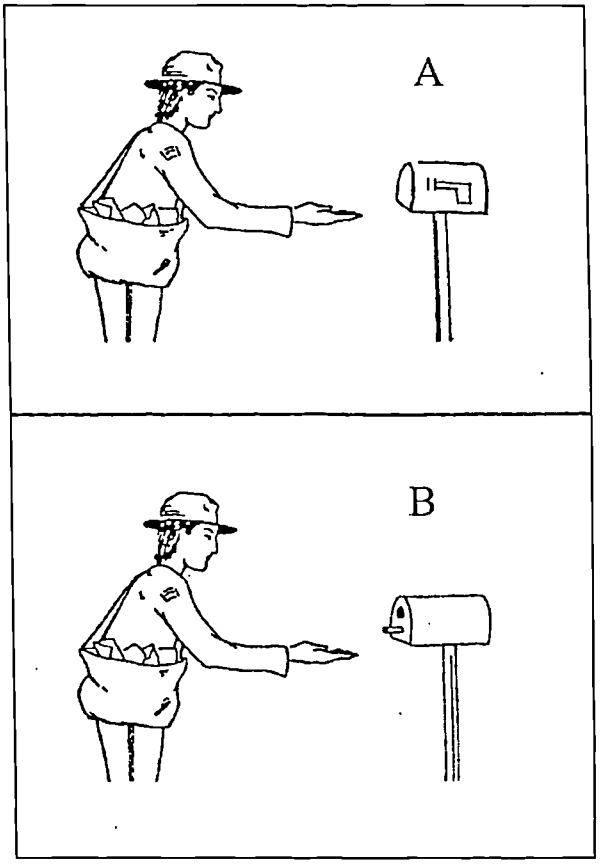
In their production study, Carlson-Radvansky and Radvansky used a sentence completion task and asked their participants to complete the sentence *the located object is* _____ *the reference object* where located and reference objects were the same as Experiment 1 reported above. However, they then restricted participants to using only one of the following terms for each sentence: *above*, *below*, *to the left of*, *to the right of*, *in front of* or *in back of*. The multiple choice paradigm was used after pilot studies showed that open-ended instructions did not elicit enough spatial terms for an analysis. They coded participants' responses as defined by Table 5.1 (on page 268 above) so that any response that concurred with the use of a reference frame in the table was classified according to that reference frame, with any other response being classified as *other*.

Looking at *intrinsic* versus *relative/absolute* terms (ignoring *other* terms) they found that *intrinsic* terms were selected significantly more than *relative/absolute* terms for the functional pictures with *relative/absolute* terms being selected significantly more than *intrinsic* terms for the non-functional pictures. However, the use of *other* terms was extremely high. Fifty percent of the completions for the non-functional pictures and 17% of completions for the functional pictures used *other* terms. Carlson-Radvansky and Radvansky suggested this was due to the ambiguity in the non-functional pictures "allowing for greater breadth in interpretation and in the number of possible spatial terms" (p. 59).

As we have seen in the production experiments reported in Chapters 3 and 4, a free-response paradigm opens the door for a wider range of responses. Much of this is

glossed over in the Carlson-Radvansky and Radvansky (1996) production task where the terms were actually *given* to the participants to select. But even here we can see that, for whatever reason, participants were reluctant to restrict themselves in using designated frames of reference when describing a scene, with 50% of responses to the non-functional scenes being *other* terms. In relation to the picture in Figure 5.3 above, *other* terms for the non-functional picture (B) would be either *above*, *below*, *to the right of* or *in back of*.

Figure 5.4. An Example of the Alternative Functional and Non-function Pictures Reported in Carlson-Radvansky and Radvansky's (1996) Study.



Note: Illustration taken from Carlson-Radvansky (in press).

Additionally, Carlson-Radvansky and Radvansky (1996) reported briefly on two comprehension and production pilot studies they conducted looking at similar types of

materials but this time using a different definition of non-functional. For these experiments, functional meant there was a relationship between the two objects present (e.g., mail carrier and mailbox, see Figure 5.4, A above) whereas non-functional meant that this relationship was not present (e.g., mail carrier and bird box, see Figure 5.4, B above). Similar results were found to those from the main experiments; participants preferred the *intrinsic* frame of reference for the functional pictures. Therefore, Carlson-Radvansky and Radvansky (1996) have clearly demonstrated functional influences on reference frame comprehension and on reference frame selection using a limited number of fixed-choice prepositions and two different interpretations of what constitutes "functional". However, the question remains, because participants were provided with descriptions of pictures and a choice of terms in their study, there was no indication whether these *relative/absolute* and *intrinsic* terms would be produced if participants were asked to *freely* describe the pictures.

Certainly, as we have seen so far in this thesis, a free-response paradigm allows for a much greater variation of terms produced to describe scenes. The experiments reported in Chapter 4 of this thesis demonstrated that, even though the spatial relation between the two objects depicted was aligned along the vertical axis, both adults and children did not restrict themselves to producing vertical axis terms (e.g., *over* or *above*) when describing their relative positions. Other terms, such as *near* and *close to* were produced. Likewise, when given pictures to describe such as those in the Carlson-Radvansky and Radvansky study (Figure 5.3), using a free-response paradigm, the sentence *the mail carrier is near the mailbox* would quite adequately describe the scene without the use of reference frames. The following two experiments reported in this thesis will use a free-response sentence completion paradigm to address the issue of whether *relative/absolute* and *intrinsic* terms would be produced *at all* when participants are asked to freely describe the pictures.

Experiment 5 was designed to examine whether the functional association between a person (located object) and an object (reference object), the orientation of the located object and the blocking of function had an effect on the way adults and children used spatial frames of reference when describing a scene. The manipulations made were based on those used by Carlson-Radvansky and Radvansky (1996) using both interpretations of functional (functional association and orientation) and an additional manipulation of blocking of function.

As mentioned above, all the objects used in Experiment 5 were positioned along the horizontal axis, therefore, *in front of* would be an ideal example of an *intrinsic* description with terms such as *left* and *right* being ideal *relative/extrinsic* descriptions. From a developmental perspective, we would expect to see even the youngest children in this study (3;8 to 5;1, mean 4;6) producing an *intrinsic* description of some of the materials. Additionally, we should see an increase in terms such as *left* and *right* with age. There has been no previous research investigating the effect of functional influences for children's reference frame use. Although in Experiments 3 and 4 we saw quantitative rather than qualitative differences between the responses of adults and children, we would expect to see some developmental difference in reference frame use due to the late acquisition of the terms *left* and *right* (Asso & Wyke, 1973; Waller, 1986). For the pictures in this study, we would therefore expect children's use of the *relative/extrinsic* reference frame to increase dramatically after the age of around seven years.

5.5. Experiment 5: The Influence of Functional Association, Blocking of Function and Orientation of the Located Object on Adults' and Children's Reference Frame use

This experiment was designed to explore the effects of functional association between located and reference objects, orientation of the located object and the blocking of function on adults' and children's reference frame use. The manipulations made were based on those used by Carlson-Radvansky and Radvansky (1996). Additional manipulations of functional association and blocking were made. The located object (always a person) in the scene was either functionally associated with the reference object (e.g., a chef and a cooker, see Figure 5.6 below) or not functionally associated with it (e.g., an artist and a cooker). Furthermore, they were either depicted with the addition of a screen between the located and reference objects thereby blocking access to the reference object for the person in the scene or no blocking was present. In order to elicit natural language production, a series of colour photographs displayed above an incomplete sentence in the form of *the located object is* _____ *the reference object* was shown to adults and children. The role of the participant was to give the experimenter the word or words to put in the sentence so that it would best describe the picture (a free response sentence completion paradigm). The dependent variable was the utterance given by the participant for each sentence accompanying the spatial scene.

5.5.1. Selection of Materials

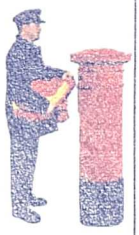
The materials used in this experiment were based on some of those used by Carlson-Radvansky & Radvansky (1996) for the horizontal axis, but alterations were made taking into consideration that young children would be participating. Figure 5.5 (a-d) below displays the located objects and their associated reference objects. Additionally, each person was matched with a second reference object where no association was thought to hold (see Figure 5.5 (e-h)).

In order to check that there was indeed a difference in association between the sets of materials, a pilot study was run. Twenty-one adults completed a rating task asking them to indicate on a scale of 1 to 7 how functionally related each pair of objects were whereby 7 suggested they were highly functionally related and 1 suggested that they were not functionally related. They were each given a sheet with the following instructions:

> *Below you will see a variety of person-object pairs. Your task is to rate how functionally related you think each pair is. That is, how much the person in each picture usually interacts with the object in the picture. For example, a photographer and a camera can be considered functionally associated whereas a photographer and a shovel may be considered non-functionally associated. Please use the scale 1-7 on the right of each person-object pair to make your rating where 7 = highly functionally related and 1 = non-functionally related. Please feel free to use any number on the scale to grade each pair of objects and circle only one number for each pair.*

A two-way within group analysis of variance was performed on the data[24]. The variables were functional association (two levels: functionally associated, non-functionally associated) and materials (four levels: chef, artist, librarian and postman). The means for the rating of the materials are displayed underneath each picture in Figure 5.5 (below).

Figure 5.5. The Reference and Located Objects used in Experiment 5; an Artist, an Easel, a Chef, a Cooker, a Librarian, a Bookshelf, a Postman and a Post box

(a)  Mean: 6.8, SD: 0.6	(b)  Mean: 6.9, SD: 0.3	(c)  Mean: 6.6, SD: 0.7	(d)  Mean: 6.5, SD: 1.3
(e)  Mean: 1.8, SD: 1.1	(f)  Mean: 1.6, SD: 0.9	(g)  Mean: 1.7, SD: 0.8	(h)  Mean: 2.6, SD: 1.7

A main effect of functional association was significant, $F(1,20) = 784.21$, $p<.00001$. The functionally associated pictures were rated higher than the non-associated pictures (means 6.7 versus 1.9). No main effect of materials was found. An interaction between materials and functional association was also significant, $F(3,60) = 5.02$, $p<.01$.

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[24] The ANOVA table for this analysis can be seen in Appendix 13.

Follow-up analysis found that all functional materials were significantly different to all non-functional materials. However, although all functional materials were not significantly different to each other, the chef and librarian non-functional pictures were significantly different to the postman non-functional picture. As this would not affect the outcome of the study, all the materials in Figure 5.5 were used.

5.5.2. Method

5.5.2.1. Design

A 5 (age group) x 2 (functional association between located and reference objects) x 2 (orientation of located object) x 2 (blocking between located and reference object) partial within-participants design was used for the main manipulations. Age group was the between participants variable with functional association, orientation and blocking as the within-group variables.

5.5.2.2. Manipulations

The experiment used a series of colour photographs of the reference objects and located objects (see Figure 5.5 for examples). The variables manipulated were:

1. Functional Association between Reference Object and Located Object

The reference and located objects were either functionally related (See Figure 5.6 below, (a-d)), or functionally unrelated (Figure 5.6 (e-h)).

2. Orientation of Located Object

Two levels of orientation were used. The located object was depicted as either facing toward (Figure 5.6 (a, c, e & g)) or facing away from the reference object (Figure 5.6 (b, d, f & h)).

3. Blocking between Located Object and Reference Object

Two levels of blocking were manipulated. Either a screen was present between located and reference objects thereby blocking access to the reference object by the located object (Figure 5.6 (c, d, g & h)), or there was no screen present (Figure 5.6 (a, b, e & f)).

5.5.2.3. Participants

One hundred and fifty one adults and children in five age groups participated in the experiment. All the participants were native English speakers with normal, or corrected to normal, eyesight and hearing. The adults (n=33) consisted of first year psychology undergraduates who received a course credit for their participation. The four groups of children had mean ages of 4;3 (n=26, range 3;5 to 5;1) for age group 1, 6;7 (n=31, range 5;11 to 7;2) for age group 2, 8;4 (n=30, range 7;11 to 8;10) for age group 3, and 10;8 (n=31, range 10;0 to 11;1) for age group 4. All the children came from a single school situated in a small town on the outskirts of a city. Children below the age of 3;5 were not used in this study as it is not until the age of around 4-years-old that children are producing *in front of* for fronted reference objects (Johnston, 1984). Additionally, the terms needed for the *relative* frame of reference are used infrequently and incorrectly by children up to 5 or 6-years of age (Asso & Wyke, 1973). Therefore, it was hoped that we would find a developmental difference between the four age groups of children in the reference frames they could use.

5.5.2.4. Materials

Colour photographs were taken of four people depicting different occupations: an artist, a chef, a librarian and a postal worker. Additionally, four objects relating to these occupations were photographed: an easel, a cooker, a bookshelf and a post box. The photographs were scanned into a computer and placed onto a white background where they were subsequently edited together to form the pictures used in the experiment.

Each spatial scene manipulation was edited together four times (once with each of the four people) with the reference object situated to the right. This resulted in 32 individual spatial scenes (see Appendix 14 for a full set of these pictures). These scenes were then reflected in order to produce a second set of pictures with the reference object situated to the left. The pictures were then divided into two picture sets. Each set contained all 32 experimental spatial scenes; 16 with the reference object on the left and 16 with it on the right. Each participant saw only one of the picture sets with (where possible) equal number of participants seeing each picture set in each of the four age groups.

The scenes were interleaved with 32 scenes from another separate experiment[25] (not reported here) along with a variety of cartoon faces that appeared for one second after each picture to keep the children's attention and to act as a distracter from the previous spatial scene (in a similar manner to Experiment 2). The interest of the youngest two age groups was maintained by playing a guessing game using these cartoon faces. For example, the experimenter asked the child to guess the hair colour of the next cartoon face to appear.

The pictures were displayed on the screen with the aid of a computer program with all aspects being the same as previously described for Experiment 2 of this thesis on page 183, the only difference was that each of the four blocks of pictures contained one picture of the six spatial manipulations.

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[25] Here, the other experiment was different for adults and children. For the children it was Experiment 2 reported in Chapter 3 of this thesis. For the adults it was Experiment 3 reported in Chapter 4 of this thesis. The difference in the spatial scenes used as a filler was not thought to be a problem. A check was made afterwards that confirmed this opinion.

5.5.2.5. Procedure

The procedure was the same as for the previous three experiments as reported in Chapter 3 on page 184 of this thesis.

Twenty-one children failed to complete the experiment. This consisted of 14 (54%) of the children in age group one (mean age 4;3), 5 (16%) from age group two (mean age 6;7) and 2 (7%) from age group three (mean age 8;4). None of the children in age group four (mean age 10;8) or the adults had any problem completing the task. The main reason for failing the task was that children talked about what was happening in the picture rather than where things were, despite being encouraged to concentrate on the latter. This was more apparent for the pictures in this experiment rather than for the pictures in the other experiment (Experiment 2) that was interleaved with it. In age group 1 (mean age 4;3), some of the children were able to successfully complete the task for the pictures in Experiment 2, but could only describe what was happening for the pictures in this experiment, despite being asked questions such as *where's the chef?*. Unsuccessful responses to such questions were answers such as *he's cooking in the kitchen* or *he's frying some eggs*. If the children were happy to do so, then they continued with the task, even though they did not successfully complete Experiment 5.

5.5.3. Coding the Data

The responses from each participant were placed into a spreadsheet and coded exhaustively (see Appendix 15 for percentage and number of utterances across age group for all the categories). As this study was a free response sentence completion task, the participants were at liberty to produce any completion they wished as long as it described *where* the person was. See Table 5.2 below for main completions (> 1% of the data in any one age group[26]) across age group.

As we can see from Table 5.2, there were many age trends within the data, and in addition to the use of reference frames, terms denoting a horizontal axis and distance terms were also common. Let us now take a look at some of these completions to see how adults and children differed in their production of them and how their production was affected by the manipulations of the study.

The preposition *at* was produced most of all by children in age groups one (7% of all their responses) and three (6%). *At* can be classified as a functional term (Coventry, 1992); indeed, Miller and Johnson-Laird (1975) suggest that there is a notion of *interaction* with *at* and that "a judgment that *x* is at *y* may depend on what *x* is doing with *y*" (p. 389).

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[26] Note: As Table 5.2 contains only data that comprises >2% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 15 for full breakdown.

Table 5.2. The Percentages (and Number of Utterances) of Main Completions (> 1% in Any One Age Group) for Experiment 5.

Completion	Age Group 1 (mean 4;3, n=12)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=33)
At	7% (26)	0% (4)	6% (53)	2% (15)	3% (27)
Behind	3% (11)	1% (10)	4% (34)	1% (10)	1% (14)
Beside	0	0% (2)	3% (27)	2% (17)	6% (68)
By	20% (75)	31% (258)	28% (254)	12% (118)	3% (30)
Close to	0	0% (4)	2% (16)	2% (23)	0
Facing	0	0% (1)	2% (15)	1% (8)	0
Facing behind	0	0	1% (10)	0	0
In front of	21% (81)	34% (282)	18% (161)	35% (344)	59% (622)
Near	13% (51)	19% (155)	13% (112)	16% (160)	3% (32)
Next to	13% (50)	11% (95)	19% (170)	27% (273)	13% (135)
Opposite	0	0	1% (11)	0% (2)	0
To the left/right of	0	0	0	0% (3)	11% (120)
With	5% (20)	0% (2)	0	0	0% (2)
Errors/Non-responses	19% (69)	1% (10)	2% (17)	0% (3)	0

It was interesting to see that *behind* was produced by all age groups including adults, but mostly by age groups one (3% of utterances, mean age 4;3) and three (4%, mean age 8;4). Strictly speaking, *behind* would be classified as an error, as the located object was only ever depicted *in front* of the reference object. *Beside* was a term produced mainly by adults and older children; it was never produced by the children in the youngest age group (mean age 4;3) in this study. One term that was produced extensively by children up to age group three (20%, 31% and 28% of utterances produced by age groups

1, 2 and 3 respectively), but less by age group four (12%) and adults (3%) was *by*. This preposition is a general term that does not specify a reference frame or an axis although it does suggest that the two objects are quite close in proximity.

As expected, the preposition *in front of* was by far the most commonly produced term across age groups, and in this study, it denoted the use of the *intrinsic* reference frame. The completion *next to* was also quite common across age groups. Finally, the terms *to the left of* and *to the right of* were mainly adult terms being uttered only three times by a single child in the oldest age group (mean age 10;8). Levinson (1996) comments that western children master projective left and right only by the age of 11 or 12, although other research has claimed it is learned much earlier than this by suggesting it is at the age of around seven that children have fully mastered both production and comprehension of *left/right* terms. However, in this study even children with a mean age of 10;8 were not freely producing such descriptions when talking about the location of the objects in this experiment. We do acknowledge, however, that this does not mean that these children could not produce the terms *left* and *right*, only that they did not produce them when describing the scenes in this experiment.

The next stage of the analysis was to categorise the data in order to undertake inferential analysis on it. For this experiment, unlike for the previous experiments reported in this thesis, the categorisation of the data for analysis was not a simple matter. For example, in Experiment 3, the data were categorised according to whether or not the words used in the completions denoted the vertical axis. For this experiment, the completions needed to be categorised according to whether or not the word or words produced for the completions utilized a particular frame of reference. It could be argued that such a categorisation scheme in a free-response paradigm might involve a much greater subjective element; which utterances use the *intrinsic* and *relative* reference frames and which do not is a debatable matter and dependent upon how each term is defined.

Although this experiment was conducted in the light of unanswered questions arising from the Carlson-Radvansky and Radvansky (1996) study, the analysis is not so straightforward. The completions in the original study were made consistent across participants as they were selected from a pre-selected choice of prepositions that neatly fitted into reference frame categories, rather than being given freely by the respondents. It became apparent that in order to classify the responses in this experiment and for Experiment 6 (reported later in this chapter) that a clear coding scheme was needed with more than one person responsible for the classification of utterances.

5.5.3.1. The Coding Scheme

Levinson's (1996) definition of reference frames, as set out earlier in this chapter, was used to classify all utterances according to whether or not they denoted a particular category of reference frame use. Additionally, each utterance was classified according to whether it denoted the *proximity* of one object to another, with *proximity* being defined as "any implication of distance (near or far)". Finally, they were categorised according to whether the words refer to the horizontal *axis*, such words being defined as "any word that is normally used to describe a horizontal spatial relation in contrast to a vertical or diagonal spatial relation" (see Appendix 16 for a full copy of the categorisation scheme used).

Three judges independently categorised the data from Experiments 5 and 6 as follows: The definition of reference frames (Levinson, 1996) was read out to each person individually (as reported on page 253 of this chapter). Examples were then given demonstrating how each reference frame can be used and care was taken not to influence the judge by the use of any specific term from the experiment. The definition of what was

meant by the category of *proximity* and of horizontal *axis* was then explained using examples for clarification. All definitions and illustrations for the definitions (i.e., Figures 5.2 on page 255, and 5.3 on page 257, above) along with examples of those definitions and examples of the scenes from the experiment were placed above the coding grid so that they could be referred back to by the judge at any time. When the judge was certain that he or she understood the task, the categorisation took place. Each spatial term was coded as to whether or not it denoted *proximity* or the horizontal *axis*, with confidence ratings between 1 and 7 being made for each classification (7 being highly confident of that classification and 1 being not confident). Additionally, each term was also coded as being either the use of an *intrinsic* reference frame, a *relative/absolute* reference frame or no reference frame use.

Table 5.3. The Percentage of Agreement between Raters 1, 2 and 3 for the Coding Scheme for Experiments 5 and 6.

	Rater 2	Rater 3
Rater 1	94.79%	88.19%
Rater 2		90.28%

Note: Overall agreement 86.46%

After all three judges had categorised the data, their classifications were then compared against each other for consistency. There were 288 judgements made across all the original categories of utterances and classifications (72 different utterances classified according to proximity, horizontal axis and reference frames). Generally, there was a high rate of agreement across judgements with an overall agreement of 86.46% (see Table 5.3 above for percentages). Those terms that were not classified identically were highlighted and a discussion took place in an attempt to clarify their categorisation. For example, one of the three judges classified the preposition *at* as the use of an *intrinsic* reference frame

because it suggests some kind of interaction with the reference object itself (Miller & Johnson-Laird, 1976). This issue was discussed (as were other issues for example, whether or not *in front of* denoted *proximity*, or *to the side of* was the use of a *relative* reference frame). Where possible, agreement was reached; usually where one person had made an error of judgement and could see the error in the light of further discussion. Otherwise, the term was classified as an *ambiguous* term for that particular category. Only those terms that were classified unambiguously were used in that category for any of the analyses (see Table 5.4 below for classification of the main spatial terms produced in Experiment 5 and Appendix 17 for a full breakdown of all terms produced in Experiments 5 and 6).

Table 5.4. The Agreed Coding of Main Spatial Terms (> 1% in Any One Age Group) According to Proximity, Horizontal Axis and Reference Frame Use for Experiment 5

Completion	Proximity	H. Axis	Intrinsic	Relative/Absolute
Against	✓	×	×	×
At	✓	✓*	✓*	×
Behind	×	✓	×	×
Beside	✓	×	×	×
By	✓	×	×	×
Close to	✓	×	×	×
Facing	×	✓*	✓*	×*
Facing behind	×	✓	×	×
In front of	✓*	✓	✓	×
Near	✓	×	×	×
Next to	✓	✓	×	×
Opposite	×	✓	✓	×
To the left/right of	×	✓	×	✓
With	✓	×	×	×

*Note: Those classifications marked with a ✓ denote a positive classification, those marked with a × denote a negative classification. Those marked with * denote ambiguous terms.*

5.5.4. Results

Initially it was of interest to analyse the data in a similar manner to that undertaken by Carlson-Radvansky and Radvansky (1996). The data were categorised according to whether each utterance could be classified as an example of the use of an *intrinsic* reference frame (Category 1), a *relative/absolute* reference frame (Category 2) or no reference frame use (Category 3). A fourth Category was used for errors, unusual and non-responses.

However, once the data were categorised as above, it became clear that there were very few instances of the use of the *relative/absolute* reference frame within the data. Overall, 36% (1,508 utterances) of the data was classified as use of the *intrinsic* reference frame, whereas only 3% (126 utterances) of the data were examples of the use of the *relative/absolute* reference frame (see Table 5.5 below for a breakdown of categories for each age group).

As we can see from Table 5.5, the use of the *intrinsic* reference frame was highest for the adults in this study (59% of completions), although all age groups of children used the *intrinsic* reference frame to some extent. What is interesting is that, although the *relative/absolute* reference frame was exclusively an adult system of referencing for these pictures (with only three utterances using the *relative/absolute* reference frame being present in the children's data) it was relatively little used, comprising only 12% of utterances in that group.

Table 5.5. The Percentages (and Number of Utterances) in Each Category for Reference Frame Use for Experiment 5

Completion Category	Age Group 1 (mean 4;3, n=12)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=33)
Intrinsic	21% (81)	34% (282)	20% (176)	35% (347)	59% (622)
Relative/Absolute	0	0	0% (1)	0% (3)	12% (122)
Other	61% (234)	64% (536)	78% (702)	64% (639)	29% (312)
Errors	18% (69)	2% (14)	2% (17)	0% (3)	0
Total	100% (384)	100% (832)	100% (896)	100% (992)	100% (1056)

The fact that children in this study rarely used this system is due to the children's lack of production of the terms *left of* and *right of* and the requirement of these terms in order to use the *relative/absolute* reference frame for the set of pictures in this experiment. This finding was unexpected as research has shown that children do produce these terms, albeit with some degree of inaccuracy, from five or six years of age (Asso & Wyke, 1973; Waller, 1986). It could be that children produce the terms *left of* and *right of* more to describe the location of unrelated or abstract objects (as in the Asso & Wyke study) rather than when describing the location of objects and people with fronts, backs and sides. However, as these are late acquired terms we would not expect them to be so frequent in children's language as they might be in adult's. While the lack of use of the *relative/absolute* reference frame with children can be explained by their language development, this explanation is less plausible to explain why adults did not use this system for the pictures they viewed in this experiment. Table 5.6 below displays the

number of adults and children in this study that used differing reference frames or types of utterances in their completions.

Table 5.6. The Percentage (and Number) of Participants Across Age Group Using Different Response Styles in Experiment 5

Types of Completion Used	Age Group 1 (mean 4;3 n=12)	Age Group 2 (mean 6;7 n=26)	Age Group 3 (mean 8;4 n=28)	Age Group 4 (mean 10;8 n=31)	Age Group 5 (adults, n=33)
Intrinsic RF Only	25% (3)	19% (5)	11% (3)	10% (3)	30% (10)
Other Only	58% (7)	62% (16)	68% (19)	48% (15)	0
Intrinsic RF & Other	17% (2)	19% (5)	18% (5)	35% (11)	48% (16)
Relative/Absolute RF Only	0	0	0	0	9% (3)
Intrinsic & Rel/Ab RF	0	0	0	0	6% (2)
Intrinsic, Rel/Ab RF & Other	0	0	4% (1)	6% (2)	6% (2)
Total	100% (12)	100% (26)	100% (28)	100% (31)	100% (33)

Note: There were 79 uses of the word 'behind' (including from one adult participant); this can be classified either as an error (because the located object was always 'in front of') or as the use of the 'intrinsic' reference frame. Here it is classified as the use of the intrinsic reference frame.

We can see from Table 5.6 that only 21% (seven) of the 33 adults participating in this study used the *relative* reference frame at all, with only two of them using it as well as the *intrinsic* reference frame. On the other hand, 91% (30) of adult participants used the *intrinsic* reference frame to describe the location of one object to another. The number of children using an *intrinsic* reference frame varied with age with 42% (5) of age group 1 children using the *intrinsic* reference frame, 39% (10) of age group 2, 33% (9) of age group 3 and 52% (16) of age group 4.

It is now clear that any analysis comparing the relative use of one reference frame to another (as in Carlson-Radvansky and Radvansky, 1996) would be meaningless with these data. Looking at the data we can see that, in addition to the use of reference frames, both adults and children use means other than reference frames as a way of expressing the location of one object with respect to another. Words such as *near*, *next to* and *by* can be used to describe the locations depicted. Indeed, 55% of the adults in this study produced just such words, along with *intrinsic* terms, to describe the location of one object with reference to another. For children this was even more pronounced, with some children producing just these terms. It was therefore interesting to see whether adults' and children's use of the *intrinsic* reference frame was affected by the manipulations of functional association, blocking and orientation of the located object. In order to do this the data were categorised in the following way: all those completions that had been previously classified as *intrinsic* terms were placed into Category 1 (1,508 utterances). Category 2 contained *other* ways of talking about the scene, including (but not exclusively) terms suggesting the use of *relative/absolute* reference frame or proximity (2,307 utterances, see Table 5.7 below for examples). The third category contained errors and non-responses and any terms deemed to be ambiguous by the judges (345 utterances). This last category also contained the *behind* utterances as although it is essentially an *intrinsic* term, its use in this experiment can be classified as an error as the located object was only ever "in front of" the reference object. There was some discussion about this point amongst the judges, and at best it was considered an ambiguous term in this study and therefore was not used as a strict example of an utterance using the *intrinsic* frame of reference. The data from one child in age group one, three children in age group three and three adults did not contribute to the analysis as they contained data categorised as errors for all four responses for at least one cell of the design.

Table 5.7. Examples of the Utterances Coded in Each of the Three Categories, Experiment 5

Category 1 (*intrinsic* reference frame completions)	Category 2 (*relative/absolute* and "other" completions)	Category 3 (errors, unusual responses, etc)
In front of	*To the left/right of*	*In the library*
To the front of	*Near*	*On*
At the front of	*Next to*	*Behind*
Opposite	*Beside*	*In the middle of*
	By	*Putting books away*
		Facing
		At

Once the data had been categorised, the percentage of Category 1 responses was calculated against Category 2 responses, ignoring Category 3 responses for each cell of the design thereby standardizing the data. A four-way partial within groups analysis of variance was performed on the data. The between groups variable was age (five groups, mean ages 4;3, 6;7, 8;4, 10;8 and adults). The within group variables were functional association (two levels: functionally associated and non-functionally associated), blocking (two levels: blocking present and no blocking) and orientation (two levels: the located object facing toward the reference object and facing away from the reference object). The means for this analysis are displayed in Table 5.8 and the ANOVA results are presented in Table 5.9.

Table 5.9. The Results from the Analysis of Variance for *Intrinsic* Reference Frame Completions, Experiment 5.

Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (4,118) = 2.94	13678.77	*
FUNCTIONALLY ASSOCIATED (F)	F (1,118) = .27	64.99	ns.
BLOCKING (B)	F (1,118) = .33	503.33	ns.
ORIENTATION (O)	F (1,118) = 4.72	398.87	*
G x F	F (4,118) = 1.07	64.99	ns.
G x B	F (4,118) = 1.74	503.33	ns.
G x O	F (4,118) = 8.08	398.87	****
F x B	F (1,118) = .01	131.09	ns.
F x O	F (1,118) = 2.07	112.37	ns.
B x O	F (1,118) = 1.75	180.71	ns.
G x F x B	F (4,118) = .36	131.09	ns.
G x F x O	F (4,118) = 1.74	112.37	ns.
G x B x O	F (4,118) = 2.67	180.71	*
F x B x O	F (1,118) = .03	129.49	ns.
G x F x B x O	F (4,118) = .53	129.49	ns.

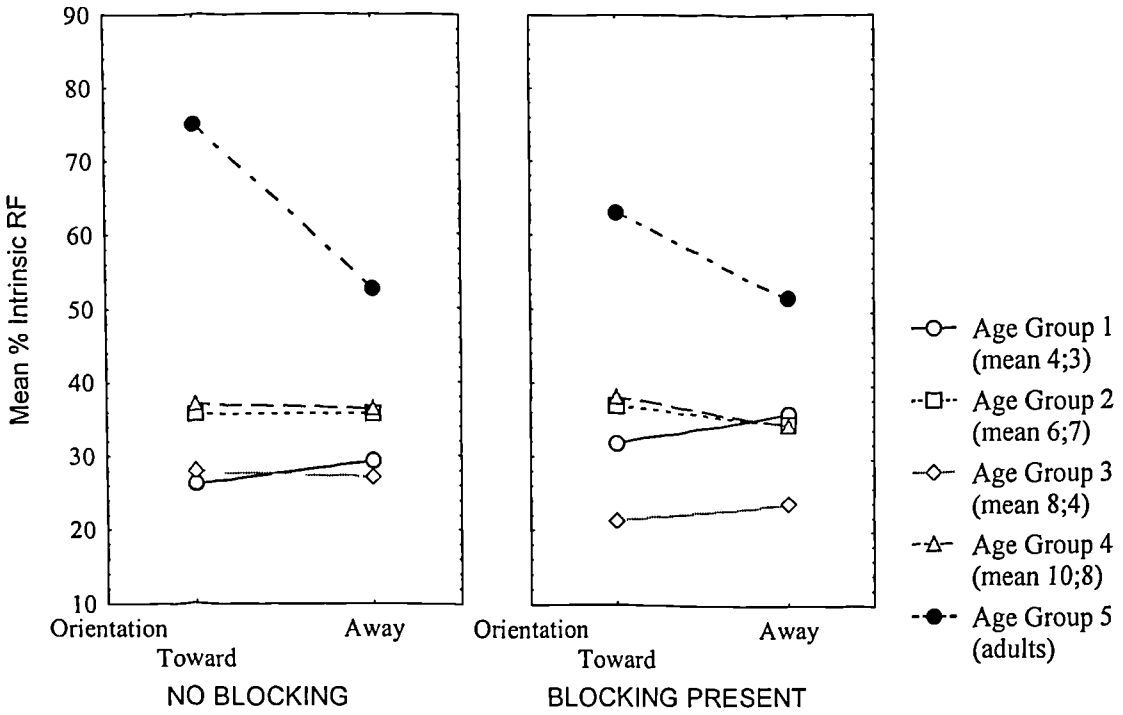
Note. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

A main effect of age group was found. The mean percentage of *intrinsic* reference frame use for each age were 31%, 36%, 25%, 37% and 61% for age groups 1 to 5 respectively. Follow-up analysis revealed a significant difference between adults (age group 5) and age group 3 (mean age 8;4), otherwise no significant differences were present. A main effect of orientation was significant. The *intrinsic* frame of reference was used significantly more when the person was orientated toward the reference object than

when the person was orientated away from it (means 39% and 36%). No other main effects were significant. However, there were two interactions. A two-way interaction between age group and orientation was found. Follow-up analysis revealed that adults used the *intrinsic* frame of reference significantly more when the located object was facing toward the reference object than when it was facing away from it (means 69% versus 52% respectively). There was no difference of orientation with any of the age groups of children. Finally, the three-way interaction between age, blocking and orientation was significant. Follow-up analysis showed that the effect of orientation for the adult group was much stronger when blocking was absent ($p<.001$) rather than when blocking was present ($p<.01$, see Figure 5.7 below).

We can interpret the adults' use of the *intrinsic* frame of reference in this study as a functional use. When blocking is present in the scene, thereby denying access to the reference object by the person, the orientation of the person influences the use of the *intrinsic* reference frame less than when blocking is absent. Although the effect of blocking was significant both when the person was orientated toward and away from the reference object, this was more dramatic for the former than the latter orientation. The means were 63% when the person was orientated toward the reference object and 52% when the person was orientated away from it. However, when there is no blocking present in the scene, the use of the *intrinsic* frame of reference is far greater when the person is facing toward the reference object than when the person is facing away from it (means 75% versus 52%). Therefore, when adults used the *intrinsic* frame of reference in this study, they did so indicating that there was some form of interaction possible in the scene.

Figure 5.7. The Three-way Interaction between Age Group, Blocking and Orientation of Located Object for Experiment 5.



It is interesting to see that the children in this study did not differentiate between any of the functional and non-functional scenes in this study using this classification scheme. Previously, we have found that children as young as 3;4 highlight functional considerations in the scene (Experiment 1) by altering the word order they produced. Additionally, children in Experiments 3 and 4 (from 6;6) produced prepositions that denoted the vertical axis more when responding to functional scenes than non-functional scenes. One reason that we did not find a difference in this study could be that, although children can produce prepositional phrases in production studies (and position objects in comprehension studies) according the *intrinsic* frame of reference, the use of this referencing system as a means of highlighting an interaction between people and objects is developed much later. This is not to say that children do not notice the functional aspects

of the scene, but that they do not yet utilise the *intrinsic* reference frame as a means of highlighting it.

In Experiments 3 and 4, we saw how children (and adults) highlighted the vertical axis in the presence of a functional relationship. It could be that in this experiment, children produced terms highlighting the horizontal axis in order to make their distinctions. As the data had already been classified according to whether or not terms denoted the horizontal axis, one further analysis of the data was undertaken.

This analysis examined whether adults' and children's production of *horizontal axis* terms was affected by the manipulations of functional association, blocking and orientation of the located object. In order to do this the data were categorised in the following way: all those utterances that were classified by the judges as *horizontal axis* terms were placed into Category 1 (2,360 utterances). This category contained all the words that were originally classified as the use of the *intrinsic* reference frame, plus other terms that referred to the horizontal axis (e.g., alongside). Category 2 contained *other* terms or ways of talking about the scene such as the use of proximity terms, (1,454 utterances, see Table 5.10 below for examples). The third category contained errors, ambiguous and non-responses (346 utterances). As before, this last category also contained the *behind* utterances as although they essentially refer to the horizontal axis, their use in this experiment can be classified as an error as the located object was only ever "in front of" the reference object. Additionally, any utterances that were deemed by the judges to be ambiguous as to whether or not they denoted the horizontal axis were omitted. Again, as a consequence of this, the data from one child in age group one, three children in age group three and three adults did not contribute to the analysis as they contained data categorised as errors for all four responses for at least one cell of the design.

Table 5.10. Examples of the *Horizontal Axis* Utterances Coded in Each of the Three Categories, Experiment 5

Category 1 (*Horizontal axis* completions)	Category 2 (*Other* completions)	Category 3 (errors, unusual responses, etc)
In front of	*Away from*	*There*
Across from	*Near*	*On*
Alongside	*Close to*	*Behind*
Next to	*Far from*	*At*
To the left/right of	*By*	*Giving letters*

Once the data had been categorised, the data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances (ignoring Category 3 responses) for each cell of the design and expressing it as a percentage. A four-way partial within groups analysis of variance was performed on this data with between and within groups being the same as the previous analysis.

The means are displayed in Table 5.11 below and the results from the ANOVA can be seen in Table 5.12 below. The only main effect was for age group (see Figure 5.8 below); the mean production of horizontal axis words were 48%, 48%, 47%, 66% and 87% for age groups 1 to 5 respectively. Follow-up analysis found that adults used horizontal axis words significantly more that age groups 1, 2 and 3, with no significant differences between age group 4 and adults. The main effects of orientation [$F(1,18) = 3.13$, $p < .079$] and blocking [$F(1,118) = 2.93$, $p < .089$] did not quite reach significance. No interactions were significant.

Table 5.11. Mean Percentage of Completions Producing *Horizontal Axis* Prepositions across Age Groups, Experiment 5

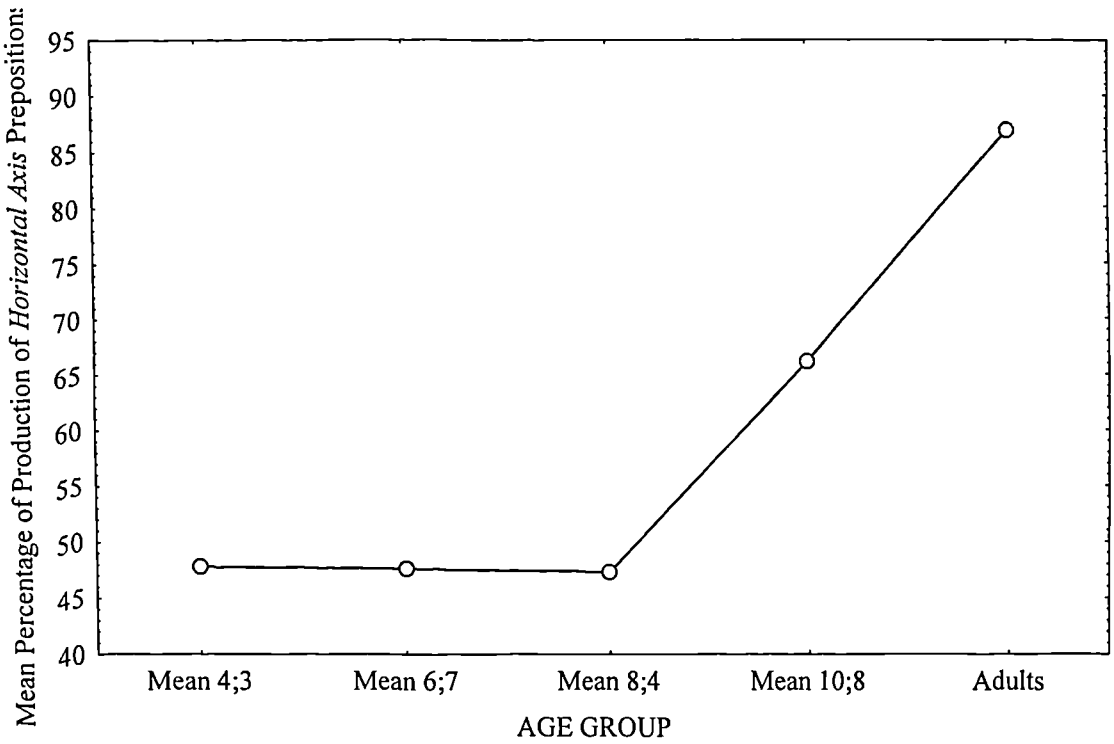
	Functionally Associated				Non-Functionally Associated			
	No Blocking		Blocking		No Blocking		Blocking	
Orientation:	Toward	Away	Toward	Away	Toward	Away	Toward	Away
Group 1 (mean 4;3, n=11)	50	52	52	45	48	45	45	45
Group 2 (mean 6;7, n=26)	49	45	48	49	50	45	49	46
Group 3 (mean 8;4, n=25)	51	51	44	47	49	48	45	44
Group 4 (mean 10;8, n=31)	71	66	65	65	66	69	63	65
Group 5 (Adults, n=30)	91	86	88	81	94	86	85	85
All Groups (n=123)	65	62	61	60	64	62	60	60

Table 5.12. The Results from the Analysis of Variance for *Horizontal Axis* Completions, Experiment 5.

Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (4,118) = 5.22	12279.39	***
FUNCTIONALLY ASSOCIATED (F)	F (1,118) = 2.08	112.11	ns.
BLOCKING (B)	F (1,118) = 2.93	581.94	ns.
ORIENTATION (O)	F (1,118) = 3.13	216.51	ns.
G x F	F (4,118) = 1.10	112.11	ns.
G x B	F (4,118) = .45	581.94	ns.
G x O	F (4,118) = 1.21	216.51	ns.
F x B	F (1,118) = .01	81.70	ns.
F x O	F (1,118) = .32	118.65	ns.
B x O	F (1,118) = .57	228.59	ns.
G x F x B	F (4,118) = .28	81.70	ns.
G x F x O	F (4,118) = 1.18	118.65	ns.
G x B x O	F (4,118) = .20	228.59	ns.
F x B x O	F (1,118) = .18	175.85	ns.
G x F x B x O	F (4,118) = 1.06	175.85	ns.

Note. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

Figure 5.8. The Main Effect of Age Group for *Horizontal Axis* Completions, Experiment 5.



5.5.5. Discussion

This experiment investigated whether functional association between objects, blocking of function and the orientation of the located object affected the way adults and children used reference frames using a free response sentence completion task. The main aims were to extend the findings of Carlson-Radvansky & Radvansky (1996) who demonstrated functional influences on reference frame comprehension and on reference frame selection using a limited number of fixed-choice prepositions. Furthermore, this experiment examined the development of reference frame use in the context of functional relations with children from as young as 3;5 years for the first time.

Let us begin by considering the children used in this study. The youngest age group of children (mean age 4;6) were considered to be the right age, according to previous research, to be able to produce an *in front of* description for situations that involved a reference object with inherent front, back and sides (e.g., Grimm, 1975; Johnston, 1982; Johnston & Slobin, 1979). However, half of the children in this age group had problems completing this experiment, even though some of these children were able to correctly respond to the materials from the experiment that focused on a support relationship, which was interleaved with it. Of those children who did complete the task, only five in age group one produced *intrinsic* descriptions, with seven children producing only *other* terms. Although 21% of the responses from the youngest age group were *in front of* utterances (the main expression denoting an *intrinsic* reference frame), 19% of their responses were either errors, ambiguous or non-responses. It could be argued, therefore, that the youngest age group in this study were perhaps too young for this particular experiment. Age group two, on the other hand, appeared more suitable; only five children in this age group had problems completing the study with ten using the intrinsic reference frame and only 2% of their responses were errors.

Let us now consider the types of completions that were produced by the participants in this experiment. Unlike the Carlson-Radvansky & Radvansky (1996) study, the participants were at liberty to produce any completions they wished as long as they described *where* the located object was. This gave rise to much variation within the data and the production of many other terms that did not utilise any frame of reference. When a frame of reference was used, however, the *intrinsic* reference frame was highly favoured by both adults and children. We had expected to see a systematic rise with age in the use of the *relative/absolute* frame of reference. This did not happen with the age groups of children that were used in this study. Moreover, only 12% of the adults' completions used the *relative/absolute* frame of reference. However, both adults and children produced

other, more general terms (e.g., *near*, *by*, *close to*), in addition to the *intrinsic* frame of reference when describing the location of the objects in the scenes.

The main findings for this experiment were that adults used the *intrinsic* reference frame significantly more when the located object (always a person) was oriented toward the reference object than when they were oriented away from it, this was particularly so in the absence of any blocking (i.e., a screen between the located and reference object). The children used in this study did not make this distinction.

This finding is interesting for it leads us to ask why it was that children's use of the *intrinsic* reference frame was not affected by the orientation of the located object. The only significant difference found in the mean use of the *intrinsic* frame of reference across age groups was between age group 3 and adults. Therefore, this finding cannot be because these children did not use the *intrinsic* frame of reference in their descriptions. It could be, however, that children do not use reference frames in order to make distinctions; they stick to one way of talking about the scenes, for example, using the *intrinsic* reference frame or not using reference frames at all. If we look back to Table 5.6 (on page 291 above), we can see that not only did the number of participants in this study whose responses included use of the *intrinsic* reference frame increase with age, so too did the number of participants whose response style included both *intrinsic* and other terms. Therefore, it could be that as adults used more diversity in their language they were more able to make distinctions.

With this in mind, a second analysis was undertaken to assess whether children were making distinctions in a different manner other than to use reference frames. Following on from Experiments 3 and 4 in Chapter 4 of this thesis in which adults and children highlighted the *vertical axis* when describing a picture that depicted a successful functional relationship between objects, the second analysis for this experiment examined whether a similar occurrence was happening for objects positioned along the *horizontal axis*. This analysis showed that this was not so; neither adults nor children highlighted the

horizontal axis for any of the manipulations in this study. However, the effects of orientation and blocking were marginal (p=.08 and p=.09 respectively). Therefore, the reason that no effects were found might be due to the number of participants that were used in this study. This issue will be addressed in Experiment 6 of this thesis.

An alternative explanation is that it could be that children's interpretation of *in front of* (the production of which was the most common preposition produced for the *intrinsic* reference frame) initially means simply "positioned to the front of the reference object". If this is so, then the orientation of the person (or object) that is *in front* is irrelevant and as such, a person who is facing the reference object is no more *in front of* it than a person who is facing away or whose access to the reference object is blocked.

Moreover, in comprehension studies young children (4 to 7 years old) have actually been shown to favour *in front of* placements for located objects with intrinsic fronts, backs and sides such that they are *orientated the same way* as the reference object rather than facing toward it (e.g., Harris & Strommen, 1972, see Figure 2.4 on page 67). Figure 5.7 (on page 297 above) also shows a slight tendency for the youngest age group of children (mean age 4;3) to use *intrinsic* descriptions more when the located object is orientated away from the reference object (mean percentages were 29% facing toward and 33% facing away). From this we can see that children's comprehension and production of *in front of* is still developing throughout their early school years as none of the children in this study used the *intrinsic* frame of reference as a way of highlighting an interaction.

However, the very fact that the people in the picture were always positioned in *close proximity* to the reference objects makes the likelihood that they are interacting with those reference objects in the scene possible. Children might consider the proximity of a person to an object to be more functionally important than the orientation of that person. When a person is depicted as being away from an object, one is less likely to infer that they are interacting with the object than when they are in close proximity to it. Therefore,

it might be that children do use *in front of* to highlight a functional interaction between located and reference objects, but no effect was found because they considered an interaction was possible for *all* the scenes and as such they were all functional.

The final experiment to be reported in this thesis follows on from Experiment 5. In order to evaluate the impact of proximity on children's reference frame use it investigates the factors of functional association between located and reference object, orientation of located object and distance between located and reference object on adults' and children's frame of reference use.

5.6. Experiment 6: The Influence of Functional Associations, Orientation and Distance on Adults' and Children's Reference Frame Use.

As we saw in Experiment 5, the *intrinsic* reference frame was used by adults significantly more when the located object (always a person) was oriented toward the reference object than when they were oriented away from it. This was particularly so in the absence of any blocking (i.e., a screen between the located and reference object). However, no difference was found in the use of the *intrinsic* frame of reference for any of the age groups of children. As it was the first free production experiment that has investigated any of these factors, Experiment 6 was designed to see if the orientation effect was robust enough to be replicated. An additional factor, that of the distance between located and reference objects, was added to assess its impact on adults' and children's use of the *intrinsic* reference frame. The manipulation of distance can be viewed as another form of functional manipulation or it can be viewed as a geometric manipulation. For the

objects depicted in this experiment, when the located and reference objects are close together, the located object is more likely to be able to interact with the reference object in a functional manner. Conversely, when the located object is away from the reference object, a successful interaction is unlikely. However, distance can also be viewed as a geometric manipulation as the distance of the located object from the reference object can affect the appropriateness of prepositions with which to describe the spatial relations. If the located object is positioned at a distance from the reference object, the position of the located object would be closer to the good region of *far away* (in terms of spatial templates) than it would be to *in front of* or *to the left/right of* (Logan & Sadler, 1996).

This experiment was designed to explore the effects of functional association, orientation of the located object and distance between located and reference objects on adults' and children's reference frame use. The manipulations made were based on those used in Experiment 5, with the same located and reference objects being used. The manipulations of functional association and orientation were the same as for Experiment 5. The manipulation of blocking was substituted with a manipulation of distance; the located object (always a person) in the scene was depicted as either being close to the reference object (e.g., see Figure 5.9 below (a, b, e & f)) or a distance apart from it (e.g., see Figure 5.9 (c, d, g & h)). In order to elicit natural language use, a series of colour photographs displayed above an incomplete sentence in the form of *the located object is* _____ *the reference object* was shown to adults and children. For this experiment, the located object was always a person who is either functionally associated or not functionally associated with the reference object, e.g., *the chef is* _____ *the cooker* or *the artist is* _____ *the cooker*. The role of the participant was to give the experimenter the word or words to put in the sentence so that it would best describe the picture (a free response sentence completion paradigm). The dependent variable was the utterance given by the participant for each sentence accompanying the spatial scene.

It was expected that adults and children would give a similar variety of prepositions in their completions to those found in Experiment 5. That is, they would not just use reference frames as a means of coordination, but other terms such as *near*, *by* and *far from* would also be produced. It was also expected that the effect of manipulation of orientation of located object in Experiment 5 would be replicated in Experiment 6; the *intrinsic* frame of reference would be used more when the person was orientated toward rather than away from the reference object. Additionally, the manipulation of distance was expected to interact with this, whereby the effect of orientation should be strongest when the located object and reference object are depicted close together rather than far apart. Developmentally, children's use of the *relative/absolute* frame of reference was expected to increase slightly with age, although following Experiment 5, it was not expected to be widely used with this set of materials. However, an effect of distance was expected whereby children's use of the *intrinsic* frame of reference would give way to other types of completion (e.g., distance terms) when the located and reference objects were positioned apart.

5.6.1. Method

5.6.1.1. Design

A 5 (age group) x 2 (functional association between located and reference objects) x 2 (orientation of located object) x 2 (distance between located and reference object) partial within-participants design was used for the main manipulations. Age group was the between participants variable with functional association, orientation and distance as the within-group variables.

5.6.1.2. Manipulations

The experiment used a series of colour photographs of the reference objects and located objects (as for Experiment 5, see Figure 5.5 on page 276 for examples and Appendix 18 for a full set of the pictures used in this experiment). Each located object was paired with a reference object. The variables manipulated were:

1. Functional Association between Reference Object and Located Object

The reference and located objects were either functionally related (See Figure 5.9 below (a-d)), or functionally unrelated (Figure 5.9 (e-h)).

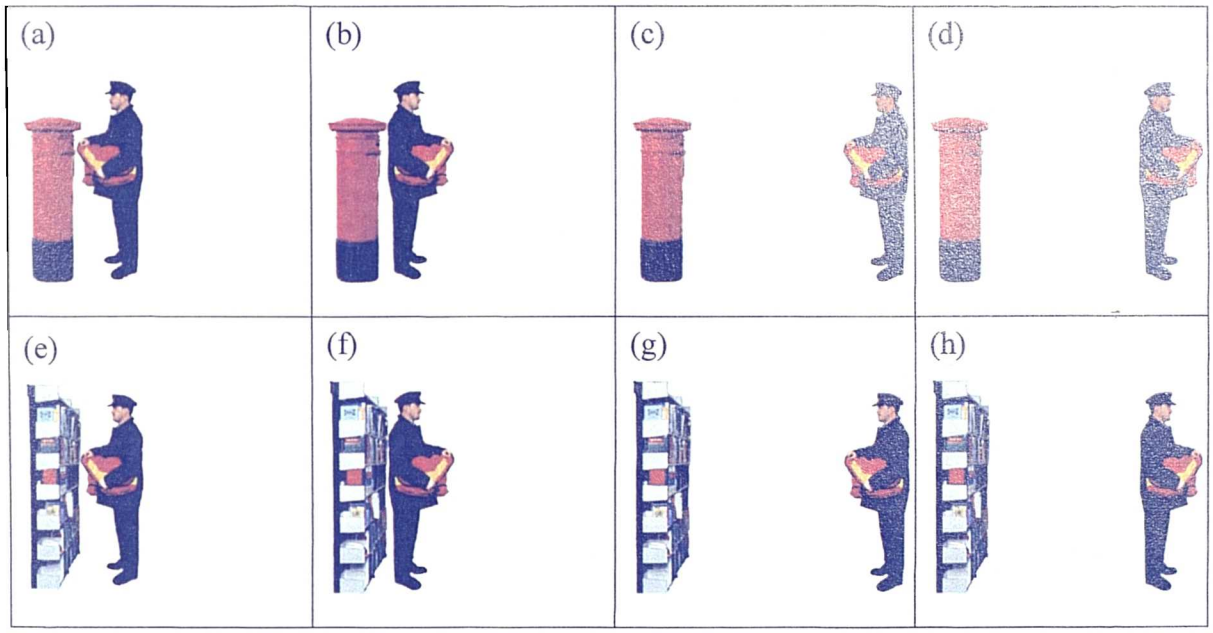
2. Orientation of Located Object

Two levels of orientation were used. The located object was depicted as either facing toward (Figure 5.9 (a, c, e & g)) or facing away from the reference object (Figure 5.9 (b, d, f & h)).

3. Distance between Located and Reference Objects

Two levels of distance were manipulated. The located object was either placed close to the reference object (Figure 5.9 (a, b, e & f)) or apart from it (Figure 5.9 (c, d, g & h)).

Figure 5.9. Examples of the Manipulations of Functional Association, Orientation and Distance in Experiment 6



A total of 32 scenes were made across the three main variables of functional association, orientation of located object and distance between located object and reference object. These consisted of four located objects being present for each level of the manipulation (4 target objects x 2 levels of functional association x 2 levels of orientation x 2 levels of distance).

5.6.1.3. Participants

Two hundred and two adults and children across four age groups participated in the experiment. All the participants were native English speakers with normal, or corrected to normal, eyesight and hearing. The adults (n=31) were first year psychology undergraduates who received a course credit for their participation. The youngest group of children in Experiment 5 (mean age 4;3) found the task quite hard. Additionally, they appeared to use the *intrinsic* frame of reference infrequently and their responses were no different to those of children in age group 2 (mean age 6;7). It was therefore decided that the youngest age group to be used in this study would be of a similar age to those in age group 2 from Experiment 5 rather than age group 1. This study used only three groups of children with mean ages of 7;0 (n=63, range 6;6 to 7;6), 9;0 (n=56, range 8;6 to 9;6), and 10;11 (n=52, range 10;6 to 11;5). Each age group comprised of a balance of children from two separate schools in different geographical areas; one situated on the outskirts of a large town with the other being a school in a large city, both in the South West of England. Due to the limited amount of children that used reference frames in Experiment 5, a greater number of children were tested in each of the age groups in this experiment. None of the participants had taken part in any study of a similar nature prior to this research.

5.6.1.4. Materials

The basic colour photographs from Experiment 5 were used for Experiment 6. Each spatial scene manipulation was edited together four times (once with each of the four people) with the reference object situated to the right. This resulted in 32 individual spatial scenes. These scenes were then reflected to produce a second set of scenes with the

reference object situated to the left. The pictures were then divided into two picture sets. Each set contained all 32 experimental spatial scenes; 16 with the reference object on the left and 16 with it on the right. Each participant saw only one of the picture sets. The scenes were interleaved with 24 scenes from one of two other separate experiments[27] along with a variety of cartoon faces that appeared for one second after each picture to keep the children's attention and to act as a distracter from the previous spatial scene.

The pictures were displayed on the screen with the aid of a computer program with all aspects being the same as previously described for Experiment 2 of this thesis on page 183, the only difference was that each of the four blocks of pictures contained one picture of the six spatial manipulations.

5.6.1.5. Procedure

The procedure was the same as for the previous four experiments as reported in Chapter 3 on page 184 of this thesis.

All 202 of the participants were able to complete the sentence so that it described the picture. Forty-one children failed to complete the task. This consisted of 28 (44%) of the children in age group one (mean age 7;0), 10 (18%) from age group two (mean age 9;0) and 5 (10%) from age group three (mean age 10;11). None of the adults had any problem completing the task. The main reason for failing the task was that children focused upon what was happening in the picture rather than where things were, despite being encouraged to concentrate on the latter. However, some children in the youngest age

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[27] The scenes were interleaved with scenes from Experiments 3 & 4 with children from one school seeing scenes from Experiment 3, and children from another school seeing scenes from Experiment 4. The adults saw scenes from Experiment 3 only. As before, the difference in the spatial scenes used as a filler was not thought to be a problem. A check was made afterwards that confirmed this opinion.

group had problems describing the location of objects in the pictures that were interleaved with this experiment, which caused them to cease the whole task[28]. These involved the use of vertical axis prepositions that are generally learned later and happened only with children in the youngest age group.

5.6.2. Coding the Data

The responses from each participant were placed into a spreadsheet for coding (see Appendix 19 for a breakdown of utterances produced in each of the categories across age groups). As in the other experiments reported in this thesis, there was a large amount of variety on participants' responses. In general, the completions either used a particular reference frame (*intrinsic* or *relative/absolute*) or were utterances suggesting distance (e.g., near to, far from, close to). See Table 5.13 below for main completions (>1% of the data for any one age group[29]).

The first impression of the utterances displayed in Table 5.13 is that there is a greater range of terms suggesting distance in Experiment 6 than there was in Experiment 5. This is hardly surprising as one of the manipulations made in this study was that of *distance*. However, these words were not produced extensively. Some terms, for example, *far from* and *very close to*, were not produced at all by the adults in this study. Looking more closely at the utterances, we can actually see that although there are a greater range

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[28] If a child appeared to be struggling to find a word with which to describe the location of the picture, the experimenter asked them if they wanted to see another picture. Sometimes, if this happened frequently, the child said that they did not wish to continue. At this point, the Experimenter terminated the session by thanking the child and taking them back to the classroom.

[29] Note: As Table 5.13 contains only data that comprises >2% of the data in any one age group the figures in this table do not add up to 100%, see Appendix 19 for full breakdown.

of terms, there are also many similarities in the words produced in Experiments 5 & 6. The same words were produced in this experiment that were produced in Experiment 5.

Table 5.13. The Percentage (and Number of Utterances) of Main Completions (> 1% in Any One Age Group) For Experiment 6

Completions	Age Group 1 (mean age 7;0, n=35)	Age Group 2 (mean age 9;0, n=46)	Age Group 3 (mean age 10;11, n=47	Age Group 4 (adults, n=31)
A few (x) feet/meters from	1% (9)	0	0% (5)	0
A few (x) inches from	0	1% (9)	0	0
A long way (away) from	0% (3)	1% (12)	0	0
At	0	1% (17)	1% (22)	3% (32)
Away from	4% (46)	5% (69)	11% (167)	8% (78)
Backwards to	0% (1)	1% (21)	0	0
Behind	3% (28)	2% (30)	0% (7)	0% (4)
Beside	4% (50)	10% (143)	8% (123)	4% (35)
By	18% (197)	12% (174)	11% (162)	2% (17)
Close to	7% (76)	4% (59)	2% (37)	2% (17)
Facing	0	0	1% (19)	0% (1)
Facing away from	0% (1)	1% (8)	0% (2)	1% (6)
Far from	1% (12)	3% (40)	1% (15)	0
In front of	22% (250)	15% (223)	25% (372)	39% (387)
Left/right of	1% (7)	1% (20)	3% (43)	13% (127)
Near	18% (206)	20% (293)	18% (266)	11% (107)
Next to	11% (125)	16% (230)	15% (225)	17% (168)
Opposite	0	2% (27)	1% (13)	0
Turned away from	1% (14)	0	0% (6)	0
Very close to	1% (15)	0% (7)	0	0
Very far away from	1% (8)	0% (4)	0	0
Very near	1% (13)	0% (7)	0% (2)	1% (9)
Unusual/errors	4% (43)	1% (21)	0% (6)	0% (1)

As expected, one of the most common completions was *in front of*. This accounted for the largest proportion of completions within age groups, for groups 1, 3 and 4 (22%, 25% and 39% respectively). Age group 2, however, used the completion *near* (20%) and *next to* (16%) more than *in front of* which they produced for 15% of their completions.

As with Experiment 5, the preposition *behind* was produced by all age groups, although this accounted for less than 1% of the data for the oldest group of children (mean 10;11) and adults. The preposition *beside* was produced more extensively in this study than for Experiment 5. Here, children in age groups 2 and 3 (mean ages 9;0 and 10;11) produced it for 10% and 8% of their completions respectively. The youngest age group of children and adults produced it for only 4% of their completions. In a similar manner to Experiment 5, *by* was produced extensively by children of all ages (18%, 12% and 11% of completions for age groups 1, 2 and 3 respectively). Conversely, only 2% of the completions produced by adults used the preposition *by*. Adults and children of all ages produced the completions *near* and *next to* frequently. *Near* was produced by age groups 1 to 4 for 18%, 20%, 18% and 11% of their completions respectively. Similarly, *next to* was produced by these groups for 11%, 16%, 15% and 17% of their completions.

Finally, the terms *to the left of* and *to the right of* displayed a very strong age trend, as expected (although we did not see this between age groups of children in Experiment 5). Children produced these terms much less than adults did, with age groups 1 and 2 (mean ages 7;0 and 9;0) producing them just 1% of the time, rising to 3% for age group 3 (mean age 10;11) and 13% for the adult group. It is interesting to note that, in this experiment, even the youngest age group of children (mean 7;0) produced these terms (albeit sparingly) with a total of 70 utterances across age groups of children. This can be contrasted with Experiment 5 where there were only three examples of such utterances with the older age group of children (mean age 10;8).

It is clear from the description of the utterances thus far that the data in this experiment are broadly similar to those from Experiment 5. Again, the data needed to be initially categorised according to whether or not they suggested the use of the *intrinsic* or *relative/absolute* reference frames. The data from this experiment was coded at the same time as the data from Experiment 5 (see the relevant section on page 286 for details of how this was done). Briefly, each spatial term was coded as to whether or not it denoted *proximity* or an *axis*, with confidence ratings between 1 and 7 being made for each classification (7 being highly confident of that classification and 1 being not confident). Additionally, each term was also coded as being either the use of an *intrinsic* reference frame, a *relative/absolute* reference frame or no reference frame use. Any completion that could not be agreed on by the judges was classified as an *ambiguous* term for that category and was not used in the analysis (see Appendix 17 for full classification of terms produced in both experiments and Table 5.14 below for details of how the main spatial terms in Experiment 6 were categorised).

Table 5.14. The Coding of Main Spatial Terms (> 1% in Any One Age Group) According to Proximity, Axis and Reference Frame Use for Experiment 6

Completions	Proximity	Axis	Intrinsic	Relative/Absolute
A few (x) feet/meters from	✓	×	×	×
A few (x) inches from	✓	×	×	×
A long way (away) from	✓	×	×	×
At	✓	✓*	✓*	×
Away from	✓	×	×	×
Backwards to	×	×	×	×
Behind	×	✓	×	×
Beside	✓	×	×	×
By	✓	×	×	×
Close to	✓	×	×	×
Facing	×	✓*	✓*	×*
Facing away from	×	×	×	×
Far from	✓	×	×	×
In front of	✓*	✓	✓	×
Left/right of	×	✓	×	✓
Near	✓	×	×	×
Next to	✓	✓	×	×
Opposite	×	✓	✓	×
Turned away from	×	×	×	×
Very close to	✓	×	×	×
Very far away from	✓	×	×	×
Very near	✓	×	×	×

*Note: Those classifications marked with a ✓ denote a positive classification, those marked with a × denote a negative classification. Those marked with * denote ambiguous terms.*

5.6.3. Results

As with Experiment 5, the data were initially categorised according to reference frame use. Therefore, each utterance was classified as either an example of the use of the *intrinsic* reference frame (Category 1), an example of the use of the *relative/absolute* reference frame (Category 2), or no reference frame use (Category 3). Errors, ambiguous and non-responses were placed into a fourth Category, see Table 5.15 below for a breakdown of the percentage and number of utterances in each Category across age groups.

Table 5.15. Percentages (and Number of Utterances) in Each Category for Reference Frame Use, Experiment 6.

Types of Completion Used	Age Group 1 (mean age 7;0, n=35)	Age Group 2 (mean age 9;0, n=46)	Age Group 3 (mean age 10;11, n=47	Age Group 4 (adults, n=31)
Intrinsic	22% (250)	17% (250)	26% (385)	39% (387)
Relative/Absolute	1% (7)	2% (23)	3% (43)	13% (127)
Other	70% (787)	77% (1129)	68% (1020)	44% (440)
Errors, ambiguous, non-responses	7% (76)	5% (70)	4% (56)	4% (38)
Total	100% (1120)	100% (1472)	100% (1504)	100% (992)

As can be seen from Table 5.15 above, in a similar manner to Experiment 5, the use of the *relative/absolute* frame of reference was very small in this study (3% of the

overall data for Experiment 5, 4% for Experiment 6). Additionally, the use of the *intrinsic* reference frame was lower in this experiment (25% of the data) than in Experiment 5 (36%). However, as we can see in Table 5.15, although the use of the *intrinsic* frame of reference was highest for the adult age group (39% of their completions), it was also frequently used by children of all ages. What is interesting to see is that in this experiment, unlike Experiment 5, all age groups of children used the *relative/absolute* frame of reference to some extent. We can see a very steady rise in its use across the three age groups of children (1%, 2% and 3%), with adults using it for 13% of their completions. Adults' use of the *relative/absolute* frame of reference here is comparable to that found in Experiment 5 (where it consisted of 12% of adult completions).

Up to this point, we have considered the number of completions in each category across age groups. We will now take a look at how the participants themselves responded. In a similar manner to Experiment 5, different participants used different combinations of responses. Some used the *intrinsic*, the *relative/absolute* reference fames or *other* types of completion by themselves, while others used a combination of these types (see Table 5.16 below for a breakdown of response styles across age groups). Taken together with the data from Experiment 5 (see Table 5.6 on page 291 above) we can see a general trend in response styles. There appears to be a general decrease in the production of purely *other* terms (e.g., *next to*, *near*, *beside* and *by*) and purely *intrinsic* terms (although adults' production of *intrinsic* terms only in Experiment 5 appeared rather high). At the same time, there appeared to be a general increase in the production of both *intrinsic* and *other* terms together. Very few participants used both the *intrinsic* and the *relative/absolute* frames of reference in order to make distinctions, as implied by the Carlson-Radvansky and Radvansky (1996) study (2 participants in Experiment 5 and only 1 in Experiment 6).

Table 5.16. The Percentage (and Number) of Participants across Age Groups Using Different Response Styles in Experiment 6.

Types of Completion Used	Age Group 1 (mean age 7;0, n=35)	Age Group 2 (mean age 9;0, n=46)	Age Group 3 (mean age 10;11, n=47	Age Group 4 (adults, n=31)
Intrinsic Only	20% (7)	2% (1)	6% (3)	3% (1)
Other Only	56% (19)	50% (23)	34% (16)	10% (3)
Intrinsic & Other	20% (7)	46% (21)	53% (25)	61% (19)
Relative Only	0	0	4% (2)	6% (2)
Intrinsic & Relative	0	0	0	3% (1)
Intrinsic, Relative & Other	0	0	0	16% (5)
Relative/other	6% (2)	2% (1)	2% (1)	0
Total	100% (35)	100% (46)	100% (47)	100% (31)

Looking across age groups we can see from Table 5.16, above, that a total of 84% (26) of the adult participants used the *intrinsic* reference frame in their responses. The number of children using the *intrinsic* reference frame rose steadily across age groups with 40% (14) of children in age group 1 (mean age 7;0), 48% (22) of children in age group 2 (mean age 9;0) and 60% (28) of age group 3 children using it. Although the *relative/absolute* frame of reference was little used, the number of participants using it was greater in the adult group than in the children's groups, with it being used by 6% (2), 2% (1), 6% (3) and 23% (7) of participants in age groups 1 to 4 respectively. It is now obvious that these data, like the data from Experiment 5, need to be re-coded and analysed taking into account how adults and children respond and the different types of distinctions they make between scenes.

The data were then re-coded in a similar manner to the data in Experiment 5 in order to assess whether adults' and children's use of the *intrinsic* frame of reference was affected by the manipulations of functional association, distance between located and reference objects and orientation of the located object. Therefore, the data were re-coded in the following manner: all those completions that had been previously coded as a use of the *intrinsic* reference frame were placed into Category 1 (1,272 utterances). Category 2 contained all the "other" ways of talking about the scene, including (but not exclusively) those terms that suggested the use of the *relative/absolute* frame of reference and distance terms (3,576 utterances). Errors, ambiguous and non-responses were placed into a third Category (240). This last category also contained the utterances of *behind,* as although it is the use of the *intrinsic* frame of reference, strictly speaking it is an error as the located object was never "behind" the reference object as it was always placed "in front of" it. Additionally, any responses that were deemed by the judges to be ambiguous were placed into the final category; see Table 5.17, below, for examples of responses in each Category.

Having categorised the data as set out above, the percentage of Category 1 responses was calculated against Category 2 responses for each participant, ignoring any Category 3 responses thereby standardising the data. This was done for each cell of the design. The data from two children in age group two, one child in age group three and two adults did not contribute to the analysis as they contained only data from the third category for at least one cell of the design.

Table 5.17. Examples of Utterances Coded in Each of the Three Categories, Experiment 6

Category 1 (*intrinsic* reference frame completions)	Category 2 (*relative/absolute* and *"other"* completions)	Category 3 (errors, ambiguous responses, etc)
In front of	*To the left/right of*	*Under*
To the front of	*Near*	*Outside*
Opposite	*Next to*	*Behind*
	Beside	*On*
	By	*Between*
	Away from	*At*
	Close to	*In*

A four-way analysis of variance was performed on both adults' and children's data[30]. The between group variable was Age (four groups, mean ages 7;0, 9;0 and 10;11 and adults). The within-group variables were functional association (two levels, functionally associated and non-functionally associated), distance (two levels, located and reference objects depicted close to and depicted far apart) and orientation (two levels, the located object being orientated toward the reference object or away from it). The means for this analysis are displayed in Table 5.18 below and the ANOVA table is presented in Table 5.19 below.

[30] As children from two different schools were used in this Experiment, an initial analysis was undertaken on the children's data only, to examine whether there were any differences between the two schools used. The results from this ANOVA showed no main effect of School and no interaction with School (see Appendix 13 for full ANOVA table).

Table 5.18. Mean Percentage of Completions Using the *Intrinsic* Reference Frame across Age Groups, Experiment 6.

	Functionally Associated				Non-Functionally Associated			
	Together		Apart		Together		Apart	
Orientation:	Toward	Away	Toward	Away	Toward	Away	Toward	Away
Group 1 (mean 7;0, n=35)	28	24	25	25	28	24	26	22
Group 2 (mean 9;0, n=44)	19	23	20	17	19	19	20	17
Group 3 (mean 10;11, n=46)	26	28	26	21	30	27	25	24
Group 4 (Adults, n=29)	53	32	49	27	57	32	47	27
All Groups (n=154)	30	26	28	22	31	25	28	22

Table 5.19. The Results from the Analysis of Variance for *Intrinsic* Reference Frame Completions, Experiment 6.

Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (3,150) = 2.29	9302.53	ns.
FUNCTIONALLY ASSOCIATED (F)	F (1,150) = .00	93.59	ns.
DISTANCE (D)	F (1,150) =4.78	649.20	*
ORIENTATION (O)	F (1,150) = 14.25	977.00	***
G x F	F (3,150) = .89	93.59	ns.
G x D	F (3,150) = .53	649.20	ns.
G x O	F (3,150) = 6.85	977.00	***
F x D	F (1,150) = .11	111.05	ns.
F x O	F (1,150) = .79	147.65	ns.
D x O	F (1,150) = .14	165.67	ns.
G x F x D	F (3,150) = .91	111.05	ns.
G x F x O	F (3,150) = .02	147.65	ns.
G x D x O	F (3,150) = 1.17	165.67	ns.
F x D x O	F (1,150) = 1.23	137.97	ns.
G x F x D x O	F (3,150) = 1.14	137.97	ns.

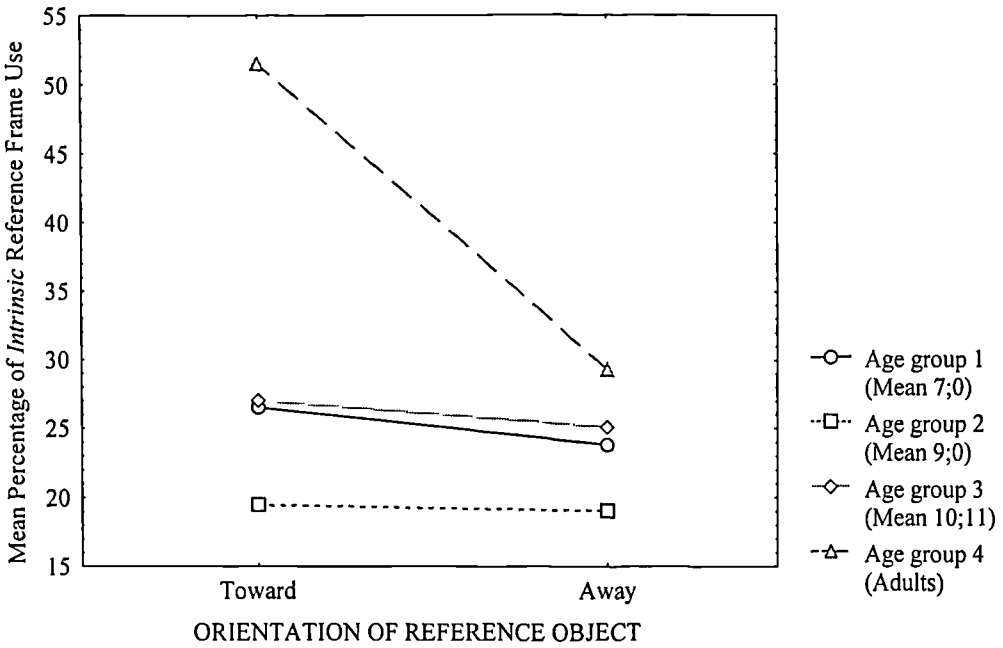
Note. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

Although the main effect of age did not reach significance, F (3,150)=2.29, p<.08, the general trend across age groups was similar in this experiment to that found in Experiment 5, with the mean use of the *intrinsic* frame of reference being 25%, 18%, 26% and 39% for age groups one to four respectively. As with Experiment 5, there was no main effect of functional association, nor were there any interactions involving this

manipulation. A main effect of distance was found which showed that the *intrinsic* frame of reference was used significantly more when the located object was depicted close to the reference object (mean 29%) than when it was depicted far apart from it (mean 26%). No interactions with the manipulation of distance were present. The main effect of orientation was found to be significant, with the *intrinsic* frame of reference being used significantly more when the located object was orientated toward the reference object (mean 31%) than when it was orientated away from it (24%). Additionally, the interaction between age group and orientation demonstrated that this was significant only for the adults in this study (52% toward, 29% away) with no differences for any age group of children (see Figure 5.10 below).

Once again, we find no differences in children's responses for the manipulation of orientation. We do see a main effect of distance with no age group interaction; therefore, children do appear to distinguish between scenes where the located object is positioned far away from the reference object than when it is close to it. However, there was no interaction between orientation and distance. If distance were being regarded as a functional (close to) or non-functional (far away) factor, then one would expect it to interact with the orientation of the located object, especially for the adults in this study. This is because when located and reference objects are far apart, the located object cannot be interacting with the reference objects depicted. Therefore, the orientation of the located object is of less importance here than when located and reference objects are positioned close to one another.

Figure 5.10. The Interaction between Age Group and Orientation of Reference Object, Experiment 6.



With the above analysis, therefore, it appears that adults and children used the *intrinsic* frame of reference in order to make distinctions when they were describing the location of objects according to the geometry of the scene (i.e., distance) whereas only adults made functional distinctions using the *intrinsic* frame of reference (i.e., orientation).

One further analysis was undertaken in order to assess whether the participants made any distinctions regarding the manipulations in this study when producing prepositions denoting the *horizontal axis*. Recall in Experiments 3 and 4 of this thesis, adults and children highlighted the *vertical axis* in their utterances when they described the location of objects that were interacting in a functional manner. However, no evidence was found that participants were doing the same for the horizontal axis in Experiment 5 of this thesis, although the effects of orientation and distance were marginal.

The data were categorised in the following way: all those utterances that were classified by the judges as *horizontal axis* terms were placed into Category 1 (2,226 utterances). Category 2 contained *other* terms ways of talking about the scene, (2,622 utterances, see Table 5.20 for examples). The third category contained errors, ambiguous and non-responses (240 utterances). Again, the data from two children in age group two, one child in age group three and two adults did not contribute to the analysis as they contained data categorised as errors for all four responses for at least one cell of the design

Table 5.20. Examples of the *Horizontal Axis* Utterances that were Coded in Each of the Three Categories, Experiment 6.

Category 1 (*Horizontal axis* completions)	Category 2 (*Other* completions)	Category 3 (errors, unusual responses, etc)
In front of	*Away from*	*Between*
Across from	*Far from*	*Facing*
Opposite	*Close to*	*Behind*
Next to	*Beside*	*At*
To the left/right of	*Near*	*Don't know*

Once the data had been categorised, The data used in the analysis was calculated by taking the ratio of Category 1 utterances against Category 2 utterances (ignoring Category 3 responses) for each cell of the design and expressing it as a percentage. A four-way partial within groups analysis of variance was then performed on this data. The between group variable was Age (four groups, mean ages 7;0, 9;0 and 10;11 and adults).

The within-group variables were functional association (two levels, functionally associated and non-functionally associated), distance (two levels, located and reference objects depicted close to and depicted far apart) and orientation (two levels, the located object being orientated toward the reference object or away from it).The means are displayed in Table 5.21 below and Table 5.22 displays the ANOVA table for this analysis.

We can see from Table 5.22 that there was a main effect of age. The mean production of *horizontal axis* prepositions was 38%, 38%, 45% and 72% for age groups 1 to 4 respectively. Follow-up analysis showed the differences to be significant between adults and all age groups of children, otherwise, no differences were present (see Figure 5.11 below).

Table 5.21. Mean Percentage of Completions Using the *Horizontal Axis* across Age Groups Experiment 6.

	Functionally Associated				Non-Functionally Associated			
	Together		Apart		Together		Apart	
Orientation:	Toward	Away	Toward	Away	Toward	Away	Toward	Away
Group 1 (mean 7;0, n=35)	42	40	34	35	44	39	35	34
Group 2 (mean 9;0, n=44)	45	46	29	24	52	48	30	24
Group 3 (mean 10;11, n=46)	56	55	34	33	58	55	33	32
Group 4 (Adults, n=29)	90	78	68	56	92	77	64	53
All Groups (n=154)	56	53	39	35	59	54	39	34

Figure 5.11. The Main Effect of Age Group for the Production of *Horizontal Axis* Prepositions, Experiment 6.

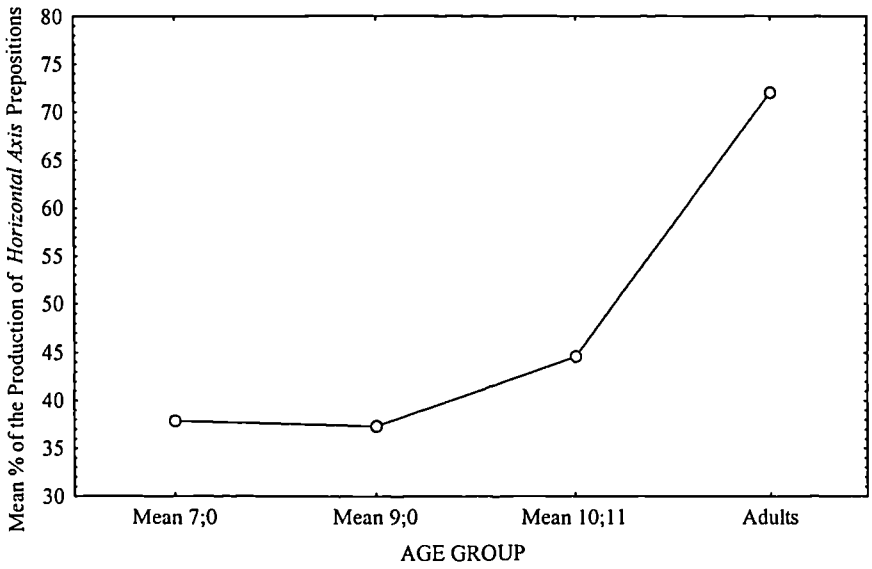


Table 5.22. The Results of the Analysis of Variance for *Horizontal Axis* Completions, Experiment 6.

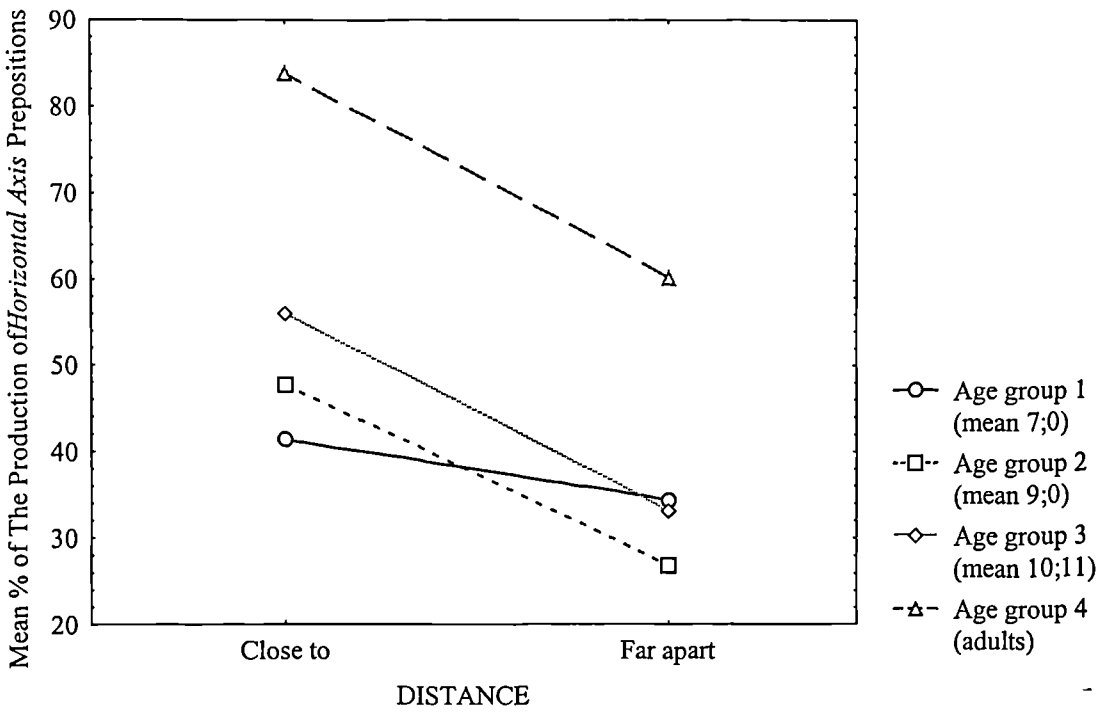
Source	df and F value	MS(error)	Significance
AGE GROUP (G)	F (3,150) = 7.78	8694.66	****
FUNCTIONALLY ASSOCIATED (F)	F (1,150) = .21	222.54	ns.
DISTANCE (D)	F (1,150) = 66.07	1565.68	****
ORIENTATION (O)	F (1,150) = 7.65	873.66	**
G x F	F (3,150) = .88	222.54	ns.
G x D	F (3,150) = 2.78	1565.68	*
G x O	F (3,150) = 2.06	873.66	ns.
F x D	F (1,150) = 1.94	193.70	ns.
F x O	F (1,150) = .90	229.92	ns.
D x O	F (1,150) = .05	298.38	ns.
G x F x D	F (3,150) = .41	193.70	ns.
G x F x O	F (3,150) = .05	229.92	ns.
G x D x O	F (3,150) = .60	298.38	ns.
F x D x O	F (1,150) = .55	219.22	ns.
G x F x D x O	F (3,150) = .04	219.22	ns.

Note. $*p < .05$, $**p < .01$, $***p < .001$, $****p < .0001$

There was a significant main effect of distance; horizontal axis prepositions were produced significantly more when the located and reference objects were close than when they were far apart (means 57% versus 38%). However, there was an interaction between distance and age group (see Figure 5.12 below). Follow-up analysis showed that all age

groups made this distinction with the exception of the youngest age group where there was no difference.

Figure 5.12. The Interaction between Age Group and Distance for the Production of *Horizontal Axis* Prepositions, Experiment 6.



Understanding why children in the youngest age group did not make the distinction between close to and far apart positions whereas older children and adults did is not a straightforward matter. As we saw in Experiments 3 and 4, children of this age can, and do, make functional distinctions when describing the location of objects placed along the vertical axis. Additionally, children of this age (mean 7;0) can typically comprehend and produce the prepositions required to make this distinction (e.g., Durkin, 1980; Sowden & Blades, 1996). Indeed, *near* and *by*, neither of which denote an axis, were produced with high frequency by the youngest age group of children. We can only conclude, therefore, that children of this age do not consider distance to be of importance when describing these scenes.

Finally, there was a main effect of orientation, whereby horizontal axis prepositions were produced significantly more when the located object was orientated toward the reference object rather than when it was orientated away from it (means 50% versus 46%). This is interesting insofar that children did not make this distinction when we analysed utterances according to use of the *intrinsic* frame of reference. It now appears that children do consider the orientation of the located object to indicate an interaction between it and the reference object. However, they distinguish between the scenes in a different manner to the way that adults do. This point will be considered further in the following two sections of this chapter.

5.6.4. Discussion

Experiment 6 was designed to investigate the factors of functional association, distance between located and reference objects and orientation of the located object on children's and adults' spatial language production. The main aims of this experiment was to discover whether the effect of orientation, as observed in Experiment 5 of this thesis, was robust enough to be replicated and whether the manipulation of distance would affect adults' and children's production of prepositions.

In a similar manner to Experiment 5, the types of completions produced by adults and children varied both within age groups and across age groups. For example, *by* was produced more by the youngest age group (18% of utterances for mean age 7;0) and its' production gradually decreased with age, consisting of only 2% of adult utterances. Conversely, the terms *left of* and *right of* increased with age; 1% of children's completions produced these utterances rising to 13% for adults' completions. Within age groups, we can see that there were various different response styles. Some adults and children stuck to

producing utterances that denoted the use of a single reference frame throughout (e.g., *intrinsic* only), whereas some participants mixed the use of reference frames with *other*, more general terms. Additionally, some participants produced only *other* terms without utilising reference frames at all. Only one adult participant in this experiment switched between the *intrinsic* and *relative/absolute* reference frames when describing the location of the objects in the scenes. As a consequence of this, a similar analysis to that used in Experiment 5 was undertaken. Therefore, the initial analysis looked at when adults and children used the *intrinsic* frame of reference versus when they did not.

The main findings of this analysis were similar to those in Experiment 5 whereby there was no effect of functional association, but an effect of orientation of the located object was present for adults' responses only. Adults used the *intrinsic* frame of reference more when the located object was orientated toward the reference object than when it was orientated away from it. Additionally, there was a main effect of distance whereby participants used the *intrinsic* frame of reference significantly more when the located object was positioned close to the reference object than when it was positioned far away from it. This was considered to be a geometric distinction. If this were a functional distinction then one would expect there to be an interaction with the orientation of the located object whereby orientation would have less effect, or no effect at all, when the located object was positioned far away.

A second analysis looking at when adults and children highlighted the *horizontal axis* was also undertaken. Here, a main effect of age group was found whereby prepositions that denoted a horizontal axis were produced significantly more by adults than by children of all ages. This is a similar finding to that of Experiment 5. However, unlike Experiment 5, a main effect of orientation was also found. Adults and children produced prepositions denoting the horizontal axis significantly more when the located object was orientated toward, rather than away from, the reference object. The reason such

a finding was not present in Experiment 5 could be due to the number of participants used; 123 participants contributed towards the analysis in Experiment 5 (93 children and 30 adults), whereas 154 participants (125 children and 29 adults) contributed towards the analysis in Experiment 6. The manipulations of blocking and orientation in Experiment 5 were both close to significance ($p < .09$ and .08 respectively). This suggests that the way children begin by making distinctions in a less sophisticated manner to adults such that the use of reference frames to suggest that an interaction is occurring between located and reference objects is a later development. This point will be considered further in the next section of this chapter.

The analysis of horizontal axis prepositions for Experiment 6 also found a main effect of distance whereby prepositions denoting a horizontal axis were produced more when the located object was positioned close to the reference object than when it was positioned far away from it. An interaction between age group and distance found that this was so for all but the youngest age group of children (mean age 7;0). These children did, however, produce the prepositions required with which to make the distinctions and similar aged children have been shown to make distinctions along the vertical axis (Experiments 3 and 4 of this thesis), therefore it was not deemed to be due to the lack of ability that this distinction was not made. The reason the youngest aged children did not make this distinction might therefore be that distance was not salient for them. As there was no interaction between orientation and distance, the distinction made for the manipulation of distance was considered to be a geometric distinction. It might be that children do not begin to distinguish between the geometric aspects of scenes such as these until after the age of around 7;0. Certainly, they do not consider distance to be of functional consideration until much later than this. Recall the results of Experiment 1 of this thesis in which children described scenes depicting various objects positioned on top of other objects in a bowl. The geometric manipulation in that experiment was the height

of the pile in the bowl. Although all the children between the ages of 3;4 and 7;8 made a distinction according to the geometric manipulation, an interaction of age and height showed that this distinction increased with age. It appears, therefore, that both geometric and functional factors continue to develop over a period of time.

5.7. General Discussion

The experiments in Chapter 5 followed on from previous research suggesting that adults prefer to use the *intrinsic* frame of reference in the presence of a functional relationship, whereas they prefer the *relative/absolute* frame of reference when a non-functional relationship is depicted (Carlson-Radvansky & Radvansky, 1996). This was found by using a fixed choice paradigm in which adults were required to select the best preposition (out of a choice of six) with which to complete a sentence in order to describe the picture they saw and also by a sentence-rating comprehension task.

The experiments reported in this chapter, however, used a free-response sentence completion paradigm. The general findings were that, when given the freedom to produce the spatial terms with which to complete a sentence, adults and children did not restrict themselves to the exclusive use of reference frames. They frequently produced other terms with which to describe the scenes, thus suggesting that we do not necessarily use reference frames in order to distinguish between scenes, as implied by the Carlson-Radvansky and Radvansky study. Once again, the results of these production studies highlight the limitations of studies that use the rating (or selecting) of prepositions and compare them against one other (as in Carson-Radvansky & Radvansky, 1996). When adults and children can freely respond, they make distinctions differently.

However, in a similar manner to Carlson-Radvansky and Radvansky (1996), the experiments reported here did find that adults used the *intrinsic* frame of reference (rather

than *other* terms) in their descriptions significantly more when the located object was orientated toward the reference object than when it was orientated away from it. Moreover, when there was a third object present blocking access to the reference object by the located object, the effect of orientation was reduced. This suggested that adults' use of the *intrinsic* frame of reference was highly influenced by functional factors. These functional factors were whether or not the person was depicted as facing the reference object and whether or not they could gain access it, both of which suggest some kind of interaction between the located and reference objects.

Developmentally, we found that children's use of the *intrinsic* reference frame was not influenced by functional factors in any way in the experiments reported here. Children's use of the *intrinsic* reference frame did increase systematically with age, with more children using it in the older age groups than in the younger age groups. When we consider that 4-year-old children can reliably produce *in front of* descriptions if the reference object has an intrinsic front (Johnston, 1984), it was surprising that so few of the children in the youngest age group for Experiment 5 (mean age 4;3) did so. Of the 12 children that completed the task, only five children in this age group produced *intrinsic* descriptions. However, it is quite possible that children do not readily use reference frames in order to make distinctions. When horizontal axis prepositions were analysed in Experiment 6, we found a main effect of orientation whereby *both* adults and children used horizontal axis prepositions significantly more when the person was orientated toward rather than away from the reference object. This was not found in Experiment 5 (which had fewer participants), although here the effect was almost significant.

When we compare the classification of the terms in the two analyses (reference frame and horizontal axis use), we can see that both classifications included the preposition *in front of*. The main difference between classifications was that the category of *horizontal axis* prepositions contained a wider range of prepositions than the *intrinsic*

reference frame category. It appears, therefore, that children do notice functional aspects of a scene (e.g., orientation being important for interaction), but they begin differentiating between the scenes by using a broader range of terms (e.g., horizontal axis prepositions versus more general terms), only later developing a more sophisticated method of highlighting functionality by focussing on the use of the *intrinsic* reference frame.

Let us not consider the use of the *relative/absolute* reference frame. In both of the experiments in this chapter it was used much less than originally expected by both adults and children. Generally, the children in these experiments did not produce the terms required for a *relative/absolute* description of the scenes (i.e., *to the left of* and *to the right of*). Although we did not think that these terms would be prolific for children in the youngest age groups, we did think that by eight or nine years of age, these terms would be relatively common. However, this might have been due to the nature of the pictures used in these experiments as even the adult participants in these experiments produced *relative/absolute* terms for only 12 or 13 percent of their overall completions.

This brings us now to consider the materials used in these experiments. One of the limitations of these experiments is the restricted range of materials used. This resulted in there also being a limited range of prepositions that could be produced for an *intrinsic* description. Therefore, our claim that adults' use of the *intrinsic* frame of reference is influenced by functional factors is tempered by the acceptance that this might not be so for scenes that require different prepositions or prepositional phrases to those required here.

Additionally, one further drawback in these experiments, and indeed in previous experiments reported in this thesis, is the diversity of the data. Ironically, this is also one of the positive aspects of these studies. However, the diversity of the utterances produced in Experiments 5 and 6 of this thesis resulted in the necessity for the development of a coding scheme by which to classify the utterances for analysis. Although three people individually classified all of the utterances produced in the experiments according to a

strictly defined criteria (e.g., Levinson's definitions of reference frames), the resulting classification scheme will have undoubtedly influenced the outcome of the experiments. For example, other definitions of reference frame used might have produced a different set of results. However, as Levinson's (1996) definitions of reference frames appear to be the most comprehensive to date, these were the obvious choice for this study.

Overall, the experiments in this chapter add to the evidence in Chapters 3 and 4 that have demonstrated the diversity of prepositions available in free-production situations. They therefore highlight the limitations of studies that either assess the comprehension of individual terms against one other or restrict the choice of terms available for selection. Additionally, Experiments 5 and 6 demonstrate that functional aspects of a scene influences adults', but not children's, use of the *intrinsic* frame of reference. They also suggest that functional influences on the use of the *intrinsic* reference frame develops over time and is not fully complete even by 10 or 11 years of age. However, functional aspects of a scene can influence the spatial expressions children produce in a different (albeit related) manner; children produce prepositions that denote the *horizontal axis* more when the located object appears to be interacting with the reference object in terms of proximity and orientation.

6. Chapter 6: Discussion and Conclusions

The experimental work outlined in this thesis aimed to investigate the relative influence of both geometric and extra-geometric factors on children's production of locative expressions in English. This research program was considered of particular interest for three main reasons. Firstly, while it has already been established that adults' comprehension and production of spatial prepositions are affected by geometric and extra-geometric information in a spatial scene, no research to date has been undertaken that systematically manipulated both of these factors in order to investigate them in children's spatial language production.

The second issue that prompted this research was that it has been argued that geometry is likely to be the main principle that specifies the representation of spatial terms such as *in*, *on*, *in front of* and *over* and that the role of extra-geometric factors is simply to modulate this geometric representation (Landau & Munnich, 1998). It has been suggested that one way we can assess this claim would be to investigate it developmentally. In doing so, we will be able to assess whether extra-geometric factors affect the representation of spatial terms later on in development after geometric awareness, or whether these factors interact with each other from the very beginning.

These two issues will be discussed in the following section of this chapter where we will consider how extra-geometric factors influence children's spatial language production, and the question of whether it is geometric or extra-geometric factors that play the primary role in children's early spatial language development.

The third reason for investigating children's spatial language production was due to the paucity of research in this specific area. Research investigating the development of children's spatial language comprehension has dominated the field, with children's

production of spatial terms often being glossed over or assumed to be of a similar nature. This issue will be discussed in the light of the research described in this thesis in the second section of this chapter. Finally, section three contains suggestions for future research.

6.1. The Influence of Geometric and Extra-Geometric Factors on Children's Spatial Language Production

The majority of the research that has investigated geometric and extra-geometric influences on adult's spatial language has done by the use of comprehension methodologies. Such a methodology typically examines the effect of these factors by asking participants to rate the appropriateness of one preposition against another. In doing so, participants invariably make distinctions between the two or more prepositions that have been presented to them. Therefore, it can be argued that the distinctions they make are somewhat artificial in nature as they do not necessarily reflect the way people might make distinctions when required to produce these terms.

We began this thesis from the perspective of how theorists have attempted to specify the lexical semantics of spatial prepositions. Recall that approaches to this have often assumed that it is the relative positions of objects in space that underlie the semantics of spatial prepositions, and specifying the appropriate geometric relations for each specific spatial term has been the focus of researchers in this area. However, there are many instances where geometry alone has been shown to be insufficient to account for adult's production and comprehension of spatial prepositions. We then considered the evidence that proposed that extra-geometric factors also underlie the meaning of spatial terms.

Some theorists have suggested that these extra-geometric factors (e.g., functional or locational control) are the central factors that underlie the meaning of spatial prepositions. Indeed, Vandeloise (1991, 1994) proposes that the container/contained relationship and the bearer/burden relationship are the main concepts that form the basis of the prepositions *in* and *on* respectively. Alternatively, it has been proposed that geometry is central to spatial language and that extra-geometric factors are mere *add-ons*. Landau and Munnich (1998) argued that although geometry is the central factor that specifies the representation of prepositions such as *in*, this geometric representation can be modulated by both the force-dynamic properties of objects (e.g., how they interact with each other), specific object knowledge and the functions carried out by objects. Therefore, the geometric region of spatial prepositions that is deemed acceptable is *modulated* by these factors, rather than them being represented directly in the lexicon. As mentioned earlier, Landau and Munnich (1998) suggested that one way of assessing this issue would be to investigate it developmentally. By establishing which comes first in children's spatial language, we can determine which is the main factor for the representation of spatial prepositions in the lexicon of adults.

The experiments that have been presented throughout this thesis have not only demonstrated for the first time that both geometric and extra-geometric factors influence children's production of spatial expressions, but due to the richness of the data obtained in these production studies it has also informed us of the true nature of how adults and children make distinctions verbally. Although the results from this research are not wholly informative with regards to how spatial language is represented in the lexicon, they arguably get at a more important issue, which is how adults and children make distinctions when interacting verbally. As such, the research reported in this thesis has demonstrated that people make distinctions differently when interacting verbally, than when rating prepositions against one another in a comprehension task. Let us now look at the issue of

whether geometric or extra-geometric factors have the earliest influence on children's spatial language production.

The true complexity of this question has been highlighted by the research reported in this thesis. As we can see from the wide variety of spatial expressions examined throughout this thesis, there is no clear-cut answer regarding the issue of when geometric and extra-geometric factors begin to influence their production. The answer to this is complex and is dependent upon both the specific geometric and extra-geometric factors that are investigated (e.g., height of pile, rotation of reference object, distance, locational control, functional interaction, etc.) and the preposition or construct that is being examined (e.g., *in*, *on*, 'vertical axis prepositions', reference frame use, etc). This research, however, clearly demonstrates that both geometric and extra-geometric factors do influence children's spatial language production and it appears that they continue to exert an even greater influence as children develop.

By way of simplifying the complexity, let us now review the first experiment that examined geometric and extra-geometric factors for the preposition *in* with children between the ages of 3;4 and 7;8 as we consider the question of whether geometric or extra-geometric factors affect children's spatial expression first. Certainly, we found that all age groups of children produced the expression *in the bowl* significantly less as the first (or only) prepositional phrase when the target object was positioned on top of a pile of other objects at higher heights, thus suggesting that this geometric factor influenced children's language production at a relatively early stage. However, we also found some evidence to suggest that the influence of geometric factors continues to develop. Although the influence of geometry was significant for the youngest age group, there was a significant interaction between geometry and age group whereby height effects became greater with age. Moreover, a similar interaction between height and age group was found for the scenes involving the plate. Conversely, we found no similar development between extra-

geometric factors and age. For example, when the pile of objects in the bowl extended upward, outside the space of the bowl, all age groups of children responded by producing the expression *in the bowl* as their first (or only) prepositional phrase significantly more when the bowl demonstrated locational control than when it did not.

However, although we found a developmental trend for the influence of geometric factors on children's production of locative expressions in Experiment 1, with no similar trend for the influence of extra-geometric factors, it is too early to conclude that extra-geometric factors are present for the preposition *in* before geometric factors. Although it was felt that it would not be feasible to have lowered the age at which the youngest children participated in this study, all groups of children displayed a significant sensitivity to both factors of geometry and function. Therefore, younger children will need to be examined before any firm conclusions can be drawn regarding which is the primary influence for children's production of *in*. In doing so, different methodologies might need to be employed as younger children might not produce both *in* and *on* freely and reliably (which was a pre-requisite of this production task). Indeed, two children in the youngest age group did not complete the video experiment for this very reason. As such, a comprehension task could give us the answer to this question by virtue of being able to reach children of a much earlier age.

We will now consider the reason why this experiment does not wholly inform us of whether geometric or extra-geometric factors underpin the semantic representation of *in*. Unlike the adult studies that specifically investigated the production and comprehension of *in*, due to the free-response paradigm used in Experiment 1, this study actually examined a different and potentially more interesting issue. This experiment measured the relative influence of geometric and extra-geometric factors on the issue of children's production of *spatial expressions*. Here we found that these factors did not influence the preposition children produced when referring to the whereabouts of an object positioned with a bowl

(e.g., *in the bowl* versus *on the bowl*), as was found in the sentence completion studies with adults (e.g., Coventry, 1992, 1998). Instead, these factors influenced the *word order* or the choice of reference object they used (either a bowl or other objects in the bowl). Although the usefulness of this particular experiment regarding the specific question of the lexical representation for *in* is questionable, the data obtained from this experiment does more than this, it demonstrates how children make distinctions in a more naturalistic manner. We can therefore conclude that geometric and extra-geometric factors are noticed by children from at least the age of 3;4 and that they do indeed affect the way they talk about the whereabouts of objects in a spatial scene. This is an important and interesting finding in its own right as it demonstrates for the first time that the production of locative expressions by young children is sensitive to the extra-geometric factors of continuity of objects and locational control in a manner hitherto unfound.

A similar argument can be proposed for the two experiments reported in Chapter 4 that investigated adults' and children's spatial language production for superior and inferior relations. These experiments followed on from research that investigated adults' comprehension of spatial prepositions that highlighted the differential influence of geometry and function for the prepositions *over*, *under*, *above* and *below* (Coventry et. al., 2001). Although both sets of prepositions were affected by the factors of geometry and function, Coventry et. al. (2001) found that the prepositions *over* and *under* were mainly influenced by the functional information in a scene whereas *above* and *below* were mainly influenced by geometry. Such research is highly informative regarding the issue of the semantic representations of these specific terms. However, although Experiments 3 and 4 of this thesis which set out to examine this same question for adult's and children's spatial language *production* were less informative with reference to this issue, they discovered for the first time how adults and children made verbal distinctions when allowed to chose their own words (rather than rating pre-selected terms against each other).

Although these experiments utilised a sentence completion task in order to get at specific spatial terms (i.e., sentence completion rather than free-response), the task remained a free-response task in that participants were free to produce any completions they so wished as long as they described *where* an object was in the scene they were viewing. As such, participants did not restrict themselves to producing, for example, *over* for functional scenes and *above* for non-functional scenes, as might have been expected following Coventry et. al. (2001). Instead, both adults and children produced completions that highlighted the vertical axis (e.g., *above*, *over* and even *higher than* for the youngest children) when they responded to scenes that depicted a functional interaction between two objects. By contrast, they produced general prepositions (e.g., *near* and *by*) that did not denote this axis when responding to non-functional scenes. This in itself is an interesting and important finding. Again, we can conclude that children notice extra-geometric factors and that functional information in a scene does affect the *way* they talk about the location of objects. Moreover, these experiments showed that both adults and children made these distinctions in a qualitatively similar manner to each other (although their productions were quantitatively different). They were also valuable in that they further informed us of the way in which adults and children made distinctions between events when verbally interacting with one another, as opposed to the individual task of rating words against one another.

As mentioned above, these production experiments did not wholly inform us of the semantic representations that underlie spatial prepositions. When adults and children responded to functional scenes by producing the words *under* or *above* this might suggest to us that the semantic representation of these prepositions contains functional information. However, when they then produced the prepositions *by* or *near* to describe the non-functional scenes, we cannot similarly conclude that these prepositions have anything represented in the lexicon regarding non-functionality. Clark (1996) has argued

that language is a nonconventional method of communication whereby the conventions of English merely specify potential uses of words rather than their actual uses. From this perspective, not only do words such as *over*, *above* and *near* have a relatively small set of fixed conventional meanings that are specified in the lexicon, but they also have a potentially much greater set of *nonconventional* meanings. During conversations we do not just search for a lexical item and then use it appropriately in context, we consider the other person (or people) who is involved in the conversation and the *common ground* that is shared. Common ground can encompass a whole range of things. For example, knowledge and beliefs that people share, including such general beliefs that objects will fall in a downward manner when unsupported, that the world is round, that when you are thirsty you need a drink, etc. Common ground can also encompass such things as events that have been jointly witnessed, previous conversations with the same people and the current conversation. Therefore, aspects such as context and joint salience between speaker and listener can aid understanding of what is meant when these words are used in this nonconventional way. During Experiments 3 and 4 that investigated adults' and children's production of superior and inferior prepositions, adults and children switched from using prepositions denoting a vertical axis for functional scenes to using more general prepositions for non-functional scenes. By changing the type of preposition they used, they were signalling that something different was happening in the scenes they were describing. As such, these experiments informed us just as much of the nonconventional ways in which spatial words can be used as they did of the conventional meanings of these words.

This now opens up the question of whether *any* production study can fully inform us of the semantics of spatial language in a way that comprehension studies do. When adults and children are given the freedom to produce any word they wish in order to complete a sentence, they have any number of choices to make from their lexicon. Lexical

choice is a complex task, with the initial stages requiring us to consider a number of mappings between the concepts we wish to convey and word generation (e.g., Bierwisch & Schreder, 1992; Levelt, 1999; Levelt, Roelofs & Meyer, 1999). Production studies such as those reported in this thesis give us valuable information about the way we form sentences or select individual terms in the context of normal spontaneous language production rather than inform us of the specific semantics of an individual word. In order to get at the lexical semantics of individual prepositions we would need to look at the comprehension of individual words using methodologies that necessarily leave out many of the complications involved in normal spontaneous language production. By isolating specific terms for analysis, and by asking individuals to make judgements about those terms (e.g., via a rating scale), we can get at the fine grained differences between individual words that might not be apparent in natural language production. By contrast, the rich data obtained from production studies can inform of us of the different way in which individuals make distinctions when interacting verbally. Perhaps one of the problems with the approach of lexical semantics is that during an interaction itself, a word can actually take on a meaning. For example, it might be that polysemy can be partly explained by the meaning a word takes on in context and its resolution might come down to joint salience; which is the most salient solution given the current common ground between speaker and listener.

The final two experiments that were reported in this thesis investigated adults' and children's frame of reference use. This research was designed to follow on from previous research that had found that adults displayed a preference for the use of an *intrinsic* frame of reference in the presence of a functional relation between two objects, whereas they preferred to use an *absolute/relative* reference frame in the presence of a non-functional relation between two objects (Carlson-Radvansky & Radvansky 1996). The functional relations were manipulated in two ways; either the located and reference object were

associated/not associated, or the located object was orientated toward/away from the reference object. They found these preferences in adults' reference frame use by getting participants to rate descriptions using different reference frames for a series of pictures (the comprehension study). They also asked a different set of adults to select (from a choice of six terms) a spatial preposition with which to complete a sentence to describe the same pictures (the production study). In Chapter 5 it was argued that this production study was little more than a comprehension study as it restricted the choice of the preposition with which to complete the sentence.

The general results of Experiments 5 and 6 confirmed that adults did indeed display a preference for the use of an *intrinsic* frame of reference in the presence of certain types of functional relations. When the located object was orientated toward the reference object, adults used *intrinsic* descriptions significantly more. Although when related and unrelated located/reference object pairs were depicted (e.g., postman/post box versus postman/bookshelf), this preference was not apparent. Additionally, we found that when given the opportunity to choose prepositions in a free-response task, the use of the *relative/absolute* frame of reference for the set of pictures given was minimal. None of the children (between 3;5 and 11;1) in these studies made such a distinction. However, in a similar manner to Experiments 3 and 4, children did distinguish between functional and non-functional scenes (i.e., orientation toward/away from reference object) by producing terms that highlighted the *horizontal axis* in their descriptions (e.g., *in front of* and *next to*) rather than terms that are vague with regard to that axis (e.g., *by* and *near*). Moreover, looking at the pattern of responses, it was thought that children begin by highlighting the horizontal axis in order to distinguish between functional and non-functional scenes, but they go on to develop a more refined way of making distinctions by the using the *intrinsic* reference frame during adulthood. Once again, these results highlight the limitations of

comprehension studies and demonstrate that people make distinctions differently when they are given the freedom to select their own terms.

Finally, let us now evaluate Experiment 2 that investigated adults' and children's production of *on*. This was based on a comprehension study by Coventry and Prat-Sala (in press) which used pairs of highly associated (e.g., bread/bread board) or low associated (e.g., brick/bread board) objects. The located objects were positioned either centrally or on the edge of the supporting surface. Additionally, the supporting surfaces were depicted in a canonical, horizontal manner, or they were rotated away from it. Coventry and Prat-Sala found that adults' produced the preposition *on* significantly less when a reference object was tilted away from the horizontal axis, and also when the located object was positioned on the edge of a reference object. Object association effects were also found. When the located object was positioned at the edge of a horizontally oriented reference object and object association was low (e.g., a brick and a plate), *on* was rated significantly higher than for a similarly positioned highly associated object (e.g., a fish and a plate). Therefore, when locational control is doubtful, the less appropriate figure appeared to highlight the support relationship while the appropriate figure made salient the possibility that locational control did not hold.

Investigating adults' and children's production of *on*, Experiment 2 however, found no such effects. The only finding here was that older children and adults produced *on* significantly more when the target object was positioned centrally than when it was positioned on the edge of the surface. Once again, this production experiment calls attention to one of the problems of comprehension studies. Namely that it may well be possible to find fine-grained distinctions when participants are asked to rate a single preposition across a variety of scenes, but just how informative and useful that is can be called into question if similar distinctions are not being made when people are asked to produce verbal descriptions of similar scenes. It appears that adults and children have little

alternative but to describe all of the scenes in a similar manner to each other. Unlike the scenes for Experiments 3 to 6 that could be described by the use of any number of projective prepositions, there is no alternative but to describe a support relationship other than to use the preposition *on*, even when the support that is afforded is dubious.

To sum up, the research in this thesis was prompted mainly by comprehension studies that investigated the role of geometric and extra-geometric factors for the lexical semantics of spatial prepositions. It was noted that prior research in this area predominantly focussed upon adults' comprehension of individual spatial terms. There appeared to be a dearth of production studies investigating the production of spatial terms, with no studies to date investigating the influence of geometric and extra-geometric factors for children's spatial language. Some researchers proposed that by looking at which factor comes first in children's language, we might understand whether extra-geometric factors are mere *add-ons* to the geometry that is lexicalised.

The free-response productions studies reported in this thesis have highlighted the point that comprehension does not equal production. While there may be fine-grained distinctions represented in the lexicon, when we produce language in a communicative context the distinctions we make are either very different or do not occur due to the limitation of terms available. Moreover, the issue of whether geometric or extra-geometric factors come first for children is more complex than it might first appear. This can depend upon how geometric/extra-geometric factors are defined and the preposition or construct that is investigated. We will now take a brief look at how the experiments reported in this thesis have contributed to our understanding of children's spatial language production before we go on to suggest future research in this area.

6.2. The Development of Production in Children's Spatial Language

As mentioned throughout this thesis, there has been a lack of research that has investigated the issue of children's *production* of spatial expressions; one of the aims of the research in this thesis was to address this issue. Research investigating children's comprehension of spatial terms has demonstrated important milestones in children's development. For example, the order in which prepositions are first understood (e.g., *in* and *on* before *under*), and the factors that influence children's responses (e.g., context, non-linguistic strategies, etc.). The production studies that have been conducted in this area (e.g., Durkin, 1980; Johnston, 1984) generally agree with these findings, although they have often pointed out that there are times when children produce prepositions before they have full comprehension of them. Conversely, there are times when children can comprehend a term, yet they are reluctant to produce it. This latter point has been echoed throughout much of the research reported in this thesis, and it is to this issue that we will now turn.

When we reviewed the research on children's spatial language production we noted that the development of the production of locative expressions that specify the position of objects along the vertical axis could often be a protracted affair with some researchers highlighting this as a specific problem for children (e.g., Asso & Wyke, 1973; Cox & Richardson, 1985; Durkin, 1980). As one of the subsidiary manipulations, Experiment 1 of this thesis showed children aged between 3;4 and 7;8 video clips of various scenes including some which depicted an 'above no-contact' relation between a target object and a bowl or a plate. When the experimenter asked the children to describe the location of the target object (positioned at the highest height) in relation to the bowl, the mean percentage of utterances for *above* or *over* were 30%, 59%, 78% and 92% for age groups 1 to 4

respectively (mean ages 4;3, 5;5, 6;1 and 7;1). Similar results were found for the plate scenes. This suggested a clear developmental trend in the production of superior relation prepositions. This concords with previous research which has shown that children do not fully develop the production of these prepositions until around the age of 7;0 (e.g., Durkin, 1980; Leikin, 1998).

However, Experiment 3 investigated adults' and children's production of superior relational prepositions and found that, although all adults produced the prepositions *over* and *above*, some children (mean ages 7;1, 9;1 and 10;11) did not. Moreover, when we examined the data from those children who did produce the prepositions *over* and *above* (and for the youngest age group *on top of* and *higher than*), the relative production of these completions increased systematically with age from 43% of age group 1 completions to 91% for adults. This suggests that there is an increase in the confidence of children to produce such prepositions. Interestingly, when children did produce these prepositions, they did so in a similar way to the adults in the study suggesting a quantitative rather than qualitative developmental trend. Conversely, Experiment 4 found that children's production of inferior relational prepositions (*under*, *underneath*, *below* and *beneath*) appeared to be relatively high, both in the number of children that produced them and in the frequency of their production suggesting that children's confidence in producing these prepositions was already present at the age of around 7;0.

One further point regarding the development of children's production of spatial terms is that the research described in this thesis looking at projective terms (Experiments 3 to 6) found that, in general, children preferred to produce terms that were relatively vague with respect to an axis or reference frame. For example, they often produced terms such as *by* and *near* rather than *above* and *in front of*. Although no comprehension tests were undertaken with these children, it is widely recognised that the term *in front of*, for example, is comprehended and produced by around 4 to 5 years of age (e.g., Kuczaj &

Maratsos, 1975; Johnston, 1982). However, in a similar manner to that found here, Durkin (1980) also found *in front of* was produced relatively infrequently with children preferring to produce the term *near* in their locative descriptions. However, although we have seen many developmental 'trends' in the data presented for the experiments in this thesis, the research described here cannot truly inform us of the intricacies of the developing lexicon as the methodologies used different age groups of children (as is the case for the majority of research in this area). In order to assert any possible claims made here, for example, the reluctance to produce certain prepositions, we would need to look at this longitudinally. This particular issue will be considered in the next section of this chapter when we consider the possibilities for future research.

Finally, one of the qualities of the six experiments described throughout this thesis is the richness of the data that has been obtained. The majority of the research that has investigated children's spatial language has looked at their comprehension of a limited number of terms (e.g., Harris & Strommen, 1972; Kuczaj & Maratos, 1975; Wanska, 1984). Moreover, even production studies seem to have concentrated upon a fixed range of prepositions (e.g., Johnston, 1984; Johnston & Slobin, 1979) whether or not children produced other terms. The experiments reported here have shown that even children as young as 3-years-old have a range of prepositions available to them and can describe the whereabouts of objects in any number of ways. Although this very point has meant that careful consideration of the types of utterances that were produced was required as there might have been more than one way of analysing the data. However, this in itself a positive aspect of the production studies. Every attempt was made to ensure that the data were categorised according to strict criteria. It is accepted that we did not always know how participants would respond to the scenes and that some of the data collected was not wholly expected. For example, we did not expect the complexity and variety of utterances that were produced by the children in Experiment 1. Although it was the complexity and

variety of the utterances that not only informed us of how children conceptualised the various scenes in terms of containment or support, but that they were able to highlight this in the word order they used to describe the scenes. Therefore, it was the richness of the data obtained in these experiments that proved to be the key to understanding how adults and children naturally made distinctions during interactions. This point will also be taken up in the following section when we consider suggestions for further research.

6.3. Suggestions for Future Research

The first and most obvious area for future research follows on from the point made toward the end of the previous section. Due to the wealth of data that has been obtained in all of the experiments reported here there are numerous possibilities with regard to its analysis. For example, although two different types of analyses were undertaken for Experiments 5 and 6 (*intrinsic* reference frame use and *horizontal axis* completions), the three people involved in the rating scheme for the completions also rated them according to whether or not the terms denoted *proximity*. No analysis was undertaken using this construct, but it could be possible to employ a similar rating scheme across the other experiments whereby the completions are rated according to a variety of well-defined constructs (e.g., functionality).

As mentioned at the beginning of this chapter, one of the aims for this body of research was to discover whether it is geometric or extra-geometric factors that exert the primary influence children's spatial language production (Landau & Munnich, 1998). However, as we have seen, this specific question might only be answered by looking at spatial language comprehension rather than production. By investigating spatial language comprehension one can examine responses from children of a much younger age. For

example, children as young as 2;6 could be examined for the prepositions *in* and *on* if the methodology used was appropriate (e.g., Clark, 1973; Halpern et. al., 1983). At this age children can typically comprehend these basic prepositions and would, for example, be able to classify utterances according to whether or not they described a picture.

The methodology that can be used to assess the influence of geometric and extra-geometric factors with younger children would be similar to that used in the experiments undertaken by researchers who have investigated children's naming of novel objects (as described in Chapter 2, e.g., Landau et. al., 1998; Smith et. al., 1996). Additionally, such comprehension methodologies will have the advantage of reaching any fine-grained differences between the various factors manipulated and individual prepositions examined in a way that these production studies could not. Moreover, the experimenter would have much greater control over the data collected and can therefore limit the problems outlined above regarding the issue of subjectivity and data classification. Such research would be highly complementary to that described in this thesis and aid our understanding of children's development of spatial prepositions.

The research reported in this thesis was the first of its kind to examine the role of geometric and extra-geometric factors in children's spatial language production. However, as mentioned throughout the thesis, and as highlighted in this chapter, rather than inform us of how spatial prepositions are specified in the lexicon, these experiments have highlighted a different and potentially more interesting aspect of spatial language, namely how people make distinctions when describing the spatial layouts of objects in scenes and how different forms of geometric and extra-geometric information affects this. As such, this research opens up the doors to further research to examine this aspect further. Although the experiments reported here have given us valuable information concerning the distinctions adults and children make when describing spatial scenes, they were not conducted in true conversational settings and therefore no claims can be made on this

basis. Further investigations regarding how adults and children alter their spatial language to make distinctions between scenes in more *natural conversations* are necessary. Moreover, examining other factors that affect this type of interaction would also be of interest. For example, the issue of whether children make these distinctions when talking to other children or only when interacting with an adult is one aspect of potential interest, as is whether adults make these distinctions when talking to children. As H. Clark (1996) pointed out the success of an interaction such as this requires the individuals concerned to coordinate based on their common ground. This not only concerns aspects such as joint salience, but also the assumption that the individuals concerned share a common lexicon (e.g., H. Clark & Marshall, 1981). During an interaction between adult and child, this assumption will depend upon many factors, including the age of the child. Moreover, investigating the influences of geometric and extra-geometric effects for both comprehension *and* production of spatial language in the same individual over a period of time would be beneficial to a better understanding of how this develops and whether children's comprehension of individual spatial terms affects their ability to communicate distinctions in this way.

6.4. Concluding Remarks

The research reported in this thesis has demonstrated for the first time that both geometric and extra geometric factors influence the production of children's spatial expressions from an early age. The exact age at which these factors come into play could not be determined by these production studies. It was therefore suggested that this factor might be better addressed by the use of a comprehension methodology.

Although these experiments were not wholly informative regarding the nature of the semantic representation of spatial terms, they highlight an arguably even more

important issue; how people make distinctions during a verbal interaction. The notion that it is possible to separate the meaning of individual words from the communicative interaction itself does not concord with recent work on dialogue. Of course, we use spatial words to describe the location of objects in space, and any given spatial word in itself has a conventional meaning in terms of its standardisations in the linguistic community. As we have seen, the role of researchers investigating lexical semantics is to specify what this meaning is. Yet this meaning by itself is inadequate because it ignores all the other possible, nonconventional, meanings that the word can have.

The research described here suggests that there is a level of agreement between people concerning the nonconventional use of words in that they made distinctions in a similar manner to each other even when they had fewer words in their lexicon. In order to distinguish between functional and non-functional situations they used different spatial terms to locate an object although the geometry of the scene remained constant. Perhaps the search for the meaning of a word in terms of its conventional meaning is by itself insufficient. To use words is not simply to transplant dictionary meanings into communication situations. Using words requires coordination between members of a collective activity (H. Clark, 1996). Perhaps we need to turn our attention towards examining the bigger picture; not just what is specified in an individual's lexicon, but the whole process that is involved in accessing the lexical meaning of a word along with the contextual and communicative factors that influences lexical selection.

7. Appendices

7.1. Appendix 1: Order of Scenes on Videos A to D

Main Bowl Manipulations

		Continuity				Discontinuity		
Target Object	Height	Locational Control	Non-Locational Control	Static	Height	Locational Control	Non-Locational Control	Static
Orange:	1	1 A	1 B	23 C	1	30 D	5 A	5 B
	2	19 B	1 C	1 D	2	16 A	31 B	5 C
	3	29 C	19 D	19 A	3	23 B	26 C	5 D
Apple:	1	27 D	9 A	9 B	1	13 C	13 D	13 A
	2	24 A	24B	30 C	2	24 D	31 A	27 B
	3	29 B	9 C	9 D	3	28 A	13 B	17 C
Ball:	1	25 C	7 D	A 7	1	28 B	3 C	17 D
	2	32 D	17 A	7 B	2	21 C	3 D	29 A
	3	21 A	17 B	7 C	3	21 D	3 A	3 B
Block:	1	25 B	11 C	22 D	1	11 A	11 B	19 C
	2	28 C	25 D	26 A	2	21 B	15 C	15 D
	3	29 D	15 A	15 B	3	32 C	11 D	8 A

Note: Number = order on video (1 - 32); Letter = video (A-D)

Subsidiary Bowl Manipulations (No-Contact Scenes)

Height	Ball		Block	
2	14 A	18 C	4 A	4 C
3	32 B	14 D	4 B	4 D
Height	**Orange**		**Apple**	
2	27 A	12 A	2 B	2 A
3	16 C	12 B	2 D	24 C

Note: Number = order on video (1 - 32); Letter = video (A-D)

Subsidiary Plate Manipulations (Contact Scenes)

	Ball		Block	
Height	Continuity	Discontinuity	Continuity	Discontinuity
1	25 A	14 B	18 A	30 B
2	10 C	28 D	8 D	8 C
3	22 B	14 C	8 B	30 A

	Orange		Apple	
Height	Continuity	Discontinuity	Continuity	Discontinuity
1	16 B	32 A	27 C	20 B
2	12 D	20 C	20 A	20 D
3	23 A	23 D	31 D	2 C

Note: Number = order on video (1 - 32); Letter = video (A-D)

Subsidiary Plate Manipulations (No-Contact Scenes)

Height	Ball		Block	
2	10 D	10 B	18 D	18 B
3	31 C	10 A	22 C	22 A
Height	Orange		Apple	
2	16 D	12 C	6 C	6 D
3	26 B	26 D	6 A	6 B

Note: Number = order on video (1 - 32); Letter = video (A-D)

7.2. Appendix 2: Order of Videos Shown to Each Participant

Participant ID	Order of Videos				Participant ID	Order of Videos			
NF2	A	B	C	D	BRA1	A	B	C	D
NF3	C	D	B	A	BRA2	A	C	D	B
NF4	D	A	B	C	BRA3	B	D	A	C
NF5	B	C	D	A	BRA4	B	A	C	D
NF6	A	D	C	B	BRA5	C	B	D	A
NF8	C	B	A	D	BRA6	C	D	B	A
NF9	C	B	A	D	BRA7	D	A	B	C
NF10	C	A	D	B	BRA8	D	C	A	B
NF11	B	C	A	D	BRA9	A	C	B	D
NF12	C	B	D	A	BRA10	A	D	C	B
NF13	D	A	C	B	BRB11	B	C	D	A
NF14	A	C	D	B	BRB12	B	A	D	C
NF15	A	D	B	C	BRB13	C	A	B	D
NF18	B	D	A	C	BRB14	C	B	A	D
NF22	C	D	A	B	BRB15	D	B	C	A
NF25	B	A	C	D	BRB16	D	A	C	B
NF28	C	A	B	D	BRB17	A	B	D	C
NF29	D	C	B	A	BRB18	B	D	C	A
B1A1	A	B	C	D	BRB19	C	D	A	B
B1A2	A	C	D	B	BRB20	D	C	B	A
B1A3	B	D	A	C	B2B21	A	B	C	D
B1A4	B	A	C	D	B2A2	A	C	D	B
B1A5	C	B	D	A	B2A3	B	D	A	C
B1A6	C	D	B	A	B2A4	B	A	C	D
B1A7	D	A	B	C	B2B22	C	B	D	A
B1A8	D	C	A	B	B2A6	C	D	B	A
B1A9	A	C	B	D	B2B23	D	A	B	C
B1A10	A	D	C	B	B2A8	D	C	A	B
B1B11	B	C	D	A	B2A9	A	C	B	D
B1B12	B	A	D	C	B2A10	A	D	C	B
B1B13	C	A	B	D	B2B11	B	C	D	A
B1B14	C	B	A	D	B2B12	B	A	D	C
B1B15	D	B	C	A	B2B13	C	A	B	D
B1B16	D	A	C	B	B2B14	C	B	A	D
B1B17	A	B	D	C	B2B15	D	B	C	A
B1B18	B	D	C	A	B2B16	D	A	C	B
B1B19	C	D	A	B	B2B17	A	B	D	C
B1B20	D	C	B	A	B2B18	B	D	C	A
B2B19	C	D	A	B	B2B20	D	C	B	A

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Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
On the oranges [apples /blocks/balls] in the bowl	49	0	2%(34)	0%(7)	1%(8)
On the oranges [apples /blocks/balls] on the bowl	1	0	0	0	0%(1)
On top of the oranges [apples /blocks/balls] in the bowl	303	0%(4)	3%(35)	5%(77)	13%(187)
On top of the oranges [apples /blocks/balls] on the bowl	5	0%(2)	0	0%(3)	0
Above the oranges [apples /blocks/balls] in the bowl	14	0	0%(2)	0%(7)	0%(5)
Over the oranges [apples /blocks/balls] in the bowl	1	0	0	0	0%(1)
With the oranges [apples /blocks/balls] in the bowl	169	6%(77)	4%(51)	1%(14)	2%(27)
With the oranges [apples /blocks/balls] on the bowl	5	0%(4)	0%(1)	0	0
Ambiguous/Errors/Non responses	56	3%(34)	1%(18)	0%(4)	0
Total:	5544	100%(1296)	100%(1368)	100%(1440)	100%(1440)

7.4. Appendix 4: Statistical Analyses for Experiments 1 and 2 Reported in Chapter 3

ANOVA Table for Main Bowl Manipulations (First Mention), Experiment 1

1 = Age Group, 2 = Height of Pile, 3 = Continuity/Discontinuity, 4 = Locational Control

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	8924.40	73.00	15508.56	0.58	0.63
2	2	370557.34	146.00	2712.47	136.61	0.00
3	1	4181.47	73.00	246.72	16.95	0.00
4	2	2830.42	146.00	157.94	17.92	0.00
12	6	6695.94	146.00	2712.47	2.47	0.03
13	3	561.88	73.00	246.72	2.28	0.09
23	2	308.41	146.00	208.28	1.48	0.23
14	6	165.58	146.00	157.94	1.05	0.40
24	4	774.06	292.00	168.68	4.59	0.00
34	2	567.21	146.00	118.04	4.81	0.01
123	6	51.92	146.00	208.28	0.25	0.96
124	12	185.80	292.00	168.68	1.10	0.36
134	6	224.82	146.00	118.04	1.90	0.08
234	4	93.56	292.00	155.77	0.60	0.66
1234	12	97.62	292.00	155.77	0.63	0.82

ANOVA Table for Main Bowl Manipulations (Second Analysis Age Groups 1-3 only), Experiment 1

1 = Age Group, 2 = Height of Pile, 3 = Continuity, 4 = Locational Control

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	18405.02	54.00	17098.36	1.08	0.35
2	2	165770.19	108.00	2694.55	61.52	0.00
3	1	2865.72	54.00	369.18	7.76	0.01
4	2	1186.62	108.00	153.56	7.73	0.00
12	4	3481.01	108.00	2694.55	1.29	0.28
13	2	649.88	54.00	369.18	1.76	0.18
23	2	135.26	108.00	155.84	0.87	0.42
14	4	187.25	108.00	153.56	1.22	0.31
24	4	732.53	216.00	164.41	4.46	0.00
34	2	631.99	108.00	128.08	4.93	0.01
123	4	81.55	108.00	155.84	0.52	0.72
124	8	72.02	216.00	164.41	0.44	0.90
134	4	51.47	108.00	128.08	0.40	0.81
234	4	110.07	216.00	153.37	0.72	0.58
1234	8	74.80	216.00	153.37	0.49	0.86

ANOVA Table for Subsidiary Plate Manipulations (First Mention), Experiment 1

1 = Age Group, 2 = Height of Pile, 3 = Continuity

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	6414.26	73	6828.16	0.94	0.42616
2	2	74913.31	146	768.14	97.53	0.00000
3	1	1731.81	73	249.32	6.95	0.01025
12	6	4466.98	146	768.14	5.82	0.00002
13	3	312.51	73	249.32	1.25	0.29675
23	2	62.38	146	189.34	0.33	0.71985
123	6	153.48	146	189.34	0.81	0.56323

ANOVA Table for Pilot Study Assessing High/low Association of Materials for Experiment 2

1 = Object Association, 2 = Materials

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	729.60	16	0.74	991.01	0.0000
2	3	13.77	48	0.62	22.18	0.0000
12	3	4.26	48	1.03	4.15	0.0108

ANOVA Table for Analysis of Data, Experiment 2

1 = Age Group, 2 = Object Association, 3 = Angle of Reference Object, 4 = Position

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	4	23555.51	136	8340.32	2.82	0.02735
2	1	7.06	136	80.91	0.09	0.76821
3	1	8.84	136	115.19	0.08	0.78213
4	1	12424.22	136	718.19	17.30	0.00006
12	4	10.35	136	80.91	0.13	0.97207
13	4	139.96	136	115.19	1.22	0.30735
23	1	46.13	136	102.15	0.45	0.50272
14	4	1975.12	136	718.19	2.75	0.03072
24	1	297.52	136	95.25	3.12	0.07941
34	1	253.42	136	128.16	1.98	0.16195
123	4	66.86	136	102.15	0.65	0.62469
124	4	54.14	136	95.25	0.57	0.68599
134	4	215.78	136	128.16	1.68	0.15731
234	1	89.58	136	76.34	1.17	0.28061
1234	4	80.97	136	76.34	1.06	0.37849

ANOVA Table for Analysis of Alternative Classification of Data, Experiment 2

As main analysis but placed "on THE top of" utterances in the second category.

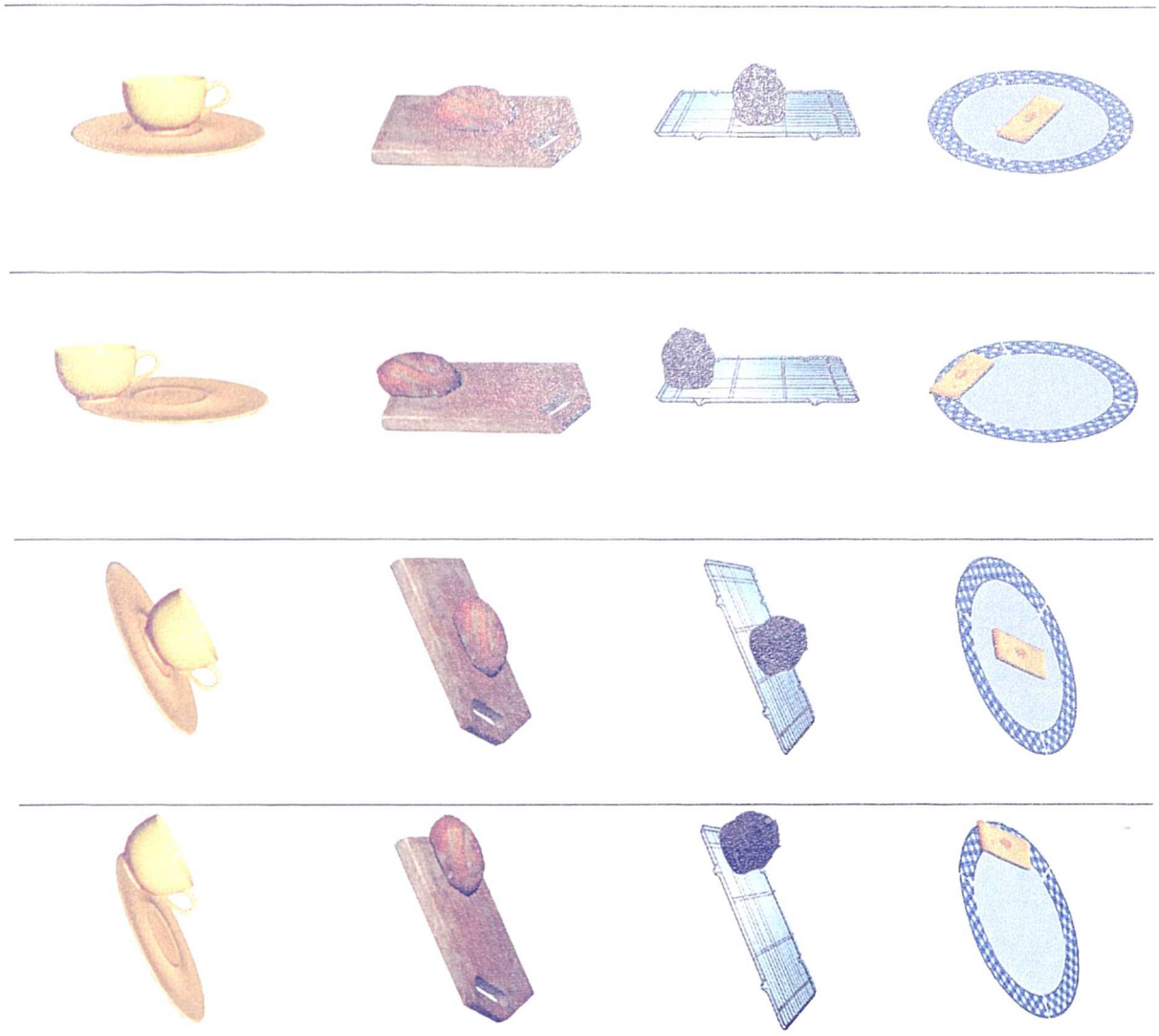
1 = Age Group, 2 = Object Association, 3 = Angle of Reference Object, 4 = Position

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	4	16431.31	136	10836.04	1.52	0.2008
2	1	6.89	136	108.00	0.06	0.8010
3	1	114.94	136	147.27	0.78	0.3785
4	1	8709.66	136	638.61	13.64	0.0003
12	4	52.94	136	108.00	0.49	0.7429
13	4	27.43	136	147.27	0.19	0.9452
23	1	88.27	136	108.57	0.81	0.3688
14	4	2132.61	136	638.61	3.34	0.0121
24	1	49.16	136	126.52	0.39	0.5341
34	1	9.43	136	107.69	0.09	0.7678
123	4	93.30	136	108.57	0.86	0.4902
124	4	53.74	136	126.52	0.42	0.7906
134	4	162.80	136	107.69	1.51	0.2022
234	1	52.22	136	71.98	0.73	0.3959
1234	4	56.63	136	71.98	0.79	0.5357

Main effect of "position" with simple *on* completions being used significantly more when the located object is situated in a central position on the reference object (78% vs 72%)

Interaction between age & position where there is no difference for "position" for the youngest three age groups, but age group 4 (mean age 10;8) show a significant difference between objects placed at the centre of the reference object (80%) and those placed at the edge of it (64%). Adults also showed significant differences (70% & 60% respectively).

7.6. Appendix 6: The Full set of Pictures Used in Experiment 2



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7.5. Appendix 5: Number (and Percentage) for All Age groups for each of the Categories of Responses for the Subsidiary Plate Manipulations, Experiment 1

Utterances	Total Frequency	Group 1 Mean 4;1 (3;4-4;6 n=18)	Group 2 Mean 5;5 (4;8-5;7 n=19)	Group 3 Mean 6;1 (5;8-6;8 n=20)	Group 4 Mean 7;1 (6;9-7;8 n=20)
On the oranges [apples/blocks/balls]	145	4%(18)	9%(40)	18%(84)	1%(3)
On top of the oranges [apples/blocks/balls]	352	26%(114)	10%(46)	20%(95)	20%(97)
Above the oranges [apples/blocks/balls]	4	0	0% (1)	0	1% (3)
In the oranges [apples/blocks/balls]	8	1% (3)	0% (2)	1% (3)	0
In the plate with the oranges [apples/blocks/balls]	3	0	0	0% (1)	0% (2)
In the plate on top of the oranges [apples/blocks/balls]	1	0	0	0	0% (1)
On the plate on the oranges [apples/blocks/balls]	1	0	0	0% (1)	0
In the oranges [apples /blocks/balls] in the plate	1	0% (1)	0	0	0
In the oranges [apples /blocks/balls] on the plate	1	0	0% (1)	0	0
On top of the oranges [apples /blocks/balls] in the plate	11	0% (1)	1% (4)	1% (4)	0% (2)
With the oranges [apples /blocks/balls] in the plate	3	0% (1)	0	0% (2)	0
Above the oranges [apples /blocks/balls] on the plate	4	0	0% (1)	0	1% (3)
On the oranges [apples /blocks/balls] on the plate	12	0	2% (10)	0% (1)	0% (1)
In[side] the plate	203	18%(76)	16%(71)	7%(33)	5%(23)
On the plate	632	27%(117)	45%(205)	34%(161)	31%(149)
On top of the plate	132	8%(36)	5%(22)	5%(23)	11%(51)
Above the plate	16	0	0	0%(2)	3% (14)
On the plate with the oranges [apples/blocks/balls]	81	3%(15)	1%(4)	6%(27)	7%(35)
On top of the plate with the oranges [apples/blocks/balls]	7	0% (1)	0	0% (1)	1% (5)
Over the plate	20	0	0	0	4%(20)
On top of the oranges [apples /blocks/balls] on the plate	111	1%(3)	4%(16)	6%(29)	13%(63)
With the oranges [apples /blocks/balls] on the plate	65	7%(29)	4%(16)	3%(12)	2%(8)
Ambiguous/Errors/Non responses	35	4%(17)	4%(17)	0%(1)	0
Total:	**1848**	**100%(432)**	**100%(456)**	**100%(480)**	**100%(480)**

7.7. Appendix 7: The Trial Sentence Completion Task

The can is [ ] the cup

Note: Every participant was required to successfully complete this sentence in order to continue with the main task. It was used in order to ensure that any problems with the task was not due to the sentence-completion task itself and was used for Experiments 2 to 6.

7.8. Appendix 8: Number (and Percentage) for All Age groups for each of the Categories of Responses, Experiment 2

Completion	Age Group 1 (mean 4;6, n=18)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=38)
On	58% (369)	81% (671)	74% (664)	67% (664)	60% (728)
Sitting on	0	0 (1)	0 (1)	2% (16)	0
Standing on	0	0	0 (2)	0 (2)	0 (3)
On top of	10% (62)	9% (71)	4% (39)	3% (25)	5% (58)
On the top of	0 (3)	1% (7)	1% (6)	1% (6)	0 (4)
At the top of	0 (2)	0	0 (1)	1% (10)	2% (20)
On the edge of	0 (1)	0 (1)	0 (2)	0 (2)	0 (4)
At the edge of	0	1% (8)	5% (46)	11% (105)	6% (67)
On the left hand edge of	0	0	0	0	0 (3)
On the left of	0	0	0	0 (3)	2% (29)
On the left side of	0	0	0	0 (2)	1% (7)
On the left hand side of	0	0	1% (5)	0 (3)	3% (35)
In the center on the left hand side of	0	0	0	0 (1)	0 (1)
On the left hand side in the center of	0	0	0	0	0 (2)
At the top and slightly to the right of	0	0	0	0	0 (1)
On the end of	0	1% (7)	1% (12)	1% (5)	0
On the side of	3% (18)	3% (21)	3% (26)	3% (32)	2% (29)
In the middle of	7% (42)	3% (29)	7% (66)	9% (86)	9% (115)
On the middle of	0 (1)	0 (1)	1% (8)	0	0
Right in the middle of	0	0	0	0 (2)	0
In the center of	0	0	0	1% (5)	4% (52)
On the center of	0	0	0	0	0 (6)
Standing in the middle of	0	0	0	0	0 (4)
Next to	5% (29)	0	0	0 (1)	0
To the left of	0	0	0	0	1% (16)
Above	0	0	0	0	0 (1)
On top and to the left of	0	0	0	0	0 (2)
On the left edge of	0	0	0	0	0 (2)
To the side of	0	0	0	0	1% (8)
On to	3% (21)	0	0	0	0
At the end of	0	0	0	0	0 (1)
In	5% (31)	0 (1)	0	0 (1)	0
At the side of	2% (13)	0	0 (1)	0	0 (4)
Lying on	0	0	0 (2)	1% (9)	0
By	0 (1)	0	0 (1)	0	0
At	1% (5)	0	0	0	0
With	0 (1)	0	0	0	0
By the middle of	0 (2)	0	0	0	0
On the outside of	0	0	0	0	0 (1)
Near	0 (3)	0 (1)	1% (5)	0	0

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Completion	Age Group 1 (mean 4;6, n=18)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=38)
Half way up and to the middle of	0	0	0	0	0 (1)
Balancing on	0	0	0	0 (3)	0
Centered on	0	0	0	0 (1)	0
Resting on the top of	0	0	0	0	0 (1)
Standing on the left hand side of	0	0	0	0	0 (2)
On the top side of	0	0	0	0	0 (2)
Off	0 (1)	0	0	0	0
On the left corner of	0	0	0	0	0 (1)
To the left and half way back of	0	0	0	0	0 (1)
Lying next to	0	0	0	0	0 (1)
In the middle and halfway up	0	0	0	0	0 (1)
Standing on the left side edge of	0	0	0	0	0 (1)
Sideways on	0	0 (3)	0	0	0
Falling off	0	0 (1)	0	0	0
Upside-down	0	0 (2)	0	0	0
Sideways on top of	0	0 (2)	0	0	0
Half off	0	0 (1)	0	0	0
Tilting on	0	0	0 (1)	0	0
Rolling down	0	0	0 (1)	0	0
Close to	0	0	0 (1)	0	0
Rolling on	0	0	0 (2)	0	0
Up the top of	0	0 (1)	0	0	0
On the top half of	0	0	0	0 (1)	0
Near the middle of	0	0	0	0 (1)	0
Leaning in the middle of	0	0	0	0 (1)	0
Sitting on the edge of	0	0	0	0 (1)	0
On the top left hand corner of	0	0	0	0 (2)	0
Half on	0	0	0	0 (1)	0
Sitting in	0	0	0	0 (1)	0
Beside	0	0	0	0	0 (1)
On the front left hand side of	0	0	0	0	0 (1)
Errors	5% (35)	0 (3)	0 (2)	0	0
Total	100% (640)	100% (832)	100% (896)	100% (992)	100% (1216)

7.9. Appendix 9: Full Set of Materials for Experiments 3 and 4

Note: The pictures displayed above were also produced a second time with the reference object positioned on the left. This was achieved by reflecting the entire image. Two sets of pictures were then constructed. Each picture set contained one example of each manipulation with the reference object positioned either to the left or to the right of the located object. Each participant saw only one of the picture sets.

7.10. Appendix 10: Number (and Percentage) for All Age groups for each of the Categories of Responses, Experiment 3

	Age Group 1 (Mean 7;1, n=17)	Age Group 2 (Mean 9;01, n=20)	Age Group 3 (Mean 10;11, n=21)	Age Group 4 (Adults, n=33)
Above	7% (28)	23% (110)	54% (274)	81% (641)
Up above	3% (13)	6% (31)	<1% (2)	0
Over	3% (14)	4% (19)	3% (16)	9% (75)
On top of	6% (24)	7% (32)	0	0
Higher than	6% (26)	7% (33)	0	0
By	11% (45)	1% (7)	4% (22)	<1% (1)
Next to	14% (58)	3% (15)	4% (22)	2% (12)
Close to	7% (27)	10% (46)	2% (12)	0
Near	8% (33)	14% (69)	8% (41)	2% (16)
In front of	7% (30)	3% (15)	4% (22)	<1% (1)
Very far away from	<1% (2)	0	0	0
Very close to	1% (5)	1% (5)	0	0
Up from	0	1% (7)	0	0
Beside	<1% (1)	<1% (2)	0	<1% (3)
Opposite	3% (11)	3% (12)	9% (47)	0
Diagonal	0	0	3% (15)	1% (9)
On the side of	0	4% (18)	0	0
Far away from	2% (10)	1% (5)	0	0
To the left/right of	0	1% (3)	<1% (1)	3% (25)
Far from	<1% (1)	2% (10)	0	0
X feet away from	2% (8)	1% (4)	0	0
High above	<1% (1)	<1% (1)	0	0
Up high from	1% (4)	0	0	0
Very high from	1% (3)	0	0	0
At an angle to	<1% (1)	0	1% (6)	0
Away from	<1% (1)	2% (9)	<1% (2)	0
Not far from	0	1% (4)	0	0
Very near	0	<1% (1)	0	0
A distance from	0	<1% (1)	0	0
Vertical to	0	0	<1% (1)	0
Facing	0	0	<1% (2)	0
Diagonally above	0	0	0	1% (8)
Errors/unusual responses	15% (62)	4% (21)	4% (19)	0
Total	100% (408)	100% (480)	100% (504)	100% (792)

7.11. Appendix 11: Statistical Analyses for Experiments 3 and 4 Reported in Chapter 4

ANOVA Table for Experiment 3

1 = Age Group, 2 = Angle of Reference Object, 3 = Functional Interaction

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	89534.11	86	4941.07	18.12	0.00000
2	1	15.61	86	293.51	0.05	0.81818
3	2	7197.36	172	414.33	17.37	0.00000
12	3	128.16	86	293.51	0.44	0.72732
13	6	478.07	172	414.33	1.15	0.33345
23	2	697.44	172	227.78	3.06	0.04936
123	6	154.65	172	227.78	0.68	0.66683

ANOVA Table for Experiment 4

1 = Age Group, 2 = Angle of Located Object, 3 = Functional Interaction

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	21581.69	97	5439.91	3.97	0.01029
2	1	738.23	97	356.26	2.07	0.15323
3	2	18387.16	194	608.50	30.22	0.00000
12	3	481.48	97	356.26	1.35	0.26230
13	6	463.79	194	608.50	0.76	0.60050
23	2	283.66	194	196.81	1.44	0.23915
123	6	370.75	194	196.81	1.88	0.08539

ANOVA Table for the Analysis of Data from Experiments 3 and 4 together

1 = Age Group, 2 = Superior/Inferior Prepositions, 3 = Angle, 4 = Functional Interaction

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	97396.30	183	5205.48	18.71	0.00000
2	1	32299.71	183	5205.48	6.20	0.01363
3	1	243.74	183	326.77	0.75	0.38891
4	2	23695.20	366	517.25	45.81	0.00000
12	3	14856.08	183	5205.48	2.85	0.03860
13	3	263.70	183	326.77	0.81	0.49148
23	1	457.84	183	326.77	1.40	0.23807
14	6	497.39	366	517.25	0.96	0.45110
24	2	1080.06	366	517.25	2.09	0.12540
34	2	199.34	366	211.36	0.94	0.39036
123	3	304.00	183	326.77	0.93	0.42723
124	6	465.91	366	517.25	0.90	0.49434
134	6	110.53	366	211.36	0.52	0.79092
234	2	811.69	366	211.36	3.84	0.02236
1234	6	390.59	366	211.36	1.85	0.08891

7.12. Appendix 12: Number (and Percentage) for All Age groups for each of the Categories of Responses, Experiment 4

Completions	Age Group 1 (Mean 7;0, n=18)	Age Group 2 (Mean 9;0, n=26)	Age Group 3 (Mean 10;11, n=26)	Age Group 4 (Adults, n=31)
Under	13% (54)	31% (193)	26% (162)	25% (189)
Underneath	25% (106)	23% (145)	21% (132)	24% (175)
Below	21% (89)	13% (82)	12% (75)	35% (259)
Beneath	< 1% (1)	1% (6)	6% (37)	2% (16)
Near	15% (65)	8% (52)	8% (49)	3% (19)
Close to	9% (41)	1% (5)	2% (12)	0
Away	< 1% (2)	3% (20)	3% (18)	< 1% (3)
Next to	0	6% (40)	8% (53)	1% (6)
By	11% (47)	4% (23)	4% (27)	< 1% (1)
Beside	< 1% (1)	6% (40)	2% (15)	< 1% (2)
Diagonal to	0	< 1% (1)	3% (16)	< 1% (3)
In front of	1% (6)	< 1% (1)	2% (11)	1% (6)
To left/right of	1% (6)	0	< 1% (2)	7% (49)
Diagonally to left/right	0	0	< 1% (3)	0
Opposite	0	< 1% (2)	< 1% (3)	0
With	0	< 1% (2)	0	0
Diagonally next to	0	1% (4)	0	0
Touching	0	< 1% (1)	0	0
Diagonally near	0	< 1% (1)	0	0
Sideways to	< 1% (1)	0	0	0
Not near/close	< 1% (2)	0	0	0
Too far away from	0	0	0	1% (5)
To the side of	0	0	0	< 1% (1)
At an angle to	0	0	0	1% (8)
Diagonally to	0	0	0	< 1% (1)
At a slant to	0	0	0	< 1% (1)
Errors/unusual responses	3% (11)	1% (6)	1% (9)	0
Total	100% (432)	100% (624)	100% (624)	100% (744)

7.13. Appendix 13: Statistical Analyses for Experiments 5 and 6 Reported in Chapter 5

ANOVA Table for the Pilot Study to Select Materials for Experiment 5

1 = Functional Association, 2 = Material Set

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	1	966.72	20	1.23	784.21	0.00000
2	3	1.10	60	0.83	1.33	0.27428
12	3	4.02	60	0.80	5.02	0.00359

ANOVA Table for the Intrinsic Reference Frame Analysis, Experiment 5

1 = Age Group, 2 = Functional Association, 3 = Blocking, 4 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	4	40148.33	118	13678.77	2.94	0.02353
2	1	17.79	118	64.99	0.27	0.60181
3	1	167.93	118	503.33	0.33	0.56462
4	1	1882.80	118	398.87	4.72	0.03181
12	4	69.59	118	64.99	1.07	0.37412
13	4	876.68	118	503.33	1.74	0.14538
23	1	0.94	118	131.09	0.01	0.93273
14	4	3224.26	118	398.87	8.08	0.00001
24	1	232.62	118	112.37	2.07	0.15285
34	1	316.99	118	180.71	1.75	0.18792
123	4	46.72	118	131.09	0.36	0.83913
124	4	195.03	118	112.37	1.74	0.14668
134	4	481.80	118	180.71	2.67	0.03574
234	1	3.92	118	129.49	0.03	0.86213
1234	4	68.21	118	129.49	0.53	0.71629

ANOVA Table for the Horizontal Axis Completion Analysis, Experiment 5

1 = Age Group, 2 = Functional Association, 3 = Blocking, 4 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	4	64099.68	118	12279.39	5.22	0.00066
2	1	233.52	118	112.11	2.08	0.15161
3	1	1705.36	118	581.94	2.93	0.08955
4	1	677.63	118	216.51	3.13	0.07946
12	4	122.86	118	112.11	1.10	0.36193
13	4	264.44	118	581.94	0.45	0.76900
23	1	0.55	118	81.70	0.01	0.93464
14	4	263.03	118	216.51	1.21	0.30822
24	1	38.08	118	118.65	0.32	0.57210
34	1	131.01	118	228.59	0.57	0.45053
123	4	22.56	118	81.70	0.28	0.89288
124	4	139.52	118	118.65	1.18	0.32501
134	4	46.43	118	228.59	0.20	0.93622
234	1	31.38	118	175.85	0.18	0.67348
1234	4	186.91	118	175.85	1.06	0.37811

ANOVA Table For Analysis With "School" as a Between Participant Variable for Intrinsic Reference Frame Analysis (Groups 1-3), Experiment 6

1 = Age Group, 2 = School, 3 = Functional Association, 4 = Distance, 5 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	7889.90	122	9009.66	0.88	0.42
2	1	811.77	122	9009.66	0.09	0.76
3	1	2.36	122	85.91	0.03	0.87
4	1	1135.24	122	607.25	1.87	0.17
5	1	805.15	122	762.28	1.06	0.31
12	2	19635.41	122	9009.66	2.18	0.12
13	2	91.47	122	85.91	1.06	0.35
23	1	5.44	122	85.91	0.06	0.80
14	2	254.87	122	607.25	0.42	0.66
24	1	1489.52	122	607.25	2.45	0.12
34	1	20.10	122	107.20	0.19	0.67
15	2	88.22	122	762.28	0.12	0.89
25	1	1210.58	122	762.28	1.59	0.21
35	1	106.77	122	121.18	0.88	0.35
45	1	40.59	122	136.75	0.30	0.59
123	2	67.01	122	85.91	0.78	0.46
124	2	219.36	122	607.25	0.36	0.70
134	2	36.13	122	107.20	0.34	0.71
234	1	2.64	122	107.20	0.02	0.88
125	2	595.22	122	762.28	0.78	0.46
135	2	28.86	122	121.18	0.24	0.79
235	1	6.30	122	121.18	0.05	0.82
145	2	182.61	122	136.75	1.34	0.27
245	1	495.21	122	136.75	3.62	0.06
345	1	60.92	122	136.62	0.45	0.51
1234	2	249.53	122	107.20	2.33	0.10
1235	2	94.83	122	121.18	0.78	0.46
1245	2	138.95	122	136.75	1.02	0.37
1345	2	156.79	122	136.62	1.15	0.32
2345	1	28.33	122	136.62	0.21	0.65
12345	2	311.04	122	136.62	2.28	0.11

ANOVA Table for the Intrinsic Reference Frame Analysis, Experiment 6

1 = Age Group, 2 = Functional Association, 3 = Distance, 4 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	21273.92	150	9302.53	2.29	0.08100
2	1	0.12	150	93.59	0.00	0.97110
3	1	3100.64	150	649.20	4.78	0.03041
4	1	13921.48	150	977.00	14.25	0.00023
12	3	83.07	150	93.59	0.89	0.44908
13	3	341.52	150	649.20	0.53	0.66503
23	1	11.75	150	111.05	0.11	0.74538
14	3	6696.87	150	977.00	6.85	0.00023
24	1	116.08	150	147.65	0.79	0.37666
34	1	22.64	150	165.67	0.14	0.71214
123	3	101.12	150	111.05	0.91	0.43751
124	3	10.74	150	147.65	0.07	0.97452
134	3	193.49	150	165.67	1.17	0.32402
234	1	169.08	150	137.97	1.23	0.27005
1234	3	157.85	150	137.97	1.14	0.33330

ANOVA Table For Analysis With "School" as a Between Participant Variable for Horizontal Axis Analysis (Groups 1-3), Experiment 6

1 = Age Group, 2 = School, 3 = Functional Association, 4 = Distance, 5 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	2	6788.21	119	9584.10	0.71	0.495
2	1	1999.31	119	9584.10	0.21	0.649
3	1	236.23	119	241.74	0.98	0.325
4	1	71324.98	119	1378.19	51.75	0.000
5	1	1576.33	119	840.62	1.88	0.173
12	2	7671.75	119	9584.10	0.80	0.452
13	2	139.41	119	241.74	0.58	0.563
23	1	81.63	119	241.74	0.34	0.562
14	2	4509.01	119	1378.19	3.27	0.041
24	1	5.16	119	1378.19	0.00	0.951
34	1	229.19	119	217.66	1.05	0.307
15	2	133.47	119	840.62	0.16	0.853
25	1	927.36	119	840.62	1.10	0.296
35	1	114.27	119	240.67	0.47	0.492
45	1	1.44	119	266.79	0.01	0.941
123	2	81.20	119	241.74	0.34	0.715
124	2	1782.87	119	1378.19	1.29	0.278
134	2	30.30	119	217.66	0.14	0.870
234	1	547.26	119	217.66	2.51	0.115
125	2	819.16	119	840.62	0.97	0.380
135	2	91.65	119	240.67	0.38	0.684
235	1	10.46	119	240.67	0.04	0.835
145	2	245.79	119	266.79	0.92	0.401
245	1	1.39	119	266.79	0.01	0.943
345	1	0.03	119	222.64	0.00	0.991
1234	2	441.79	119	217.66	2.03	0.136
1235	2	270.56	119	240.67	1.12	0.328
1245	2	173.04	119	266.79	0.65	0.525
1345	2	94.03	119	222.64	0.42	0.656
2345	1	1.63	119	222.64	0.01	0.932
12345	2	670.96	119	222.64	3.01	0.053

ANOVA Table for the Horizontal Axis Completion Analysis, Experiment 6

1 = Age Group, 2 = Functional Association, 3 = Distance, 4 = Orientation

	df Effect	MS Effect	df Error	MS Error	F	p-level
1	3	67679.61	150	8694.66	7.78	0.00007
2	1	47.69	150	222.54	0.21	0.64410
3	1	103449.78	150	1565.68	66.07	0.00000
4	1	6683.20	150	873.66	7.65	0.00639
12	3	196.74	150	222.54	0.88	0.45091
13	3	4353.13	150	1565.68	2.78	0.04312
23	1	375.81	150	193.70	1.94	0.16571
14	3	1796.80	150	873.66	2.06	0.10843
24	1	206.28	150	229.92	0.90	0.34506
34	1	14.34	150	298.38	0.05	0.82676
123	3	78.69	150	193.70	0.41	0.74873
124	3	11.69	150	229.92	0.05	0.98480
134	3	178.82	150	298.38	0.60	0.61642
234	1	121.32	150	219.22	0.55	0.45808
1234	3	8.62	150	219.22	0.04	0.98955

7.15. Appendix 15: Number (and Percentage) for All Age groups for each of the Categories of Responses, Experiment 5

Completion	No in Data Set	Age Group 1 (mean 4;3, n=12)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=33)
Against	4	0	0	0	0	0% (4)
At	125	7% (26)	0% (4)	6% (53)	2% (15)	3% (27)
Behind	79	3% (11)	1% (10)	4% (34)	1% (10)	1% (14)
Beside	114	0	0% (2)	3% (27)	2% (17)	6% (68)
By	730	20% (75)	30% (253)	28% (254)	12% (118)	3% (30)
In front of	1430	13% (51)	34% (280)	18% (160)	32% (317)	59% (622)
Near	510	13% (51)	19% (155)	13% (112)	16% (160)	3% (32)
Next to	692	13% (50)	11% (95)	19% (169)	24% (243)	13% (135)
To the left/right of	120	0	0	0	0	11% (120)
To the side of	2	0	0	0	0	0% (2)
With	24	5% (20)	0% (2)	0	0	0% (2)
Standing by	10	0	1% (5)	0% (4)	0% (1)	0
In the front of	24	6% (23)	0	0	0% (1)	0
At the front of	9	2% (7)	0	0% (1)	0% (1)	0
Right in front of	2	0	0% (2)	0	0	0
In	6	2% (6)	0	0	0	0
On	3	1% (2)	0% (1)	0	0	0
Close to	43	0	0% (4)	2% (16)	2% (23)	0
Opposite	13	0	0	1% (11)	0% (2)	0
Quite close to	2	0	0	0	0% (2)	0
Standing next to	31	0	0	0% (1)	3% (30)	0
Standing in front of	26	0	0	0	3% (26)	0
Very close to	5	0% (1)	0	0	0% (4)	0
Facing	24	0	0% (1)	2% (15)	1% (8)	0
Facing behind	10	0	0	1% (10)	0	0
Right behind	2	0	0% (2)	0	0	0
On the side of	1	0	0	0% (1)	0	0
Quite near	1	0	0% (1)	0	0	0
Nearby	3	0	0	0	0% (3)	0
On front of	4	0	0	0% (4)	0	0
Standing near	4	0	0	0% (4)	0	0

/CONTINUED...

/CONTINUED from above…

Completion	No in Data Set	Age Group 1 (mean 4;3, n=12)	Age Group 2 (mean 6;7, n=26)	Age Group 3 (mean 8;4, n=28)	Age Group 4 (mean 10;8, n=31)	Age Group 5 (adults, n=33)
On the left/right hand side of	3	0	0	0	0% (3)	0
Facing away from	2	0	0	0	0% (2)	0
Alongside	3	0	0	0	0% (3)	0
Facing backwards to	1	0	0	0% (1)	0	0
In the middle of	3	0	0% (3)	0	0	0
Outside	2	0	0	0% (2)	0	0
Turned away from	1	0	0% (1)	0	0	0
An inch away from	1	0	0% (1)	0	0	0
Errors etc.,	91	16% (61)	1% (10)	2% (17)	0% (3)	0
TOTAL	4160	100% (384)	100% (832)	100% (896)	100% (992)	100% (1056)

the speaker or some other perceiver (in any sensory modality) of the scene. Therefore, it can be conceived as having a triangulation of three points utilising the coordinates fixed on the viewpoint to assign the position of the located object to the reference object. Although the position of the body that is taken as the viewpoint can be used as the anchoring point for the coordinates, other things such as the direction of gaze might be equally used. Indeed, Levinson (1996) asserts that the *relative* frame of reference system is closely linked with visual criteria.

Finally, the *absolute* frame of reference mainly uses co-ordinations based on salient features of the environment. In English, gravity and canonical views of the visual horizon can be used and as such, the absolute reference frame often coincides with the canonical viewpoint of the speaker. Utterances such as *the church is to the north of the station* and *the picture is above the fireplace* are examples of using the *absolute* reference frame. For all the pictures you will see, the relative and absolute reference frames are together.

A FULL SET OF PICTURES FOR EXPERIMENTS 5 & 6 WERE DISPLAYED HERE

EXAMPLE OF RATING GRID:

Confidence rating : 7 = highly confident, 1 = not at all confident

	Proximity	*confidence*	Axis	*confidence*	Intrinsic	Rel/Ab	*confidence*
At		1-2-3-4-5-6-7		1-2-3-4-5-6-7			1-2-3-4-5-6-7
Far from		1-2-3-4-5-6-7		1-2-3-4-5-6-7			1-2-3-4-5-6-7

7.17. Appendix 17: Agreed Classification for all Completions in Experiments 5 and 6

Final agreement of classification of term for analysis. All shaded boxes represent where there is no clear agreement or raters agreed that terms are ambiguous. For all these cases, the ambiguous term was excluded from the analysis.

	Proximity	Axis	Intrinsic	Relative/Absolute
A distance away from	✓	×	×	×
A distance from	✓	×	×	×
A few (x) feet/meters from	✓	×	×	×
A few (x) inches from	✓	×	×	×
A little bit far (away) from	✓	×	×	×
A long way (away) from	✓	×	×	×
Across from	✓	✓	×	×
Against	✓	×	×	×
Alongside	✓	✓	×	×
An inch away from	✓	×	×	×
At	✓	✓	✓	×
At an angle to	×	✓	×	×
At the side of	✓	✓	✓	✓
Away from	✓	×	×	×
Backwards to	×	×	×	×
Behind	×	✓	×	×
Beside	✓	×	×	×
By	✓	×	×	×
Close by	✓	×	×	×
Close to	✓	×	×	×
Closer to	✓	×	×	×
Facing	×	✓	✓	×
Facing apart from	✓	×	×	×
Facing away from	×	×	×	×
Facing backwards to	×	×	×	×
Facing behind	×	✓	×	×
Far away from	✓	×	×	×
Far behind	✓	✓	×	×
Far from	✓	×	×	×
Further away from	✓	×	×	×
In front of	✓	✓	✓	×
Just in front of	✓	✓	✓	×
Left/right of	×	✓	×	✓
Near	✓	×	×	×
Near left of	✓	✓	×	✓
Nearby	✓	×	×	×
Nearly by	✓	×	×	×

/CONTINUED…

/CONTINUED from above…

	Proximity	Axis	Intrinsic	Relative/Absolute
Next to	✓	✓	×	×
Not a long way (away) from	✓	×	×	×
Not by	✓	×	×	×
Not facing	×	✓	✓	×
Not far from	✓	×	×	×
Not near	✓	×	×	×
Not very close to	✓	×	×	×
On front of	✓	✓	✓	×
On the left/right hand side of	×	✓	×	✓
On the side of	✓	✓	×	✓
Opposite	×	✓	✓	×
Outside	×	×	×	×
Quite close to	✓	×	×	×
Quite far (away) from	✓	×	×	×
Quite near to	✓	×	×	×
Really close to	✓	×	×	×
Right next to	✓	×	×	×
Standing behind	×	✓	×	×
Standing over	✓	✓	✓	×
The other side of	×	✓	×	×
Tight to	✓	×	×	×
To the far left/right of	✓	✓	×	✓
Too far away from	✓	×	×	×
Touching	✓	×	×	×
Turned away from	×	×	×	×
Very close to	✓	×	×	×
Very far away from	✓	×	×	×
Very near	✓	×	×	×
Very very near to	✓	×	×	×
With	✓	×	×	×

7.18. Appendix 18: Full Set of Materials for Experiment 6

Note: The pictures displayed above were also produced a second time with the reference object positioned on the left. This was achieved by reflecting the entire image. Two sets of pictures were then constructed. Each picture set contained one example of each manipulation with the reference object positioned either to the left or to the right of the located object. Each participant saw only one of the picture sets.

7.19. Appendix 19: Number (and Percentage) for All Age groups for each of the Categories of Responses, Experiment 6

Completions	Age Group 1 (mean age 7;0, n=35)	Age Group 2 (mean age 9;0, n=46)	Age Group 3 (mean age 10;11, n=47	Age Group 4 (adults, n=31)
A distance from	0	0% (4)	0% (2)	0% (1)
A few (x) feet/meters from	1% (9)	0	0% (5)	0
A few (x) inches from	0	1% (9)	0	0
A long way (away) from	0% (3)	1% (12)	0	0
Across from	0	0% (6)	0	0
Against	0	0% (4)	0	0% (1)
At	0	1% (17)	1% (22)	3% (32)
At the side of	0% (1)	0	0% (1)	0
Away from	4% (46)	5% (69)	11% (167)	8% (78)
Backwards to	0% (1)	1% (21)	0	0
Behind	3% (28)	2% (30)	0% (7)	0% (4)
Beside	4% (50)	10% (143)	8% (123)	4% (35)
By	18% (197)	12% (174)	11% (162)	2% (17)
Close to	7% (76)	4% (59)	2% (37)	2% (17)
Facing	0	0	1% (19)	0% (1)
Facing away from	0% (1)	1% (8)	0% (2)	1% (6)
Far from	1% (12)	3% (40)	1% (15)	0
In front of	22% (250)	15% (223)	25% (372)	39% (387)
Left/right of	1% (7)	1% (20)	3% (43)	13% (127)
Near	18% (206)	20% (293)	18% (266)	11% (107)
Near left of	0	0% (2)	0	0
Next to	11% (125)	16% (230)	15% (225)	17% (168)
Not a long way (away) from	0	0% (2)	0	0
Not by	0	0% (1)	0	0
Not facing	0% (1)	0	0% (1)	0
Not far from	0% (2)	0% (1)	0% (1)	0
Not near	0% (4)	0	0% (2)	0
Not very close to	0	0% (1)	0	0
Opposite	0	2% (27)	1% (13)	0
Quite close to	0	0% (4)	0	0
Quite far (away) from	0	0% (3)	0	0
Quite near to	0	0% (2)	0	0
Really close to	0	0% (6)	0	0
To the far left/right of	0	0% (1)	0	0

/CONTINUED...

/CONTINUED from above...

Completions	Age Group 1 (mean age 7;0, n=35)	Age Group 2 (mean age 9;0, n=46)	Age Group 3 (mean age 10;11, n=47	Age Group 4 (adults, n=31)
Touching	0	0	0% (1)	0
Turned away from	1% (14)	0	0% (6)	0
Very close to	1% (15)	0% (7)	0	0
Very far away from	1% (8)	0% (4)	0	0
Very near	1% (13)	0% (7)	0% (2)	1% (9)
With	0% (1)	0% (4)	0	0
Unusual/errors	4% (43)	1% (21)	0% (6)	0% (1)
Total	100% (1120)	100% (1472)	100% (1504)	100% (992)

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