# Understanding and Use of Small-Scale Models as Representations of Large-Scale Spaces, in 3 to 6 Year Old Children: An Investigation of the Effects of Varying Task and Method.

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# CONTENTS

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## Declaration

I declare that the work undertaken and reported throughout this thesis was completed solely by the undersigned. This work has not been included in another thesis.

Victoria L. Perry

## Publications

The following publications/conference presentations have been adapted from experimental work reported in this thesis:

Perry, V.L. & Campbell, R.N. (2000). Task variation and young children's understanding of a model of a familiar space. *Current Psychology of Cognition, 19,* 3, 307-332.

Perry, V.L. & Campbell, R.N. (1999). The development of young children's understanding of the relationship between a model and the room it represents. *Proceedings of the British Psychological Society, 8,* 1, 26.

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**“What do you consider to be the *largest* map that would be really useful?”**

**“About six inches to the mile.”**

**“Only *six inches*!” exclaimed Mein Herr. “We very soon got to six *yards* to the mile. Then we tried a *hundred* yards to the mile. And then came the grandest idea of all! We actually made a map of the country on the scale of *a mile to the mile*!”**

**“Have you used it much?” I enquired.**

**“It has never been spread out, yet,” said Mein Herr: “the farmers objected; they said it would cover the whole country and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well.”**

***(Lewis Carroll, 1893)***

## Abstract

Spatial representations are external, physical entities, which are used to symbolise real world environments. These kinds of symbols provide information about the world, and shape the way that we think about it. Previous research into children's understanding and use of spatial representations has led to differing conclusions about how and when such abilities develop. This may be due to the diversity of different tasks and methods which have been adopted in the past. The aim of this thesis was to provide a systematic investigation of some of these tasks and methods, in order to establish whether they assess the same underlying abilities, and whether children perform similarly on all such tasks, using all such methods. A series of studies compared performance on two tasks – positioning and retrieval – and on two methods – inferring from a representation to a referent space, and from a referent space to a representation. Error data and time data were recorded in addition to success and failure. Results show that when target locations are completely concealed, levels of absolute success are similar on the two tasks. However, children take more time on the retrieval task, which may indicate a difference in the way they approach tasks presented in a familiar game format. Results also show that the two methods may not be equivalent. Performance under these two methods differs in younger children particularly. Familiarity with the referent space leads to improved performance when inferring from referent to representation, and to more sophisticated response strategies overall. The presence of irrelevant material in either space does not affect performance. Results support the notion that some representational understanding can be achieved early in development, so representations of space can begin to be used

from three years of age. However, despite this early achievement of representational understanding, deficits in spatial cognition mean that the ability to fully understand and use spatial representations is still developing at 6 years of age.

## Thesis Outline

This thesis explores the understanding and use of external representations of space by children, focusing particularly upon changes in children's performance due to the use of different tasks, methods of assessment, and experimental designs. The aim of this section is to provide a general overview of the purpose of each chapter.

Chapter One is a general introduction, providing a definition of spatial representations and an insight into their importance. It also serves to outline some of the theories of development in children, which allow for an understanding of how the understanding and use of spatial representations might develop.

Chapter Two provides a detailed review of some of the tasks and methods which have previously been used in this domain, to assess children's understanding and use of spatial representations. Traditionally, research in this area tends to use a real world environment as a referent space, and some representation of that space, and requires children to manipulate either the space or the representation in some way, in order to demonstrate their understanding of the relationship between the two. From this review it is clear that there are many possible representational media which have been used in different studies as well as a variety of different specific experimental tasks which children have been required to carry out. In addition, many aspects of these tasks have differed between studies – for example, whether the referent space used is familiar or unfamiliar, or whether it is a natural space or a contrived experimental space. This chapter suggests that because of the diversity of methods used in previous research, making judgements about children's abilities in this domain is difficult.

Performance is therefore the result of a trade-off between children's actual competence and the cognitive load of the particular experimental design employed. The chapter explains the overall aim of the project reported here, in explicitly addressing the issue of just how performance is affected by the use of different methods, tasks and by other experimental variables such as familiarity with the referent space.

Chapter Three outlines the general methodological approach adopted in all of the studies within the project. The method has been adapted from that used by Judy DeLoache since her original (1987) study in this area. Using this method, children view a room as the referent space, and they view a small-scale model of that room as the representation. They then view a target object hidden or placed at some location in one of the two spaces, and are required to themselves retrieve or position an analogous object from the analogous location in the other space. In this way, they demonstrate their understanding of the representational relationship between the model and the room, as well as their ability to identify correct spatial locations.

Chapter Four reports the first study carried out as part of this project, Experiment One, in which children complete the standard task with their own classroom as the referent space. This initial study aims to compare children's performance on two specific tasks – retrieval and positioning – and using two methods – inferring from Model-To-Room, or from Room-To-Model.

Chapter Five explores whether the children's familiarity with the referent space might have affected the pattern of performance in Chapter Four, and thus Experiment Two reported here replicates the previous experiment using a completely novel referent space.

Chapter Six presents Experiments 3A and 3B. Having explored a highly familiar referent space (Experiment One) and a completely novel referent space (Experiment Two), the studies in this chapter examine how performance changes when the level of familiarity with the referent environment, varies from slightly familiar to highly familiar.

Chapter Seven explores the effect of the quality of the representation itself. Experiments One, 3A and 3B use a fairly basic model, containing only structural elements of the referent room. However, Experiment Two uses a more detailed model containing soft furnishings as well as structural elements, and the colours of objects in the representation were truer to the colours in the referent space, to a much greater extent than was the case in Experiments One, 3A or 3B. Experiment Four therefore aims to compare performance using a basic model with that using a detailed model.

Chapter Eight examines the possibility that selective attentional capacities might be responsible for differences between Experiments One and Two, rather than the complete novelty of the referent space in Experiment Two. In Experiment One, the referent space is the children's own classroom, and therefore contains a great deal of irrelevant information in the form of additional material like toys and books. In Experiment Two, however, there is no additional material of this sort in the referent room. Therefore, it is suggested that children might be distracted by this additional material when inferring from model to room. Thus, this distraction might account for differences between Experiments One and Two, rather than the differences in the level of familiarity with the referent space. Experiments Five and Six reported here, explore children's performance when irrelevant material is present in the room, when it is not present at all, when it is present in the model, and when it is present in both model and room.

Chapter Nine provides a general discussion of the studies in the project. It summarises the main findings, and draws some conclusions regarding developmental issues. Based on the research presented within this thesis, this chapter suggests how children's performance on tasks designed to assess understanding and use of spatial representations is affected by the variations in task, method and other variables which were explored in this project. In addition, some suggestions for further research are made.

# CHAPTER ONE

## General Introduction

### *Definitions*

The term "spatial representation" has several meanings. Firstly, it is applied to internal, mental spatial information about any real-world environment. Historically speaking, internal models of large-scale environments have been referred to differently, and also in different research domains. They have been called "imaginary maps" (Trowbridge, 1913), "mental maps" (Shemyakin, 1962), "environmental images" (Appleyard, 1969), "spatial images" (Boulding, 1956) and "spatial schema" (Lee, 1968). However, probably the most familiar term to psychologists is "cognitive maps". This type of terminology suggests pictures or maps, but in fact these internal models of space may not be maps, and may not even be map-like. As Siegel & White (1975) point out, they are often fragmented and distorted. It is also often the case that they are actually separate but connected models of smaller chunks of the whole environment.

However, the term "spatial representation" can also be used to refer to any external, physical, tangible entity, which is used to symbolise some real world environment. It is important to emphasise this distinction between internal and external spatial representations. Very often, it is assumed that an individual's internal spatial representation can be assessed through some task using an external representation of that environment (see Spencer, Blades and Morsley, 1989, Chapter One, for a review of such methodologies). Thus the two are undoubtedly related. However, the nature of internal representations, or "cognitive maps" is an issue of human spatial cognition, whilst an external representation is a physical entity. It is the aim of this thesis to examine the understanding and use of external spatial representations, and to investigate how manipulations of such external entities and their referents may affect this understanding. Such understanding may well rest upon cognitive abilities and this will be explored within the thesis, but it is the external representations which remain the prime focus throughout. Henceforth, the term "spatial representation" will be used to refer to external, physical representations of space. Where internal representations are the focus of discussion, this will be made explicit.

***The importance of spatial representations***

The emergence of the ability to use symbols in general is an important stage in many theories of cognitive development (e.g. Werner & Kaplan, 1969; Piaget & Inhelder, 1969). The ability to use language marks an important stage in any child's development. But symbolic functioning is also evident when a child, for example, turns a cup upside down and uses it as a hat. This represents a significant stage in development because the child understands that the object is a thing-in-itself, but that it can also be used to represent something else. DeLoache (1993) calls this "One of the foremost achievements of early human development." She goes on to explain,

> *"Children come to realise that a variety of culturally defined symbol systems represent or stand for other objects, events, or ideas. They learn*

*that pictures, numbers, and maps have referents, that they stand for something other than themselves." (p91)*

DeLoache and Burns (1994) expand upon this, and explain just why this type of understanding is so important, although in the first sentence of this quote they may have overstated their point.

*"Our capacity for the creative and flexible use of symbols is what sets us apart from other species. In modern, industrial societies, there are many symbol systems that must be mastered for full participation in society. We must speak fluently and use gestures comprehensible to others. We must be able to count and do math, to read and to write." (p513)*

Maps and models are also types of symbols, but instead of representing objects, they represent space. These types of symbols are of particular importance because they provide us with information about the world, but also because they influence the way that we think about the world, and are culturally defined in the same way that other symbol systems are (see Gauvain, 1993, for a full discussion of the socio-cultural aspects of spatial thought).

Siegel & White (1975) explain that any type of spatial knowledge is essentially encoded in symbols, and these symbols are affected by the conventions of the individual's particular society or culture. In several studies of Inuktitut (Eskimo) spatial deictics, Peter Denny (1978; 1982) explores the fact that different cultures have very different words to describe spatial concepts, and that this leads to very different ways of thinking about space. For example, he suggests that in Westernised cultures non-deictic locatives such as "down-the-road" or "round-the-corner" can be used to adequately relate space to human actions. However, natural environments such as the Arctic tundra, have not been shaped to facilitate human action, and therefore one way to relate the space to human activity is to use deictic spatial concepts which centre space on the speaker. In English, the two words "here" and "there" make up the spatial deictic system, contrasting the speaker's location with all other possible locations. In Eskimo, however, the spatial deictic system comprises 88 words which, Denny argues, enable Eskimos to think about spatial locations in very different ways to English speakers.

Siegel and White (1975) describe a race of people for whom the sea is particularly important, and which therefore forms a central part of their system of spatial referencing. This is evident from one anecdote in which a member of this society was heard telling another that "..you have mud on your seaward cheek.." (p16) As Siegel & White point out,

> *"Being a social animal and developing within a social context, man construes reality in the terminology of his culture. Part of this reality is symbolised space." (p16)*

Spatial representations also provide us with information about the world which we would otherwise not have access to. We are able to learn about places we have never visited, and to have a conception of where certain landmarks, cities and countries are in relation to others. One example, of satellite images of Earth, demonstrates clearly how representations provide us with information that we otherwise could not possibly hope to have (Liben, 1997).

In addition, spatial representations are important because they influence the way we think about the world, and the way in which we visualise it. It is therefore important that we investigate how young children understand spatial representations in order to gain an insight into how they can think about the world. Blades and Cooke (1994) explain the importance of this type of understanding.

> *"Understanding an external representation is an important developmental achievement, one that has implications not only for theories of spatial abilities per se, but also for several other aspects of development. For example, children's recognition that a representation provides a particular view of the world is one facet of perspective taking...; their ability to select information from a map or a model and apply that information to the represented environment can be considered in the context of early analogical reasoning...; and children's use of external representations is an example of learning from culturally mediated symbolic tools.." (p202)*

Similarly, Blades and Spencer (1994) comment that,

> *"Spatial representations are an important and common aspect of most cultures- they both provide information about the world and influence the way that people think about and visualise the world....and with the rapid development of computer based Geographical Information Systems it is*

*likely that spatial representations will become even more important, for both professional and non-specialist users.." (p4)*

Recent research, then, has investigated young children's developing understanding and use of spatial representations as abilities in their own right, as well as for what they can add to our understanding of the development of spatial cognition in general.

### *Theories of spatial development*

Various theories of spatial development have been suggested over the years. This section will explore some of these theories and how each of them aims to explain children's developing understanding of spatial representations.

Piagetian theory

In terms of explaining Piaget's theory of the development of the concept of space in the child, it is first necessary to explain the important distinction which he makes between perceptual space and cognitive space (Piaget & Inhelder, 1956: p3). Perceptual space is, in Piaget's view, concerned with the more figurative aspects of knowledge, whilst cognitive space is concerned with the operative aspects of knowledge. According to Piaget, knowledge of any sort must include these two aspects, since to know any object is to construct or reconstruct it. The essentially operative aspect is related to the actions or the operations by which the subject submits the object to the transformations necessary for its reconstruction. Thus, it is dependent upon intelligence. The figurative aspect relates to the perception (direct or pictorial) of the successive states or momentary configurations between which the transformational activities must intervene. Thus, it is dependent upon perception or the mental image.

Piaget stresses that intelligence does not arise out of perception, but rather that a reciprocal influence or functional interaction must operate between the two. The information which comes from perception or the mental image is the raw material for the intellectual action. Yet reciprocally these intellectual activities have an influence upon perception (either directly or indirectly), thus enriching and increasing the flexibility of its functioning with development. In this way, intelligence remains distinct from perception, yet the two remain related aspects of knowledge and reality. Their development can be complementary, but often in very different directions. In Piaget's works he indicates that the perception of space, as opposed to the conception of space, is always essentially relativistic in character. It is never really free from systematic distortions, because of the irreversible nature of the perceptual structures.

The development of sensori-motor space, according to Piaget, occurs during the first two years of childhood, and is one of the major achievements of sensori-motor intelligence. The actions of the child and their displacements, which involve both their perceptual functions and their motor functions, lead to a progressive structuring of space through increasingly complex co-ordinations. In this way sensori-motor space clearly involves more than just mere perception, and depends greatly upon the intelligent or operative aspects of knowledge. Piaget describes this sensori-motor space as a space which is practical, experienced, organised and balanced, at the level of action or behaviour. Nevertheless, at this early stage in development, the absence of the symbolic function means that the child is unable to imagine this space, or to mentally reconstruct it. However, these perceptual sensori-motor structures form the foundation of the construction of representational space (p5).

With the advent of the symbolic function in the child, at about the age of two years, representational space begins to develop. This is more than just an internalisation or image reproduction of sensori-motor space (p3). Spatial representation is added to and derives from sensori-motor space, and enables the child to act upon objects which are symbolised or mentally represented, as well as those which are physically present. It develops progressively, and involves a long period of internalisation, from action to operation.

From geometry, Piaget identifies three main types of geometrical relations, and he traces their development in children. The most basic relation in developmental terms, is topological space. This depends purely upon the qualitative relations which are inherent in a particular figure, such as nearness or proximity, separation, order or spatial succession, and enclosure or surrounding. Thus topological space is restricted to the internal properties of particular objects, and allows only for analyses which operate from the standpoint of each figural object in isolation (p153). This is followed by projective space and Euclidean space.

> *"With projective and Euclidean space we encounter a new and different problem, that of locating objects and their configurations relative to one another, in accordance with general perspective or projective systems, or according to co-ordinate axes. Projective or Euclidean structures are therefore more complex in organisation and are only evolved at a later stage in the child's development." (p153)*

In projective space the concept of the straight line serves as the basis for spatial relationships. Thus projective space is concerned with the relation of one object to others, but from a particular perspective or point of view (p154). The final stage in development comes with the advent of Euclidean space, which is based mainly upon the concept of distance. The child is able to locate an object in terms of a system of axes or co-ordinates. Euclidean and projective space both derive from topological space, but are then constructed parallel to one another. Though distinct from one another, they nevertheless remain closely related.

In terms of the development of understanding of external representations of space, Piaget actually had very little to say, since he believed that any understanding of external representations of space was derived from an already established internal representation of space. However, Piaget & Inhelder (1956) did some very early research using two identical models, one of which was to serve as a representation of the other. A doll was positioned on one of the models, and the child had to position another doll at the equivalent position on the second model.

Stage I children (ages 3.0-4.0 years) appeared only to be able to focus upon one aspect of the doll's position in the first model. Piaget's explanation for this behaviour was to say that these children relied upon simple topological concepts, i.e. that the child just thought of the doll as being "in" a particular area, or "near" a particular object. So, if the doll was in a field on the first model then the child might place the second doll in a field on the second model, but would not attend to *which* particular field by noting, for example, which other objects it was near to.

In Stage II, children began to position the doll in relation to two or three features, and then after the ages of seven or eight, the children were always successful. Thus, in Piaget's view, children's failure to understand spatial representations can be seen as a result of their reliance upon simple topological concepts.

In another task children viewed a model village and were then presented with a set of identical objects which they were to use to construct a replica of the original model. These objects were either of the same scale as the original model, or of a smaller scale. Children were presented with either the same number of objects as were in the original or more, in which case the child would have to choose between the available objects and select the correct ones to use (Holloway, 1967).

In Stage I children were able to achieve neither spatial correspondence between the sets of objects, nor one to one correspondence. Sometimes certain proximities may have been observed, but usually objects were either bunched together, or put in a line in a different order to that which they assume in the original. By seven or eight years children were able to copy the model perfectly, apart from precise measurements and reductions to scale. Performance therefore improves as they progress through reliance upon projective and finally Euclidean concepts, and the ability to understand and to use a representation of space would be a late developing skill, emerging at around seven years of age.

In addition, Piaget and Inhelder's (1956) well-documented "three mountains" task suggests that until nine or ten years of age, children have difficulties appreciating perspectives other than their own. Children were shown a model of three mountains and were asked how it would look to an observer situated at a different location. The children responded by building a model, or by selecting a picture which showed the mountains from various perspectives. Until nine or ten years, children tended to respond by selecting the view which showed the mountains from their own perspective.

External representations of space tend to show the referent environment from a different perspective to that which a child is likely to encounter. Thus, Piaget's views about perspective, coupled with his account of the development of the concept of space, seem to suggest that we should expect the ability to understand and to use spatial representations to be a late developing one.

Perhaps because of this Piagetian framework, young children's abilities in understanding and using representations of space, were overlooked by researchers until more recently. Liben (1982) explores some alternatives to the traditional Piagetian tasks used in assessing spatial cognition generally, which other researchers have employed. She advocates caution in drawing conclusions from Piagetian methods, since children's actual spatial competencies may not be adequately reflected by their performance on such tasks. In addition, the findings of more recent studies indicate that the ability to understand and use spatial representations specifically, may not be as late to develop as Piaget's theory suggests. Mark Blades in the UK and Judy DeLoache in the US have separately been at the forefront of research within this domain, carrying out many different studies aimed at exploring young children's understanding and use of spatial representations, and their research suggests this to be a much earlier developing skill than had previously been thought.

<u>DeLoache's theory</u>

DeLoache (1995a; 1995b) proposes a model of young children's symbol understanding and use, which is based on her extensive research into children's understanding and use of small-scale models. However, she explains that she intends the model to apply to a broad range of different symbol types, apart from just models, and not restricted to representations of space. This model is a revision and extension of the model posited previously in DeLoache (1990), and is shown in Figure 1.

DeLoache's model can be seen to be similar to Gentner's (1983;1989) theory of analogical reasoning, which outlines the development of the ability to recognise that a set of related items have some relationship to another set of related items, though Gentner did not focus upon relationships between representations of space and their referents specifically.

In DeLoache's model, the behaviour which represents the output is the appropriate use of a symbol. DeLoache bases her model on research using her typical experimental paradigm. Children view a room as the referent space, and a small-scale model of that room as the representation. A target toy is hidden at some location in the model, and children are asked to retrieve a previously hidden analogous toy from the equivalent location in the room itself (or vice-versa). In the research upon which DeLoache bases her model, the behaviour which represents the output would constitute retrieval of the previously hidden object, from either the small-scale model, or from the referent room.

Immediately underpinning the ability to make appropriate use of a symbol in this model, is the ability to map the elements of the referent to those of the symbol, or vice-versa. This Mapping ability is therefore bi-directional.

Underpinning the ability to map in this way, is the central component of the model – a higher-order appreciation of the relationship between the symbol and its referent, which DeLoache terms "representational insight".

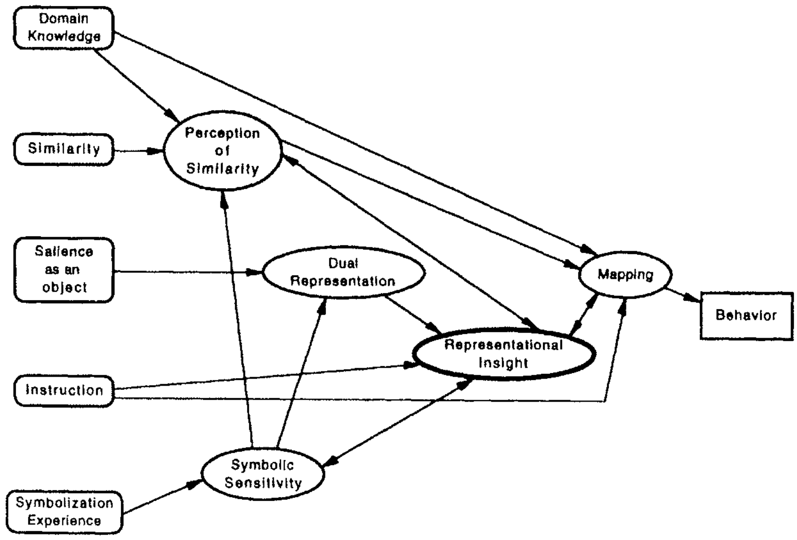


*Figure 1. DeLoache's model of symbol understanding and use. (Taken from DeLoache, 1995).*

In the model, representational insight is facilitated by a combination of multiple factors. The first of these is "Instruction". In the majority of DeLoache's studies, she employs an extensive orientation phase prior to commencing testing. However, when this instruction phase is modified to provide less instruction to children, they perform more poorly. DeLoache emphasises that this fits with Gentner's (1983) theory of analogical reasoning, since in her terms instruction ought to foster "structural alignment" between the symbol and the referent, by encouraging children to compare their mental representations of the room and the model. Instruction represents a developmental component of the model, since older children require fewer and less detailed instructions to successfully use a symbol, than younger children do.

Similarity is a second factor which contributes to attaining representational insight. DeLoache notes several different types of similarity which may exist between referent and representation. Similarity in scale, when the referent and representation are close to one another in terms of size, appears to aid children's ability to appreciate the relation between the two. Similarity between elements of the referent and the representation also assists with the achievement of representational insight. In DeLoache's scale-model studies, when objects within the two rooms look alike (similar fabric, colour etc.) children appear better able to appreciate the overall relation between the two spaces. In addition, background similarity also contributes – so when walls of the model and the room are painted in similar colours, the relation between the two is more easily appreciated. In Gentner's terms, increased similarity between elements of a model and the room it represents entails a recognition of 'object correspondences' based on similar object attributes.

Relational similarity is a further type of similarity which DeLoache notes may contribute to children's understanding overall. This refers to similarity not between corresponding individual objects in the two spaces, but between the spatial arrangement, or the relations between those objects. Gentner also makes a distinction between object correspondences, as mentioned previously, and this type of 'relational correspondence', which rests upon a recognition of the relations between objects within a set. This is also a developmental aspect of DeLoache's model, since older children are able to understand and to use a symbol which is less similar to its referent, whereas younger children often require high levels of similarity to succeed.

A further factor which contributes to the achievement of representational insight according to DeLoache's model, is Dual Representation. Uttal et al. (1998) report that on DeLoache's standard model retrieval task, 2½ year old children are notoriously unsuccessful. However, they acknowledge that these same children nevertheless grasp several important components of the task.

> *"First, they understand that they are to find the large toy in the room, as evidenced by their enthusiasm during the symbol-based retrieval. Second, they are very good at remembering where the original toy was hidden in the model. Their memory-based retrieval performance is always near ceiling, on par with that of 3 year olds. Thus, their inability to find the toy in the room is not because they fail to remember where the miniature toy is hidden in the model. Finally, 2½ year olds can match the corresponding objects (e.g. large and small chairs) in the two spaces." (p65)*

So the reason for failure, then, must lie elsewhere, with the children's understanding of the relationship between the model and the room as a whole. It appears that the children simply do not understand that the model and the room are related, and they therefore do not understand that they have any way of knowing where in the real room the larger toy is hidden.

This is DeLoache's own view. She proposes the "dual orientation hypothesis" which states that younger children have difficulties in recognising the symbolic relationship between the model and the referent space, because a model is a "thing-in-itself" as well as being a representation of something else. Models are salient as objects. They are three-dimensional and can be touched and manipulated by children. Photographs, on the other hand, have no function in themselves, thus their only purpose is to represent. Children therefore find photographs easier to appreciate as representations than models. DeLoache's research suggests that children can use a photograph to identify the location of a target object in a referent room at just 2½ years, whereas they appear unable to do so with a small-scale model until 3 years.

This is a factor which she has explored in many of her studies, and relates to the ability to appreciate a symbol in two ways simultaneously: firstly to appreciate it as an object in itself with features of its own, and secondly to appreciate its more abstract features as a symbol for something else. DeLoache's dual representation hypothesis asserts that the more salient an object is as an object in its own right, the more difficult it is to appreciate it as a symbol. She argues that it is the representational element of the link between referent and symbol which is problematic for young children. DeLoache, Miller, Rosengren and Bryant (1993) and DeLoache, Miller and Rosengren (1997) allowed children to view a large-scale room followed by a small-scale model of the room, but convinced the children that a "shrinking machine" had simply reduced the size of the room from large to small. Children observed a large toy hidden in the large room, and were then asked to retrieve the "shrunken" toy from the "shrunken" room. Under these circumstances DeLoache et al (1997) observed much higher levels of success in children than would normally be expected. They suggest that this is because the children now perceive a causal link between the two spaces which does not have any representational component – the two rooms are simply considered to be the *same* room viewed before and after the transformation of size.

As further support for this hypothesis, Troseth and DeLoache (1998) carried out several studies in which children viewed a hiding event in a room live, on a video monitor, and were then required to enter the room and successfully retrieve the object which the had previously observed being hidden. However, children who watched the hiding event through a window performed dramatically better than children watching on a video monitor. Thus, watching precisely the same events elicits very different results depending upon whether children observe the events directly, or via a live video link. The authors interpret these results as showing that it is the representational nature of the video medium which impairs children's performance. If children do not fully appreciate the representational relationship between the video and real life, then they will be unable to recognise that the video can provide them with information about the real world. To test this, Troseth and DeLoache carried out another experiment, this time comparing children's performance using the standard video monitor, with performance using a video window. Under this latter condition, children were told that they would be watching a hiding event through a window, whereas in fact they were watching a video. Thus, children in both conditions viewed exactly the same things. The only difference was that the standard video group knew that they were watching a video whilst the video window group thought that they were looking through a window. The results supported the authors' hypothesis, in that children in the video window condition performed significantly better than those in the standard video condition. Thus, it seems that appreciating the symbolic nature of a representation is a difficult task for young children to achieve, but if the necessity for appreciating this representational aspect is removed, the task becomes a more straightforward one.

In contrast, though, an earlier study by Menzel, Premack and Woodruff (1978) showed chimpanzees a black-and-white closed-circuit television picture of a caretaker walking in an outdoor field and then hiding. When subsequently released into the field the chimps were more successful at finding the caretaker than if they had not viewed the television image, which suggests that even chimps are able to recognise the relationship between what they see on a screen and the real world, and that they were able to utilise the information from that representational medium to complete a task in the referent space. However, Menzel et al. report that the chimps' performance under these conditions was similar to that when viewing the same scene normally, rather than on video. It could be argued that perhaps the video and the real life views were indistinguishable to the chimps, and that there was therefore no need for them to appreciate the representational nature of the video images. In contrast to Troseth and DeLoache, though, it seems that the performance of non-human primates is unaffected by the representational nature of the medium through which this information was conveyed.

Dow and Pick (1992) make additional suggestions as to the abilities of children to understand and to use a small-scale model, also based upon DeLoache's original research. They suggest that the difficulty which children appear to have in holding a dual representation of the model, may not be due only to its more salient three-dimensional nature. They point out that DeLoache told children that the model was "Little Snoopy's room", whereas the photograph was not introduced to children as being the possession of any agent. They suggest that if an object is presented as being the possession of some agent, then this contributes to its being viewed as a thing-in-itself. Their study therefore used a model which was presented as "Little Teddy's room" and a photograph which was also presented as "Little Teddy's room". In addition, they used a model which was not introduced as being the possession of any agent, and photographs which were not introduced as the possessions of any agent. Under these conditions, children performed better using photographs that were not possessions and thus served only a representational function, than they did with models, and photographs that were introduced as possessions. These latter items were therefore all presented as "things-in-themselves" as well as representations. For this reason, Dow and Pick suggest that the difficulties that young children in DeLoache's study appeared to experience because of their inability to hold a dual representation of the model, may have been exacerbated by the model also being referred to as "Little Snoopy's room".

Bremner & Andreasen (1998) investigated models and maps, and compared 4.5 and 5 year old children's abilities to use these two types of representations as aids to route following through a maze. On DeLoache's dual orientation hypothesis, one would expect that children would find a map easier to understand as a representation of space, than a model, since a map generally serves no other purpose than to represent a space, whilst a model may be more easily viewed as a "thing-in-itself" as well as a representation. However, the results of this study showed that children were actually more successful at using the model than the map, thus contrasting with DeLoache's hypothesis. It would appear that there is something of a contradiction in the research in this area. DeLoache's dual orientation hypothesis was based on the results of her early research. However in later work, Marzolf & DeLoache (1994) hypothesise that using a map might be more difficult for young children than a model due to the more abstract nature of maps. They explain that even if items on maps share attributes like colour with their referents, they will still be more abstract than items in a model. Whilst a blue chair might be represented on a map by a blue square, this is not as iconic as a small-scale model of that chair.

This hypothesis seems somewhat surprising given the dual orientation hypothesis, which states that representations are easier to understand if they do not also have a function as "things-in-themselves". A model is a three-dimensional object which can be manipulated and played with etc. Therefore it should be more difficult to view as a representation of something else. A map, however, has no purpose other than to represent. It should therefore be easier to understand as a representation.

Domain knowledge in DeLoache's model might comprise knowledge of the symbol itself, or of the symbol-type. Alternatively, it might comprise knowledge of the referent. Domain knowledge is also a significant contributor to analogical reasoning. This model suggests that knowledge will assist with mapping, by facilitating children's appreciation of the similarity between the referent and the symbol. However, DeLoache points out the distinct lack of empirical evidence which exists to support the supposition that knowledge will actually improve children's understanding and use of symbols. DeLoache (1995a) reports on one study in which children were brought to the referent room a total of nine times in the space of three weeks, and on each occasion they took part in a variety of activities within the room. When these children then participated in the scale-model retrieval task, there was no difference in their performance over children who had no prior experience in the referent space. And in fact, DeLoache (2000) reports that children who were allowed 5-10 minutes to play with a small-scale model prior to commencing testing actually performed more poorly than children who had no prior experience with the model. Therefore, it is not entirely transparent just what the role of domain knowledge is within the "model" – whether it facilitates or impedes performance – but DeLoache argues that it is nevertheless likely that this affects children's understanding and use of symbols in some way, and should therefore remain a component of the model.

DeLoache posits symbolisation experience as the main developmental aspect of the model, since it is concerned with the amount of experience which a child has had with different symbols and symbolic media. This component of the model interacts with Symbolic Sensitivity and therefore Representational Insight, in that the more experience a child has had with symbols in general, the more likely it is that the child will subsequently be able to appreciate a novel object as a symbol as well as an object in its own right.

Blades' theory

Blades (1991) discusses the influence of the Piagetian framework upon subsequent research in this domain, and emphasises the distinction made earlier between perceptual and conceptual thought, in Piaget's theories. Piaget's ideas about the development of spatial abilities centred upon conceptual abilities rather than perceptual ones, although he himself emphasises that perceptual abilities develop prior to conceptual ones in children. Blades notes that tasks involving representations of space are not all alike, but emphasises that many of them can be solved through perceptual spatial thought alone, without reliance upon conceptual thought. Thus, he makes the suggestion that children may well be able to understand and to use representations of space earlier than Piaget indicated, if the tasks employed rely upon perceptual spatial abilities.

Blades (1991) and Blades & Spencer (1987a) suggest that performance on tasks designed to assess children's understanding of spatial representations depends upon a developing understanding of progressively more complex relationships. The first stage in this progression is when a child understands that the spatial representation actually is a representation. The child must recognise that there is a relationship between the representation (map or model etc.) and the environment it represents. Blades too relates this to Gentner's (1983) theory of analogical reasoning, and refers to this as the recognition of correspondence. As in DeLoache's model, this correspondence may be recognised at the level of individual objects, for example, through an appreciation that a small chair in a model looks like a large chair in a referent room. Or, correspondence may be recognised at the level of relations, by noticing that the chair in a model is located between the door and the bookcase, and then noticing that these objects are in the same configuration within the referent room. Blades (1991) does not believe that an understanding of object correspondence only represents a full appreciation of a spatial representation, but that both object and relational correspondence must be present for a true understanding to exist. Blades carried out a study using DeLoache's standard model-room paradigm, but included identical locations as well as unique ones. So, for example, there were two green boxes in the model and the room rather than just one. This meant that for children to succeed they had to be able to differentiate between the two identical green boxes by means of distinguishing their spatial location. In DeLoache's task since all the locations were unique, a child could succeed merely by matching the green box in one space to the green box in the other space, without any need for appreciating the spatial relations between the two. Blades found that children could distinguish between unique locations at just three years, as had DeLoache. However, when the locations to be identified were not unique, four year old children still had difficulties with the task.

These finding are supported by those of Breuer and Marzolf (1999). Using the standard model-room paradigm, they implemented two different conditions. In one condition, both spaces contained five identical boxes, which meant that in order to succeed, children had to rely upon spatial correspondences only. In the second condition, the target locations were unique, but were arranged differently within each space. To succeed, children had to utilise the spatial information regarding location of the target, and ignore the object correspondences. Their results show that even four year old children can use spatial correspondences to solve the task when there is no other information available. However, when unique locations were used, the same children ignore the spatial information and rely upon object correspondence instead.

In contrast to this, Meyers (1999) presented three year old children with a model and a room containing five boxes, which were uniquely identified by a picture of a different cartoon character on each box. A toy was hidden in one of the boxes in the model, and children were asked to retrieve an analogous toy from the analogous box in the room. The analogous toy was either hidden in a box with the corresponding character in the same spatial location as the model (object and spatial condition), or in a box with the corresponding character, but a different spatial location (object only condition), or in a box with a different character but the correct spatial location (spatial location only condition). In this way, Meyers was able to test whether children would perform better when able to succeed using object correspondences only. Her results showed that in fact children only performed above chance in the "object and spatial" condition. Thus, this study suggests that young children's understanding of spatial representations is not limited to an appreciation of object correspondences, as Blades suggests.

It is here that the apparent disparity between DeLoache's and Blades' work arises. DeLoache has asserted that children as young as three years of age are capable of understanding and successfully using a small-scale model as a representation of a large-scale space. Blades, however, has argued that children in DeLoache's tasks can succeed merely through a reliance upon simple object correspondences, and that if the task requires appreciation of relational correspondence, these children cannot succeed. Since, for Blades, a true understanding of spatial representations requires both object and relational correspondence, DeLoache's conclusions seem exaggerated.

This complaint seems justified, since DeLoache's conclusions refer to understanding of spatial symbols in particular. However, it is important to bear in mind that she originally claimed that her concern was with assessing symbolic functioning at a general level. If DeLoache's work is viewed as an attempt to explore understanding of a model as a straightforward symbol of a room (or of elements within a room), and not an attempt to additionally assess spatial capacities, both researchers' work might be more easily married. Indeed, Tomasello, Striano and Rochat (1999) point out that DeLoache's model of representational understanding and use should really be considered in relation to less complex symbol-referent relations than small-scale models and rooms, because of the additional cognitive processes involved.

The second stage in Blades' progression requires the child to be able to select appropriate information from the representation and encode it in such a way that it can be used to complete a task. This second stage, then, may take a variety of forms, which he refers to as "strategies".

Blades agrees with Piaget's account of development, in that the strategies employed by children progress from a reliance upon simple topological relations, to a more complex appreciation of projective relations which does not emerge until after five years of age. Some tasks, however, require more complex strategies to be employed. For example, if a map is rotated by 180 degrees then the child will have to employ a strategy which compensates for its lack of alignment. One possibility might be to physically rotate the map until it is aligned. If this is not possible, then a conceptual spatial strategy must be employed. A child might be able to mentally rotate an image of the representation, for example. These conceptual abilities are the ones which are late developing in Piaget's view. However, often children may succeed through reliance on more perceptual spatial abilities. For example, they might identify the target location in terms of its spatial relationship to other features (e.g. next to the chair; between the table and the door), which are not affected by the lack of alignment between the representation and the environment.

Blades suggests that the final stage in the progression rests upon the child's ability to locate himself within a representation of the environment, although he accepts that self-location is not necessary for all tasks using spatial representations. However, for any task requiring way-finding, self-location is an essential prerequisite for success.

It is clear from this overview, that there are several theories about the development of understanding of spatial representations, and whilst there are similarities between them, nevertheless there are some differences. One point which has been raised recently, however, is that as well as there being different theories of development in this area, there are also a large variety of tasks and methods which have been adopted to assess these abilities, with little in the way of any systematic comparisons of them, in order to establish whether they are all assessing the same underlying abilities, and whether children would therefore perform similarly on all such tasks, using all such methods. The following chapter provides an overview of some of these different tasks, methods and experimental variations, in order to illustrate the diversity which exists in the literature, and to alert the reader to the potential differences which may emerge in researchers' conclusions about children's abilities, due to the use of alternative procedures, rather than due to differences in children's underlying competencies.

# CHAPTER TWO

## Assessing Children's Understanding of Spatial Representations: A Review

Whilst it may be generally accepted that children have the ability to understand spatial representations, still the issue remains of which particular tasks should be used in order to best assess that understanding. Many tasks are complicated and novel to young children and as a result may be loaded with cognitively very difficult requirements, making it hard to separate out the children's actual competence in this domain from their difficulties with a particular task.

### *Types of representations*

Perhaps the most common and widely used physical representations of space in everyday life are maps. However, there are other specific forms of representation, such as pictures, photographs, models, diagrams and television or computer-generated images. Yet it has been argued that in fact these are all just different types of maps, since what defines a map is, in fact, its function rather than its form.

For example, Downs (1985) explains that previous attempts to define maps have focused too strongly upon their form and their structure. He suggests that in defining a map it is more useful to be more concerned with its function, since this is what underpins its form and structure. According to Downs, the function of a map is "to render the experience of space comprehensible".

> *"The map is neither mirror nor miniature: it is a model of the world. The map is a representation, and thus a carefully controlled symbolic abstraction." (p 325)*

In this sense, then, a map should not be a precise replication of the real world, but a persuasive representation of it. Therefore, a map can take a variety of forms and structures, so long as it serves as a comprehensible symbol of some environment (see MacEachren, 1995, for a discussion of map definitions).

Vasiliev, Freundschuh, Mark, Theisen and McAvoy (1990) explore various previous definitions of maps, and by reviewing dictionaries, textbooks and journal articles for definitions, were able to amalgamate the most frequently used terms to give one synthesised general definition as " a representation of the earth's geographic surface". However, their subsequent research into how people generally classify maps, suggests that whilst a representation's similarity to a prototypical map, like a Mercator world map or a folding road map, adds to a representation's "map-ness", it is not necessary nor sufficient in itself. They therefore conclude that the definition of a map ought to be expanded "to include related objects, products and representations".

Blaut and Stea (1971) point out that traditional maps contain text and depend upon other symbolic conventions which require to be learned. Therefore, with younger children who do not have the necessary reading skills, or who have not yet had enough experience with maps to understand their conventions, other representations which perform the same functions as a map can be more usefully used.

Whilst different forms of representations might all serve the same function, nevertheless research does seem to indicate that different types of representations elicit different responses from young children. For example, DeLoache (1987) compared children's performance on analogous tasks using both a model and photographs as representations of a room. She found that whilst two and a half year old children were able to succeed on the task using photographs, it was not until three years that children could succeed using the model. Thus, the particular representational medium employed may affect the outcome of a study, in terms of children's performance.

### Maps

Maps have been used by many researchers in this field. Bluestein and Acredolo (1979) conducted one of the earliest studies using a map to represent an environment through which children could actually move, in order to test the children's ability to understand that map as a representation of the environment, and to use it to guide them through it. A collapsible room was used as the referent space, with four boxes positioned in the centre of each wall. A map of the room was positioned either on a table in the centre of the room or on a table just outside the room, and the map was either aligned with the room or rotated at 180° to the room. Three groups of children (of three, four and five years) were tested on a task in which a toy elephant was hidden somewhere in the room and its location indicated on the map. Children were asked to retrieve the toy from the room on the basis of information from the map. The results suggested that children of three years of age had problems even when the map was aligned and within the room itself. Children were not fully successful under these conditions until five years. When rotated, children of four years still had great difficulty in completing the task[1]. Maps are two-dimensional representations which contain only limited information relating to the most prominent features of a particular environment. This may make them easier or more difficult to understand.

DeLoache's (1987) dual orientation hypothesis would have us believe that the more obviously representational a representation is, the easier it should be for younger children to appreciate and understand. However, some later work by DeLoache suggests that maps may in fact be a more difficult type of representation to understand after all.

Marzolf & DeLoache (1994) hypothesise that using a map might actually be more difficult for young children than a model due to the more abstract nature of maps.

> *"Maps, on the other hand, are more abstract representations; even if items on a map share some physical attributes (e.g. color) with their referents, they are unlikely to be as perceptually faithful as the realistic pictures and models we have used in the past. For example, a blue square on a map is not iconic in relation to the chair it represents to the same degree that a picture of the chair is. Nor does the blue square share dimensionality and category membership with its referent, as does a miniature chair" (p9)*

[1] It should be noted that precise details of levels of performance are not always made available by authors, and therefore cannot be consistently included throughout this chapter. Where available, though, such details have been included.

These suggestions seem somewhat surprising given the dual orientation hypothesis, which states that representations should be easier to understand if they do not also have a function as "things-in-themselves". Since a model is a three-dimensional object which can be manipulated and played with, it should be more difficult to view as a representation of something else. A map, however, has no purpose other than to represent. It should therefore be easier to understand as a representation.

If maps are, in fact, a more difficult type of representation to understand than other, more iconic representational media, perhaps it is because the more perceptually similar the representation is to its referent, the less of a representation it actually is. Downs' (1985) comments regarding the nature of representations suggests that true representations should not be straightforward copies of their referents, but that they should be symbolic. If referent and representation are very similar, then any task requiring an understanding of them could be solved using simple matching abilities, without the need for higher-level representational skills.

This is further supported by the views of Mark Blades explored in Chapter One, regarding the development of understanding of spatial representations. He clearly believes that a task which can be solved using object correspondences alone, does not demonstrate a full understanding of such a representation. Therefore, if maps are a more difficult representational medium than pictures, for example, it may be because to be understood, maps require truer representational capacities. However, the somewhat contradictory views of DeLoache, coupled with the lack of comparative research into different representational media makes it difficult to judge whether maps should be easier or more difficult for young children to understand than others.

Models

In contrast to maps, models are three-dimensional, more iconic representations. In many domains, children perform better when using richer and more interesting stimuli, and some studies have even found non-human primates to have the ability to appreciate the representational relationship between a model and a room (e.g. Kuhlmeier, Boysen and Mukobi, 1999). Thus it might be expected that models would enable children to demonstrate more understanding than, for example, maps. However, referring again to DeLoache's dual orientation hypothesis, we can see that this rich and three-dimensional nature of models could be the very thing which prevents the child from appreciating their symbolic function.

For example, DeLoache (1987) found that children had more difficulty appreciating models than pictures, and has suggested that whilst children of just two and a half years can appreciate a picture as a representation of some referent environment, they cannot do the same with models until three years.

As mentioned in Chapter One, Piaget used tasks with models in which children were required to identify target locations. In this way he investigated their awareness and understanding of Euclidean space. He found that it was not until Substage 3a (6½ – 7 years) that children had a full appreciation of the models, and that rotation of one model no longer had an effect. In another task children viewed a model village and were then presented with a set of identical objects which they were to use to construct a replica of the original model. Not until seven or eight years of age were children able to copy the model perfectly, apart from precise measurements and reductions to scale. This indicates that understanding of models may be a later-developing skill, as suggested by

DeLoache. However, on DeLoache's account it would appear that Piaget had still grossly underestimated the age at which such understanding emerges.

Nevertheless, Piaget consistently used screens between the models in his studies, and rotated one model at 180° to the other one. In this way, Piaget made these tasks conceptual ones, rather than ones which could be completed by relying only on perceptual space. Therefore, perhaps DeLoache's tasks could be successfully completed through a reliance on perceptual space only, making the comparison between DeLoache and Piaget more difficult. This may be so, but a study by Blades and Cooke (1994) showed that four year old children were able to succeed on a DeLoache-style task using two models when the models were aligned, but also when they were rotated. Thus, even bearing in mind Piaget's use of rotation, it still seems that he has underestimated the abilities of children in this area.

Again, as mentioned previously, Blades (1991) has found that children are less successful on DeLoache's standard task if identical locations are used, necessitating a full understanding of spatial as well as object correspondences, which might indicate an overestimation on DeLoache's part. However, Blades' results continue to suggest an underestimation by Piaget, with children of around five or six years succeeding on these tasks.

One of the few studies to compare different representational media was carried out by Bremner & Andreasen (1998). They investigated models and maps, and compared four-and-a-half and five-year-old children's abilities to use these two types of representations as aids to route following through a maze. They constructed a large-scale "L-shaped" maze layout with barriers at four points through the maze, and toy animals to be collected. They initially used a map showing the L-shaped maze to help children negotiate the maze without making wrong turns. They found that children were less successful with the map after the turn in the maze, and suggest that this is because after the turn the map was no longer aligned with the maze. In their second study they used a linear map to represent the non-linear maze, and a linear model as well, to compare performance using these two different representational media. Performance using the linear map was found to be superior to the non-linear map, but interestingly, the children also performed better using the model than the map. In a third study, Bremner and Andreasen (1998) found that five year old children on an initial test trial, performed significantly better using a model than a map, which is consistent with the results of their previous study.

On DeLoache's (1987) dual orientation hypothesis, one would expect that children would find a map easier to understand as a representation of space than a model, since a map generally serves no other purpose than to represent a space, whilst a model may be more easily viewed as a "thing-in-itself" as well as a representation. However, the results of this study showed that children were actually more successful at using the model than the map, thereby contrasting with DeLoache's hypothesis. Thus, the contradictions in this area continue to emerge.

<u>Photographs</u>

Many studies have investigated photographs as a symbolic medium (e.g. Robinson, Nye and Thomas, 1994; see Beilin, 1999, for a review). However, few have assessed their understanding and use as spatial representations in particular. Photographs, DeLoache has argued, provide a less salient stimulus than models due to their two-dimensionality, and the fact that they serve no purpose other than to represent. In terms of exploring children's understanding of spatial representations, then, photographs provide what might be considered a "halfway" point between maps and models. They are rich in information, like a model, yet retain the two-dimensional, and thus obviously representational quality, of a map. Indeed, DeLoache has found that children of just two and a half years appreciate the symbolic nature of a photograph, and are able to use a photograph to locate a hidden object in a room. This cannot be accomplished using a model until three years (DeLoache, 1987; 1991; DeLoache and Burns, 1994).

As mentioned in Chapter One, Dow and Pick (1992) compared children's performance using models and photographs as spatial representations and found, like DeLoache, that photographs were more easily understood by young children. However, they point out that DeLoache told children that the model was "Little Snoopy's room", whereas the photograph was not introduced to children as belonging to anybody. They suggest that if an object is presented as belonging to someone, then this will contribute to its being viewed as a thing-in-itself. They therefore used a model which was presented to children as "Little Teddy's room" and a photograph which was also presented as "Little Teddy's room", as well as models and photographs which were not introduced as belonging to anyone. Children performed better using photographs that were not possessions, and which thus served only a representational function, than they did with models, and with photographs that were introduced as possessions. Thus, it seems difficult to judge whether photographs really are significantly easier to appreciate as spatial representations than models, or whether this difference has just exacerbated by the element of possession in research by DeLoache done prior to, and since, Dow and Pick's (1992) study.

Aerial Photographs

An increasing number of researchers have investigated children's understanding of aerial photographs as representations of space. In many ways, aerial photographs are similar to maps in that they are small-scale, and provide an overhead view of the referent environment. However, in contrast to maps, there are no conventional iconic symbols on aerial photographs. For example, on a map, a cross may be used to represent a church. In an aerial photograph, the church is simply represented by an overhead view of it. In this way, aerial photographs are similar to models, in that the items represented in them really do look like the things they represent, albeit from a different perspective to that which would usually be seen.

Blaut and Stea (1971) tested children just entering first grade (six years of age) on their ability to recognise what an aerial photograph of a landscape actually was, and to identify features on the photograph. Groups of first grade children were shown aerial photographs (scale 1:3000 or 1:2000) of their own home town, and were asked to name and to point to features which they recognised. Almost all of the children were able to do so, and in a follow-up study, children of one year younger were also highly successful.

Recently, Sowden, Stea, Blades, Spencer and Blaut (1996) investigated pre-school children's ability to interpret a black and white aerial photograph of a nearby town (scale 1:1300), to identify features on the photograph, and to solve a simulated navigation task between two points on the photograph. They argue that despite the lack of conventional symbols on aerial photographs, as there are on maps, there is still some abstraction from the referent because of the reduction in scale, and the translation from colour to black-and-white. They found that four year old children could successfully identify features on an aerial photograph of an unfamiliar environment, and could successfully draw a route on the photograph between two points.

This research suggests that young children understand what an aerial photograph actually is, at pre-school age. However, all of these studies use aerial photographs in isolation, without a corresponding referent space as has been the case in the map, model and photo research discussed previously. The tasks children are asked to carry out with the aerial photographs require them to reflect upon their understanding of the representation, and then to carry out a navigational task on that representation itself. There is no externalisation or application of that understanding to the referent environment. Thus, the difference in tasks used to assess understanding and use, once again presents difficulties in making useful comparisons between different representational media.

***Features of the representation/referent space***

<u>Scale</u>

Apart from just the different types of representations which have been used, there are similar differences with regards to the features of the environment being represented. In general, representations tend to be small-scale, whilst their referents are large-scale. Possibly the only exception to this would be molecular models, in which the representation may be millions of orders of magnitude larger than its referent. Some researchers maintain that in order for us to get a true picture of children's understanding of external spatial representations, we should use large-scale environments as the referent spaces. Spencer and Darvizeh (1981) argue that small-scale, laboratory-based studies in any area of environmental cognition, may significantly underestimate children's actual spatial abilities, as evidenced by their everyday competence on spatial tasks. Blades & Spencer (1986; 1987b) tested children's ability to use maps through a series of studies. Initially they used a room or a small playground layout as the referent environment, but then went on to advocate the exploration of map use when the referent environment was not perceivable in its entirety at one viewing.

> *"...in practice, maps are used when a route has to be planned through an environment which is not completely visible." (Blades and Spencer, 1986, p50)*

To achieve this, they designed a large-scale maze in a school playground, and placed 1.5 metre high screens at various positions in the maze, to limit children's views of it. The youngest group of children, who had a mean age of 3 years 11 months (3;11) performed no better than chance, but four other older groups of children (mean ages ranging from 4;6 to 6;2) performed significantly better than chance. This indicates that from four and a half years children can successfully use a map to navigate a realistic large-scale referent environment.

Acredolo (1976) conducted two studies in which children viewed a room and were subsequently blindfolded. They were then walked around the room to another location, where the blindfold was removed. The children were then asked to return to the original location at which they had been blindfolded, in order to assess their ability to maintain their orientation in a large-scale space. However, the room used in the second study, though still large-scale, was smaller than the room in the first study. Acredolo reports more egocentric responding among three year olds in the first study than the second study, which indicates that children can maintain their orientation better in a smaller sized space than a larger sized space, even though both spaces are large-scale. This further suggests that the size of an environment affects children's performance on spatial tasks.

Uttal (1994) asked pre-school children to memorise maps of objects' configurations, and then to reconstruct real objects in the correct configurations. He found that though children's reconstructions often preserved the spatial elements of the configurations on the maps, they often did not take account of the larger scale of the real objects' configurations.

This suggests that using small-scale referent spaces might aid children's performance on such tasks, and indeed, other researchers see no difficulty in using small scale referent spaces. For example, Piaget used two identical model villages to represent one another – no matter that both villages were of the same scale. Similarly Blades (1991) has used referent spaces which are identical in scale to the representations of them. Nevertheless, it may be argued that since representations that children are likely to come into contact with in the real world will almost certainly be of a smaller scale than that which they represent, that it is less valuable to assess children's understanding of representations using small scale referent environments.

However, it is not only the use of small-scale or identical scale spaces which may introduce difficulties. Indeed, Downs and Liben (1987) suggest that if referent spaces are too large, as in their tasks using cities, then this might introduce additional confusion into a task. Thus, perhaps reducing the scale of the referent space is a useful endeavour. Nevertheless, it has been argued that reducing the difference in scale between a representation and its referent space runs the risk of exiting the representational domain altogether. As discussed earlier in this chapter, a representation should, by definition, represent its referent, not replicate it. A replica is identical to something else, and thus there is no element of symbolisation – just identity. Nevertheless, several researchers continue to adopt tasks and methods which use spaces which appear to be verging on replicas rather than representations. For example, DeLoache et al. (1991) investigated young children's abilities on her standard model task, using a referent room which was only twice as large as the model which represented it. They found that performance increased when the size difference between the two spaces was lessened, so that two and a half year old children were performing at a level equivalent to that of older three year old children – attaining between 70 and 75% correct responses.

These findings are further supported by DeLoache, Peralta de Mendoza and Anderson (1999). A group of three year old children were tested using a referent room that was twice as large as the representation of it, but they were afforded minimal instructions to aid their appreciation of the relationship between model and room. The children achieved significantly higher success rates than a group in a previous study who had also had minimal instructions, but with a greater scale difference between model and room. DeLoache et al. (1999) use these results to argue that increased similarity between a representation and its referent improves performance. In fact, what these findings may suggest is not that increased similarity between referent and representation improves performance, but that reducing the need for symbolisation is what improves performance – and this in itself is not surprising. Indeed, this is a possibility which DeLoache (1995a) herself acknowledges. She makes the suggestion that when the two spaces are similar in scale, children may interpret the two rooms as "the same kind of spaces" – that is, that they do not regard one as a symbol or representation of the other.

Acredolo (1977) investigated the ability of three, four and five year old children to co-ordinate different perspectives of a large-scale or a small-scale space, in order to locate a hidden object. Three, four and five year old children were trained to find an object in a large or small-scale space, to their left or to their right. Their view of that space was then reversed by altering their position. When subsequently asked to find the object again, their choice of left or right indicated whether they had successfully co-ordinated the two views of the space. Results showed that children of three and four years were more capable of combining perspectives of a small-scale space, then they were of a large-scale space. Thus, despite alterations in their own viewpoints, these children were better able to maintain their own orientation when viewing a small-scale model than when viewing a large-size room. This may indicate that children's spatial development in terms of the progression from merely topological to projective concepts, is overestimated by research using only small-scale spaces, and that in order to gain insight into how children's understanding of real-world, large-scale spaces develops, such large-scale spaces ought to be used in preference to small-scale spaces.

Further support for the hypothesis that tasks using small-scale spaces may not elicit the same pattern of performance in children as those carried out in large-scale spaces is gained from a study by Siegel, Herman, Allen and Kirasic (1979).

In an experiment divided into four conditions, children were exposed to a spatial layout of buildings which they were then required to reconstruct. Two spaces were used – one small-scale and one large-scale. Children were exposed to either the large-scale or the small-scale space, and were then required to carry out the reconstruction in one of the two scales of space, thus creating four possible combinations of exposure and construction and therefore four experimental groups. Children of pre-school age (mean age5:9), second grade (mean age 7;6) and fifth grade (mean age 10;1) took part in the study.

Constructions improved in accuracy with age, but the findings also showed that children performed similarly when they were exposed to the same scale as they were required to construct. Thus, children in the Expose Large-Construct Large condition performed at a similar level to those in the Expose Small-Construct Small condition. However, if children were required to construct on a different scale to that which they had originally been exposed, they appeared to be better at construction in a small-scale space than in a large-scale space. These results, then, suggest that children will do better if referent and representation are of the same scale.

Uttal and Wellman (1989) carried out an experiment in which pre-school children learned a map of a large-scale spatial layout, and then had to negotiate their way through that layout on the basis of the information from the map. They found that four and five year olds had difficulties with this task. However, in a follow-up study using a small-scale referent space, children performed significantly better than they had using the large-scale space. They interpret these results in terms of the ability to co-ordinate perspectives, and suggest that a representation will be easier for children to understand and to use, if the referent environment can be perceived all at once.

In contrast to all of this, Liben and Yekel (1996) carried out a study to compare performance using the same space, when viewed either from a seated position on the ground, or from a raised position in an observation booth affording an overhead view of the area. Two groups of children took part in the study – one with a mean age of four years four months, and the other with a mean age of five years four months. They found that at both age groups, the children's ability to indicate the locations of objects in their classroom on a map was unaffected by whether the children viewed the classroom from a seated position or from the vantage point of a raised booth enabling a full view of the classroom. Thus, viewing the entire referent space from one perceptual position, in the same way that maps are viewed, did not improve the children's ability to appreciate the map and thus to complete the task more successfully. Liben and Yekel point out that this fits with the cartographic perspective, that maps by definition *ought* to afford a different perceptual experience of the referent space. We should not be concerned that the way in which an environment is experienced in itself, and the way it is experienced through a map, are different. Indeed, if they were not different then the map would cease to be a representation, and become a replica.

All of this once again adds to the difficulty in comparing studies when the referent environments used are sometimes large-scale, sometimes small-scale and sometimes the same scale as the representation.

Recently, some attention has been directed in the literature to spatial environments which are computer-generated, and with the increase in virtual reality technology, some researchers have attempted to explore spatial cognition through this medium. Initial research in this area has focused upon the question of whether it is really possible for people to learn about real-world environments through experience in virtual worlds. If so, then this will certainly provide a valuable tool for the future, since virtual environments can be large-scale and can be explored in the same way as real-world environments, but unlike the real world, virtual worlds can be controlled and manipulated by the experimenter much more closely for the purposes of investigations. Thus, virtual environments can recreate genuine, large-scale environments, but have the added advantage that they can be manipulated in the way that small-scale environments can.

Ruddle, Payne and Jones (in press) tested adults' knowledge of a building after exploration of a virtual simulation of that building, and found that performance was very similar to that which had been found in a previous study when people originally explored the environment itself (Thorndyke and Hayes-Roth, 1982). In addition, Wilson, Foreman and Tlauka (in press) have compared spatial knowledge of a real building following prior exploration of either the building itself or a virtual representation of the building. These studies, then, have compared learning in a virtual large-scale space, with learning in a real large-scale space, and the results indicate similarities in subsequent performance between both types of prior experience.

All of this suggests that human experience within a virtual reality environment is similar to that in the real world environment. Thus far, though, there is no research explicitly addressing whether young children appreciate these environments in the same way as they do real-world ones. However, some research has been carried out with disabled children, to assess whether their spatial knowledge of a real-world environment can be enhanced through exploration of a simulated version of that environment. Physically disabled children often do not develop as good internal representations of space as their able-bodied counterparts, and it may be that this is due to their lack of ability to independently navigate their environment. Stanton, Wilson and Foreman (1996) found that disabled children who had the opportunity to explore a virtual environment and who were then tested on their knowledge of certain locations in the real environment, were significantly better than a group of able-bodied controls who had not had the extended virtual reality exploration. This gives some indication that virtual environments may provide children with a similar experience to a genuine environment. Therefore, future research might usefully utilise this technology to generate large-scale virtual referent spaces, which can then be used in assessments of children's ability to understand representations of those spaces.

Physical similarity

Apart from similarity of scale, in exploring children's understanding and use of spatial representations, researchers have often strived to make the representation as similar as possible to the referent. For example, Blades (1991) used two models as representations of one another, which were not only the same size, but which also contained identical features. That is, all of the items of furniture in the two models were absolutely identical. Children watched as a toy was hidden at a particular location in one model, and then were asked to retrieve an analogous toy from the equivalent location in the second model. Overall, children in this study performed very well, with three and four year olds scoring about nine or ten out of a possible twelve, respectively.

DeLoache, Kolstad and Anderson (1991) used a large-scale room and small-scale models, but increased the physical similarity of objects within the two spaces, and of the surrounding walls of the two spaces. Object similarity was achieved by making the surface appearance of the objects in the model very similar to those in the room. In another model, however, the objects' surface appearance was quite different to those in the room. Surround similarity was achieved by making the walls of the model from the same materials as the room, but in another model, the walls were simply made of cardboard. With higher levels of both types of similarity, children performed significantly better on the standard retrieval task, than when the rooms were not similar, although the object similarity was found to be more important than the surround similarity.

These studies suggest that when the internal features of a representation are highly perceptually similar to those of the referent, children will be able to understand and to use that representation more successfully. However, given Downs' suggestions, it seems once again as though we ought to consider whether these kinds of practices really provide us with a true indication of children's understanding of spatial representations, since the very nature of a representation entails symbolisation rather than duplication. The more similar a representation is to its referent, the less representational it is. In relation to physical similarity, then, it once again appears unclear whether the same underlying processes are being tapped using different levels of similarity, which serves to illustrate once more the difficulties of separating children's abilities from the cognitive load of the experimental design.

Familiarity

Another area of difficulty is encountered regarding the level of knowledge that a child has of the referent environment. DeLoache's (1995a) model of symbol understanding and use, as discussed in Chapter One, suggests that familiarity has a role to play, but does not state whether it should help or hinder such abilities. It has been suggested that environments with which children are already familiar will allow a better assessment of their understanding of a representation of that environment, since their performance will not be confounded with a poorly established internal representation of the environment. Downs and Liben (1987) suggest that difficulties encountered by children in their tasks using aerial photographs and maps might be due to the children's own ignorance of the places being represented. The simple matter of forgetting exactly where a particular item is might be less likely to occur with a familiar environment than it would with a novel environment, and thus children's classrooms have been used in some studies, as familiar referent spaces. Liben and Yekel (1996) conducted one such study using plan and oblique maps of a group of three and four year old children's own classroom. The children in this study had to indicate the location of a target object in the classroom on a map, and generally performed poorly across a number of conditions, achieving a maximum mean score of just 52%.

Other studies, though, have preferred to use novel environments. This may also have advantages, in that the level of children's prior knowledge can be controlled for when no child in a study has encountered an environment before. Therefore, we can be sure that we are in fact assessing their understanding of the representation with which they are being presented, rather than assessing the child's long-term "cognitive map" of an environment. For example, Siegel and Schadler (1977) suggest that since it is within spaces which children encounter and interact with regularly that they actually develop and use their spatial knowledge, it is within such spaces that such knowledge should be investigated. They suggest that internal spatial representations of familiar spaces will be better than those of unfamiliar spaces, and their study investigated whether young children's spatial representations of their classroom do, in fact, improve over time and with increased experience within that space. Children were asked to construct a model of their pre-school classroom. One group of children (mean age 5;8) were tested in the Spring after approximately eight months experience in the classroom. A second group (mean age 5;2) were tested in Autumn following only one to two months experience. The results of this study indicated that children's ability to reconstruct an accurate model of their classroom did indeed improve with greater experience in the referent space. A comparison of the results from the younger children in the Spring group with those of the older children from the Autumn group indicates that this difference is not attributable to age. Thus they conclude that familiarity enhances internal spatial representations in children, leading to better understanding of external representations.

These results were supported by Herman and Siegel (1978) who investigated how children's spatial knowledge of large-scale space develops. Children were repeatedly exposed to a large-scale model town and were then asked to construct that town again themselves by replacing buildings in the correct spatial layout. Results showed that children at kindergarten age (mean age 5;7), grade two (mean age 7;7) and grade five (mean age 10;7), all improved the accuracy of their reconstructions after repeated experience in the model town.

This supports Siegel and Schadler's (1977) findings that children's cognitive maps of the environment improve as they become more familiar with that environment.

These studies, then, suggest that the amount of experience children have in an environment will improve their cognitive maps of that environment. However, Herman (1980) took this one step further and investigated the effect of different types of experience in the development of children's cognitive maps, rather than just the amount of experience alone. A large model town was constructed, which the children then encountered in one of three different ways. Under one condition they walked around the town and the different buildings were pointed out to them by the experimenter. Alternatively, they walked through the town itself and the experimenter pointed out the different buildings. Or under a third condition children again walked through the town and the buildings were pointed out to them, but the spatial relationships between each building and others were also pointed out. The child's cognitive map of the town was then assessed by asking the child to reconstruct the town. The results of this study showed that walking through the town facilitated more accurate construction than walking around the town. Having the spatial relationships of a building pointed out also facilitated more accurate (though not significantly so) constructions.

This supports the view that motor activity within an environment improves children's spatial knowledge of that environment. This study also found that performance improved over successive encounters with, and constructions of the town. The author concludes that this provides support for Herman and Siegel's (1978) finding that familiarity with a referent space improves children's spatial knowledge of that space, and thus improves their understanding of external representations of that space.

In contrast, DeLoache (1995a) reports a study in which children were brought to play in a referent room on nine occasions over a period of three weeks, prior to those children taking part in her standard model retrieval task. These children subsequently performed no better than a control group who had no prior experience of the room. This suggests that familiarity with a referent space does not improve children's understanding and use of representations of that space.

In addition, DeLoache (1993) conducted an experiment to assess the effect of familiarity with the representation itself, rather than with the referent space. In this study, prior to completing her standard model-room task, children were allowed to play with the model for five to ten minutes. She found that performance on the standard task was subsequently poorer in the group with increased familiarity, and explains this with reference to her dual orientation hypothesis. She says that because children were familiar with the model, it became more salient as an object in itself, and the representational nature of the model therefore became more difficult for children to appreciate.

Therefore, it is clear that familiarity, with referent or with representation is another factor which requires to be taken into consideration in this research area, as differing levels of familiarity may involve different underlying processes and thus lead to different levels of performance in young children.

Reality/complexity

Apart from familiarity, there is another aspect of the referent space which has differed between studies, and that is whether the environment is a genuine one, or one contrived for the purposes of experimentation only. Examples of contrived spaces can be seen in several authors' work. DeLoache et al. (1993), for example, describe a collapsible room used in some of her experiments. This room was constructed from hollow tent-like poles, which were then covered using translucent cloth to form the walls of this room. This type of contrived room has its obvious benefits from the experimenter's point of view in that it may be taken from school to school, and set up each time, thus providing the same environment for many children. Another advantage of this very contrived space is that the contents of the space and the contents of the representation can very easily be matched precisely. Spencer and Darvizeh (1981) acknowledge the convenience of using contrived, laboratory-based spaces for research, and concede that many experimenters cannot afford the time investment required to conduct studies in real world environments. However, they suggest that researchers bear in mind that behaviour in contrived spaces may not be generalisable to real world behaviour. Rather than abandoning real world studies in favour of laboratory ones, they propose that observations of real world behaviour be used to generate hypotheses which can then be tested using contrived experiments in the everyday environment.

Authors who have used naturalistic spaces for various reasons, are faced with the inevitable problem that the real world and spaces in it are invariably, and by their very definition, far more complex, fuller, and richer than any representation. In studies using natural classroom environments, whilst researchers may well be able to recreate the main features of the classroom in a model, for example, they will find it very difficult to represent everything present in the classroom. Most studies of this type feature only furniture items in the representation (e.g. Liben & Yekel, 1996). Boxes of crayons and pencils, assorted toys and games strewn on the floor, the children's coats and bags on the backs of their chairs, the papers, pencils and other items which will lay on the children's desks, are all very problematic to recreate. Not only this, but these types of objects vary in their presence or absence in the classroom from hour to hour and from day to day. Thus creating and maintaining a fully accurate model, photograph or map would be no mean feat. In addition to all of this, even if a genuine room could be represented accurately for an experiment at one school, that room could not be transferred to the next school, and thus at each stage a new and equally complex representation of the environment would need to be created.

Having said all of this, it could equally be argued that using a natural environment is still a preferable method of assessing children's understanding of spatial representations. This might be because in real life, the representations children actually encounter will be of genuine, and not contrived, environments. Thus although a representation is not a faithful reconstruction of every element in the environment, nevertheless it serves to represent the main features of the environment, and this is all that a genuine representation does. A map of a city indicates the main streets, buildings and areas of parkland. It does not indicate every car present on the road, or the location of every litter bin on the streets. And neither should it, for as a representation this is not something required or expected of it.

Thus it could be argued that to use contrived environments in research of this kind, and representations which indicate every single entity in that environment, is simply not ecologically valid. Nevertheless, for experimental purposes, this is often the only really viable option.

From the preceding discussion, it can be seen that there are advantages and disadvantages to all of these different possible features of both the representation used in a particular study, and the environment chosen to be represented. Whilst it would not be possible to vary all of these in every study, nevertheless it seems important that researchers are aware that these differences exist and do not simply assume that all of these variations will elicit similar types of performance.

***Tasks***

Hide-and-seek

Another interesting question is what particular task should be used to best assess children's understanding of a spatial representation. Again, past research has employed a wealth of different experimental methods. One method popularised by DeLoache, is the hide-and-seek type of retrieval task, as outlined in Chapter One. In these tasks a target object is hidden at a particular location in a genuine environment. Children are then shown on the representation where the object is hidden, and are asked to retrieve the hidden object from the analogous location in the real world. This task can also be done vice-versa, with the object being hidden first in the representation, and the location being indicated in the real environment. This task is particularly relevant to research using models, as it can be done in both directions as indicated. Using maps or pictures, it is difficult, if not impossible, to conceal a hidden object in the representation. Thus retrieval can only be done from the real world environment.

Positioning

An alternative task to this one is a simpler positioning task, as employed by Piaget. In this case, the experimenter places a target object at a particular location in either representation or referent space, and subsequently asks the child to simply position an analogous object at the analogous location in the other space. Piaget's results suggested that children were unable to do this until seven or eight years of age.

Liben and Downs (1993) asked children to place a sticker on a map to indicate that they were able to appreciate the location of another person in the environment. Children from kindergarten age (mean age 5;9) to sixth grade (mean age 11;5) took part in the study. An experimenter moved to certain locations in the children's classroom, and the children were asked to place a coloured sticker on a map of the classroom, to indicate where the experimenter was located. The map was either aligned with the room, or rotated by 180°. Across all conditions, children performed quite poorly until about six years of age (72 months), when they were scoring a mean of around five out of six correct placements. Liben and Yekel's (1996) study required children to find a target object in their classroom by visual search, but then to indicate that object's location by positioning a sticker in the appropriate place on a map of the classroom.

These results appear comparable with those obtained using other tasks, and the underlying assumption seems to be that positioning is equivalent in its demands to the retrieval-style task. However, DeLoache (1989) carried out a series of placing trials with children in which the experimenter placed a toy at a particular location in one space (model or room), and asked the child to place the analogous toy into the corresponding position in the other space. These trials were carried out as part of an extensive orientation phase, prior to the commencement of the test phase. DeLoache initially comments that these trials were to serve as practice trials, to assist in making the correspondence between model and room explicit. Thus, it would appear that she is assuming that this task will be an easier one for children to complete than the hide-and-seek test trial.

However, she later uses performance on these practice trials as an independent measure, and compares the test trial performance of children who were successful on practice trials with the test performance of those who failed the practice trials. The results indicate that initial practice performance is a good indicator of later test performance, in that those succeeding on the practice trials did well on the test trials, and those failing the practice trials were also unsuccessful on test trials. She goes on to point out that in a previous study (DeLoache, Kolstad and Anderson, 1987), the extent of orientation prior to testing was varied in order to investigate the effect upon test performance. When orientation was reduced to just one single positioning trial there was no detrimental effect upon test performance. This suggests that rather than serving as a simpler practice task, the positioning task ought to be regarded as equivalent to the retrieval task, since if children have the necessary skills and abilities to succeed on one, then they should also succeed on the other. Without such skills, they will be unsuccessful on both types of task.

Nevertheless, Blades and Cooke (1994) used placing tasks similar to DeLoache's, in a study using two identical models as representations of one another. Again, these were used as part of an orientation phase prior to testing, in order to facilitate appreciation of the relationship between the models. A miniature dog was placed on a particular item of furniture in one model, and the children were asked to place a second toy dog at the analogous location in the second model. Results for these practice trials were not reported, which suggests that performance on this task was not of interest in itself. This indicates that positioning was viewed as a more straightforward task, and one which does not rely upon the same underlying abilities as the hide-and-seek task.

It is clear, then, that there is some ambiguity about whether positioning is a task which can be used usefully to assess understanding of spatial representations in children, or whether it is somehow a different type of task altogether, which is useful only as an orientation tool. It is not entirely clear from Blades and Cooke's (1994) account, precisely why positioning should be any easier. Certainly the results of DeLoache (1989) suggest the two may be equivalent, and other authors have adopted this task as a means of assessment without discussion.

Wayfinding

Yet another task has been wayfinding, where children are asked to negotiate their way around an environment, often a maze, using a representation to guide them. Blades & Spencer (1986) carried out a series of different tasks using maps and models. They investigated performance on hide-and-seek tasks, as well as self-location and wayfinding tasks. In one experiment, a series of buckets were laid out in different positions in a school playground. Children were given a map which showed the buckets' locations and a route drawn between them. Children were asked to carry the map, and to walk through the playground following the route marked on the map. They concluded that at just three years, children can identify locations through the former two types of task, but that it is not until four and a half years that they can successfully use a map to negotiate a route.

However, in this study the referent playground environment was completely visible to the children at all times, and as has been mentioned previously, it may be the case that having a map of a referent environment which can be viewed from one perspective, is atypical of the way in which maps are traditionally used. Thus, a further experiment was carried out to investigate whether children would still be successful when the referent space could not be viewed all at once. A large-scale maze was constructed, and children given a map of the maze, which they had to follow in order to successfully negotiate a route through the maze. As with the playground experiment, children of about four and a half years of age were able to negotiate this maze using a map.

Uttal and Wellman (1989) investigated the ability of four and five year old children to negotiate their way through a large-scale space after memorising the information from a map of that space. The space to be navigated was a large playhouse consisting of six adjoining rooms. They report that using the map, children's performance was "far from perfect", but a follow-up study using six and seven year olds indicated that these older children's performance was almost at ceiling level. These results seem to suggest that Blades and Spencer's (1986) study may have overestimated the abilities of children in this domain. However, a critical difference between this study and Blades' one is that in Uttal and Wellman's study, the map was viewed outside of the referent space, and had to be memorised before completion of the task. In Blades' study, as in many others, the children had continuous access to the representation itself whilst carrying out the task in the referent space. This would fit with Piaget's distinction between conceptual and perceptual thought in development, since the requirement to hold information from a map mentally requires conceptual spatial abilities, whereas if the necessary information is available perceptually, this is not necessary. Uttal and Wellman's (1989) third study compared the performance of children who learned the map outside of the referent space with a group learning it within the referent space itself, but found no difference between these groups. This makes sense, since despite learning the map within the referent room, children were still required to conceptualise the relevant information in order to solve the task. The map was not available for consultation during the testing period.

Construction

One other type of task, again popular when using models, has been to ask the child to construct or re-construct a model environment, on the basis of the real one. This task was adopted by Piaget, as mentioned previously. This type of task has been done in classroom studies, when children have been asked to place small replica items of furniture into a model in the same position as they are to be found in their own classroom. For example, Siegel and Schadler (1977) asked pre-school children to construct a small-scale model of their kindergarten playroom, and assessed differences in construction accuracy for differing levels of familiarity with the referent space. They found that these children, aged around five years, were somewhat successful at this task. However, they were better at locating items in the model in relation to other items, than they were at locating objects in their correct absolute positions. Thus, children tended to cluster items together in the model, which were located proximally within the referent space. Siegel, Herman, Allen and Kirasic (1979) utilised the same task paradigm with pre-school, second grade (7½ year old) and fifth grade (10½ year old) children. In this study, the youngest children scored a mean of only 28% correct placements, which improved to 67% correct in the oldest children.

Hart (1981) asked pre-school children to create a model of their local area, including their own house and their school. He provided children with elements of the model to represent features of the local environment such as houses, and also provided clay and crayons with which the children could supplement their model. He found that children's models exhibited the highest levels of spatial organisation in the area immediately around their own home, and even the youngest children were able to model elements in relation to other fixed landmarks or routes. Outside of the home cluster, however, children's models appeared to represent a series of unconnected journeys, each of which began with the home itself. This was seen in children right up until the age of about seven years.

However, the construction-type task has also been done in the large-scale, when children, with the aid of the experimenter, have actually repositioned some genuine items of furniture in the classroom after the experimenter has previously removed them from their usual locations. Liben, Moore and Golbeck (1982) asked pre-school children and adults to reconstruct a model of a familiar classroom environment. They also asked them to replace the full-scale items in the correct location within the classroom itself. All furniture from the classroom that was not fixed, was moved into the hallway outside the class. Black cardboard forms in the shape and the scale of the missing furniture items were given to the child, and the relationship between the form and the furniture item itself was pointed out. The child was then asked to place the form for each item of furniture in the correct location within the classroom itself. Children performed significantly better when reconstructing the actual classroom layout itself than when reconstructing the model, which led the authors to suggest that children's underlying internal representations of space may be underestimated by research which assesses this knowledge using model construction tasks. However, as has already been discussed, tasks using external representations like models require more than just spatial skills, they also require representational appreciation. It could be argued that reconstructing the classroom itself, rather than a model of that classroom, may not require the same level of representational appreciation. Thus, it is unsurprising that children did better if less representational understanding was required. This underlines the importance of researchers having an explicit appreciation of the underlying abilities which their tasks tap. In this instance, Liben et al. (1982) made direct comparisons between two tasks which in actual fact may rely upon somewhat different competencies.

Uttal (1994) asked pre-school children and adults to memorise a map of a particular configuration of objects, then reconstruct the real objects from memory, in the correct configuration. Their results showed that children's reconstructions preserved spatial characteristics of the configurations depicted on the maps, but that the change from information in a map to real objects led to errors of scale translation, which were not evident in the adult group. However, children's reconstructions were still less accurate than adults', even after adjustment for scale translation.

One final study, carried out by Golbeck, Rand and Soundy (1986) again asked children to reconstruct a small-scale model of their familiar classroom environment. Kindergarten children (mean age 4;6) took part in the study. The results showed that children's performance was improved by adult guidance in the form of continued reminders to observe the location of objects in the referent space, prior to placing the analogous objects in the model. They also assessed children's underlying cognitive restructuring abilities, using the Embedded Figures Test (Coates, 1972). This was intended as an assessment of underlying spatial competencies, and the results showed that children who scored highly on this test also scored more highly on the model reconstruction task. In a follow-up study, however, children were tested in either a "clustered" or a "non-clustered" condition. In the clustered condition, the experimenter explicitly directed children's attention to different functionally organised areas of the classroom within which each item was located in the referent space, prior to the children placing the analogous item in the model. In the non-clustered condition, attention was not guided in this way. The results of this study showed that children performed significantly better in the clustered condition, and the authors suggest that children can capitalise on existing spatial knowledge if they utilise categorical and organisational information about items in the referent space. Interestingly in this second study, performance was unaffected by the children's level of underlying cognitive restructuring abilities. Golbeck et al. (1986) suggest that this is due to the referent space in the second study containing more bounded locations than the space in study one. Thus, in study one, children could not utilise boundary and landmark cues to assist with the task, which meant that underlying abilities were primarily responsible for performance. In the second study, the classroom contained more distinctly defined areas, which assisted in completing the task, and meant that underlying spatial competencies had less of an effect. These findings once again serve to illustrate the point that the demands of the particular task employed, as well as aspects of the representation or the referent space can significantly affect performance. This underlines the difficulty in comparing different studies which purport to be measuring the same competencies, even when the studies are reported by the same authors within the same paper, since small differences in procedure can lead to large variations in performance.

### Self-location

Liben & Downs (1993) point out that being able to identify one's own position in a referent space, rather than just the position of something or someone else, is a crucial first step in being able to successfully use a representation for wayfinding and navigation. Large numbers of the studies in this field require children to observe a representation outside of the space itself, which means that the child does not actually have a location in the referent space. But once the child enters the referent space, they must still be able to relate their own position to those of the other features of the environment, if they are to successfully apply the information gained from the representation. Therefore, in most studies, the ability to locate oneself would appear to be assumed, though never explicitly tested.

Nevertheless, some studies have used self-location as a task for assessing the ability to understand and to use a representation of space. Blades and Spencer (1986) carried out a task in which children stood in a room and then viewed a model of that room. They were asked to place a doll in the model to indicate their own position in the room. Sixteen out of a total of twenty children, aged between three and four years were able to successfully complete this task. Blades (1991) drew a chalk grid in a school playground, and showed children a map of the grid. Each child stood in a square on the grid, and then used a doll to indicate their position on the map. Four-year-old children scored a mean of just 4.6 out of 10 correct when the map and grid were aligned, and this score rose to 8.3 at seven years of age.

Blades believes that the ability to identify one's own position on a map is a somewhat separate ability to that of extracting information from a map and applying it to a task in the environment. In explanation, he says that it may be possible to relate the position of a location in space to its position on a map, without any appreciation of one's own position on the map. This may be so, but this latter task, of inferring from referent space to representation, is actually a different task to the former one he mentioned, of inferring from map to referent space, as is further explored in the following section.

***Manipulate the space or the representation?***

In some of the studies which have been described previously, children are simply required to reflect upon a representation, or upon the differences between different representational media used. This has been referred to in the literature as a "meta-representational method" (e.g. Liben, 1997). For example, Sowden et al. (1996) showed children an aerial photograph then asked the children to identify what the photograph was, and to identify specific features of the photograph. Children were then asked to negotiate a route between two points on the photograph itself. In tasks like this, there is no direct involvement with the referent space. Whilst the referent space exists in reality, the child is not required to make any links between representation and referent. They are not required to interact with the real world environment in any way.

However, the majority of studies discussed regarding the ability of children to understand spatial representations, involve some referent space as well as the representation of that space. Regardless of whether the referent space is large- or small-scale, contrived or natural, familiar or unfamiliar, and regardless of whether the representation is a model, a map or a photograph, and regardless of whether the particular task is retrieval, positioning or construction of some sort, children are required to make some inference from one to the other. However, another aspect of experimental design which has varied between studies concerns whether the particular task which the child is asked to complete requires a manipulation of the referent space itself, or a manipulation of the representation.

Blades and Spencer (1987a) tested the abilities of four to eight year old children to use a map in order to locate a particular path through a large-scale layout. In this case, the children were using information from the representation to complete a task in the referent space. In contrast, Liben and Yekel (1996) asked four and five year old children to place stickers on a map of their classroom, to signify the location of certain objects in the real classroom itself. In this way, children were using information from the referent space in order to complete a task on the representation.

DeLoache's (1987) study involved a retrieval task using a model and a room, and children were required either to retrieve from the referent room on the basis of where an object had been hidden in the model, or to retrieve from the model on the basis of where an object had been hidden in the room. In this study, children were being required to operate in both "directions" – from referent space to representation, and from representation to referent space. DeLoache found that there was no difference between the performance of children when retrieving from the model as opposed to retrieving from the room. DeLoache (1995a) explains that in most of her earlier work, retrieval was counter-balanced between subjects from the model or from the room. She explains that results did not differ between these two conditions, and as a result subsequent studies omitted this counterbalancing procedure. However, there is a distinct shortage of research which varies these two methods systematically, and it is not necessarily the case that the underlying processes involved are equivalent.

Blades and Spencer (1994) assert that "using" a representation requires selecting information from the representation and applying that information to solve a problem in the referent space. It is interesting to note, however, that this contrasts with later assertions by the same authors (Sowden et al., 1996). In this study, meta-representational methods were employed by asking children to negotiate a route between two points on an aerial photograph. The authors conclude from children's success on this task that *"Children entering school have an ability, untaught, to read aerial photographs, to understand and use simple iconic maps of large environments." (p110).* But since the children in this study were never required to apply the information gained from the photos to the referent space itself, this does not fit with their own prior definition of "use". DeLoache (1995a) posits a model of symbol understanding and use, as outlined in Chapter One, and in this model appropriate use comprises retrieval of the previously hidden object, irrespective of whether that retrieval is from the room on the basis of information from the model, or from the model on the basis of information from the room.

If it is the case that map use requires an application of knowledge from a representation to the referent environment, then a task like that adopted by Liben and Yekel (1996) would not, according to Blades and Spencer (1994), constitute map use, but instead should be viewed as the externalisation of environmental knowledge. A task requiring a child to draw a sketch map of an area, or to construct a model of a given space, would not provide an assessment of their ability to understand and use that representation, but an assessment of their requisite knowledge of the referent environment. This point of view presents some difficulty in the light of studies which have asked children to manipulate a representation in some way with the referent space in full view.

For example, in Liben, Moore and Golbeck's (1982) study, pre-school children were asked to reconstruct a model of their classroom outside of the classroom in one condition, but within the classroom itself under another condition. Whilst children did better with the classroom in view, the difference between these two conditions was not dramatic, and even with the classroom in view, performance overall was far from good. In two further studies, Golbeck, Rand and Soundy (1986) again asked children to construct a small-scale model of their classroom, with the classroom in full view. Their results showed that even the most successful groups of children only got a mean proportion correct of 0.51 and 0.59 – thus scoring only just over half correct. This suggests, then, that the ability to manipulate a representation on the basis of information from a referent space must be tapping more than just the child's requisite knowledge of the referent space, because even with that space constantly in view, children still have difficulties in manipulating a representation.

Liben (1997) suggests that manipulating a representation on the basis of a referent space, and the converse of that – manipulating a referent space on the basis of a representation – both provide useful ways of assessing children's ability to understand and use representations. However, she suggests that the two methods may be tapping slightly different aspects of those abilities. In fact, Liben suggests that these two methods may represent the difference between "Comprehension" and "Production" skills in this domain. She suggests that methods in which children first view a representation and then manipulate the referent space might represent "comprehension" methods, since children first view the representation and are then required to demonstrate their comprehension of it through completion of some task or other. Methods which require children to view the real referent space and then manipulate the representation, however, she labels "production" methods. This is because she feels that these methods require children to generate, manipulate or create a representation. Thus it is not enough for the child merely to <u>comprehend</u> the representation – they must translate some aspect of their experience in the referent space <u>to</u> the representation as well.

In other areas of development, comprehension skills emerge prior to production skills. This is true in language learning, for example. For this reason, Liben believes that we have good reason to expect that transferring knowledge from the representation to the referent might be easier than going from the referent to the representation. However, she acknowledges that the lack of research which systematically compares these two methods makes it difficult to judge whether the processes underlying them are similar or different. Nevertheless, one study by Siegel, Herman, Allen and Kirasic (1979) may provide some support for the view that they are different.

In this study kindergarten (mean age 5:9), second grade ( mean 7;6) and fifth grade (mean 10;8) children viewed either a large-scale or a small-scale space. They then had to reconstruct the model from memory, on either a large or a small scale. Children who viewed a small-scale space and were then required to construct on a large-scale performed most poorly overall. Those children who first viewed a large-scale space and then constructed on a small-scale performed better than this first group, and no worse than those who viewed and constructed on the same scale. Since viewing a representation and then manipulating a referent would typically involve translating knowledge from a small to a large scale, the "view small – construct large" condition can usefully be thought of as a Comprehension task in Liben's terms. And therefore the "view large – construct small" condition would correspond to Liben's Production method. Thus, these results can be seen to provide some tentative evidence that performance may not be comparable using these methods.

However, the findings contrast with Liben's (1997) notion of the Comprehension task being easier than Production, since Siegel et al.'s results indicate, if anything, that Production appears easier than Comprehension. Nevertheless, there is another important point which should be borne in mind from a cartographic perspective. That is, that maps and models etc., by their very nature, represent the real world. Thus, we alter our representations in keeping with the way the world really is. This is what is happening when the child is asked to carry out these tasks in the model. They have observed some manipulation of the real world, and are therefore required to alter the representation so that it continues to be an accurate representation of it. Conversely, however, we do not typically alter the real world to converge with some alteration to a representation. In other words, if a map is changed in some way, we would not change the world simply to ensure that the map remains correct. It might, therefore, be counter-intuitive, and thus more difficult, for a child to manipulate a referent space simply because of some manipulation of a representation of that space, which may explain Siegel et al.'s (1979) results.

Thus, as with the many different tasks available, these two methods appear to have been treated as if they were interchangeable – that is, that they both assess the same underlying abilities. Some suggestions have been made that this might not be the case, yet there is a lack of research addressing this question explicitly, and that which there is seems to provide conflicting indications as to just how they might differ.

### *Summary*

From the preceding review, then, it should be clear that several different tasks and methods have been used in researching children's understanding and use of spatial representations, and from this exploration of them it should be clear to the reader that selecting an appropriate one is not at all easy. There appear to be potential advantages and disadvantages to all of them, yet still no systematic comparison has been made in order to establish whether there is one particular method or task which best enables children to demonstrate their ability to understand and to use an external spatial representation of a referent environment. Therefore, the overall aim of this thesis is to provide a starting point for an investigation of just some of the tasks and methods which have been used in the past, as well as investigating the effect of just some of the other factors which may contribute to children's performance on tasks which assess their understanding and use of external representations of space.

The particular representational medium which this project will employ is a small-scale model. This medium has been chosen for several reasons. Firstly, the initial study aims to replicate the pioneering work reported by DeLoache (1987), and that paper explored understanding of spatial representations through the use of a small-scale model. Secondly, the work reported in this thesis developed from undergraduate research in which a small-scale model was also used as the representational medium. In addition, the aim of the present investigation is to maximise children's potential for success in understanding a spatial representation, so that the effects of other variables can be assessed without performance being confounded with the use of a difficult representation. DeLoache's (1987; 1995b) work has suggested that children can understand and use small-scale models from just three years of age, whilst Bluestein and Acredolo's (1979) work indicates that understanding of maps may not emerge until around five years of age. It is also hoped that a three-dimensional model will prove to be a more salient, stimulating and interesting representation for young children than other, two-dimensional representational types like maps or pictures. Finally, as will be seen in later chapters of this thesis, a model lends itself more readily to the manipulation of variables which are explored in the experiments reported here. For example, hiding games are only really possible when using a three-dimensional representation. Also, the inclusion or removal in a representation, of aspects of the referent space such as soft furnishings, is more readily achievable through the use of a model. For these reasons, then, small-scale models will be used as the spatial representations to be investigated.

# CHAPTER THREE

## General Method

All of the experiments reported in this thesis were adapted from the experimental paradigm of DeLoache's (1987) experiment using a small-scale model of a referent room.

### *Participants*

The participants in Experiment One and Experiments 3A and 3B were taken from the University of Stirling Psychology Department Playgroup. Parents of these children had already agreed to their children taking part in research underway at the university, so a simple information sheet was all that was required to inform parents/guardians of the form and purpose of the studies. A copy of this information sheet is included as Appendix One.

Participants in all other experiments came from schools in and around the Stirling area. A research proposal was submitted to Stirling Council's Education Services (see Appendix Two), and ethical approval was granted for the project (see Appendix Three).

Headteachers were then approached initially by letter, with a brief overview of the project and what would be required of children taking part. An example of such a letter is included as Appendix Four. Those schools responding favourably to this initial approach were then contacted by telephone, and a meeting arranged with the head teacher and class teachers to discuss the project in more detail. Consent forms were then issued to the school, for distribution to parents/guardians. These forms sought either negative or positive consent, depending upon the wishes of the particular school. Positive consent forms required parents to respond stating whether or not they were happy for their child to take part in the study. An example of such a form is included as Appendix Five. Negative consent forms required parents to respond only if they did not want their child to take part in the study. An example of a negative consent form is included as Appendix Six.

***Materials***

For all experiments a room was used as a referent space. In Experiment One and Experiments 3A and 3B, the room used was the Playroom in Stirling University's Psychology Department (see Appendices Seven and Eight). In all other experiments it was an Elddis Shamal Caravan (see Appendix Nine). Small-scale models of these rooms were used as representations in all experiments (see Appendices Ten and Fifteen).

Many studies have used representations which are small in scale, but not precisely to scale with their referents. For example, Robinson, Nye and Thomas (1994) used pictures as representations which were small-scale but not to scale. In addition, DeLoache (e.g. 1991) has used models which are small scale in relation to their referents, but are nevertheless not exactly to scale. Exact scaling of models is easier when the referent space has also been constructed for the purposes of experimentation. However, the present project utilised genuine referent spaces, rather than contrived experimental referent spaces and therefore the models had to include many more complex and intricate features. It was necessary to construct these features adequately, so that they could include hiding places like drawers and cupboards which could be manipulated by young children without difficulty. It was found that if the models were constructed to scale, it would be difficult to include all of these features, and to construct the contents of the model such that doors could be opened and closed, and hiding places be large enough to conceal objects from sight. Therefore, within the present project, the models were constructed on a small scale, but were not exactly to scale.

Those studies which have used representations constructed to an exact scaling, nevertheless vary greatly in the scaling that the use. For example, Uttal and Wellman (1989) used a map of scale 1:12, whilst Blades and Spencer (1987a) used maps of a scale 1:50. Blades and Spencer (1986), however, used maps of a scale 1:100. Furthermore, although some researchers report that their models are constructed to scale, it is usually only the shell of the room itself which is to scale. The items within the model are usually simply reported as being "miniature" or "small" versions of the corresponding item in the referent space (e.g. DeLoache, 1995). Therefore, even these representations are not truly to scale.

In the present project, the contents of the caravan were far more intricate and complex than those of the playroom, and experiments using the playroom had already been completed prior to the caravan studies. Therefore, when construction of the caravan model commenced, it was necessary to construct this on a different scaling to that of the playroom model, in order to adequately represent the constituent features of the referent room. Other studies have also compared representations of different scalings within the same experimental report. For example, DeLoache (1989) used photographs of the same room, measuring 28 x 36 cms in one study, but measuring 20 x 25cms in another. She also compared these two studies with one in which a model measuring 71 x 65 x 33cms, of the same room, was used. Nevertheless, she attributed observed differences in performance to variables other than scaling.

Despite DeLoache's use of models which are not precisely to scale, she nevertheless reports that the scale of a representation affects children's ability to understand and to use that representation (DeLoache et al., 1991; DeLoache et al., 1999). However, this conclusion is drawn from studies which use a model of scale approximately 1:2. No other researchers have reported differences in performance due to differences in the scale of representations, and as discussed in Chapter Two, it may be that these findings of DeLoache were due to the extreme similarity in scale between the large model and its referent room. As discussed previously, it may be that when a representation is so similar in size to its referent, the representational element of the task is removed, and it becomes a more straightforward matching task.

Whilst ideally it may be desirable to use exact scaling when constructing representations, this is not always possible, and previous research indicates that representations of different scales can nevertheless be usefully compared. This fits with theories about the cognitive abilities required to understand spatial representations, as discussed in Chapter One. The theories of both DeLoache and of Blades suggest that in order to understand a representation, children require to appreciate the overall representational relationship between it and its referent. That is, to recognise that the model looks like and stands for, the room. They then need to be able to distinguish spatial relationships between items within a referent space. Despite differences in scalings, these kinds of relationships tend to remain stable within representations, making them valid representations of that space for these exploratory purposes, regardless of different scalings. So if a chair is located between the door and the bed in a referent room, then provided that chair is located between the door and the bed in a model of the room, children should be able to successfully identify its location, irrespective of the particular scaling of that model. Therefore, whilst exact scaling was not used for the models within this project, the models nevertheless provide an accurate representation of the items within the room, and of the relationships between items within the space.

Playroom

The dimensions of the room were 800 x 560 x 262cms. Appendices Seven and Eight show the playroom, which contained tables, chairs, shelves, cupboards, a wendy-house, a see-saw, a climbing frame, a slide, a painting easel, a water play area and a sink. In addition, the playroom contained toys such as dolls, books, boxes of jigsaws, containers of crayons, lego, toy cars and model trains. The room was carpeted throughout.

Playroom model

This is shown in Appendices Ten to Twelve. The dimensions of the model were 60 x 30 x 25cms. The model was constructed from plywood, and items in the model were constructed from cardboard. The model contained miniature versions of all the main features of the playroom: doors; windows; tables; chairs; climbing frame; slide; cupboards; shelves; see-saw; sand pit; wendy-house; easel. Additional material present in the real playroom but not represented in the model included: dolls; boxes of jigsaws; containers of crayons; lego; toy cars; model trains etc. etc. The model was not carpeted and nor were all of the items in the model identical in material nor colour to the analogous objects in the playroom itself.

Caravan

An Elddis Shamal caravan was used in Experiments Two, Four, Five and Six, as the referent room. It was taken to the participants' schools, where it was parked in the playground, just outside the main door. The dimensions of the inside of the caravan were 440 x 195 x 180cms. The caravan contained couches, cupboards, drawers, wardrobe, toilet room, cooker and fridge. In addition, the caravan was carpeted and contained curtains and lights. Appendices Thirteen and Fourteen show photographs of the inside of the caravan.

Caravan model

The dimensions of the model were 75 x 45 x 25cms respectively. The outer shell of the model was made from plywood, with holes cut out for windows, and a hinged door. Wooden circles were attached to the sides to represent wheels. The furniture inside the model was constructed out of cardboard. Within the model, the couches, cupboards, drawers, wardrobe, toilet room and kitchen were represented. Soft furnishings (mattresses/cushions) were made using cushion foam, with material covers. Curtains were also made out of material. Dolls' house carpet was used as floor covering for the model. This model is shown in Appendices Fifteen to Seventeen.

<u>Other materials</u>

Two toy dogs were used as target objects. The smaller of the two dogs was approximately 2½ centimetres in length, whilst the larger was approximately 25 centimetres in length. These were Walt Disney "101 Dalmatian" dogs, and are depicted in Appendix Eighteen. A stopwatch was used to record the time taken on each test trial.

***Procedure***

For all experiments, the model was positioned inside the referent room itself, and was oriented with the room. For experiments using the playroom, the model was positioned in the "quiet corner" of the room, and other children were present in the main room. Children in all studies were tested individually. They were seated on the floor in front of the model, opposite the Experimenter.

Children either completed a traditional hide-and-seek task, or a positioning task. Every child completed a total of four trials on their allocated task: two in which they viewed the model then manipulated the real room, and two in which they viewed the real room and manipulated the model. The order in which they completed these two types of trial was randomly varied between subjects.

Each session began with a phase of orientation, where the relationship between the model and the room was explicitly pointed out. Each item in the room was identified with the analogous object in the model. The two dogs were then introduced after which time the test phase began.

Orientation phase

Each child first took part in an extensive orientation phase, prior to the test phase. The experimenter explicitly pointed out the correspondence between the model and the real room, identifying the main features of the model (all items of furniture and the door) and the corresponding features of the real playroom.

*"Come and look at this. Can you see what this is? This is a little room that looks just like the big room."*

*"Look. Here is a little chute [Point] that looks just like the big chute [Point]. And here is a little wendy-house [Point] that looks just like the big wendy-house [Point]" etc. etc.*

Once the child had observed the corresponding items in both the model and the room, he was then introduced to the target objects. The child was introduced to the two toy dogs in the following way:

*"Now I'm going to show you something else. Look [Show small dog]. Do you know what this is? That's right, it's a little dog. This is a little dog, but I also have a big dog that is just like the little dog [Show larger dog]."*

*"Now the little dog likes to play in the little room, and the big dog likes to play in the big room. And both dogs like to do the same things, so whatever the little dog does in the little room, the big dog does in the big room."*

Following familiarisation with the target objects, the test phase began. During this phase children completed either a Positioning task, or a Retrieval task.

Positioning

On Positioning trials the child observed while the Experimenter placed an object at a particular location in one of the rooms (real or model), and was then required to position an analogous object at the same location in the other room.

Retrieval

On Retrieval tasks the child observed while the Experimenter hid an object at a particular location in one of the rooms, and was then required to retrieve the analogous object from where it had previously been hidden whilst the child was not looking, in the other room.

Children were randomly assigned to complete either Retrieval or Positioning tasks. Each child completed some trials using the Room-To-Model method, and some using the Model-To-Room method. Order effects were controlled for by varying which type of trial was completed first. On Room-To-Model trials, the children watched as the Experimenter placed/hid the object in the real room, and were required to position/retrieve the analogous object from the model. Conversely, on Model-To-Room trials the children watched as the Experimenter placed/hid in the model first, and were then required to position/retrieve the analogous object from the real room.

Model-to-Room procedure

The child observed as the experimenter either hid or positioned the small toy dog at a particular location in the model room. The child was then required to either retrieve (if completing a Retrieval task), or to position (if completing a Positioning task) the larger toy dog at the equivalent location in the real playroom.

Positioning: *"Now I'm going to put the little dog somewhere in the little room. Watch [Place small dog]."*

*"But do you remember that both dogs like to do the same things? So now I have to put the big dog in the right place in the big room. Would you do that for me? [Allow child to position larger dog]"*

Retrieval: *"Now. The big dog is hiding somewhere in the big room. But do you remember that both dogs like to do the same things? So now I have to hide the little dog in the right place in the little room. Watch [Hide little dog]."*

*"Do you see where the little dog is hiding in the little room? So could you go and get the big dog for me from where he's hiding in the big room? [Allow child to retrieve big dog]"*

<u>Room-to-Model procedure</u>

Following orientation, the child was introduced to the two toy dogs in the same way as above.

The child then observed as the experimenter either hid or positioned the larger toy dog at a particular location in the real room. The child was then required to either retrieve (if completing a Retrieval task) or to position (if completing a Positioning task) the small toy dog at the equivalent location in the model room.

Positioning: *"Now I'm going to put the big dog somewhere in the big room. Watch [Place larger dog]."*

*"But do you remember that both dogs like to do the same things? So now I have to put the little dog in the right place in the little room. Would you do that for me? [Allow child to position small dog]"*

Retrieval: *"Now. The little dog is hiding somewhere in the little room. But do you remember that both dogs like to do the same things? So now I have to hide the big dog in the right place in the big room. Watch [Hide big dog]."*

*"Do you see where the big dog is hiding in the big room? So could you go and get the little dog for me from where he's hiding in the little room? [Allow child to retrieve little dog]."*

During the test phase, labels for the items in the two rooms (e.g. "couch", "easel") were used. DeLoache (1989) carried out a study in which the effects of incorporating labels into the task instructions were examined, and found no effect on performance of labelling during testing. However, Solomon (1999) found that a group of 2½ year olds performed better using enriched instructions, which incorporated specific labels into the test phase, than a control group using standard instructions without labels. Whilst she was unable to replicate this result in a subsequent study, Solomon suggests that the provision of labels during the test phase may enable children to succeed merely by matching an object in one room, with its counterpart with the same label in the other room. Callaghan (1999) also found young children's ability to understand the symbolic relationship between a picture of an object and its referent, to be significantly improved when verbal labels were provided. However, Adams and Blades (1999) carried out a study in which the effect of questioning style on children's understanding of aerial photographs was explored. Two forms of questioning style were used – one in which the experimenter pointed to each item and asked "Can you tell me what this is?" and a second in which the child was asked "Could you find me a ______?". The results show no difference between performance using these two different forms of questioning style, which suggests no real benefit to children of introducing labels into the orientation phase.

Memory check procedure

Following each trial, a memory check was carried out, where the child was asked to go and get the original toy which the experimenter had hid or positioned. The child was asked:

*"Now, can you go and get the small/big dog from where I put him?"*

If a child was unable to successfully retrieve or position a toy, they were encouraged to return to the original space to complete the memory check trial, prior to making their final decision as to where the target toy was hidden/to be placed. They were told:

*"Can you remember where the little/big dog was in the little/big room? Can you show me?"*

They were then encouraged to complete the test trial. This procedure prevented children from succeeding on the memory check trial due to being cued after finding/positioning the target toy. For example, a child might actually have forgotten the location of the toy, but might nevertheless find the toy in the real room after searching all possible locations. Thus their test trial would be scored as unsuccessful. Despite this memory loss, however, they might still succeed on the memory check trial, because finding the target toy cued their recall as to the original toy's location.

### *Dependent variables*

For each trial, a number of measures were recorded. Success/lack of success on the test trial was noted, as was success/lack of success on the memory check trial. In addition, the time taken to complete each test trial was recorded, and details of any errors were recorded.

#### Score

For each test trial the child scored 1 if successful and 0 if unsuccessful. Each child's final score was then converted to a percentage correct for analysis, as has been done by previous researchers (e.g. DeLoache, 1987; Liben and Yekel, 1996). This conversion also allowed for more straightforward comparisons between conditions and experiments which had different numbers of trials.

A Positioning trial was scored as successful if the child correctly positioned the toy at the target location, provided that was the first place that the child put the toy. Therefore, if the target toy was on the table then the trial would be scored as correct if the child placed the analogous toy on the analogous table, irrespective of whether it was placed towards the left side of the table or the right side of the table etc. A Retrieval trial was scored as successful if the child correctly retrieved the toy from the target location, provided that was the first place that the child searched for the toy.

Time

Previous research using similar methodologies has recorded only correct/incorrect responses. No studies have attempted to record the length of time taken by children. This variable was included as an exploratory measure for several reasons. Firstly, the precise definition of a "successful" trial in DeLoache's original work is not explained. It cannot simply be that the child retrieves the toy, since this is inevitable eventually. In the present study the criteria for success is more rigidly defined. However, in order to investigate the possibility of more reliable or sensitive measures of success, time was measured in addition to the traditional discrete measures of success or failure.

Furthermore, it was hoped that the length of time taken on different trials might reveal more about the particular strategies being adopted by children in attempting to complete the tasks. For example, if children who are highly successful take, on average, the same amount of time as those who are unsuccessful then this might indicate that both groups are equally as certain of their responses. If more time is taken on one task than another, regardless of levels of success, then this might suggest that the complexity of one task is greater, and thus that the thought and reasoning processes required are more lengthy.

In this way, time was included as a novel and previously unexplored variable within this domain, in an attempt to improve our understanding of the processes and strategies employed by children attempting to successfully complete such tasks.

Error data

Errors have been explored by Blades (1991), Blades and Spencer (1987), and more recently by Solomon (1999) to allow for more sensitive analysis of children's responses, and to provide information about possible strategies which children may employ in order to succeed. Blades and Spencer (1987) designed an experiment in which a large-scale octagonal layout was designed, with an outside path and eight paths leading inwards to one central point. At the end of each of the eight paths was a box. Children were given a map on which roadblocks were marked down some of the paths. Their task was to find the path which did not have a roadblock on the map, and to walk down it to the central point. Blades and Spencer identified eight different possible strategies which children could employ on this task. Each strategy would result in a particular pattern of performance, and by examining children's performance it was possible to identify which strategies were being employed.

In the present study, on unsuccessful test trials, error data were collected, so that the precise incorrect location which the child chose was noted. Although error data have been reported by only a very few researchers, nevertheless by analysing the kinds of mistakes which children make at different ages, or on different tasks, we can surely gain access to much more detailed information concerning the cognitive processes involved in completing these tasks. Thus, it was hoped that by recording the kinds of errors made, it would enable us to build up a more comprehensive picture of the way in which children are processing information in their attempts to understand and to use representations of space. Errors in the present study were classified in one of four ways, based on the main theories of development explored in Chapter One.

Memory check control trials have been used by DeLoache to establish that simply forgetting the original location is not the source of failure on a particular trial. Thus, if a test trial was unsuccessful and the child subsequently failed the memory check, that error was classed as "Memory based".

DeLoache attributes failures which are not due to memory, to the representational domain. However, the late development of a full concept of space, as outlined by Piaget, is another possible source of failure. Blades (1991) has also shown that spatial awareness and not just memory may be responsible for a lack of success. If required to choose between two or more identical locations, children with a poorly developed appreciation of spatial relations may fail due to an inability to use spatial relations to distinguish between them. Therefore when a child was unsuccessful, but first searched/placed at a location which was identical in appearance, but in a different spatial location, to the correct one, then that error was classified as an "Identical location" error.

In addition to these two types of errors, Solomon (1999) and O'Sullivan, Mitchell and Daehler (1999) have found that another common mistake made by young children is perseveration. Thus, children will search or position at the location where they last saw the target object, rather than on the basis of new information about its current location. Therefore, if a trial was unsuccessful and the location which had been chosen by a child was the one which had been correct on the immediately preceding trial, such errors were classified as "Perseverative".

All other errors were classed as "Other" errors, and it was thought that the majority of these errors would comprise those due to a general lack of appreciation of the representational relationship between model and room.

All of the studies in this thesis followed this general methodological format. Variations from this are reported in the relevant experimental chapter itself.

# CHAPTER FOUR

## Research Questions and Initial Investigation

## Experiment One

### *Introduction*

As has been discussed in Chapter Two, the ability of children to understand and use a spatial representation has been assessed in different studies in very different ways. The experiment discussed here was therefore intended as a general investigation into the comparability of just two of the methods and two of the tasks which have been used in assessing these abilities in children.

The difference between tasks which require an inference to be made from a representation to a referent, and the converse (requiring an inference from referent to representation) is one which has been explored in Chapter Two. This is an interesting difference, and one which other authors have suggested requires further investigation (e.g. Liben, 1997). Therefore, this experiment was designed to allow for a direct comparison between equivalent tasks using both of these methods.

Furthermore, the experiment was designed to assess the equivalence of two of the many different tasks discussed in Chapter Two. In the past, studies which have required children to perform Retrieval tasks (e.g. DeLoache, 1989) have shown that they are able to do so at just two and a half years of age. However, when asked to perform Positioning tasks children have sometimes been unable to do so until seven years of age (Piaget & Inhelder, 1956: CH. XIV, Sec.

6). Whilst it is difficult to make comparisons between these different studies, they do nevertheless suggest that children might not perform equally on Retrieval and on Positioning tasks, and this experiment was therefore designed to allow for a direct comparison of these two tasks.

The particular type of representation to be used in this experiment was a small-scale model. Whilst this is just one of the many different forms of representation which previous research has investigated, it was decided that this would be the particular one used for the purposes of investigation here. The aim was to maximise the children's potential for success in understanding the particular representation, so that the variables of method and task used could be clearly assessed without confounding performance by using a difficult representational type. DeLoache (1987; 1995b) has found that children can appreciate small-scale models as representations of space from three years of age, whereas Bluestein and Acredolo (1979) suggest that children do not have a full appreciation of maps until around five years of age. It was also hoped that a three-dimensional representation might prove to be more stimulating for younger children than, for example, a map or a picture.

The referent space to be used was the children's own playroom, and was thus already familiar to the participants. Again, it was hoped that children would be able to appreciate a representation of an already familiar space more easily than they might with a novel space, and that this might facilitate performance and therefore allow for a clearer assessment of the variables of interest.

Siegel and Schadler (1977) found that boys were more successful at constructing a model of their classroom than girls, whilst Solomon (1999) found that on an adaptation of DeLoache's model-room task, girls were more successful than boys. However, as Solomon points out, gender differences in this type of research are unusual. Few studies within this area have found gender differences to exist and, as has been shown, those that have are inconsistent in their findings. Therefore, gender will be explored in relation to the results of this study merely as an exploratory measure, to check for any unexpected differences which may emerge between the performance of boys and girls. Later studies will continue to explore gender as a factor only if early experiments reveal that differences do, in fact, exist.

### *Method*

#### Participants

26 children from a university playgroup took part in the study. Of these, 13 were boys and 13 girls. Their ages ranged from 34-50 months (2;10 – 4;2), with a mean age of 43 months (3;7). Although this sample size is small, these were all the children enrolled in the playgroup at the time. The following year's cohort of children provided the participants for later experiments, and therefore could not also take part in Experiment One. The children had approximately six months experience in the playroom at the time of testing, and it was thought undesirable to bring in additional participants from outside the playgroup, since performance might then be confounded with poor internal spatial knowledge of the referent space.

Apparatus

The study was carried out in a quiet corner of the playgroup. The playroom itself was used as the referent space, and a small scale model of the playroom was constructed to act as the representation. The model contained miniature versions of all the main features of the playroom itself, as indicated in the General Method, Chapter Three. Four target locations were used within the model/room: two tables, a climbing-frame and a painting easel. The easel and the climbing frame served as unique hiding locations and the tables served as identical locations. Each child completed two unique location trials and two identical location trials, and these were counterbalanced across Model-to-Room and Room-to-Model Conditions.

Model-To-Room procedure

Prior to the test phase there was an orientation phase. The experimenter explicitly pointed out the correspondence between the model and the real room, identifying each feature of the model and the corresponding feature of the real playroom, as indicated in Chapter Three (General Method). The child was introduced to the two toy dogs, and then observed as the experimenter either hid or positioned the small toy dog at a particular location in the model playroom. The child was then required to either retrieve (if completing a Retrieval task), or to position (if completing a Positioning task) the larger toy dog at the equivalent location in the real playroom.

Room-To-Model procedure

Following orientation, the child was introduced to the two toy dogs in the same way as above. The child then observed as the experimenter either hid or positioned the larger toy dog at a particular location in the real playroom. The child was then required to either retrieve (if completing a Retrieval task) or to position (if completing a Positioning task) the small toy dog at the equivalent location in the model playroom.

Children were randomly assigned to complete either Retrieval or Positioning tasks. Each child then completed four trials on their allotted task. Of these four, two were Model-To-Room tasks and two were Room-To-Model tasks. Order effects were controlled for by varying which type of trial was completed first. For each trial the child scored 1 if successful and 0 if unsuccessful. Thus, each child had a final overall score out of 4, which was converted to a percentage correct.

Memory check procedure

Following each trial, a memory check was carried out, where the child was asked to go to get the original toy which the experimenter had hid or positioned.

***Results***

Overall, performance was poor. The mean score overall was 44.2% correct. This is in contrast, however, with performance on the Memory Check control trials, on which the children scored 100% correct, and this difference is highly significant ($t_{25} = -8.7$, $p < 0.01$). The results for the test trials are more interesting when broken down by task and method used, as shown in Table 1.

A 2 (Condition: Model-To-Room vs. Room-To-Model) x 2 (Task: Retrieval vs. Positioning) x 2 (Gender: Boys vs. Girls) ANOVA, with Condition as a within-subjects variable, showed that children scored significantly higher on Retrieval tasks than on Positioning tasks ($F_{1, 22} = 8.016$, $p=0.01$). There were no other significant effects or interactions.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Positioning (n = 14) | 28.6 | 37.8 | 25.0 | 37.9 | 30.4 | 34.2 |
| Retrieval (n = 12) | 70.8 | 33.4 | 50.0 | 42.6 | 60.4 | 22.5 |
| Total (n = 26) | 48.1 | 41.2 | 36.5 | 41.4 | 44.2 | 32.6 |

*Table 1. Mean score in each Condition, by Task.*

On Positioning tasks children performed very poorly overall. Thus, it had little effect whether the method used was Model-To-Room or Room-To-Model. However, on Retrieval tasks, which the children appeared to be capable of, children score higher on Room-To-Model than on Model-To-Room. This difference can be seen in Figure 1.

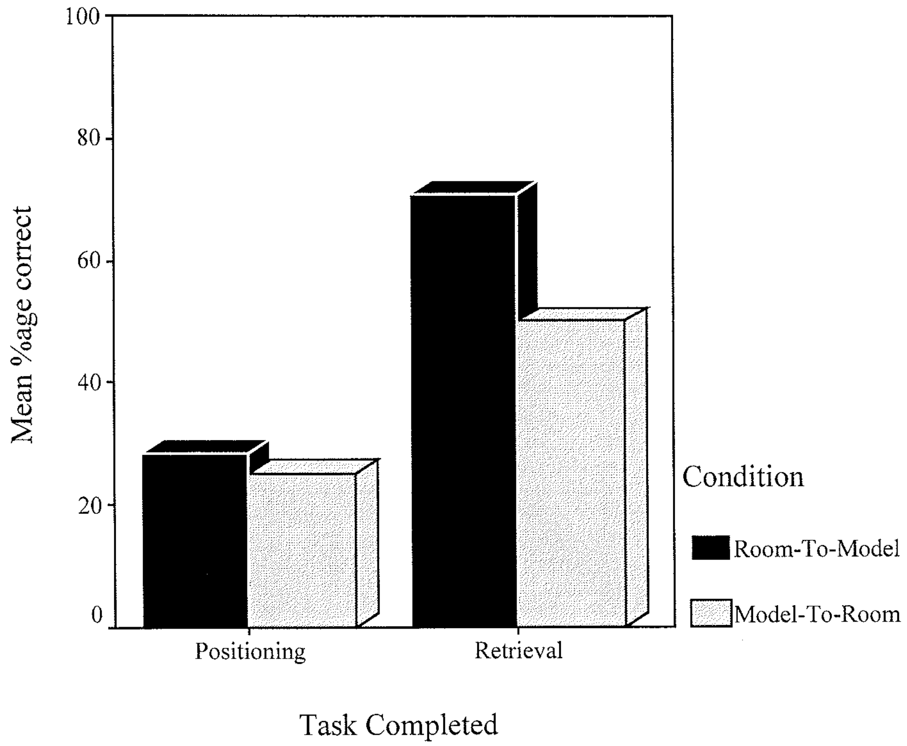


*Figure 1. Mean score in each Condition, by Task.*

Time taken

Table 2 illustrates the times taken by children on each Condition, by Task. These results suggest that children took longer in the Model-To-Room Condition, and also that the Retrieval Task took longer than the Positioning Task. Table 3 shows the times taken by children in both Conditions, depending upon their level of success. Children were classified into groups according to their level of success in each of the two conditions. A 2 (Task: Positioning vs. Retrieval) x 3 (Level of Success: 0 vs. 1 vs. 2 correct) ANOVA was carried out on the data for each of the two Conditions, to investigate whether success or failure on particular tasks affected the amount of time that children were taking. In addition, a 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs.

Positioning) within-subjects ANOVA was carried out, to assess whether there was an overall difference between the time in the two Conditions.

The results reveal significant main effects of Condition ($F_{1, 24} = 13.388$, $p < 0.01$) and Task ($F_{1, 24} = 12.999$, $p < 0.01$), thus supporting the differences illustrated in Table 2, in that children took longer in the Model-To-Room Condition, and that they also took longer to complete Retrieval trials than they did to complete Positioning trials. The analyses show that the effect of Task is significant in both Conditions, as well as overall.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Positioning (n = 14) | 5.75 | 4.44 | 5.89 | 4.95 | 5.82 | 3.40 |
| Retrieval (n = 12) | 11.55 | 11.95 | 27.74 | 18.97 | 19.65 | 13.92 |
| Total (n = 26) | 8.43 | 9.04 | 15.97 | 17.16 | 12.20 | 11.86 |

*Table 2. Mean time taken in each Condition, by Task.*

As well as these main effects, the results also reveal a significant interaction between Task and Condition ($F_{1, 24} = 12.927$, $p < 0.01$). As Figure 2 shows, children took similar amounts of time when Positioning, on both Room-To-Model and Model-To-Room trials. However, when Retrieving, children took significantly longer on Model-To-Room than Room-To-Model trials.

| | Condition | | | |
|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | |
| Number of correct responses | Mean time (secs) | SD | Mean time (secs) | SD |
| 0 | 9.66 (n = 9) | 14.05 | 16.25 (n = 12) | 15.82 |
| 1 | 5.28 (n = 8) | 4.49 | 14.69 (n = 7) | 9.28 |
| 2 | 9.99 (n = 9) | 5.11 | 16.79 (n = 7) | 26.06 |

*Table 3. Mean time taken in each Condition, by level of success.*

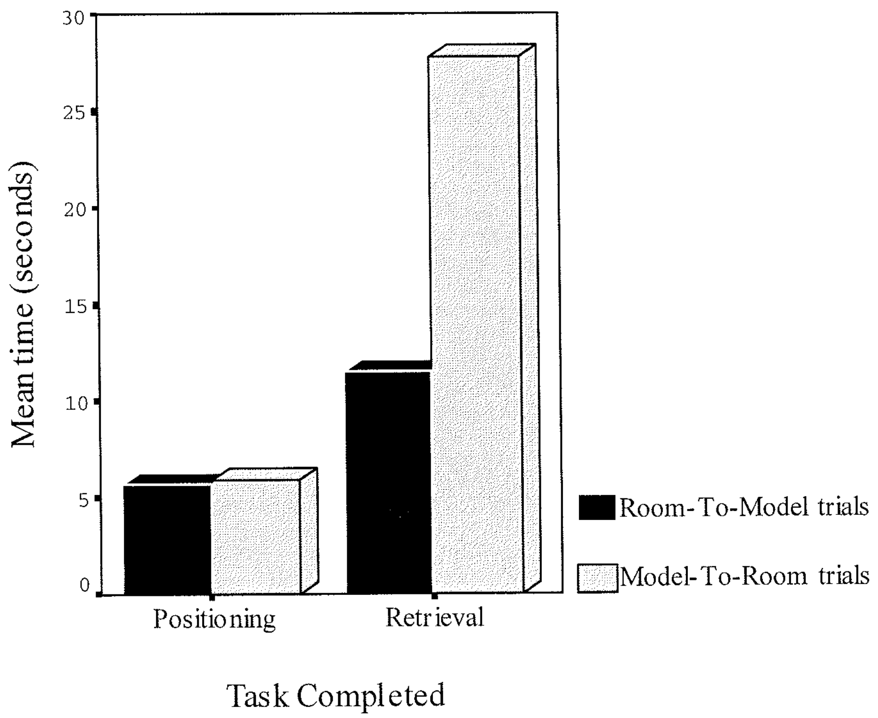


*Figure 2. Mean time taken in each task, by Condition*

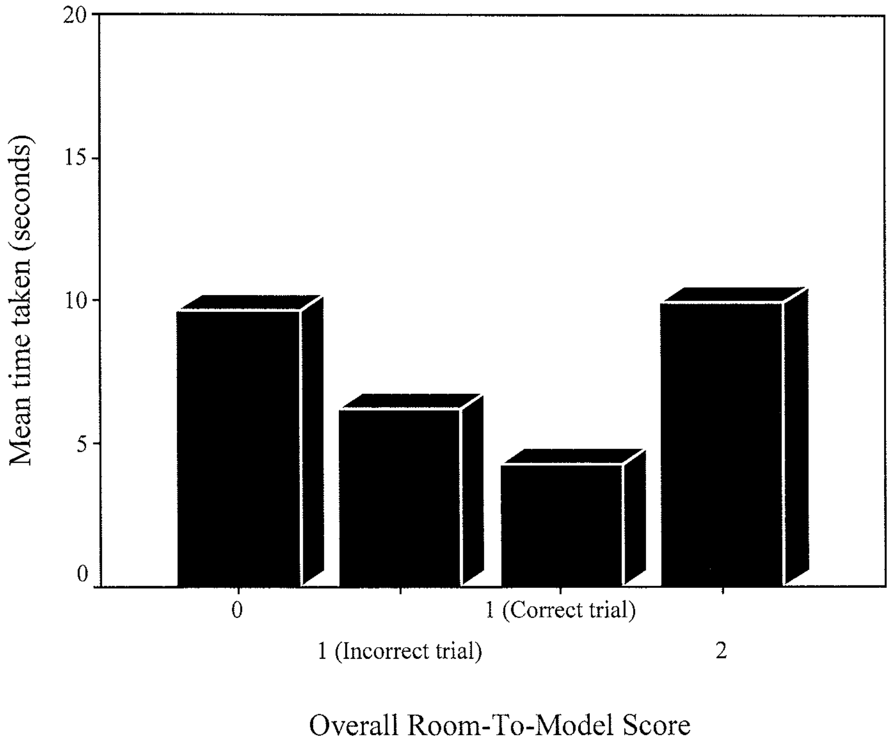


*Figure 3. Mean time taken, by score in Room-To-Model Condition*

The analyses also revealed a main effect of Level of Success in the Room-To-Model Condition ($F_{2, 20} = 23.313$, $p < 0.01$), though this was not significant in the Model-To-Room Condition. As Table 3 shows, the time taken by children scoring 1 correct is relatively less than the time taken by those scoring 0, but the time taken then increases again in the group scoring 2 correct. Figure 3 illustrates the different times that were taken by children at different levels of success on the Room-To-Model Condition. In this graph, the data for the group scoring one correct has been split to show the times taken by this group of children on their one successful trial, and that on their unsuccessful trial. Whilst the group scoring 1 correct took less time overall than those scoring 0 correct, Figure 3 illustrates that on their unsuccessful trial, the children scoring 1 correct took slightly more time than they did on their successful trial. However, a paired sample t-test revealed that this difference was not significant ($t_7 = 0.739$, $p = 0.484$). Figure 4 illustrates the times that were taken by children at different levels of success on the Model-To-Room Condition, once again with the data for the 1 correct group being split to show the time taken on their unsuccessful versus their successful trial. Table 3 illustrates that in this Condition children who scored 1 correct took less time overall than those scoring 0 and 2 correct, but Figure 4 shows that the 1 correct group took more time on their unsuccessful trial than their successful trial. However, this difference is not significant in this Condition either ($t_6 = 2.040$, $p = 0.087$).

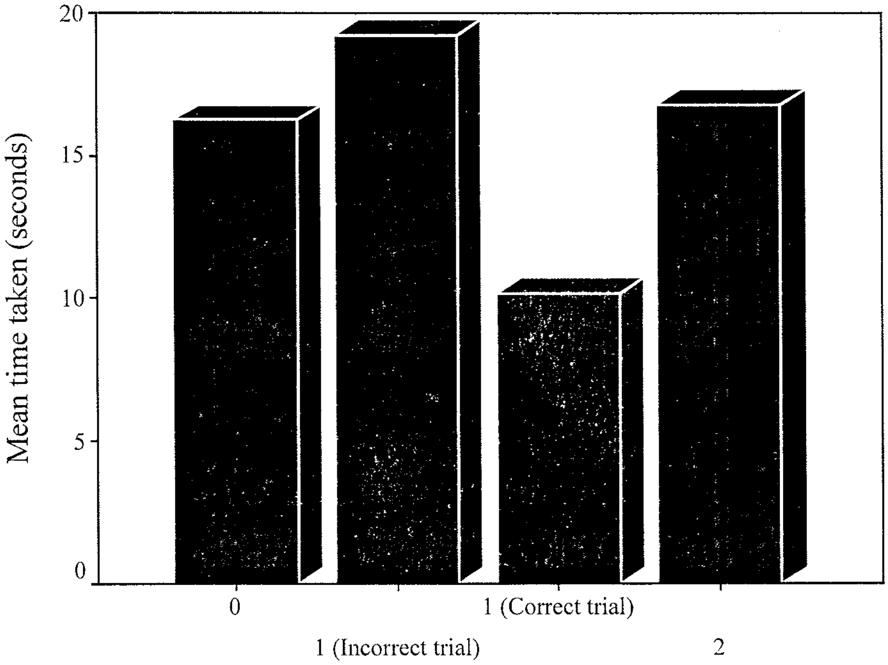


*Figure 4. Mean time taken, by score in Model-To-Room Condition*

There was also a significant interaction between Task and Level of Success, in the Room-To-Model Condition ($F_{2,20} = 27.024$, $p < 0.01$). The interaction was not significant in the other Condition. These interactions are illustrated in Figures 5 and 6. It appears that in both of these Conditions, children take approximately the same amount of time when Positioning, irrespective of their score. When

Retrieving, however, there are differences between the two Conditions, and differences between the different levels of success.

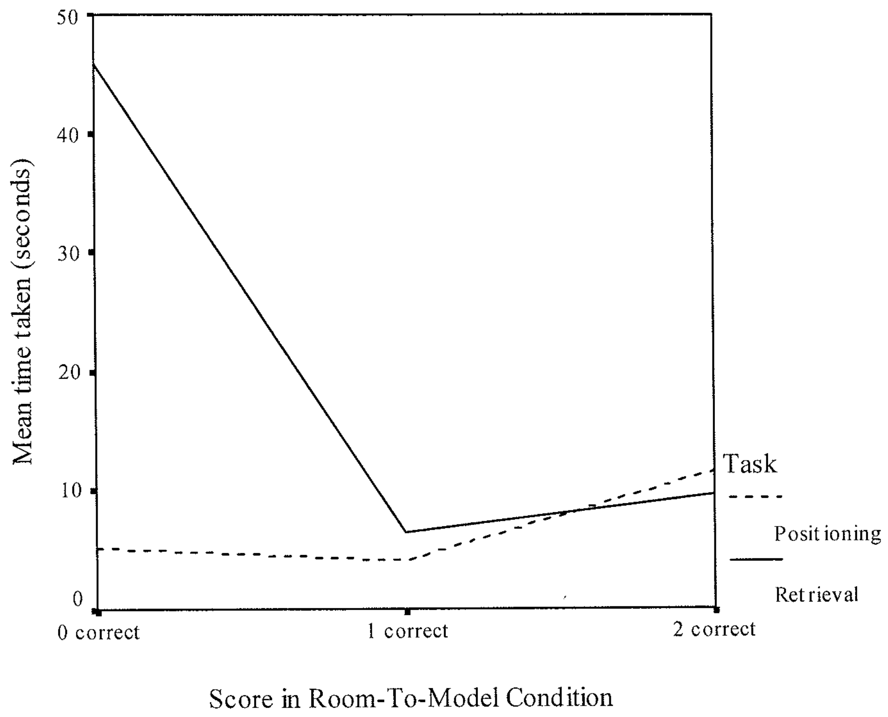


*Figure 5. Mean time taken, by score in Room-To-Model Condition.*

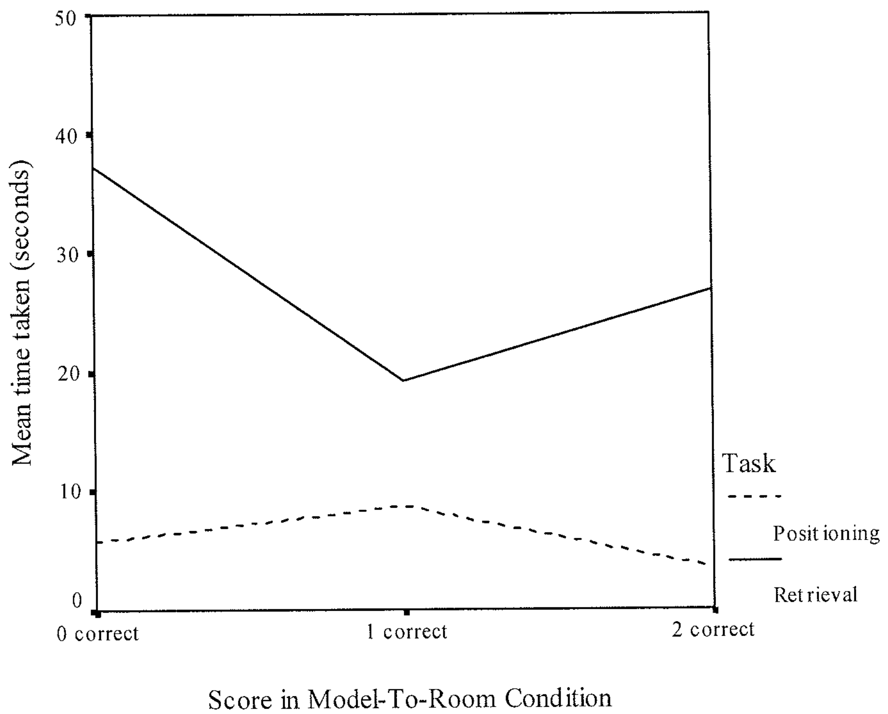


*Figure 6. Mean time taken, by score in Model-To-Room condition.*

When Retrieving on the Room-To-Model Condition, children take a great deal longer when they score poorly. As their level of success increases, they appear to take less time. On the Model-To-Room Condition, children also take longer on Retrieval when they score poorly, and take less time as their scores increase. However, the time taken then increases again for those children who achieve the highest levels of success. There were no other significant effects or interactions.

Error data

The errors made by children on test trials were classified into groups, based on previous research, as discussed in Chapter Three. If, having failed a test trial, a child subsequently failed the memory check control trial, then the test trial error was classified as Memory-based. If the target location on a given trial was not a unique one, and the location the child selected was an identical one to the target, then the error was scored as an Identical location error. If the incorrect location chosen by the child was the location at which they had last retrieved or positioned the target object, then the error was classified as Perseverative. Any remaining errors were classified as Other errors.

Table 4 shows the mean numbers of the different types of errors which were made by children in both of the two Conditions. Overall, children made the highest numbers of "Other" errors. Identical location errors made up the next largest group, with only small numbers of Memory-based and Perseverative errors. This overall pattern of errors is illustrated by Figure 7.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.00 | 0.00 | 0.15 | 0.37 | 0.00 | 0.00 | 0.85 | 0.83 |
| Model-To-Room Condition | 0.00 | 0.00 | 0.15 | 0.37 | 0.08 | 0.27 | 0.96 | 0.87 |
| Total | 0.00 | 0.00 | 0.31 | 0.55 | 0.08 | 0.27 | 1.81 | 1.41 |

*Table 4. Mean number of errors made in each Condition.*

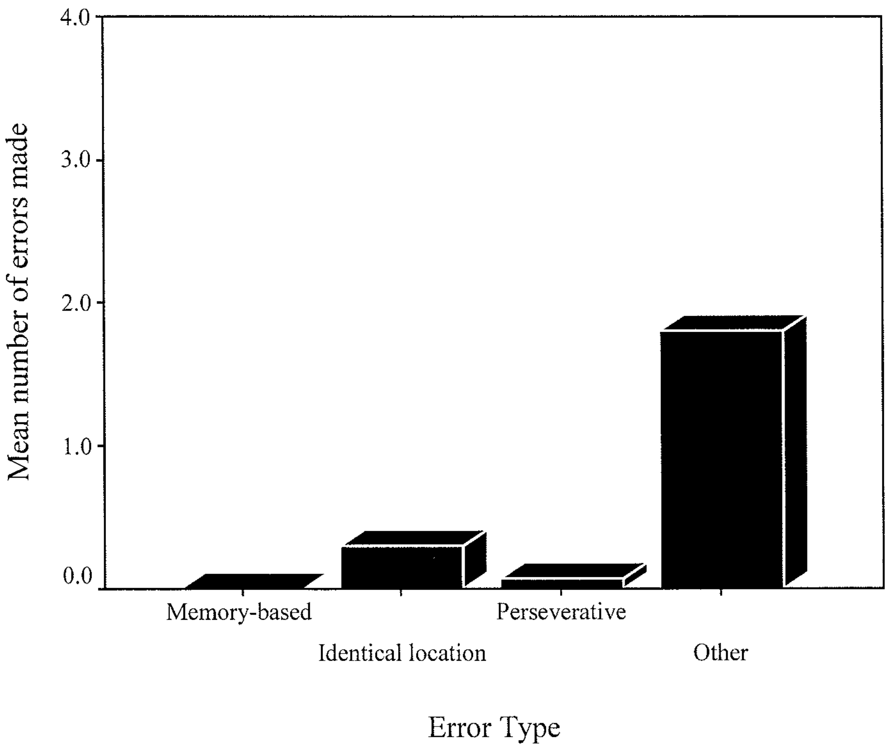


*Figure 7. Mean number of errors made.*

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA, with Condition as a within-subjects variable, was carried out on the data for each of the four error types. There was no effect of Condition on any of the four error types, showing that children made similar numbers of each error type on both Room-To-Model and Model-To-Room trials.

We already know from the Scores analysis, that children made more errors on Positioning than on Retrieval trials, but the only error type which differed significantly between Tasks was Other errors ($F_{1,24} = 7.310$, $p < 0.05$). The number of "Other" errors made on Positioning trials is much greater than on Retrieval trials.

This effect of Task on Other errors is further affected, however, by Condition, resulting in a significant interaction ($F_{1,24} = 6.590$, $p < 0.05$). This interaction is also significant for Identical location errors. Figures 8 and 9 illustrate the differences between the types of errors made on each Task, for the Room-To-Model Condition (Figure 8) and Model-To-Room (Figure 9).

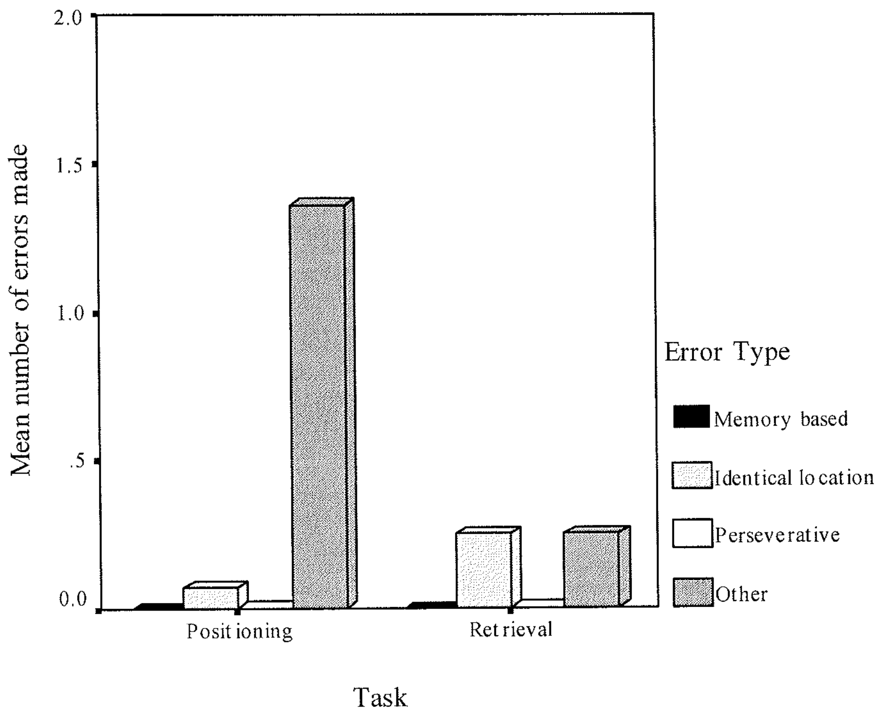


*Figure 8.* *Room-To-Model Condition: Mean number of errors made on each Task*

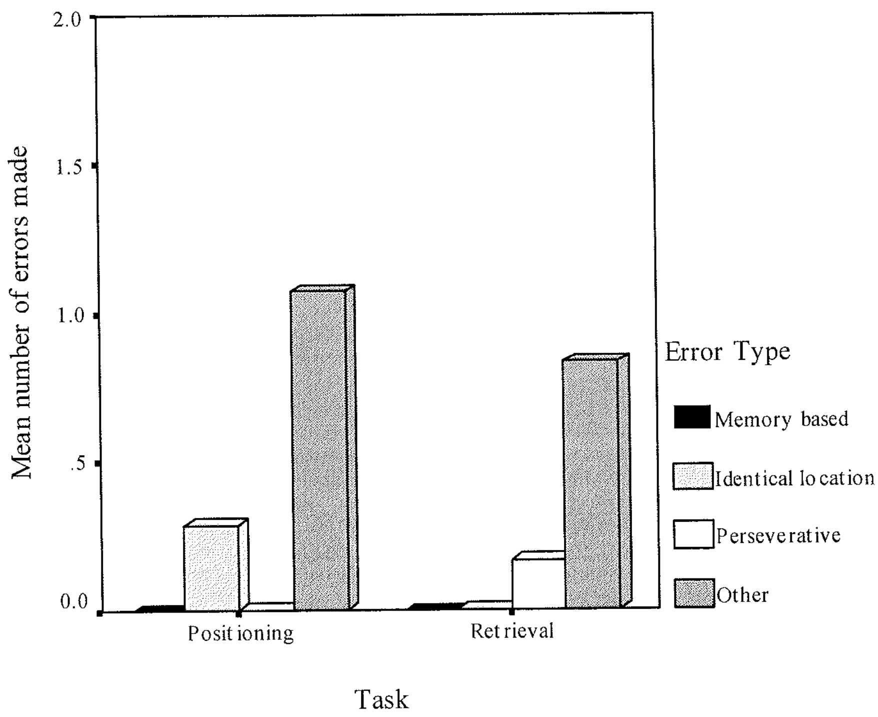


*Figure 9.* *Model-To-Room Condition: Mean number of errors made on each Task*

***Discussion***

Scores

In general, children's performance on these tasks was poor, thus contrasting with previous research which has suggested that young children understand a scale model at just three years of age (DeLoache, 1987). However, since the present experiment utilised both unique and identical target locations, the results fit with Blades' (1991) findings that children perform more poorly when the task requires them to utilise spatial information in the identification of locations. Using identical locations, Blades found that children were unable to understand and use external representations until around five years of age, which is more consistent with the findings of the present study.

Most of the children were able to recognise that the model looked like the playroom, even if they did not succeed on the tasks. This is consistent with previous research which has suggested that the ability to recognise the correspondence between a symbol and that which it represents, and the ability to appreciate that a representation can actually serve some purpose in providing information about the real world, are two distinct skills. (Liben, 1999) The success on the memory trials also suggests that forgetting the original target location can be ruled out as a possible source of error, and this too is consistent with previous research (DeLoache, 1987; 1989).

However, Retrieval tasks were significantly easier than Positioning tasks. These results are surprising, given that other studies have used placing tasks as practice tasks, prior to beginning the experiment proper, and have found children quite capable of this (e.g. Blades & Cooke, 1994). However, these results may be due to some inherent difference between the two types of task in the particular paradigm utilised by the present study. Playing a "hide-and-seek" type game may just be inherently more appealing and motivating than simply placing an object. Alternatively, it is possible that the ambiguities involved in scoring a successful Retrieval simply leave more room for overestimation error than does the scoring of a successful Positioning. Both of these possibilities require further exploration. Nevertheless, this finding has some support from a study by Bridges and Rowles (1985). They investigated three to seven year old children's understanding of the way in which an obstruction restricts a person's view, using a "hide-and-seek" type task. They suggest that with the younger children in their study, hiding games merely tap children's understanding of how to play hide-and-seek. They conclude that researchers should beware of adopting a familiar game as the setting for testing some ability, since this can misrepresent their abilities. In this study, it is possible that the children simply did not understand the paradigm of the Positioning task, but because the Retrieval task was framed in a familiar "hide-and-seek" format, children may have been more successful.

As has been discussed in Chapter Two, different tasks and methods appear to elicit different results in children, which would suggest that the "load" of different experimental paradigms differ. One of the primary goals of this research project was to investigate which particular methods and tasks place the heaviest "load" on children, in order that we might better appreciate their actual levels of competence. The results of the present study begin to suggest that under some circumstances, at least, Positioning tasks like those which have been adopted by some authors (e.g. Blades & Cooke, 1994; Liben & Downs, 1993; Siegel et al., 1979) are more difficult for a child than Retrieval tasks, which have been used by others (e.g. Bluestein and Acredolo, 1979; DeLoache, 1987, 1989).

Perhaps the most interesting result is that under some conditions, children were more successful on the Room-To-Model method than on the Model-To-Room method. This contrasts sharply with DeLoache's (1997) findings that performance on both tasks is equivalent. However, it also contrasts with Liben's (1997) suggestion that a Model-To-Room task might be equivalent to a Comprehension task, and should therefore be easier than a Room-To-Model task, which would be equivalent to a Production task.

In a study by Acredolo (1977), children's performance on an object finding task was compared when conducted in a space with no landmarks, a space with landmarks, and a small-scale model of the space. Acredolo reports that,

> *"The data...suggest that behaviour within a large-scale space is not isomorphic with manipulation of a small-scale model. Contributing to the ease with which even the youngest children dealt with the model was the fact that the ....smallness of the model may have reduced the memory load by allowing the child to see the entire space at one glance." (p7)*

Commenting on this study, Acredolo (1981) explains that the experimenter trained children to find a trinket hidden either to their right or to their left. The children were then moved to the opposite side of the space and allowed to search. Performance of this task in a specially constructed landmark-free large-scale space resulted in significantly less "egocentric" responding among five year olds than three and four year olds. However, this age difference disappeared completely when the task was presented in a regular classroom using a small-scale model of the landmark-free room; there was practically no egocentrism exhibited at all.

This demonstrates, then, that in some tasks performance is not equivalent when inferring from a model to a large space and vice-versa, which is what has always been found by DeLoache. In addition, Acredolo's study, like the one reported here, found performance to be superior when the task was to be carried out in the model. Clearly the two experiments are very different, but nevertheless this supports the finding that children may, under certain circumstances, find it more difficult to work in a referent space then in a model of that space.

Commenting on these results, Acredolo (1981) describes possible reasons for this pattern of performance. One reason she suggests is the mode of response required for the two different tasks.

> *"When....performance in the two spaces requires very different motor abilities, we should not be very surprised to find different developmental patterns" (p72)*

Another possible explanation for the results may be the way in which the two different spaces are viewed.

> *"....many small-scale models can be apprehended from a single vantage point, something which is not possible when one is located within a space....When only a single vantage point is necessary, the memory load is reduced and the additional problem of co-ordinating different perspectives is eliminated." (p73)*

Thus, the findings of the present study, that performance when carrying out the task in a model is superior to performance when carrying out the task in a referent space, might likewise be explained in terms of reduced memory load, since the children could view the model from a single vantage point. However, research by Liben and Yekel (1996) required children to place stickers on a map of their classroom, to indicate the location of target objects. Children were either seated on a chair in the room, or they were positioned in a raised booth which afforded them a clear view of the entire room from a single vantage point. The results showed that the single vantage point did not benefit children in terms of their performance, which suggests that viewing methods may not be responsible for children's superior performance in the model in Experiment One. A smaller sized referent space which could be viewed more easily from a single vantage point might enable this hypothesis to be tested.

<u>Time taken</u>

Table 2 reports that children took significantly longer on Model-To-Room trials, which is unsurprising given the fact that children under this Condition had to get up and carry out a task in the referent space itself. From Table 1 it is clear that the scores obtained under this Condition were also lower.

Hardwick, McIntyre and Pick (1976) suggest that performance in small-scale spaces may not be generalisable to large-scale environments due to memory load. They refer to a study by Smothergill (1973) which showed that whilst children performed equivalently to adults on an immediate visual localisation task, these same children were significantly less accurate when required to hold the target location in memory from between 5 and 25 seconds. In addition, Uttal, Schreiber and DeLoache (1995) found that children performed significantly worse on the standard model/room task if they were delayed by two or five minutes prior to retrieving the target object. This kind of attentional issue may have affected the results of the present experiment. Children in the present study when identifying the target location in the model were able to do so almost immediately after viewing the target location in the real room. However, when identifying the location in the room itself, children first had to get up and then move about within the room in order to get to the target location. This time delay then, may have affected children's performance just as it did in Smothergill's study. Therefore, perhaps the reason for this poorer level of performance is the amount of time that the children were required to hold information in memory. Once again, the use of a smaller sized referent space might be advantageous, in order to reduce the amount of time for which children must hold information in memory when completing Model-To-Room trials. Nevertheless, since the referent space and the model were in view at all times, the relevant information about the target location was constantly available to the child. Therefore, memory load would have been minimal.

However, Table 2 also reports that children took longer to complete Retrieval trials than they did to complete Positioning trials. And as Table 1 reports, children were actually significantly more successful on Retrieval trials. Therefore, it appears that in this case the length of time for which information was held in memory did not detrimentally affect performance. If anything, children who score highly take longer. In addition, the ceiling effect observed on Memory Check control trials appears to convincingly rule out the possibility that children had difficulties in holding the relevant information about the target location in memory. DeLoache has consistently argued that if a child fails a test trial, but completes the Memory Check trial, then the difficulties must lie in the representational domain, not within the domain of memory.

One further possibility is that children perform more poorly on Model-To-Room trials than they do on Room-To-Model trials, not because of the increased memory load and time, but because when carrying out a task in a real room, they are distracted by the additional, irrelevant material present in the room, which is not present in the model. This idea stems from studies of selective attention, which have found that young children's performance is poorer on tasks which require irrelevant information to be ignored (see Enns, 1990, for a review). In the present study the referent space used was a genuine, not a contrived room. The scale model contained representations of only the most salient features of the real room, thus resulting in a great deal of additional, irrelevant stimuli being present in the real room.

In DeLoache's (1987) study, every feature of the referent room was represented in the model, and vice-versa, which may possibly explain why children found that task easier to perform. When working in the real room in the present study, though, the children had to take in a good deal more information that had not been present in the model. Indeed, Liben, Moore and Golbeck (1982) also used a classroom as the referent space in their study, and in discussing the results they suggest that comparison with other studies may be difficult since the necessary complexity of a genuine environment necessarily exceeds that of a contrived laboratory space. The use of a large-scale referent space which does not contain large amounts of irrelevant information would enable this possibility to be further explored.

Table 3 shows that children scoring 1 correct take less time than those who score 0 correct, but that times then increase again for the children who score 2 correct. This initial pattern of less time being taken with increased success is supported by Figures 3 and 4, which illustrate that in both Conditions, children who scored only one correct took slightly more time on their unsuccessful trial than they did on their successful trial. However, the time taken then increases again in the group of children scoring 2 correct.

Figures 5 and 6 illustrate that the time taken by children on each Task also differs according to their level of success. The time taken by children completing Positioning trials, irrespective of Condition, appears to be relatively unaffected by performance. Therefore, children who score highly respond fairly quickly, but even children who are wholly unsuccessful take no extra time to consider their response.

This is in contrast to Retrieval trials, on which the time taken does differ depending upon success. In the Room-To-Model Condition, which children generally completed more quickly, those scoring most poorly take the longest amounts of time. This therefore suggests that when unsure, children take longer to consider their response, which they do not do when Positioning. These results should be treated with caution, though, since only one child in the Retrieval group scored 0 correct. The time taken then decreases in those children scoring more highly. This initial pattern is the same in the Model-To-Room Condition, suggesting that despite the small number of subjects in some groups within the other Condition, the pattern may be a reliable reflection of performance in general. However, in the Model-To-Room Condition, the time taken by children scoring most highly then increases. Therefore, children who understand the task and are correct about the target location, nevertheless take longer to select that location when in the room. This supports the notion that perhaps in this Condition, even the most successful children are distracted by the presence of the additional, irrelevant material in the room itself.

Errors

DeLoache has consistently argued that if a child fails a Test trial, but succeeds on the Memory Check control trial, the Test failure can reliably be attributed to a failure in the representational domain. As has been discussed in Chapter Three, however, further research has suggested that errors may arise for other non-representational reasons. Work by Blades (1991) indicates that failure can also arise when the target location is not unique, and the child is unable to use the necessary spatial information to determine which is the correct one. Furthermore, Soloman (1999) has identified Perseverative errors which arise when children simply opt for the last location at which they saw the target object. Thus, it is suggested that having classified errors as either Memory-based, Identical location errors or Perseverative errors, the remaining "Other" errors will comprise those which have arisen due to representational difficulties.

The present study's findings indicate that whilst "Other" errors still comprise the largest group, children do indeed make errors which are not Memory-based, yet not representational, as DeLoache has suggested. In fact, Identical location errors comprise the next largest group of errors overall, which supports Blades (1991) findings, that the absence of any identical hiding places in DeLoache's early studies may have contributed to the high levels of success that she observed.

The pattern of errors observed in the present study differs on Positioning and Retrieval tasks. Since performance on Positioning trials was poorer overall than on Retrieval trials, the number of errors made on Positioning trials is logically higher. However, it appears that most of the additional errors present on Positioning trials, fall within the classification of "Other" errors. The numbers of Memory-based, Identical location and Perseverative errors is similar for both Tasks, but children make far more "Other" errors. If the difficulty children have in completing these tasks lies within the representational domain, then there is no real reason to suppose that a child would be able to complete a Retrieval task more successfully than they would a Positioning task. If a child can appreciate the representational relationship between the model and the room, then we would expect them to do equally well irrespective of the Task. These results therefore suggest that errors classified as "Other" may include errors which are still not due to representational difficulties.

As discussed previously, it is possible that children perform better on Retrieval trials due to the familiar nature of the Task. Errors classified as "Other" may therefore include mistakes which occur as a result of the child not understanding the task. This would explain why Positioning trials incur a larger number of "Other" errors, rather than increased numbers of errors in all four categories.

Additionally, there are different patterns of errors made on Room-To-Model and Model-To-Room Conditions, when these are broken down by Task, as shown in Figures 8 and 9. On Positioning trials, the errors made by children are similar in both Conditions. However, on Retrieval trials the patterns are different. On Retrieval trials, the score data has already shown that children perform more poorly in the Model-To-Room Condition. Therefore, we would expect to see more errors in this Condition. However, once again, the additional errors made in this Condition appear to be concentrated in the "Other" errors category.

Children are no more prone to forgetting in this Condition, which challenges the earlier argument that it is the additional memory demands of this Condition which make it more difficult. Neither do they have any more difficulties in utilising spatial information to select the appropriate non-unique location. They make only slightly more Perseverative errors, but the majority of the additional errors in this Condition are classified as "Other". Under DeLoache's interpretation, this might be interpreted as an indication that appreciation of the representational relationship is more difficult in this Condition. However, in relation to the arguments presented previously, it may simply be that children have difficulty in processing the additional, irrelevant information present in the more complex and detailed real room, and that this causes the additional errors to occur. This would fit with the Time data, which indicates that children also take longer on this Condition than any other (see Figure 2).

Familiarity

Another interesting factor is that all of the children in the present study were highly familiar with the referent room. Several studies have found children's performance to be affected by familiarity with the referent space. Hart (1981) reports

> *"My research suggests that the development of children's spatial activity in their everyday geographic environment, and*

> *variations in the freedom of this spatial activity, are the most important forces influencing the quality, as well as the extent, of children's ability to represent the spatial relations of places in the large-scale environment." (p207)*

Thus we might expect that children would have the greatest understanding of a referent space with which they are already familiar. This being the case, the present study ought to have elicited better performance from the children than would have been the case if an unfamiliar referent space had been used.

Siegel and Schadler (1977) investigated children's ability to construct a model of their kindergarten classroom at the beginning of the school year, and then again at the end of the school year. The results show that increased familiarity enhances young children's ability to construct spatial representations of their classrooms. Discussing the advantages of using familiar spaces in spatial cognition research, they say

> *"With a few exceptions...experimental research on the development of children's knowledge of macrospace has been limited to the study of knowledge in novel, artificial, and/or simple environments...Little attention has been paid to the investigation of children's knowledge of actual and familiar large-scale spaces, yet it is within these domains that children develop, acquire and use their spatial knowledge." (p388)*

Siegel, Herman, Allen and Kirasic (1979) carried out a study with children using a large and a small-scale model town, which children were exposed to and then required to reconstruct. They found that children's construction accuracy improved over repeated exposures to the referent space, thereby supporting the notion that familiarity with a referent space can improve children's ability to understand representations of that space.

Herman and Siegel (1978) allowed children to repeatedly encounter a large-scale environment, which they were subsequently required to reconstruct, and found that performance did indeed improve after repeated experiences in the environment. It therefore seems reasonable to expect that children's performance on a spatial task using an environment which they had previously repeatedly encountered, would be better than performance on a task with an unfamiliar environment.

Feldman and Acredolo (1977) found that children were better able to relocate an object in an environment if they had originally explored that environment alone, than if they had originally explored it whilst holding an experimenter's hand. Thus it would appear that not only do children better appreciate a referent environment if they are familiar with it, but that the nature of their previous experience with that environment is also a factor. Feldman and Acredolo conclude that children are more sensitive to the spatial cues in an environment if they are free to explore that environment themselves. In the present study, since the referent space was the children's own playroom, all of the children had been free to explore the environment by themselves. Therefore, we would expect that they would be even more aware of the spatial arrangement of the room then they would be if an unfamiliar, unexplored space had been used.

In addition to this, Herman (1980) conducted an experiment where children experienced a model town, and were then required to reconstruct the town. Some of the children experienced the town by walking through it, whilst others only walked around it. Results showed that children were consistently more accurate in their reconstructions after having walked *through* the town, than if they just walked around the town. This suggests that the type of experience a child has of a particular space affects the quality of their cognitive maps of that space. This being the case, once again one might expect to find differences in performance on tasks where children are able to move freely within a particular space (as was the case in the playroom in the present study) as opposed to their performance on tasks where they can only observe from outwith a space (as was the case with the model in the present study).

Quality of the representation

The model which served as the representation in this experiment was a very basic, structural one, which depicted the main items of furniture only. Elements like soft furnishings, carpets and curtains, were not represented. The elements which were represented in the model were constructed from cardboard and did not necessarily correspond to the analogous objects in the real room in relation to colour, texture etc. The walls of the model did not match in colour the walls of the referent room. Previous research by DeLoache (1991) has indicated that the structural similarity between elements of a model and the room it represents, can affect children's ability to understand and to use that model as a representation of space.

Other authors, however, argue that the nature of a representation is such that it ought to represent and not replicate its referent (e.g. Downs, 1985). Therefore, if a child recognises the symbolic relationship between a model and its referent room, then this recognition should not be significantly affected by physical similarity between the two. If it is, then this might suggest that the children are succeeding based on understanding of correspondence or analogy, rather than a greater appreciation of a representational relationship (see discussion in Chapter Two). Further research might therefore investigate whether performance on these types of tasks is affected by the quality of the representation, in terms of its structural similarity to the referent space.

***Conclusions/Further research***

In relation to the original aims of this experiment, then, the results support the hypothesis that different methods and tasks used to assess children's understanding of spatial representations may not be equivalent in their demands, nor in the underlying cognitive processes which they tap.

Children's performance was not equivalent using Referent-To-Representation methods and Representation-To-Referent methods. Nor was performance shown to be equivalent on Positioning tasks and Retrieval tasks. Both of these findings fit with the original hypotheses for the study. Furthermore, this lack of equivalence exists not only in absolute levels of success, but also in the types of errors children make, and the amount of time they take.

On the basis of these results, though, several research questions can be formulated for further experiments to address. Firstly, this study used a referent space that was highly familiar to the subjects. One topic for further study will therefore be to investigate how children perform in a similar experiment using a completely novel referent space. Another study will investigate how children's understanding and use of a representation is affected as familiarity with the referent space increases over time.

In addition, the present study used a very basic, structural model as the representation. The issue of whether performance is affected by the physical similarity between a model and its referent space will be investigated in a further study.

Another issue to emerge is that when using a naturalistic space (e.g. a classroom) as the referent, as was the case in this experiment, there is necessarily a large amount of irrelevant material present that will not be present in a representation of that space. As previous research has also indicated, the necessary complexity of a genuine referent space makes comparisons with laboratory-based research using contrived referents very difficult. Further studies will therefore be designed to investigate just how children's understanding and use of a representation is affected by the presence of such irrelevant material in the referent space, and furthermore, to investigate how performance changes if, conversely, it is the representation which contains the irrelevant material.

Finally, the difference between Referent-To-Representation and Representation-To-Referent methods requires further exploration. Several suggestions have been made in the preceding discussion about what factors might be responsible for this difference. All subsequent experiments will be designed to pursue this issue, and to explore how children's abilities to infer in these two different "directions" might be affected by issues such as familiarity with the referent space, presence of irrelevant material and so on, as has been discussed here.

# CHAPTER FIVE

# The Effect of Using a Completely Novel Referent Space

## Experiment Two

### *Introduction*

The results of Experiment One indicated that children found completing a Retrieval task easier than a Positioning task, and also that under some circumstances they found inferring from a referent space to a representation, easier than inferring from the representation to the referent space. Apart from these differences in absolute levels of performance, some differences were also observed in the amount of time taken on different tasks and conditions, as well as in the types of errors made.

However, Experiment One made use of a referent space which was already highly familiar to the children. Other researchers have suggested that children's performance might differ when using familiar and unfamiliar spaces (e.g. Acredolo, 1982). This second study was therefore designed to investigate how children would perform in an analogous study to Experiment One, but using a completely novel room as the referent space.

A secondary aim of this study was to refine some methodological aspects, in order to examine whether these might have been responsible for one of the findings from Experiment One. Experiment One found that children were significantly more successful on the Retrieval Task than on the Positioning Task.

Several possible reasons for this were explored. Firstly, it is possible that finding tasks are just intrinsically easier for children than placing tasks. This might be due to their prior familiarity with "hide-and-seek" type games, or to motivational factors, if Retrieval tasks are more fun and therefore more enjoyable to complete.

Alternatively, it may be that methodological considerations contributed to the ease of the Retrieval tasks in Experiment One. The hiding places used in Experiment One were "under the table"/ "under the easel"/ "under the chute". It is possible that children were able to engage in a visual search that was not detected by the experimenter, and thus found the hidden object correctly by chance and not through their understanding of the representational function of the model. This is one difficulty which arises when using a naturalistic setting as a referent space. The experimenter must use the best hiding places already available in the environment, but these may be by no means ideal.

It seems unlikely, although not impossible, that the cognitive abilities required to Position and to Retrieve a toy, are so different that they might have contributed to the significant difference in performance observed in Experiment One. However, this was not a possibility to be ruled out at this stage, and the following experiment was designed to pursue the methodological issues first.

### *Preparation*

Several practical issues were taken into consideration when designing this experiment. It was decided that for the remainder of the project, it would be necessary to have a referent room which could remain constant throughout further experiments. A specially allocated room at the university was considered as one option, but the difficulties associated with then having to bring participating children from their schools to the university to take part, insurance issues, amount of school time missed, coupled with the potential concerns of parents, made this a less viable option. It was therefore decided that a caravan would be purchased and would serve as the referent room in future experiments. This had several benefits in that the same room could be used by many children at many different schools/nurseries. It also meant that schools would not have to provide the experimenter with space in which to carry out the experiments. To this end, a caravan was purchased, and arrangements were made for storing the caravan within the University gardens. Photographs of the caravan are included as Appendices Thirteen and Fourteen. A small-scale model of the caravan was then constructed.

This experiment, and subsequent ones, were carried out outwith the university itself, in schools in and around Stirling. Ethical approval therefore had to be sought from the Education Department at Stirling Council. A copy of the letter confirming that ethical approval was granted is included as Appendix Three. Following confirmation of Council approval, letters were sent out to Head Teachers of schools in the Stirling area, outlining the project, and asking for co-operation. An example of one of these letters is included as Appendix Four. Those schools which responded positively to these letters were then contacted by telephone by myself, and meetings with head teachers and class teachers were arranged. At these meetings, suitable dates were arranged for me to visit the school.

## *Method*

### Participants

Thirty-six children from St. Ninian's Primary School in Stirling served as participants in the experiment. Information sheets and consent forms were sent out to all children in the Nursery and Primary One classes. An example is included as Appendix Five. 56 forms were sent out altogether. The forms required parents/guardians to indicate whether or not they were happy for their child to take part in the study. 38 forms were returned indicating that consent was granted, and 7 were returned indicating that consent was not granted. The remaining 11 forms were not returned at all, and those children for whom forms were not returned were not included in the study. This gave a total possible sample of 38 children. Of these children, one did not want to "play the games", and one was absent from school due to illness. This left a total of 36 children, 24 from the Nursery and 12 from Primary One. 18 children were girls and 18 boys. The mean age of the Nursery children was 53 months (4;5), and this group was subdivided by means of a median split, into Nursery Young (mean age 49 months, 4;1) and Nursery Old (mean age 56 months, 4;8) groups. The mean age of the Primary One children was 65 months (5;5). The youngest child overall was aged 43 months (3;7) and the oldest 71 months (5;11).

### Materials

The caravan served as the referent room. A small-scale model of the caravan was constructed, the outer shell being made from plywood, with holes cut out for windows, and a hinged door. Wooden circles were attached to the sides to represent wheels. The furniture inside the model was constructed out of cardboard. Dolls' house carpet was purchased as floor covering for the model. Soft furnishings (mattresses/cushions) were made using cushion foam, with material covers. Curtains were also made out of material. Photographs of the model are included as Appendices Fifteen to Seventeen.

Using the Psychology Department car, the caravan was towed to the school the evening before testing was to commence. It was parked in the school playground as close as possible to the main entrance.

Procedure

See Chapter Three (General Method) for an overview of procedure.

This experiment was carried out in the same way as Experiment One, with children being randomly allocated to complete either Retrieval Tasks or Positioning Tasks. Children then completed four trials of their allocated Task, two of which were Model-To-Room trials, and the other two of which were Room-To-Model trials. A Memory-check control trial was completed after each Test trial.

Potential hiding places in the caravan were in the wardrobe; in the bathroom; in a drawer; in a cupboard. The wardrobe and the bathroom served as Unique locations, since there was only one wardrobe and only one bathroom. The drawers and cupboards served as Identical locations, since there were several drawers in a chest which the child would have to choose between, and several identical cupboards under the beds which the child would have to choose from.

For each test trial, success, time taken and details of any errors made were recorded, as detailed in Chapter Three.

***Results***

Scores

Table 1 shows the scores for both Conditions by Task. It can be seen that there was no difference between Retrieval and Positioning Tasks. As the table shows, though, children scored higher on the Model-To-Room Condition than they did on the Room-To-Model Condition.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Positioning (n = 18) | 41.7 | 39.3 | 66.7 | 34.3 | 53.1 | 32.6 |
| Retrieval (n = 18) | 52.8 | 40.1 | 61.1 | 36.6 | 55.6 | 33.8 |
| Total (n = 36) | 47.2 | 39.5 | 63.9 | 35.1 | 54.3 | 32.8 |

*Table 1. Mean score in each Condition, by Task.*

The overall mean score on test trials was just 54%, which is in sharp contrast to performance on control trials, where the mean score was 95%. A paired samples t-test revealed this to be a highly significant difference ($t_{35} = -6.59$, $p < 0.01$).

Table 2 shows the mean scores in the two Conditions, for each of the three Age Groups. It appears that scores increased as children got older, in both Conditions, but scores were consistently higher in all three Age Groups, on the Model-To-Room Condition.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| Age Group | %age correct | SD | %age correct | SD | %age correct | SD |
| Nursery Young (n = 11) | 20.8 | 33.4 | 45.8 | 39.7 | 31.7 | 29.9 |
| Nursery Old (n = 13) | 50.0 | 36.9 | 62.5 | 31.1 | 54.2 | 29.8 |
| Primary One (n = 12) | 70.8 | 33.4 | 83.3 | 24.6 | 77.1 | 22.5 |

*Table 2. Mean score in each Condition, by Age Group.*

Preliminary analyses revealed no effect of Gender, so this variable was omitted from subsequent analyses. The data were analysed using a 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Positioning vs. Retrieval) x 3 (Age Group: Nursery 3 years vs. Nursery 4 years vs. Primary One) mixed ANOVA, with Condition as a within-subjects variable.

The difference between the two Conditions observed in Table 1 was significant ($F_{1,30} = 6.923$, $p = 0.013$). There was also a main effect for Age Group ($F_{2,30} = 8.444$, $p < 0.01$), supporting what is shown in Table 2. The interaction between Condition and Age Group was not significant, but as Figure 1 illustrates, children's performance on the two Conditions does appear to change as they get older.

As can be seen from Figure 1, children in all three age groups scored higher on the Model-To-Room Condition than they did on Room-To-Model. However, the difference between the two Conditions was most pronounced in the youngest age group. The difference is less in the middle age group and for the eldest children.

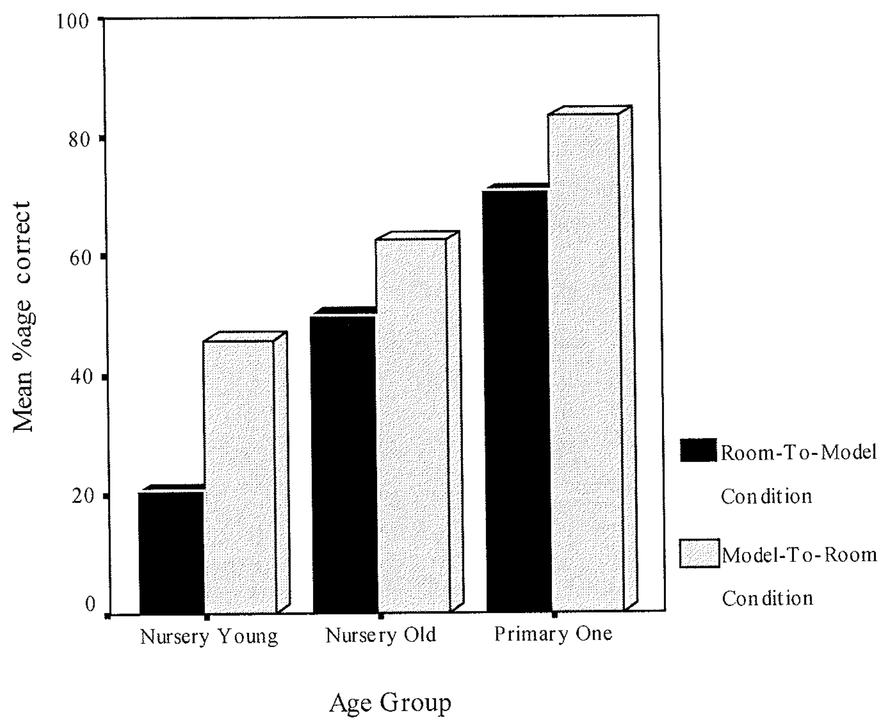


*Figure 1. Mean score in each Condition by Age Group.*

Time taken

Table 3 shows the times taken by children in each Condition, by Task. In general, there does not appear to be any difference between the times taken in the two Conditions, but Retrieval trials seem to have taken longer overall than Positioning. Table 4 shows the times taken by children in both Conditions, depending upon their level of success. Children were classified into groups according to their level of success, as in Experiment One. These results seem to indicate a general decrease in time taken, as the children's levels of success increased. Table 5 shows the times taken by children in each Condition at each Age Group.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Positioning (n = 18) | 6.04 | 3.29 | 8.59 | 4.04 | 7.32 | 2.74 |
| Retrieval (n = 18) | 15.79 | 7.85 | 12.69 | 8.95 | 14.24 | 7.95 |
| Total (n = 36) | 10.91 | 7.72 | 10.65 | 7.15 | 10.78 | 6.83 |

*Table 3. Mean time taken in each Condition, by Task.*

The time data were analysed in the same way as for Experiment One, with the inclusion of an additional Age Group variable. Thus, a 2 (Task: Retrieval vs. Positioning) x 3 (Level of Success: 0 vs. 1 vs. 2 correct) x 3 (Age Group: Nursery Young vs. Nursery Old vs. Primary One) mixed ANOVA was carried out on the data for each of the two Conditions. As in Experiment One, this was to investigate whether the level of success on particular Tasks affected the amount of time that children took.

| | Condition | | | |
|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | |
| Number of correct responses | Mean time (secs) | SD | Mean time (secs) | SD |
| 0 | 13.49 (n = 12) | 8.69 | 17.25 (n = 5) | 13.31 |
| 1 | 10.74 (n = 14) | 7.83 | 12.12 (n = 16) | 5.48 |
| 2 | 8.08 (n = 10) | 5.76 | 6.88 (n = 15) | 3.43 |

*Table 4. Mean time taken in each Condition, by score.*

As in Experiment One, this analysis revealed a main effect of Task in the Room-To-Model Condition ($F_{1,23} = 18.057$, $p < 0.01$) and the Model-To-Room Condition ($F_{1,21} = 8.365$, $p < 0.01$). This supports what is shown in Table 2, as well as the results of Experiment One, in that children took significantly more time when completing a Retrieval Task, than they did when completing a Positioning Task. However, the difference between the two Tasks is more marked on Room-To-Model trials, as illustrated by Figure 2.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| Age Group | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Nursery Young (n = 11) | 12.30 | 7.43 | 10.30 | 6.16 | 11.30 | 5.82 |
| Nursery Old (n = 13) | 12.95 | 9.51 | 14.07 | 8.79 | 13.51 | 8.64 |
| Primary One (n = 12) | 7.48 | 4.96 | 7.57 | 4.91 | 7.53 | 4.48 |

*Table 5. Mean time taken in each Condition, by Age Group.*

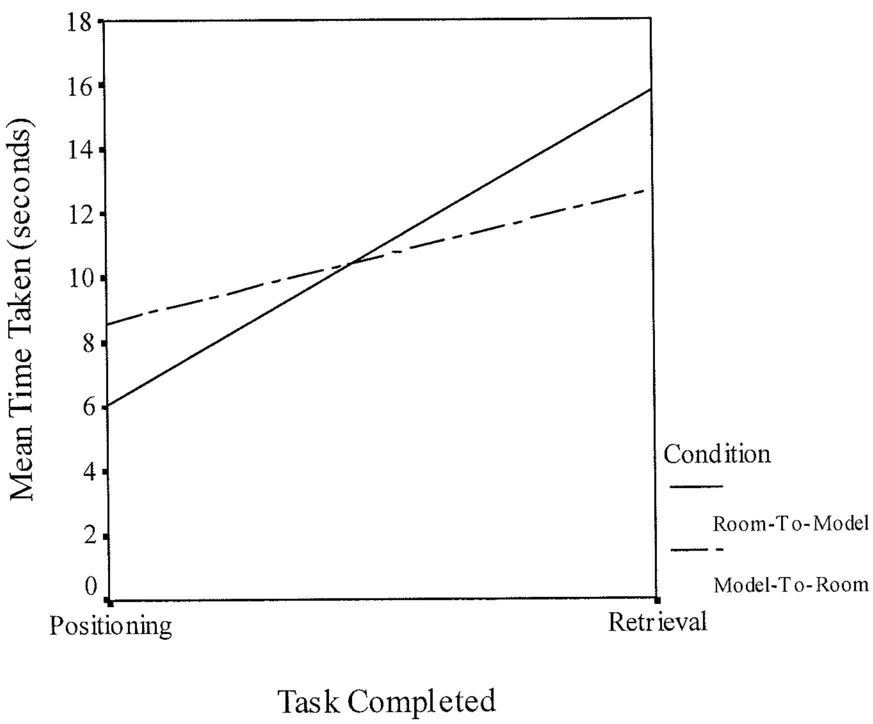


*Figure 2. Mean time taken on each Task, by Condition.*

Figure 3 shows that the time taken by children in each of the two Conditions differs according to the Age Group of the child. This effect of Age Group was only significant in the Model-To-Room Condition ($F_{2,21} = 6.772$, $p < 0.01$). Post-hoc Tukey tests show that the difference between the Nursery Young group and the Nursery Old group is approaching significance ($p = 0.058$), and the difference between Nursery Old and Primary One is highly significant ($p < 0.01$).

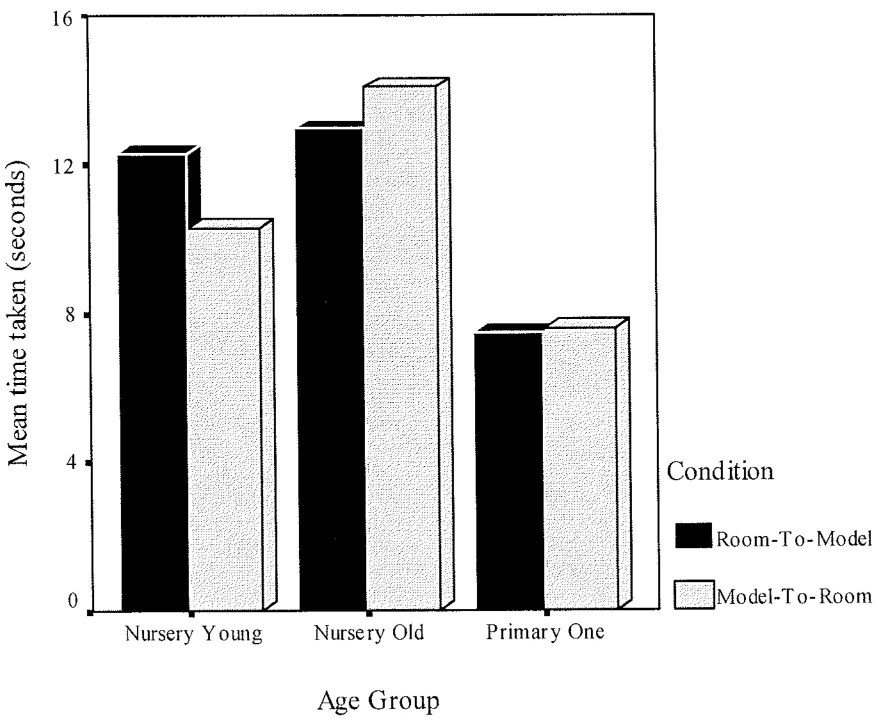


*Figure 3. Mean time taken in each Age Group, by Condition.*

As in Experiment One, the analyses here revealed a significant main effect of Success in both the Room-To-Model Condition ($F_{2,23} = 4.150$, $p < 0.05$) and the Model-To-Room Condition ($F_{2,21} = 10.654$, $p < 0.01$). Table 4 shows the different times that were taken by children at different levels of success. It is clear that children with the lowest levels of success take longest, and time decreases with each increased level of success. This same pattern of time taken is evident in both Conditions. Post-hoc Tukey analyses reveal that on Model-To-Room trials, there are significant differences between all possible combinations of Level of Success. In the Room-To-Model Condition, however, the only difference lies between 0 and 2 correct.

Figures 4 and 5 show the time taken by children in each of the two Conditions, but the data for the groups scoring one correct has been split to show the time taken by these groups on their one incorrect trial and that on their one correct trial. These figures illustrate that the groups scoring one correct took longer when they were unsuccessful then when they were successful. Paired sample t-tests showed that the difference between these groups' times on incorrect versus correct trials was significant in both the Room-To-Model Condition ($t_{13}$ = 2.953, p = 0.011) and the Model-To-Room Condition ($t_{15}$ = 3.415, p = 0.004).

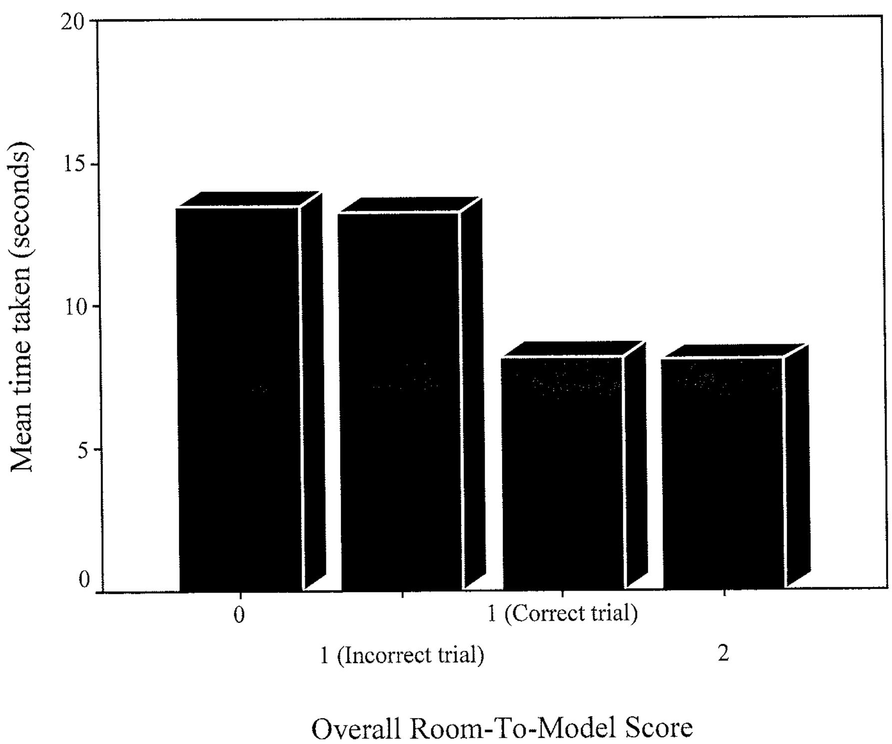


*Figure 4. Mean time taken, by score in Room-To-Model Condition.*

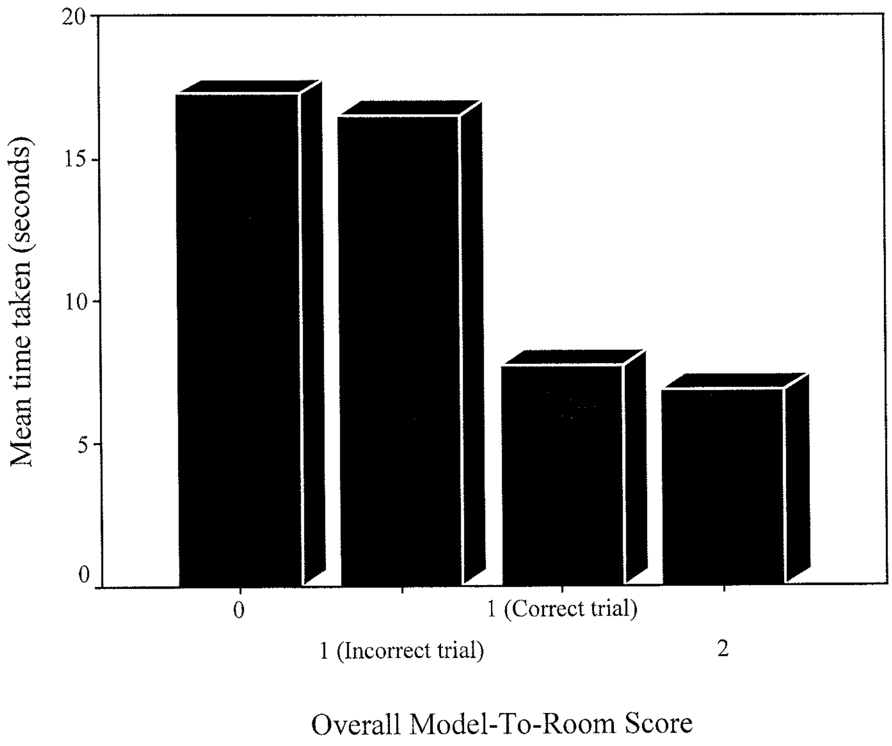


*Figure 5. Mean time taken, by score in Model-To-Room Condition.*

As has already been mentioned, Age Group was observed to significantly affect time taken in the Model-To-Room Condition. In addition, Age Group interacts significantly with Level of Success in that Condition ($F_{3,21} = 3.596$, $p < 0.05$). As shown in Figure 6, the youngest children take more time overall as their level of success increases. However, for the two older age groups, the time taken is less as their level of success increases. In the oldest group of children, this decrease in time taken is more dramatic between the group which scored 0 and the group which scored 1. Later analyses will explore the different types of errors made at different age groups (see Figure 11). It should be noted that ideally one would want to conditionalise the data shown in Figure 6 upon that in Figure 11, to allow for a more sensitive analysis of the particular types of errors made by children of different age groups at different levels of success. Unfortunately within the present project there would be too few data points to permit a powerful analysis of this nature.

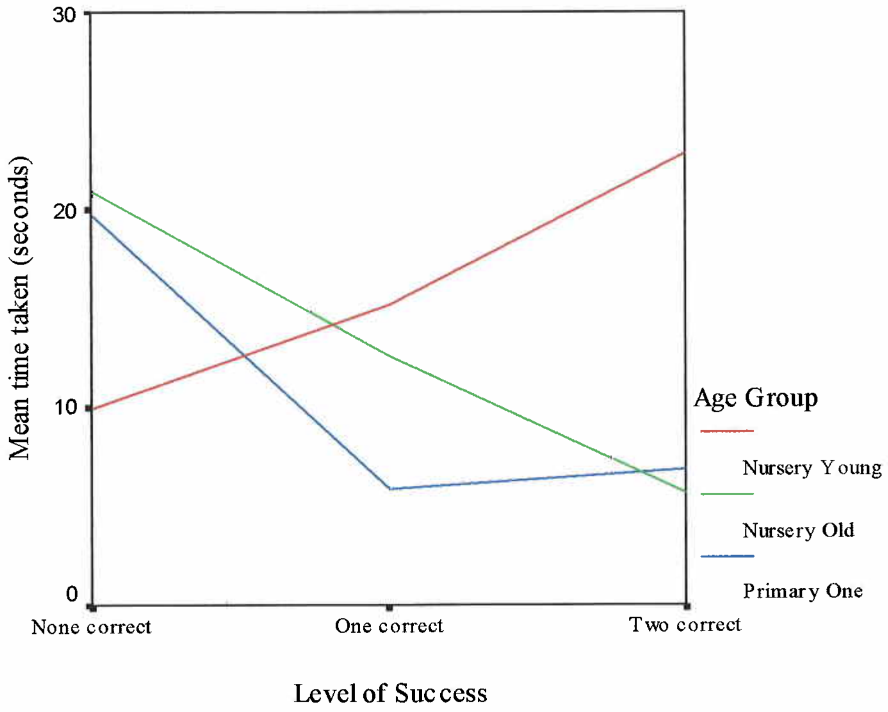


*Figure 6. Mean time taken in Model-To-Room Condition, by score.*

<u>Error data</u>

The errors that the children made were classified into four categories, as in Experiment One (see Chapter Three, General Method, for an overview). Thus, each error was classed as "Memory-based", "Identical location", "Perseverative" or "Other". The mean numbers of the four types of errors made are given in Table 6. Children made fewer errors overall on the Model-To-Room Condition. This is no surprise, given that we have already seen from the Scores analysis that children scored significantly higher on this Condition. Figure 7 illustrates the mean number of each error type that children made. Clearly Identical location and

Other errors comprise the largest groups of errors, with much fewer Perseverative and Memory-based errors.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.00 | 0.00 | 0.39 | 0.49 | 0.08 | 0.37 | 0.58 | 0.84 |
| Model-To-Room Condition | 0.05 | 0.23 | 0.22 | 0.42 | 0.11 | 0.32 | 0.36 | 0.64 |
| Total | 0.05 | 0.23 | 0.61 | 0.64 | 0.19 | 0.62 | 0.92 | 1.25 |

*Table 6. Mean number of errors made in each Condition.*

A 2 (Condition: Room-To-Model vs. Model-To-Room ) x 2 Task (Retrieval vs. Positioning) x 3 (Age Group: Nursery Young vs. Nursery Old vs. Primary One) ANOVA, with Condition as a within-subjects variable was carried out on the data for each of the four error types. There were no significant effects of Task, nor of Condition, for any of the four error types. However, the pattern of errors made on the two Conditions appears to differ slightly, as illustrated by Figures 8 and 9.

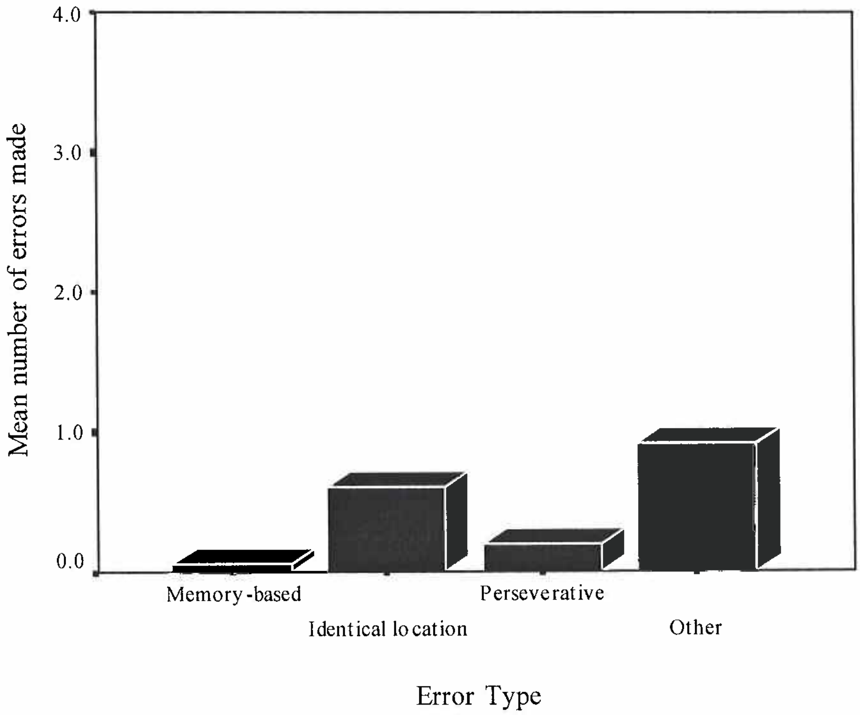


*Figure 7. Mean number of errors made.*

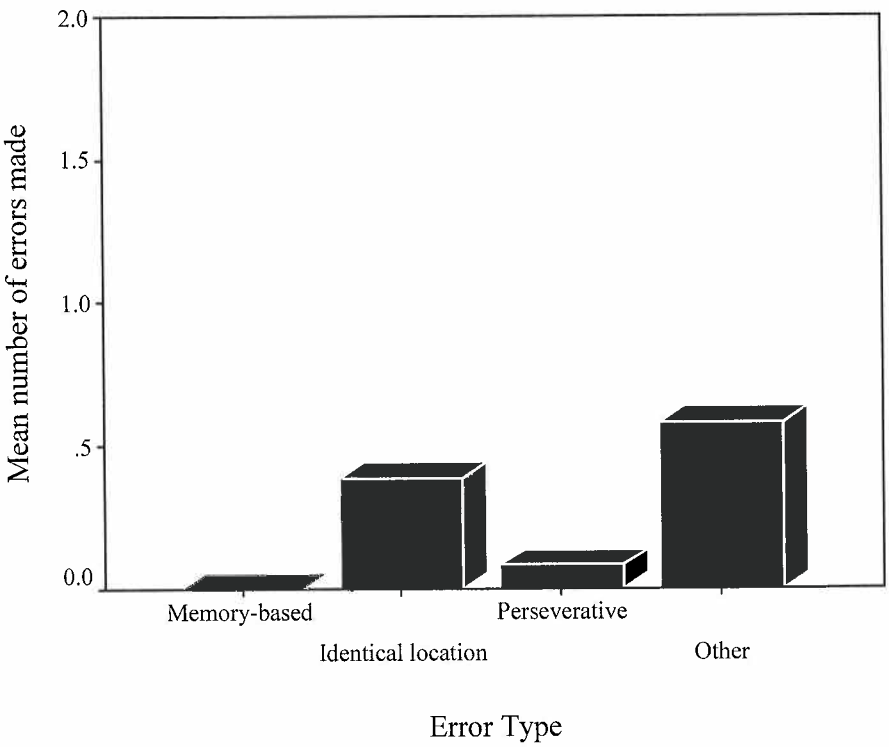


*Figure 8. Mean number of errors in Room-To-Model Condition.*

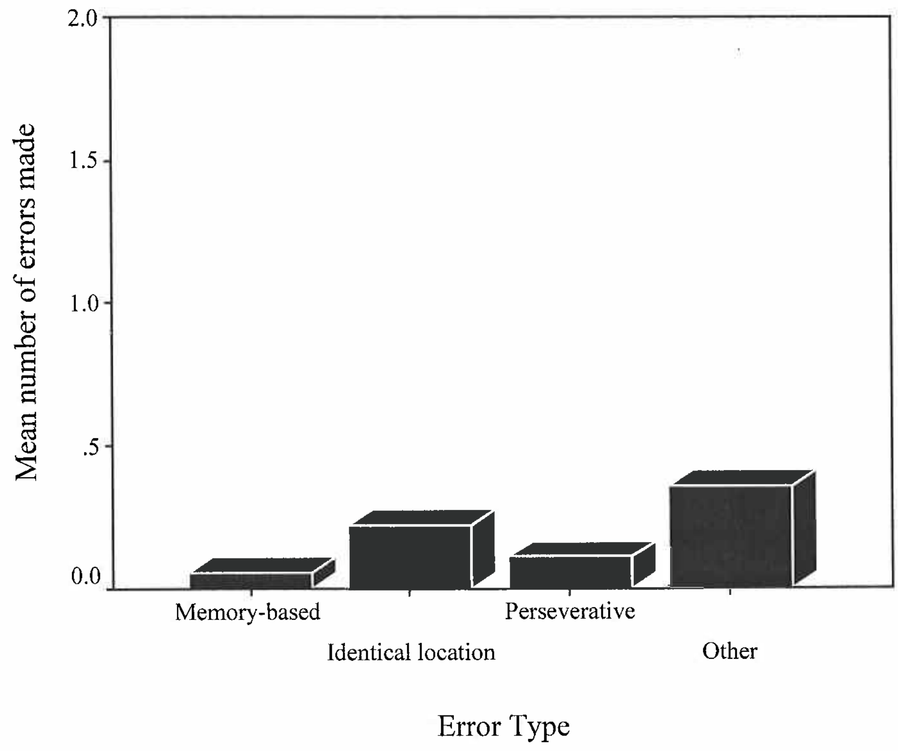


*Figure 9. Mean number of errors in Model-To-Room Condition.*

Children in both Conditions make similar numbers of Memory-based and Perseverative errors. However, in the Room-To-Model Condition, children seem to make more Identical location and Other errors.

The analysis also revealed a significant main effect of Age Group on Other errors ($F_{2, 30} = 6.708$, $p < 0.01$) and a marginally significant effect of Age Group on Identical location errors ($F_{2, 30} = 3.162$, $p = 0.057$). Thus, it appears that the pattern of errors may be slightly different at different age groups. This is illustrated by Figure 10. The pattern of errors for the Nursery Old and Primary One groups is similar, however, it is clear from this graph that the youngest children are making a different pattern of errors altogether. Whilst the number of Memory-based errors remains low, these children make far fewer Identical location errors than either of the older two groups. Perseverative errors occur more frequently than for the older children, and errors classified as Other are by far the largest group.

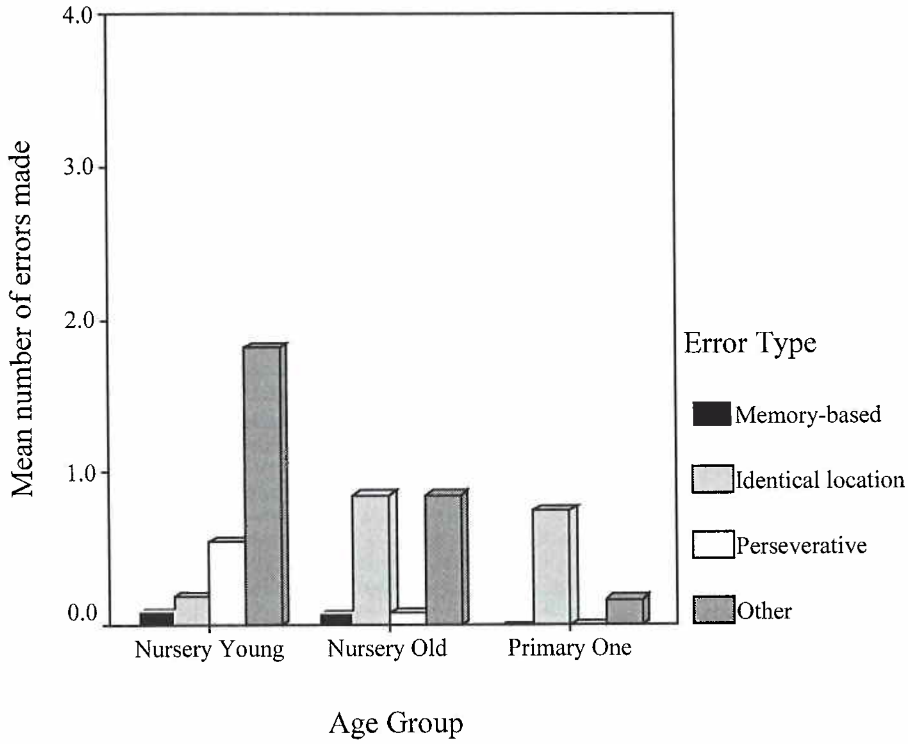


*Figure 10. Mean number of errors for each Age Group.*

***Discussion***

Scores

Experiment Two was designed to assess children's performance under similar conditions to Experiment One, but using a completely novel referent space. Like Experiment One, performance on Experiment Two was much poorer than had been found by DeLoache (1989), with children here scoring an overall mean of 54% correct on test trials. However, high levels of success were observed on Memory check control trials, which fits with the findings of both DeLoache and of Experiment One.

Experiment One revealed that children found Retrieval Tasks easier than Positioning Tasks, and several possible explanations were proposed for that difference. Experiment Two ensured the use of completely hidden target locations, to guard against the possibility that children were engaging in an undetected visual search on Retrieval Tasks in Experiment One.

With these methodological differences in place, the results from Experiment Two reveal no significant difference between children's scores on Retrieval and Positioning trials. It is therefore likely that in Experiment One, methodological issues made it easier for children to succeed on Retrieval trials than on Positioning trials. Certainly, it no longer seems likely that positioning an object on the basis of information from a representation is an intrinsically more complex task than finding an object on the basis of the same information, which was a possibility discussed previously. Nevertheless, it is still likely that children find a hide-and seek task more familiar than an object placement task, although this familiarity with the Task does not necessarily improve performance.

In a sharp contrast to Experiment One, Experiment Two found that children performed significantly better on the Model-To-Room Condition, than they did on the Room-To-Model Condition. This fits with the suggestions of Liben (1997) that perhaps tasks which require children to make an inference from a representation to a referent space might represent Comprehension tasks in this domain, whereas tasks which require the converse inference to be made might usefully be thought of as Production tasks. Under Liben's hypothesis, we would therefore expect Comprehension skills to emerge earlier in development than Production skills, and the results of Experiment Two appear to support that hypothesis. However, as Liben, Moore and Golbeck (1982) point out, studies which utilise familiar referent spaces should not necessarily be assumed to be equivalent to studies utilising novel referent spaces.

The observed contrast between the results of Experiments One and Two certainly appears to suggest that familiarity with the referent space has a considerable effect on the performance observed in children. However, it might not necessarily be the level of familiarity with the referent space which contributed to the differences in performance between Experiments One and Two, since certain other factors could not be controlled for between the two experiments. The different scalings of the models used in Experiments One and Two was discussed in Chapter Three. Whilst unlikely, it is possible that the use of a different scaling of model was responsible for the reversal in the pattern of performance between the two experiments.

Furthermore, the referent room used in Experiment Two was smaller in size than the room in Experiment One, and this was therefore another factor which could not be controlled for, and which might therefore have affected the results. However, if the large sized referent room in Experiment One caused children to score worse on the Model-To-Room Condition in that experiment, we might have expected the smaller sized room in Experiment Two to have elicited comparable levels of performance between the two Conditions in the second experiment. In fact, what was observed was a completed reversal of the pattern of performance from Experiments One to Two. This factor thus seems unlikely to account for the difference between Experiments One and Two, but should not be entirely ruled out in explaining the results.

Furthermore, there were some differences between the groups of subjects used in these two experiments. Those in Experiment One were taken from a university playgroup made up almost entirely of children of university staff and students. Children in Experiment Two, in contrast, came from a suburban local education authority primary school. It is possible that the different backgrounds of these groups had an effect upon their performance. Furthermore, since the children in Experiment One were tested within their own playroom, and the referent space was one with which they were familiar, and in which they were comfortable. In contrast, children in Experiment Two were tested away from their own classroom in a completely novel room. Thus, the social context of the experimental setting differed between the two groups, and might also have had an effect upon performance.

The effect of additional, irrelevant information in the referent space was discussed in relation to the results of Experiment One. In that experiment, children performed more poorly in the Model-To-Room Condition, and it was suggested that this might be due to the distraction caused by additional material present in the room, which was not represented in the model. In Experiment Two, although the referent room was still a genuine and not a contrived laboratory space, nevertheless it contained very little additional material which was not represented in the model. Thus, it could be argued that it was this difference which led to the change in performance on Experiment Two.

However, if the presence of this irrelevant material in the referent space had an effect on Model-To-Room performance in Experiment One, then we would have expected performance under the two Conditions to become almost equal in Experiment Two. Yet this was not the case. In fact, performance was significantly better in what was previously the significantly poorer Condition.

Thus, it seems unlikely that the lack of irrelevant material in the referent space was responsible for the change in performance in Experiment Two, although the specific effect of irrelevant material on performance will be investigated in later experiments.

In addition to Liben's explanation for the difference between Model-To-Room and Room-To-Model Conditions, Chapter Two also discussed the idea that inferring from a representation to a referent space is the way that maps and other representations of space are typically used. Using a referent space to complete some manipulation of a representation is generally a less common task, and might therefore be more difficult merely due to its being counter-intuitive. However, it appears that whichever reason is responsible, this difficulty of inferring from a referent space to a representation is reduced when children use a highly familiar referent space.

It is also important to note that the difference between performance on Room-To-Model and Model-To-Room Conditions which was observed in Experiment Two, differs depending upon the child's age. Figure 1 illustrates that this difference is most pronounced in the youngest children, and post-hoc analyses confirm that in the oldest group the difference is no longer significant. This suggests, then, that whilst inferring from a representation to a referent space might be an easier task for younger children, the understanding required to infer in the opposite "direction" equally as successfully has developed by around 6 years of age.

The youngest group of children in Experiment Two had a mean age of 49 months (4;1). The children in Experiment One, however, had a mean age of 43 months (3;7). It is possible that this 6 month difference in age was responsible for the difference between performance on the two Conditions in both experiments, rather than any effect of familiarity. Given the trends evident in Figure 1, though, this seems unlikely. If anything, on the basis of Experiment Two, we would expect a younger group of children to perform more poorly overall, and to show an even greater disparity between the Model-To-Room and Room-To-Model Conditions. In fact, the children in Experiment One actually scored higher overall than the youngest group in Experiment Two – a mean of 44.2% versus 31.7% correct respectively. Thus, the difference in performance on Model-To-Room and Room-To-Model Conditions, between Experiments One and Two does not appear to be a developmental one, nor the result of the lack of additional material in the referent space. It seems to be the case that the lack of any prior familiarity with a particular referent space affects performance on these two Conditions.

<u>Time taken</u>

Table 3 shows that children took comparable amounts of time overall, on both Conditions. This is in contrast to Experiment One, in which children took significantly longer on the Model-To-Room Condition. It was suggested that in Experiment One, the reason for this was that on the Model-To-Room Condition children had to get up and carry out a task in a large-scale space, whereas in the Room-To-Model Condition, they merely had to carry out a task in a small-scale model in front of them.

In Experiment Two the referent space was smaller in size than the playroom which was used in Experiment One. Nevertheless the caravan used in Experiment Two was still a large-scale space, and it is therefore somewhat surprising that the amount of time taken on the Model-To-Room Condition was not even slightly more than in the Room-To-Model Condition.

This suggests that it was perhaps not merely the scale of the room which was responsible for the additional time taken in the Model-To-Room Condition in Experiment One. Perhaps it was the children's familiarity with the referent space which hindered the children on this Condition and caused them to take more time. Alternatively, it may have been the additional material present in the room which distracted them and increased the length of time they took, as mentioned previously.

In Experiment Two, the amount of additional material was approximately the same in both model and room, but in Experiment One there was more in the room. If this was a factor affecting the length of time taken on the Model-To-Room Condition in Experiment One, then in Experiment Two we would expect children to take similar amounts of time on both Conditions. In fact, this is exactly what was observed, so it may well be the case that this variable affected performance.

Hardwick et al. (1976) and Smothergill (1973) have suggested that memory load might contribute to the difficulty which children sometimes have on tasks in large-scale environments, compared to small-scale environments. In relation to the results of Experiment One, it was suggested that children's poor scores on the Model-To-Room Condition might be due to the additional time required to complete tasks in this Condition.

If this is the case, then on Experiment Two, we would expect children to score equally as well on both Conditions, since they took similar amounts of time on both. In fact, this was not what was observed. Despite the fact that children took similar amounts of time, they actually performed significantly better on the Model-To-Room Condition. It therefore seems unlikely that the amount of time for which information had to be held in memory was responsible for the poorer performance of children in the Model-To-Room Condition in Experiment One.

As in Experiment One, the results of Experiment Two revealed a significant difference between the amount of time taken on Retrieval trials and the amount of time taken on Positioning trials. As shown in Table 3, the Retrieval Tasks once again took children significantly longer to complete overall. However, as the Scores analysis has already shown, children are no longer scoring higher on Retrieval Tasks, as they were in Experiment One. Thus, it appears that a task requiring children to find a hidden object will consistently take longer than a placing task.

In addition, the results seem to show that whilst children did take consistently longer on Retrieval than on Positioning trials, in the Model-To-Room Condition, the difference is relatively small. However, in the Room-To-Model Condition, on which children were less successful overall, the difference is more marked. In this Condition, children were even quicker on the faster of the two Tasks (Positioning), and even slower on the slower of the two Tasks (Retrieval).

As has been mentioned previously, there was no overall difference between the time taken in the two Conditions. However, as Figure 3 shows, the times taken on the two Conditions differed in the three Age Groups. Children in the youngest Age Group were slowest in the Room-To-Model Condition. The middle group of children seem to take similar amounts of time in both Conditions, though they are slightly slower in the Room-To-Model Condition. The oldest children took similar amounts of time on both Conditions.

As in Experiment One, the results of Experiment Two revealed a significant main effect of Success in both Conditions. Table 4 shows that in both Conditions, the amount of time taken was greatest in the group scoring 0 correct responses. The group scoring 1 correct response took less time, and the group scoring all correct took least time. In addition, Figures 4 and 5 show that the group who scored 1 correct response were faster when they were correct than when they were incorrect.

This clearly suggests that children respond more quickly overall if they are confident about the correct target location. However, on the face of it, this seems to contrast with the results of Experiment One, which indicated that although the amount of time taken decreases with increased success from the 0 to the 1 correct group, the most successful group then increase in time taken again. However, the significant Age Group x Level of Success interaction in the Model-To-Room Condition within the present experiment suggests that the amount of time taken according to level of success might alter developmentally. Figure 6 shows the time taken by each of the three Age Groups, and it is clear from this that the pattern of time taken by the youngest group at each level of success is actually very similar to the pattern found in Experiment One.

The youngest children in Experiment Two are the closest in age to the children in Experiment One, as has been mentioned previously. And this group in Experiment Two are the only group whose times increase with increased success, which is similar to what was found in Experiment One. It may be, then, that when younger children are unsure of a correct response, they respond quickly with little consideration. Whereas when older children are unsure, perhaps they consider their response prior to responding.

Error data

The pattern of the four different types of errors is similar for both Experiments One and Two, with "Other" and "Identical location" errors making up the two largest groups. Once again this supports Blades' (1991) suggestion that children find it quite difficult to differentiate between identical hiding places, and that the use of entirely unique locations in DeLoache's original experiment might well account for the high level of success she observed.

This also lends further support to the idea that it is not only difficulties within the representational domain, or difficulties with the dual nature of representations, which lead to children's failure on tasks using representations, which is what DeLoache has suggested.

As Figures 8 and 9 illustrate, the number of Memory-based and Perseverative errors is relatively unaffected by Condition. It is only Identical Location errors and Other errors which increase on the Room-To-Model Condition. If children's poorer performance on the Room-To-Model Condition was due solely to the counter-intuitiveness of this method, or to the fact that this might represent a more difficult "Production" type task, then we would expect the difficulties to lie in the representational domain, and to therefore be classified as Other errors. In fact, whilst the number of Other errors does increase, so too does the number of Identical Location errors, which suggests that representational problems cannot be the only additional factor affecting performance in this Condition.

It appears that distinguishing between two or more identical locations is also harder to do in a model than it is in a real room. This might well be because of the scale of a model. Perhaps because of the small distances between locations in the model, it is easier to become confused as to which is the correct one. In the referent room, however, distances between items are much larger, and therefore different locations are more distinct from one another.

It is interesting to note, however, that no such increase in Identical Location errors was observed in this Condition in Experiment One (see Chapter Four, Table 4). This may be due to the high level of familiarity which the children in that experiment had with the referent space. It seems likely that children would be more capable of correctly distinguishing identical locations if they were familiar with the referent space.

Figure 10 shows that the pattern of errors made was affected by Age Group. This is very interesting, as it illustrates a difference between the kinds of mistakes which children of different ages make. It clearly shows that the oldest group of children make very few Other errors indeed. Thus suggesting that these children have no difficulties in appreciating the representational relationship between the model and the referent room. For these children the only remaining problem appears to be in utilising the information about spatial relationships, in order to correctly distinguish between identical locations.

The middle group of children have similar difficulties in distinguishing spatial relationships, but they are also still making Other errors. This suggests that they still have difficulties in appreciating the representational relationship between the model and the room, or that they still do not fully understand the task. However, the pattern of errors is very obviously different for the youngest group of children.

These children make small numbers of Memory-based errors, and therefore do not appear to fail due to forgetting the target location. But they also make very few Identical location errors. This is very significant in shedding light on the kinds of strategies which children adopt in order to solve these tasks. The older children are clearly attempting to use basic representational information about object correspondence to identify the target locations, but are failing to correctly utilise the available spatial information which would enable them to differentiate between two or more identical objects. But these youngest children have clearly not yet grasped even the basic representational information which is available to them. They make higher numbers of Perseverative errors then either of the other two groups, which is a typical response bias in many domains, and make very large numbers of Other errors.

All of this strongly supports several theories as to how the understanding of spatial representations develops, as discussed in Chapter One. For example, Gentner's (1983) theory of analogical reasoning, as incorporated into DeLoache's (1995) model, supports the notion that children's understanding develops from a lack of any appreciation of any relationship between representation and referent space, to a basic understanding of object correspondences, and finally an appreciation of relationships between objects. The errors made by children here seem to support this theory of development. They also seem to support Piaget's theory that a full concept of space emerges late in development, and therefore that the ability to fully understand and use spatial representations is a later developing skill than has been suggested by DeLoache.

### *Conclusions*

It appears, then, that using a completely novel referent space has had a considerable effect upon children's ability to understand and to use a representation of that space. When the environment is unfamiliar, inferring from the representation to the referent space is significantly easier for children than inferring from the referent space to the representation. Given the results, it seems unlikely that the lack of irrelevant material in the referent space is responsible for this pattern of performance, and nor does it seem likely that the age difference between the children in Experiments One and Two is responsible.

These results fit well with several different hypotheses about children's understanding and use of external representations of space – firstly Liben's (1997) suggestion that the inference from representation to referent space might represent an easier Comprehension task for young children, and secondly, the suggestion (see Chapter Two) that this inference is easier because it is the way in which representations are typically used. The results indicate, though, that by around six years of age, children are capable of making both types of inference equally as well.

In addition, slightly different patterns of errors emerged in the two Conditions. In the Room-To-Model Condition, which was where children made more errors, those additional errors appeared in the Identical location and the Other categories. If the above hypotheses are correct about the reason for the difficulty of this Condition, then we might expect the additional errors to fall only in the "Other" category. What was observed, however, was an increase in Identical location errors as well. This suggests that something about this Condition makes it more difficult for children to distinguish between locations in a small-scale model, than in a large-scale room. Given that DeLoache's studies used only unique hiding places, perhaps this contributed somewhat to the comparability of performance in both Conditions which she has previously observed.

The methodological refinements implemented in this experiment appear to have removed the advantage for children completing Retrieval trials. Children scored comparably on both Retrieval and Positioning Tasks. However, completing a Retrieval trial consistently takes more time than completing a Positioning trial. The additional time required, however, does not adversely affect children's scores.

Some interesting developmental issues emerge from the results. The amount of time taken was seen to differ depending on how successful children were overall, with the more successful children taking less time than the less successful ones overall. However, this pattern was different in the youngest group of children. The group of least successful younger children actually took less time than the more successful groups. This strongly suggests that in younger children, when a child is unsure of the correct response, they do not spend any additional time considering what their response might be – they simply make an incorrect response more quickly. However, in older children, a child who is unsure of the correct response will spend more time in consideration of their response, even though the response they eventually make is still incorrect.

Some interesting developmental trends also emerge from the analysis of the children's error data. The oldest children in this study made very few Other errors. Their overall performance was by no means at ceiling, but their errors indicate strategic responding. Almost all of the errors made by children in this group were classed as Identical Location errors, which strongly suggests that the children had grasped the representational relationship between the model and the room, and that they had a good understanding of object correspondences. However, their failures resulted from the lack of an appreciation of spatial relationships between objects in the room. For example, a child could clearly recognise that the small dog was in a drawer in the model, and realised that this information could enable him to locate the large dog in the room. In addition, the child could then recognise the correspondence between the drawers in the model and the drawers in the room. However, they would be unable to differentiate between the two possible drawers by using the spatial information which would allow for an identification of the correct one through its relation to other items.

The middle group of children also made large numbers of these Identical location errors, but were also still making Other errors, which suggests that they had not yet fully developed an understanding of basic object correspondences. The youngest children, however, made very few Identical location errors. Their errors were mainly Perseverative or Other. Perseveration is a typical response bias in young children. This suggests that the younger children were responding quite randomly, without even a basic grasp of the representational relationship between model and room.

This study builds upon the findings of Experiment One, by illustrating the differences in children's understanding and use of a representation of space, when the referent space is completely novel. It also highlights the different strategies adopted by children of different ages, when carrying out different tasks, under different conditions. It is clear from these results, that although these different methods are all aimed at assessing the same underlying abilities, nevertheless they can cause performance to differ substantially.

# CHAPTER SIX

## The Effect Of Varying Familiarity With The Referent Space

## Experiment Three

### *Introduction*

As was discussed in Chapter Two, the ability of children to understand and use a spatial representation has been observed to differ according to the level of familiarity the children have with the referent space itself. Results reported by Siegel and Schadler (1977) and Herman and Siegel (1978) suggest that the ability to appreciate the nature of a representation increases with increased familiarity with the referent space. However, DeLoache (1993; 2000) reports studies in which children were allowed to play with a model of a referent space for 5-10 minutes prior to commencing the representational task. Their performance actually decreased with increased familiarity. On the basis of these studies, DeLoache therefore suggests that in line with the dual representation hypothesis, increased familiarity with an object may prevent it from also being viewed in a different way – as a symbol. Theories of Psychological Distance support this notion (see Cocking and Renninger, 1993, for a review). DeLoache suggests that when children are familiar with something as a "thing-in-itself", it makes it more difficult for them to then achieve the psychological or cognitive distance which is required if they are to also view it as a representation of something else. If this is the case, then perhaps children will find it more difficult to view a room that they are already familiar with as a referent space relating to a representation of that room.

DeLoache (1995a) mentions a further study in which children visited the referent room a total of nine times over the course of three weeks, and on each occasion they took part in different activities within the room. Despite this, these children performed no better than those who had no prior experience in the referent room. It is therefore unclear whether we ought to expect children's performance to increase, decrease or to remain unchanged as a result of increased familiarity with the referent space.

Experiment One assessed young children's ability to understand and use a spatial representation of an already familiar referent space, and Experiment Two explored performance using a completely novel referent space. The primary aim of Experiment Three, then, was to investigate more directly the effect that an increasing level of familiarity with the referent space has. In addition, Experiments One and Two compared children's performance on tasks requiring inferences to be made from Representation-To-Referent, with that on tasks requiring inferences to be made in the opposite direction. It was found that when using a familiar referent space, performance was slightly better when inferring from the referent space to the representation. Yet when using a completely novel referent space, children were more successful at inferring in the opposite direction. It was hoped that Experiment Three might build upon those of the previous experiments, in examining how children's performance using these different methods changes over time, as familiarity with the referent space increases.

Finally, it was observed in Experiment One that Retrieval tasks were found to have been easier than Positioning tasks. It was suggested that methodological issues, or elements of the experimental design may have left more room for overestimation error on Retrieval trials, and the results of Experiment Two seem to support this. The secondary aim of Experiment Three, then, was to remove some elements of the experimental design which might have contributed to making Retrieval trials easier than Positioning trials, in order to further support the suggestion that it was these methodological issues which contributed to superior performance on the Retrieval Task in Experiment One.

### *Method*

#### Design

In order to assess the effect of increased levels of familiarity with the referent space, this experiment was carried out in two parts – once at the beginning of the school year, and then at the end of the school year. At the beginning of the school year, children had approximately one month's experience in the referent space. At the end of the year, children had approximately eight months' experience in the referent space. Children's performance with a slightly familiar referent space could then be compared with that using a highly familiar referent space. Henceforth, these two phases of Experiment Three will be referred to as Experiments 3A and 3B.

#### Participants

Fourteen children from the Psychology Department took part in the study. Nine of the children were boys and five girls. For Experiment 3A their ages ranged from 34 to 45 months (2;10 – 3;9), with a mean age of 39 months (3;3). For Experiment 3B, ages ranged from 42 to 53 months (3;6 – 4;5), with a mean age of 47 months (3;11).

Apparatus

These were exactly the same as for Experiment One, with slight alterations to some of the small items of furniture in the model. These alterations were made to ensure that there was no chance of the child inadvertently spying the small toy dog in its hiding place on Retrieval trials.

Procedure

See Chapter Three (General Method) for an overview of Procedure.

Experiments 3A and 3B were conducted in exactly the same way as for Experiment One, with each child being allocated to complete either a Retrieval or a Positioning Task. Within their allocated Task, each child completed four trials – two Model-To-Room and two Room-To-Model. Thus, by the end of Experiment 3B, each child had completed a total of eight trials. The order in which children completed Room-To-Model and Model-To-Room trials was randomised between subjects, and Memory Check trials were carried out as controls after every test trial.

***Results: Experiment 3A***

Scores

Table 1 shows the scores which children achieved in each Condition and Task, on Experiment 3A. From these scores, it appears that children scored higher on the Room-To-Model Condition than the Model-To-Room Condition, and slightly higher on the Retrieval Task than on the Positioning Task.

From Table 1, it can also be seen that the overall mean total score on test trials was 46.4%. However, as in Experiment One, children were performing almost at ceiling on the Memory Check control trials. The mean score for these trials was 98.2% correct. This difference between Test trials and Memory Check trials was highly significant ($t_{13} = -6.1$, $p < 0.01$).

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Positioning (n = 7) | 42.9 | 44.9 | 42.9 | 44.9 | 42.9 | 32.3 |
| Retrieval (n = 7) | 71.4 | 39.3 | 28.6 | 39.3 | 50.0 | 32.3 |
| Total (n = 14) | 57.1 | 43.2 | 35.7 | 41.3 | 46.4 | 33.8 |

*Table 1. Experiment 3A: Mean score in each Condition, by Task.*

Figure 1 indicates a slightly different pattern of performance between the two Tasks, in relation to Model-To-Room versus Room-To-Model performance. Positioning appears to be equally as difficult in both directions, but Retrieval seems easier on the Room-To-Model condition. A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) x 2 (Gender: Boys vs. Girls) mixed ANOVA, with Condition as a within-subjects variable, revealed no significant main effects or interactions. However, an examination of the results for the Retrieval group only, showed that on this Task, Room-To-Model scores were significantly better than Model-To-Room scores ($t_6 = -2.52$, $p < 0.05$) – thus supporting what is shown in Figure 1.

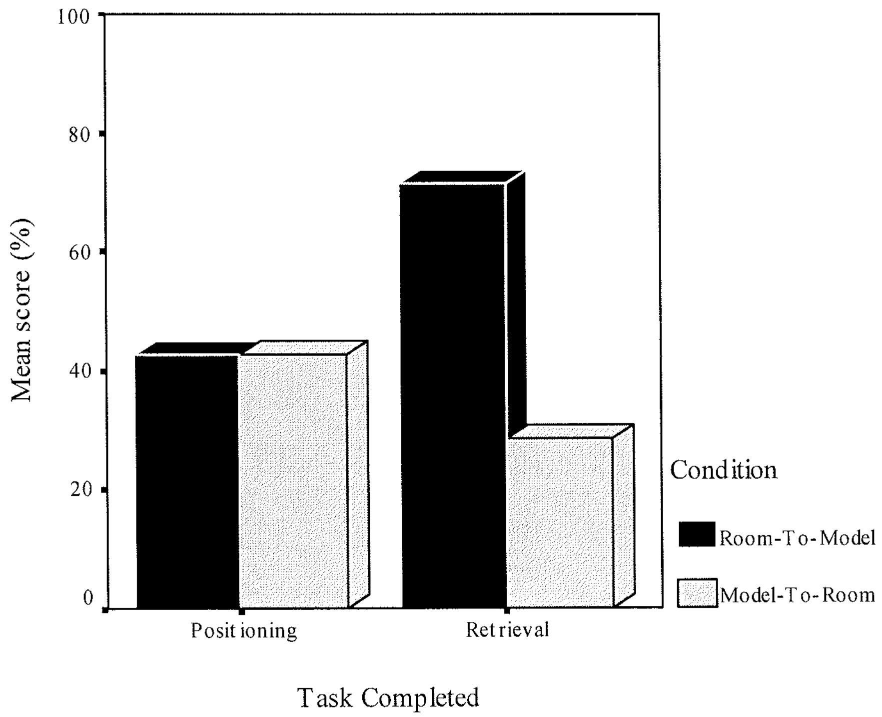


*Figure 1. Experiment 3A: Mean score in each Condition, by Task.*

Time taken

Table 2 shows the amount of time taken for each Condition, by Task. The results suggest that in general children took longer in the Model-To-Room Condition, and that Retrieval took longer than Positioning. Table 3 shows the times taken by children in both Conditions, depending upon their level of correct responses. This seems to indicate less time being taken in the more successful groups of children.

A 2 (Task: Retrieval vs. Positioning) x 3 (Level of Success: 0 vs. 1 vs. 2 correct) ANOVA was carried out on the data for each of the two Conditions. As in Experiment One, this was to investigate whether the level of success on particular tasks affected the amount of time that children took. In addition, a 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA, with Condition as a within-subjects variable, was carried out to assess whether there was an overall difference between the time taken in the two Conditions.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Positioning (n = 7) | 6.16 | 4.97 | 9.27 | 5.25 | 7.71 | 5.26 |
| Retrieval (n = 7) | 7.21 | 5.45 | 16.05 | 6.99 | 11.63 | 7.62 |
| Total (n = 14) | 6.68 | 5.14 | 12.66 | 6.98 | 9.67 | 6.78 |

*Table 2. Experiment 3A: Mean time taken in each Condition, by Task.*

The analyses revealed a significant main effect of Condition ($F_{1, 12}$ = 10.332, $p < 0.01$), as well as a significant main effect of Task ($F_{1, 12}$ = 7.474, $p$ = 0.018). These results support what is shown in Table 2, in that the Model-To-Room Condition took longer than the Room-To-Model Condition, and that Retrieval trials took consistently longer than Positioning trials. However, the separate analyses for the two Conditions show that though Retrieval took longer overall, the difference is only really marked on Model-To-Room trials, leading to a marginally significant effect of Task in that Condition ($F_{1, 8} = 4.097$, $p = 0.078$), as illustrated in Figure 2.

Table 3 shows that the time taken on both Conditions decreased marginally as the level of success increased, but the analyses showed that the effect of Level of Success was not significant in either Condition.

| | Condition | | | |
|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | |
| Number of correct responses | Mean time (secs) | SD | Mean time (secs) | SD |
| 0 | 7.28 (n = 4) | 2.42 | 15.39 (n = 7) | 6.09 |
| 1 | 7.00 (n = 4) | 4.59 | 11.13 (n = 4) | 5.64 |
| 2 | 6.07 (n = 6) | 4.49 | 8.33 (n = 3) | 1.52 |

*Table 3. Experiment 3A: Mean time taken in each Condition, by level of success.*

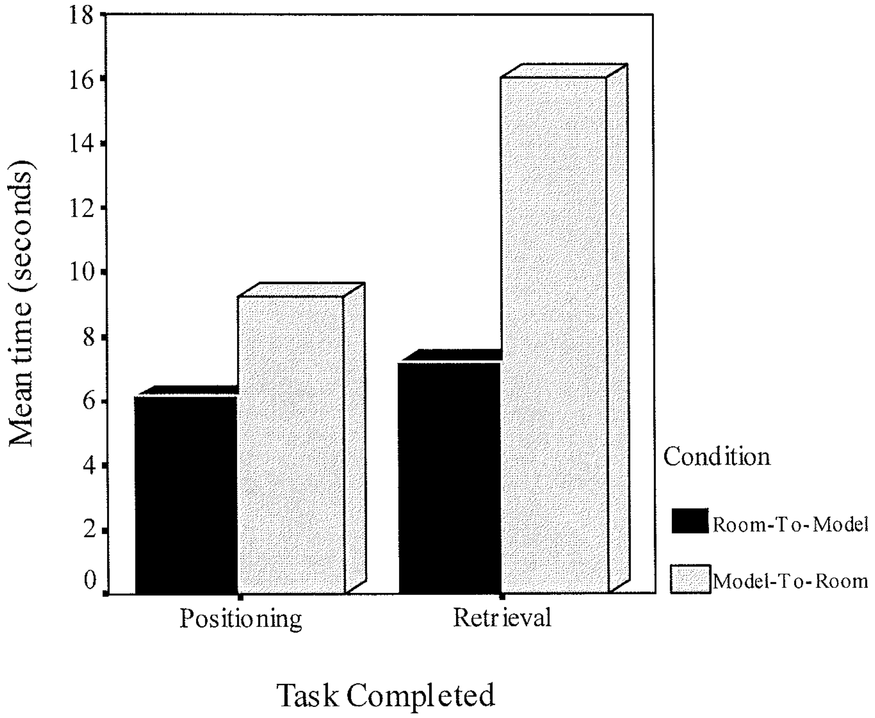


*Figure 2. Experiment 3A: Time taken on each Task, by Condition.*

Error data

Errors were classified into four categories, as in previous experiments. Table 4 shows the mean numbers of the different types of errors which were made by children in both of the two Conditions. Figure 3 illustrates the different numbers of errors of each of the four types which children made.

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA, with Condition as a within-subjects variable, was carried out on the data for each of the four error types. The analyses revealed no significant effects of Task nor of Condition, on any of the types of errors.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.00 | 0.00 | 0.21 | 0.43 | 0.00 | 0.00 | 0.64 | 0.84 |
| Model-To-Room Condition | 0.07 | 0.27 | 0.14 | 0.36 | 0.07 | 0.27 | 1.00 | 0.88 |
| Total | 0.07 | 0.27 | 0.36 | 0.63 | 0.07 | 0.27 | 1.64 | 1.28 |

*Table 4. Experiment 3A: Mean number of errors made in each Condition.*

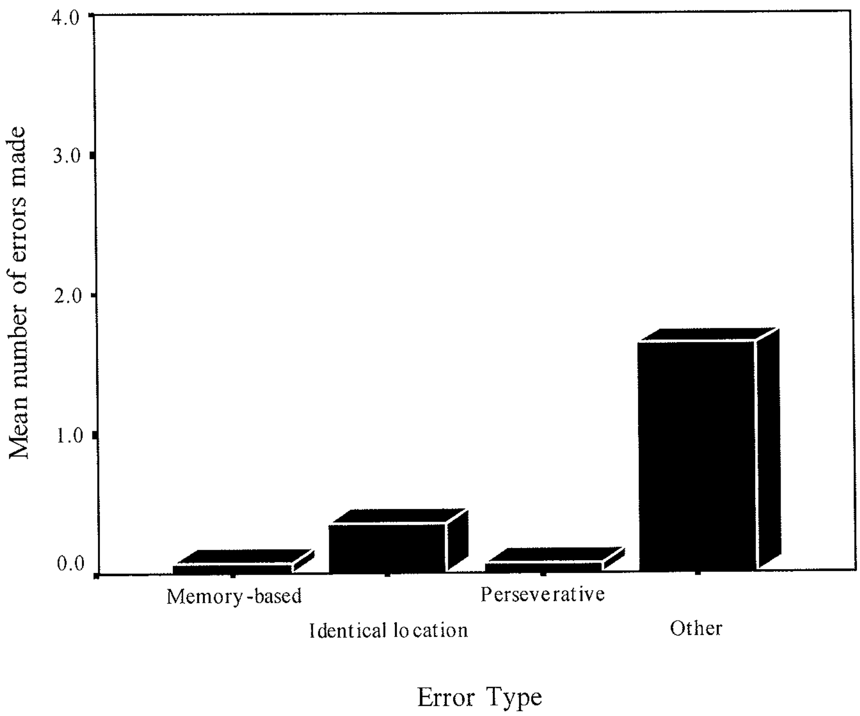


*Figure 3. Experiment 3A: Mean number of errors made.*

However, the pattern of errors made on the two Conditions appears to differ slightly, as illustrated by Figures 4 and 5. Children make more errors overall on the Model-To-Room Condition. These additional errors fall into the categories of "Memory-based", "Perseverative" and "Other", but the number of "Identical location" errors is actually slightly less in this Condition.

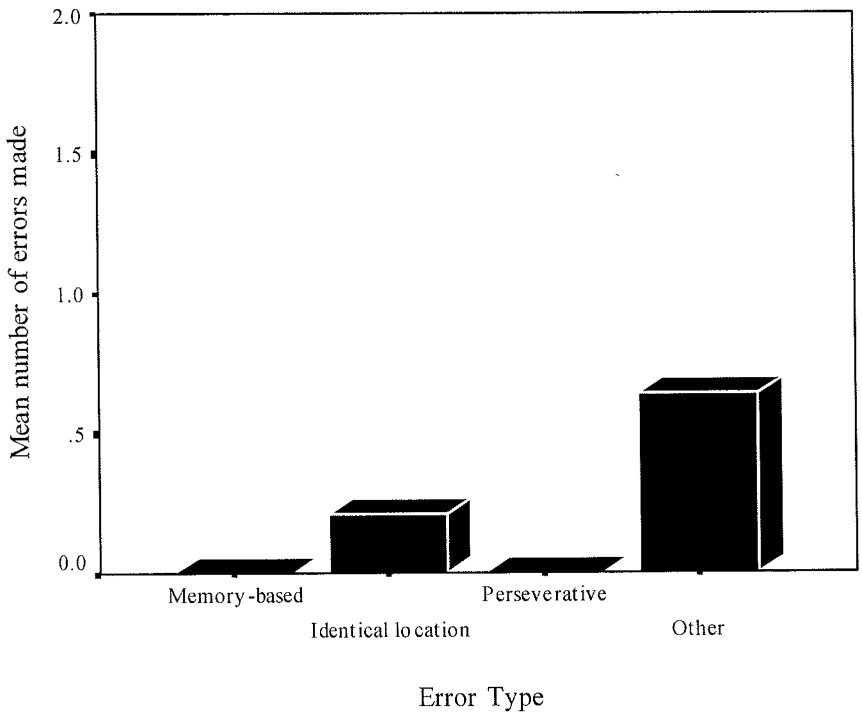


*Figure 4. Experiment 3A: Mean number of errors in Room-To-Model Condition.*

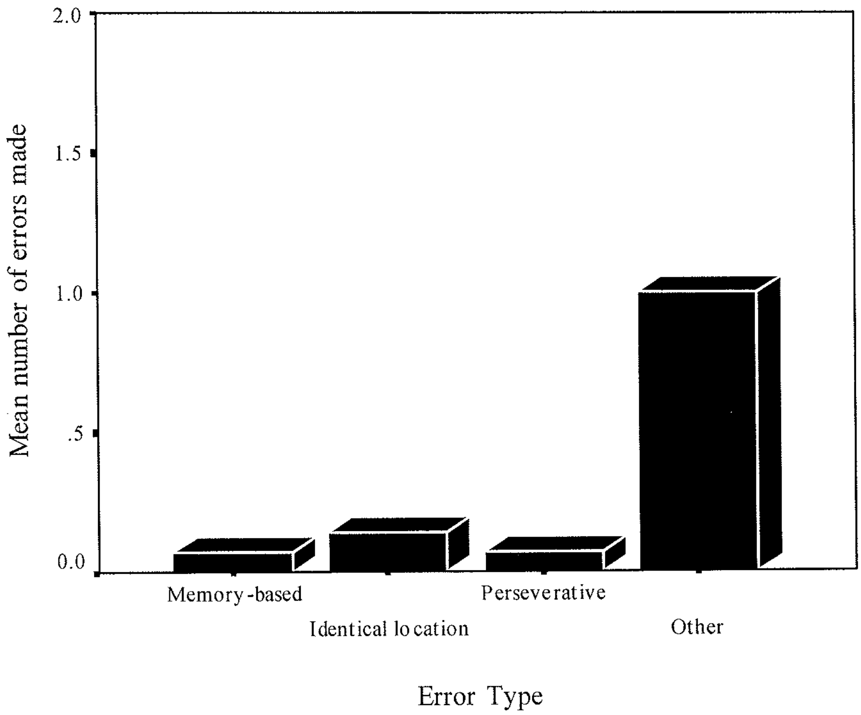


*Figure 5. Experiment 3A: Mean number of errors in Model-To-Room Condition.*

***Discussion: Experiment 3A***

Scores

In this experiment, carried out at the beginning of the school year, children's scores were comparable to those seen in Experiment One, with children scoring higher on Retrieval than Positioning, and higher on Room-To-Model than Model-To-Room Conditions. This is exactly the same pattern as was observed in Experiment One, although neither of these differences was statistically significant in Experiment 3A. It should be noted that the small number of participants in Experiment Three reduces the power of the analysis, thus making statistically significant results more difficult to obtain. Nevertheless, some methodological alterations were made to try to prevent children from inadvertently viewing hidden objects in the model on Retrieval trials, as in Experiment Two, and this may have contributed to the comparability now observed between scores on both Tasks. It is still possible, though, that children were engaging in undetected visual searches. Experiment Two was designed to eliminate this possibility entirely, and assessed whether children continued to score higher on Retrieval trials overall, when all target locations were completely concealed. The results of Experiment Two suggested that under these conditions, there was no difference between performance on Retrieval and Positioning Tasks. Experiment 3A's results support these findings.

Time taken

The time taken by children overall was also similar here to the times taken in Experiment One. Children took longer on Model-To-Room trials than they did on Room-To-Model trials. These results and those of Experiment One show that carrying out a task in a large-scale space, unsurprisingly takes longer than carrying out the same task in a small-scale space. It was suggested in relation to the results of Experiment One, that perhaps this additional time required on the Model-To-Room Condition, contributed to the lower scores in that Condition. However, the results of Experiment Two have effectively ruled this out. In Experiment Two, children took similar amounts of time in both Conditions, yet consistently scored higher in one Condition than the other. This strongly suggests that the additional cognitive load of holding information in memory for longer, does not detrimentally affect children's success.

Error data

The errors on Experiment 3A show a very similar pattern to those in

Experiment One, with "Other" errors making up the largest group, and Identical location errors forming the next largest group. Only small numbers of Memory-based and Perseverative errors were made overall. The pattern of errors made in each Condition differs slightly, though, as illustrated by Figures 4 and 5.

Children scored higher on the Room-To-Model Condition, and we therefore expect to see additional errors occurring in the Model-To-Room Condition. Under DeLoache's interpretation, we would expect that errors falling into the "Other" category, are those which are due to difficulties within the representational domain. In the more difficult Condition, the number of "Other" errors is higher. Therefore, perhaps the Model-to Room Condition makes an appreciation of the representational relationship more difficult for children when they are already slightly familiar with the referent space. However, this cannot be the only explanation for the difficulty of this Condition, since additional errors also occur in the Memory-based and the Perseverative category. Therefore, something else must be contributing to the increased difficulty of this Condition. One alternative explanation which was also explored in relation to the results of Experiment One, is that the irrelevant information in the room distracted children, thus causing them to make more errors in the Condition on which they were carrying out a task in the referent space. Later experiments address this possibility.

In addition, Figures 4 and 5 show that despite the Room-To-Model Condition being the more successful one, nevertheless children actually made more Identical location errors here. This fits with the results of Experiment Two, which also found that children made more Identical location errors on the Room-To-Model Condition, suggesting that perhaps distinguishing between two or more identical locations is harder to do in a model than in a room. This might simply be due to the smaller scale of a model, which leads to reduced distances between items and an increased likelihood of confusing locations. In a room, since the distances between items is larger it might be easier to distinguish between them, which may mean that children can encode the identical locations within the room itself, but then have difficulty transferring that knowledge to the small-scale space.

### *Results: Experiment 3B*

Scores

Table 5 shows the scores for test trials on Experiment 3B, when broken down by Condition and Task. As in Experiment 3A, children scored higher on the Room-To-Model Condition. Scores were slightly higher on Positioning than Retrieval trials. The overall mean score was 35.7%, which was actually lower than in Experiment 3A. However, children performed almost at ceiling on the Memory Check control trials, with the mean score being 92.9% correct. Once again, this difference between Test trials and Memory Check control trials was highly significant ($t_{13} = -6.752$, $p < 0.01$).

These data were subjected to the same analysis as the scores from Experiment 3A. As in that experiment, there were no significant effects or interactions here. Yet once again, there was a slightly different pattern of results for the two Tasks when broken down by Condition, as illustrated by Figure 6. From this graph it can be seen that by the end of the school year, children were performing consistently better in the Room-To-Model condition, regardless of which particular Task they were carrying out.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Positioning (n = 7) | 50.0 | 40.8 | 28.6 | 26.7 | 39.3 | 28.3 |
| Retrieval (n = 7) | 35.7 | 24.4 | 28.6 | 39.3 | 32.1 | 23.8 |
| Total (n = 14) | 42.9 | 33.1 | 28.6 | 32.3 | 35.7 | 25.4 |

*Table 5. Experiment 3B: Mean score in each Condition, by Task.*

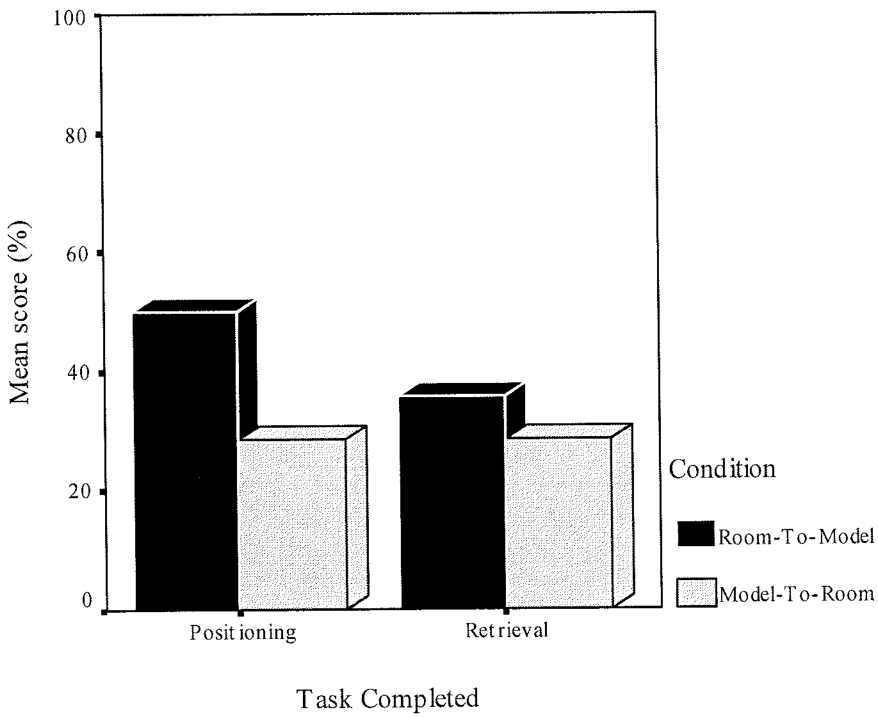


*Figure 6. Experiment 3B: Mean score in each Condition, by Task.*

Time taken

Table 6 shows the amount of time taken in each Condition, by Task. Children still seem to take longer in the Model-To-Room Condition, although this difference is not as marked as in Experiment 3A. Retrieval still seems to take longer than Positioning.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Positioning (n = 7) | 6.41 | 4.35 | 9.29 | 7.95 | 7.85 | 6.46 |
| Retrieval (n = 7) | 16.37 | 10.51 | 25.25 | 18.99 | 20.81 | 15.73 |
| Total (n = 14) | 11.39 | 9.38 | 17.26 | 16.43 | 14.33 | 13.59 |

*Table 6. Experiment 3B: Mean time taken in each Condition, by Task.*

The times taken by children depending upon their level of success are shown in Table 7. Children were classified into groups according to their level of success, as in previous experiments. A 2 (Task: Retrieval vs. Positioning) x 3 (Level of Success: 0 vs. 1 vs. 2 correct) ANOVA was carried out on the data for each of the two Conditions as previously, to investigate whether success or failure affected the amount of time taken. In addition, a 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA was carried out, with Condition as a within-subjects variable, to assess whether there was a difference in the time taken in the two Conditions.

These analyses revealed that the effect of Condition was not significant ($F_{1, 12} = 3.302$, $p = 0.094$), although there was a significant main effect of Task ($F_{1, 12} = 12.240$, $p < 0.01$). This supports what is shown in Table 6, in that children took longer in the Model-To-Room Condition than they did on the Room-To-Model Condition, though not as markedly so as previously. It also shows that the Retrieval Task took longer than the Positioning Task These findings are consistent with those of the first part of Experiment Three, and also with those of Experiment One.

The analyses revealed a marginally significant effect of Level of Success in the Room-To-Model Condition ($F_{2, 9} = 3.956$, $p < 0.059$) and a highly significant effect of Level of Success in the Model-To-Room Condition ($F_{2, 9} = 8.236$, $p < 0.01$). Table 7 shows that in relation to time taken overall, higher Room-To-Model scores have the effect of decreasing time slightly. Thus, if anything, the time taken is less in the group of most successful children. In relation to scores on the Model-To-Room Condition, whilst initially the pattern of time taken is similar to the other Condition – the least successful group takes longer than the middle group, whose times decrease – the time taken then increases dramatically in the group of most successful children.

These results should be treated with caution, however, as with an N of only 1 in the most successful Model-To-Room group, the time taken overall reflects only the performance of one individual subject, and may not be indicative of the likely performance of all possible successful children.

| | Condition | | | |
|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | |
| Number of correct responses | Mean time (secs) | SD | Mean time (secs) | SD |
| 0 | 14.55 (n = 4) | 12.74 | 19.15 (n = 7) | 13.54 |
| 1 | 9.88 (n = 8) | 5.37 | 9.95 (n = 6) | 5.13 |
| 2 | 11.11 (n = 2) | 2.05 | 47.96 (n = 1) | N/A[1] |

*Table 7. Experiment 3B: Mean time taken in each Condition, by score.*

Figures 7 and 8 illustrate the times taken by children depending upon their score in each of the two Conditions. In these figures, the data for the groups who scored one correct response have been split to show the time taken by these children on their one incorrect trial and their one correct trial. Paired sample t-tests show that the difference between the times taken on these groups' incorrect trials versus their correct trials is not significant in the Room-To-Model Condition ($t_7 = -0.063$, $p = 0.952$) nor in the Model-To-Room Condition ($t_5 = 0.226$, $p = 0.830$). However, the overall pattern of Figures 7 and 8 seem to suggest that children are likely to take less time when they are successful and more time when they are unsuccessful. Therefore, the time taken by the one subject scoring two correct on the Model-To-Room Condition may well simply be an atypical outlier.

However, it should also be noted that this pattern of performance is similar to what was found in Experiment One, where the times taken dropped initially

[1] N = 1, thus M-R score for 2 correct is constant.

from the 0 correct to the 1 correct groups, but which then increased in the most successful group.

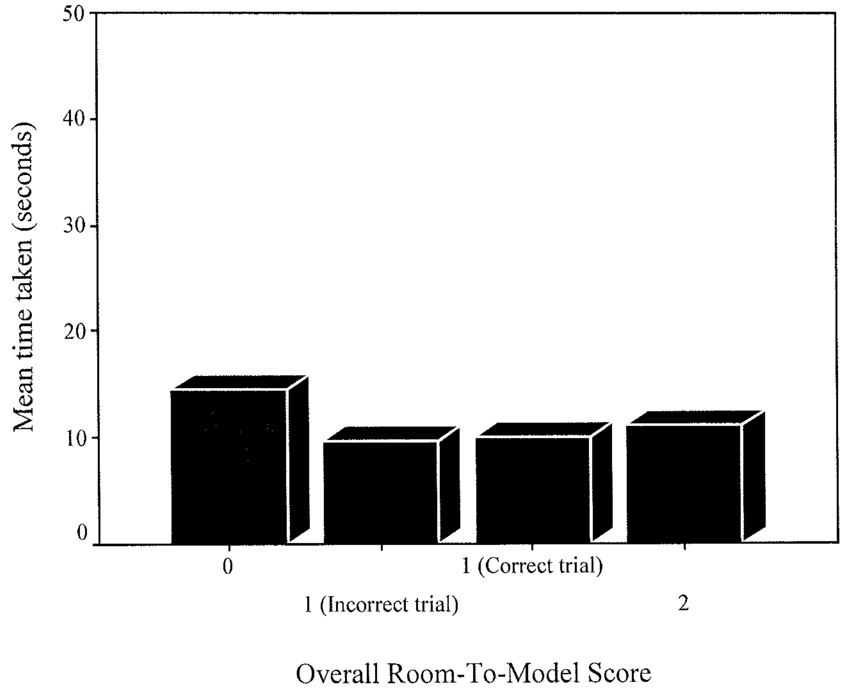


*Figure 7. Experiment 3B: Mean time taken, by Room-To-Model score.*

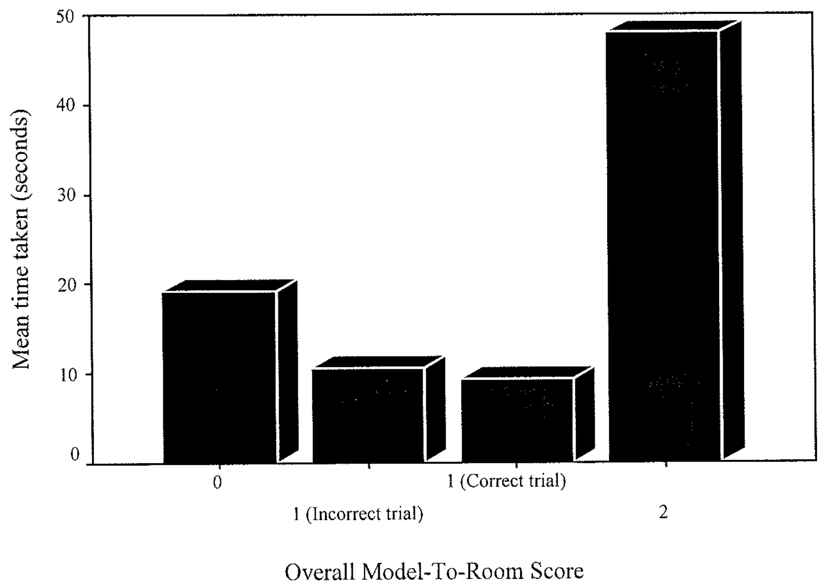


*Figure 8. Experiment 3B: Mean time taken, by Model-To-Room score.*

Error data

Errors were classified into four categories, as previously. Table 8 shows the mean number of errors of each type that were made by children in both of the two Conditions. Figure 9 shows the numbers of each type of error made overall. The same pattern of errors is evident here as in Experiment 3A, in that "Other" and "Identical location" errors make up the largest groups. However, there appear to be almost comparable levels of these two errors types here, whereas in Experiment 3A, Other errors were more frequent than Identical location errors.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.07 | 0.27 | 0.43 | 0.51 | 0.29 | 0.47 | 0.36 | 0.49 |
| Model-To-Room Condition | 0.21 | 0.43 | 0.50 | 0.52 | 0.00 | 0.00 | 0.71 | 0.91 |
| Total | 0.29 | 0.47 | 0.93 | 0.73 | 0.29 | 0.47 | 1.07 | 1.21 |

*Table 8. Experiment 3B: Mean number of errors made in each Condition.*

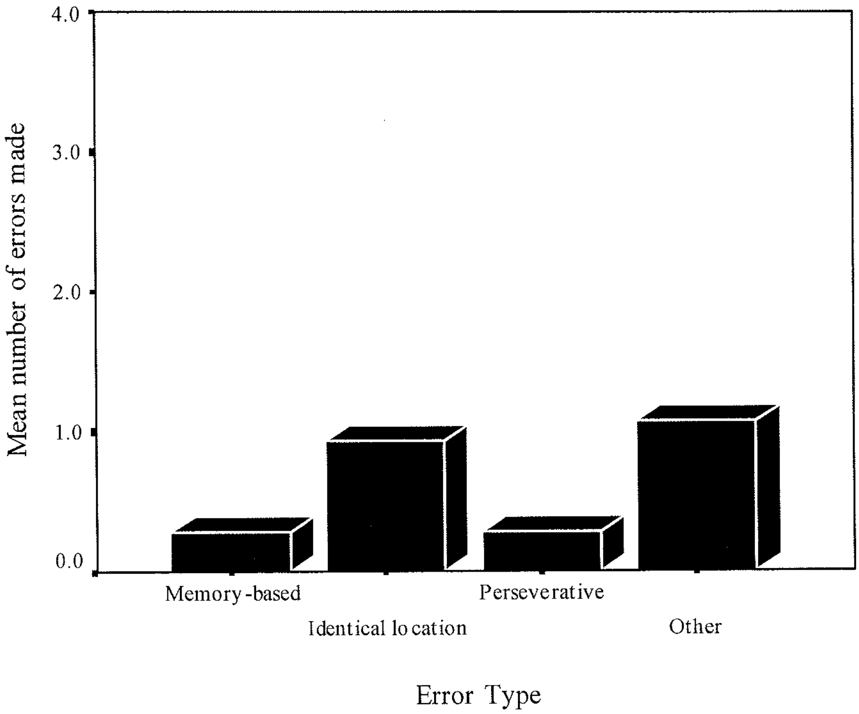


*Figure 9. Experiment 3B: Mean number of errors made.*

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA was carried out on the data for each of the four error types, with Condition as a within-subjects variable. Only one significant effect emerged from these analyses – a main effect of Condition on Perseverative errors ($F_{1, 12} = 0.571$, $p < 0.05$). As Table 8 shows, no Perseverative errors were made on the Model-To-Room Condition at all. However, the mean number of Perseverative errors made on the other Condition was still very small (0.29).

***Combined results***

Combining the data from Experiments 3A and 3B, it is possible to draw some direct comparisons between performance with a slightly familiar and a highly familiar referent space.

Scores

Table 9 shows the scores in each Condition for Experiments 3A and 3B. Table 10 shows the scores in both experiments for the two Tasks. In general, there was a decrease in scores on Experiment 3B, using a highly familiar referent space. Overall total scores decreased, as did both total Positioning and total Retrieval scores. The total score for the Model-to-Room Condition decreased, and similarly the total Room-To-Model score decreased. Thus, scores were apparently worse when using a highly familiar referent space.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Year Start | 57.1 | 43.2 | 35.7 | 41.3 | 46.4 | 33.8 |
| Year End | 42.9 | 33.2 | 28.6 | 32.3 | 35.7 | 25.4 |

*Table 9. Mean score in each Condition, at beginning and end of school year.*

| | Task | | | |
|---|---|---|---|---|
| | Retrieval (n = 7) | | Positioning (n = 7) | |
| | %age correct | SD | %age correct | SD |
| Year Start | 50.0 (n = 7) | 32.3 | 42.9 | 37.4 |
| Year End | 32.1 (n = 7) | 23.8 | 39.3 | 28.4 |

*Table 10. Mean score on each Task, at beginning and end of school year.*

A 2 (Familiarity: Low vs. High) x 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 Task (Retrieval vs. Positioning) mixed ANOVA was carried out on the data, with Familiarity and Condition as within-subjects variables, in order to establish whether there were any interactions between children's scores when they had a low level of familiarity with the referent space (beginning of school year), as opposed to when they had a high level of familiarity with the referent space (end of school year). The analysis showed that the level of familiarity had no effect on children's scores in each Condition, nor on each Task. Thus, there was no significant difference between performance on Positioning and Retrieval Tasks using a highly familiar or a less familiar space, and nor was there any difference between Room-To-Model scores and Model-To-Room scores overall using these two different levels of familiarity.

Time taken

Table 11 shows the amount of time taken at the beginning and at the end of the school year, for each Condition. Table 12 shows the amount of time taken on these two occasions, for each Task. It appears that children took longer overall at the end of the year.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Year Start | 6.68 | 3.78 | 12.66 | 5.83 | 9.67 | 3.28 |
| Year End | 11.39 | 7.59 | 17.27 | 13.92 | 14.33 | 9.46 |

*Table 11. Mean time taken at beginning and end of year, by Condition.*

| | Task | | | |
|---|---|---|---|---|
| | Retrieval (n = 7) | | Positioning (n = 7) | |
| | Mean time (secs) | SD | Mean time (secs) | SD |
| Year Start | 11.63 | 3.09 | 7.72 | 2.19 |
| Year End | 20.81 | 9.07 | 7.85 | 3.73 |

*Table 12. Mean time taken at beginning and end of year, by Task.*

A 2 (Familiarity: High vs. Low) x 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 Task (Retrieval vs. Positioning) ANOVA was carried out on the data, with Familiarity and Condition as within-subjects variables. From the previous analyses of time taken for each Experiment separately, it was already clear that the times taken were significantly different on each Condition and on each Task, with Retrieval taking consistently longer than Positioning, and Model-To-Room taking longer than Room-To-Model. Therefore, the concern of this analysis was whether there was any overall effect of Familiarity on the time taken, and also whether there were any interactions between Familiarity and Condition, or Familiarity and Task.

The results support what is shown in Table 11, in that there was a main effect of Familiarity. Children took significantly longer at the end of the year than at the beginning of the year ($F_{1, 12} = 6.017$, $p < 0.05$). The results also support what is shown in Table 12, in that there was a significant interaction between Familiarity and Task ($F_{1, 12} = 5.676$, $p < 0.05$). The time taken on Positioning trials remained similar at the start and the end of the year, but the time taken on Retrieval trials was significantly more at the end of the year. This is illustrated by Figure 10.

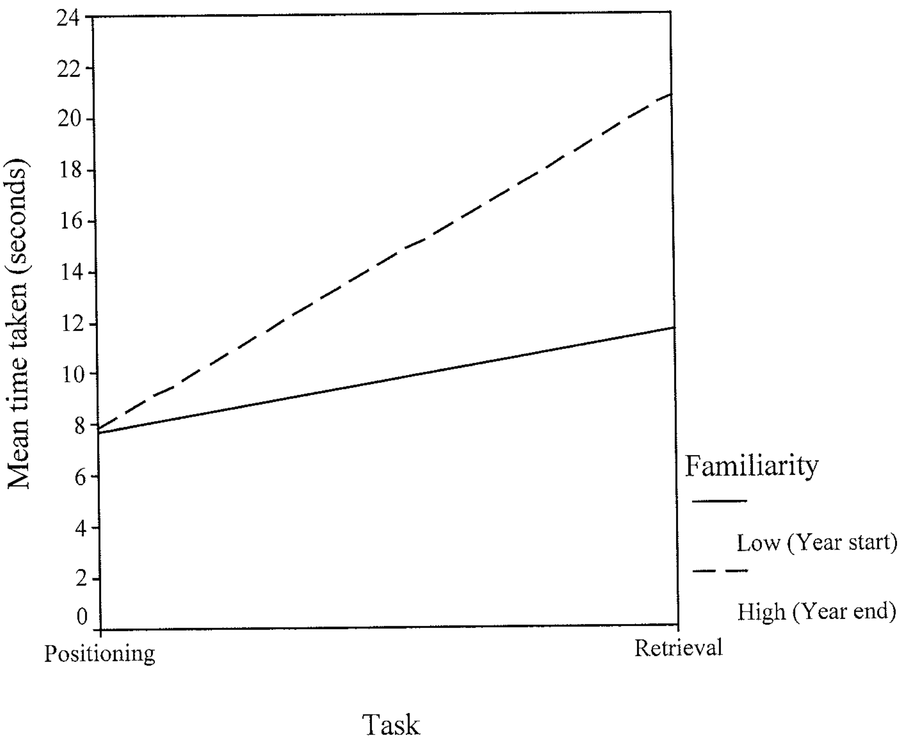


*Figure 10. Mean time taken on each Task, by level of Familiarity.*

<u>Error data</u>

Table 13 shows the numbers of each different type of error that children made when their level of familiarity with the referent space was low (beginning of the school year) as opposed to when their level of familiarity was high (end of the school year). The data for each of the four error types were analysed using a 2 (Familiarity: Low vs. High) x 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) ANOVA, with Familiarity and Condition as within-subjects variables.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Year Start | 0.07 | 0.27 | 0.36 | 0.63 | 0.07 | 0.27 | 1.64 | 1.28 |
| Year End | 0.29 | 0.47 | 0.93 | 0.73 | 0.00 | 0.00 | 1.07 | 1.21 |

*Table 13. Mean number of each type of error made at the beginning and end of the school year.*

Previous Scores analyses for Experiments 3A and 3B combined have already indicated that there was no overall difference between the numbers of errors children made at the beginning as opposed to at the end of the school year. What was of interest in these analyses, then, was whether increased familiarity with the referent space significantly affected the particular error types that were being made.

The results of these analyses revealed that Familiarity only had an effect on Identical location errors ($F_{1, 12} = 6.194$, $p < 0.05$). Identical location errors were significantly higher at the end of the school year, whilst all the other error types were relatively unaffected by Familiarity.

### *General discussion*

Experiment Three aimed to explore how children's performance when using a spatial representation might change as their level of familiarity with the referent space increased over time. Therefore, the study was conducted in two parts – at the beginning, and then at the end of one school year.

#### Scores

The results indicate no statistically significant difference in children's performance when the referent space was highly familiar, which is consistent with DeLoache's (1995a) findings. In fact, children's scores were slightly lower at the end of the year than they were at the beginning. In terms of absolute levels of performance, children appeared to perform similarly when they were only slightly familiar with a referent space, to when they were highly familiar with it. Therefore, increasing children's familiarity with an already familiar space does not appear to improve their scores on tasks of this nature.

Time taken

The time taken by children in general was similar to Experiment One, in that Retrieval trials took longer, and the Model-To-Room Condition took longer. However, since children were no longer scoring more highly on Retrieval trials, the additional time taken to complete these trials does not seem to have affected their scores, as had been discussed in relation to Experiment One.

As in Experiment One, the additional time taken to complete Model-To-Room trials is unsurprising, given the size of the referent room in which children had to work in this Condition. Since Room-To-Model trials required only a manipulation of a small-scale model, it would be expected that this would take less time, and that these values would therefore be comparable to Experiment One.

Apart from one outlier, the results support those of Experiment Two, in that the time taken by children appeared to decrease with increased success, which indicates that children take more time to consider their responses when they are unsure, but that they respond more quickly when they are confident of the correct target location. However, the differences between the time taken on incorrect versus correct trials by the groups who scored one correct, were not significant.

In relation to the issue of increasing familiarity which is of interest in the present experiment though, children actually took significantly more time at the end of the year than at the beginning of the year. It could be argued that this is merely a developmental issue, though, since at the end of the year, the children were eight months older than they had been at the beginning of the year. Perhaps children simply take additional time to consider their responses more carefully as they get older. The children in Experiment 3A had a mean age of 39 months

(3;3), and were therefore the youngest group to take part in the project overall. The children in Experiment One were slightly older, with a mean age of 43 months (3;7), and those in 3B had a mean age of 47 months (3;11). These three groups of children took an average of 9.67 seconds, 12.20 seconds and 14.33 seconds respectively overall. This would therefore strongly support the notion that children take more time as they get older.

In addition to this general increase in time taken, children took longer at the end of the year on Retrieval trials in particular. Once again, the three groups of children mentioned previously took 11.63 seconds, 19.65 seconds and 20.81 seconds respectively on Retrieval trials, which again suggests a developmental trend in relation to how they approach a familiar "game", rather than one related to the increase in familiarity in Experiment Three.

Error data

The differences in Errors made at the beginning and the end of the year are very interesting. It appears that the strategies children adopted in solving the tasks are different at the start and at the end of the year. This is particularly interesting because it does not appear to be a developmental trend, but one which is due to the increased familiarity.

We saw from the analysis of scores for Experiment Three, that despite an increase in mean age from 39 to 47 months (3;3 to 3;11), children in Experiment 3B actually scored lower overall than children in Experiment 3A. Thus, it would seem at first that as they get older, children's performance, if anything, decreases rather than increases. However, the error data actually suggests that by the end of the school year, children were responding much more strategically than they were at the beginning of the year, even though this was not improving their overall score.

Children in Experiment One (mean age 43 months, 3;7) and in Experiment 3A (mean age 39 months, 3;3) were both relatively unfamiliar with the referent space, and both show very similar patterns of responding. They make more "Other" errors than any other type of error, which suggests a very random form of responding, consistent with their having serious problems in the representational domain, or just generally not understanding the task This is also seen in the youngest group of children in Experiment Two (mean age 49 months, 4;1. See Chapter Five, Figure 11), to whom the referent space is completely unfamiliar. This group in Experiment Two are slightly older than those in Experiments One and 3A, and they make slightly more Perseverative errors than the other two groups, which suggests the beginnings of some strategic responding. However, the majority of these three groups of young children's errors fall into the "Other" category.

All of these results fit with several theories about the development of understanding of spatial representations. Several authors suggest that a basic recognition of the overall similarity between a representation and the referent space emerges in younger children, which is then followed by the ability to recognise correspondences between individual objects, although without being able to utilise information about spatial relationships in order to distinguish between two or more identical objects in a space. Thus, the children in Experiments One, 3A and the youngest group in Experiment Two, appear to have difficulties in appreciating the overall spatial relationship between the model and the room – resulting in the largest proportion of their errors being "Other" errors.

However, in contrast to all of this, the group of interest – those in Experiment 3B, who are highly familiar with the referent space – exhibit very different patterns of errors to these other three groups. The children in Experiment 3B had a mean age of 47 months (3;11), and were therefore actually slightly younger than those in the youngest group in Experiment Two. However, despite being younger, the children in Experiment 3B were responding in a far more sophisticated way than these older children. They were making almost equal numbers of Other and Identical location errors, suggesting that they were able to appreciate object correspondences, though were not yet able to utilise spatial information. This pattern of errors was also seen in the middle age group of children in Experiment Two, whose mean age was 56 months (4;8) – 9 months older than those in 3B.

It therefore appears that the children who were highly familiar with the referent space were adopting strategies of responding which would be more typical of an older group of children. Thus, the difference in the strategies adopted by children at the beginning and the end of the school year does not seem to be attributable to increased age, because an even older group of children have not yet managed to attain this level of strategic responding. These results suggest, then, that increased familiarity with the referent space might improve children's awareness of the correspondences between objects in the referent space and the representation, thus enabling them to respond in a less random way, although their lack of an understanding of spatial relations does not allow them to fully take advantage of this awareness in distinguishing between identical locations.

### *Conclusions*

In summary, it appears that an increasing level of familiarity with the referent space does not improve children's ability to understand and to use a spatial representation in terms of absolute performance. However, from the results it seems likely that being highly familiar with the referent space enables some kind of acceleration of the process of development in terms of this understanding.

A high level of familiarity with the referent space allows children to more easily identify correspondences between particular objects in a representation and a referent space. This appreciation of object correspondences therefore emerges earlier in the developmental process than it does when the referent space is less familiar or completely novel.

It seems, then, that whilst increasing children's familiarity with a referent space might not lead to higher scores on a given task, a closer examination of performance reveals different strategies being utilised, and hints at the possibility of a slightly different process in terms of the development of the ability to use a representation of a familiar, versus an unfamiliar referent space.

# CHAPTER SEVEN

# The Effect of the Quality of the Representation

## Experiment Four

### *Introduction*

Experiments One and Three used a familiar referent space, and revealed different results from Experiment Two, which used a completely novel referent space. It has been suggested that these differences might be attributed to the difference in familiarity with the referent space, but another possibility is that these differences might be due to the differing quality of the models which were used as representations. Experiments One and Three utilised a very basic, structural model, containing only cardboard replica items of furniture. However, the model used in Experiment Two contained not only items of furniture, but also carpet, curtains, and soft furnishings on the furniture, which were of similar colourings to the items in the referent space. Therefore, the model used in Experiment Two was a better quality representation, since it was more detailed and accurate than the one used in Experiments One and Three.

It could be argued that the differences observed between these experiments were due to this difference in model quality, rather than to the different levels of familiarity with the referent space. Experiment Four, then, was designed to investigate this possibility, by comparing children's performance using the higher quality model as in Experiment Two, with a lower quality representation that contained only the basic structural items of furniture, as in Experiments One and Three.

DeLoache et al. (1991), carried out a study using the typical model/room retrieval paradigm, in which they systematically varied the level of perceptual similarity between the model and the referent space. Their results indicated that children were more successful when the model was highly similar to the room. In addition, they found this effect to be more pronounced in younger children, with older children being relatively unaffected by differing levels of similarity. However, Piaget (1962) comments that in fact, as children get older, the representations used in symbolic play become more exact replicas of what they are supposed to represent, than when children are younger.

> *"In other words, the ludic symbol is evolving towards a straightforward copy of reality, only the general themes remaining symbolic, while the exact details of the scenes and of the constructions tends toward exact accommodation"* (Piaget, 1962, page 137)

It is unclear, then, whether we ought to expect children to perform better or worse with a very detailed representation. Nor is it clear whether younger or older children might benefit most from a more accurate representation of space. Experiment Four set out to address this issue by exploring children's performance using different qualities of representation.

***Method***

Participants

Participants were 39 children from the Nursery and Primary One classes of a primary school in the Stirling area. 16 of the children were boys, and 23 girls. Ages ranged from 43 to 72 months (3;7 to 6;0), with a mean age of 60.8 months (5;0).

Materials

The caravan was used for this experiment, as in Experiment Two. The same model was also used, but children viewed it in one of two possible set-ups. They either viewed it as a structural model, containing only basic cardboard representations of the main items of furniture, or they viewed it as a detailed model, in which case it also contained appropriately coloured carpeting and curtains. In addition, the detailed model also contained seat coverings and cushions. Appendices Fifteen to Seventeen show photographs of the detailed model, whilst Appendices Nineteen to Twenty-One show the basic model.

Procedure

See Chapter Three for an overview of the General Method used.

This study was carried out as previously, but for this experiment all children completed the Retrieval Task. The children were divided into two groups: Basic Model and Detailed Model. Within these two groups, all children completed a total of four trials: two in the Room-To-Model Condition, and two in the Model-To-Room Condition. All children completed a Memory Check control trial after each Test trial.

Correct or incorrect responses were recorded, as were the times taken on each test trial. Details of any errors that were made were also recorded.

## *Results*

<u>Scores</u>

Table 1 shows the children's scores in each Condition, using the two different model types. Table 2 shows children's mean scores in each Condition, according to their Age Group[1]. The overall mean score on Test trials was 55.8% correct. However, the mean score on the Control trials was 96.8% correct. A paired samples t-test showed this difference to be highly significant ($t_{38} = -7.179$, $p < 0.01$). As can be seen from Table 1, children's scores were slightly higher when using a basic model than when using a detailed one. Scores were also slightly higher in the Model-To-Room Condition then the Room-To-Model Condition.

[1] It should be noted that the number of children in the Primary One group was far larger than the number in the Nursery group (25 vs. 14). This was not the case in Experiment Two, nor any subsequent experiments. Therefore, for the purposes of Experiment Four, the Primary One group was also subdivided into two age groups using a median split.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Full model (n = 19) | 52.6 | 35.3 | 55.3 | 43.8 | 53.9 | 35.6 |
| Basic model (n = 20) | 60.0 | 34.8 | 62.5 | 39.3 | 57.5 | 31.5 |
| Total (n = 39) | 56.4 | 34.8 | 58.9 | 41.2 | 55.8 | 33.2 |

*Table 1. Mean score in each Condition, by Model Type.*

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Nursery Young (n = 7) | 35.7 | 24.4 | 50.0 | 40.8 | 39.3 | 24.4 |
| Nursery Old (n = 7) | 50.0 | 40.8 | 35.7 | 47.6 | 42.9 | 37.4 |
| Primary One Young (n = 13) | 67.8 | 31.7 | 67.9 | 37.2 | 67.9 | 30.1 |
| Primary One Old (n = 12) | 59.1 | 37.5 | 68.2 | 40.5 | 59.1 | 35.8 |

*Table 2. Mean score in each Condition, by Age Group.*

Preliminary analyses revealed no effects of gender, so this variable was omitted from subsequent analyses. A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Model Type: Basic vs. Detailed) x 4 (Age Group: Nursery young vs. Nursery old vs. Primary One Young vs. Primary One Old), with Condition as a within-subjects variable, was carried out on the data. This revealed no significant main effects of Condition, Model Type, nor Age Group, and no significant interactions.

Nevertheless, it is interesting to note that whilst the children scored slightly higher in the Model-To-Room Condition overall, the difference between these two Conditions is more pronounced in the youngest group of children than in either of the two oldest groups, as shown in Table 2.

Whilst the interaction between Age Group and Model Type was not significant, nevertheless it is interesting to note the trends which emerge from an examination of children's scores, as show in Figure 1. The youngest group of children scored higher overall using the basic model. The next oldest group then performed better using the more detailed model, but for the older children there was very little difference between the two.

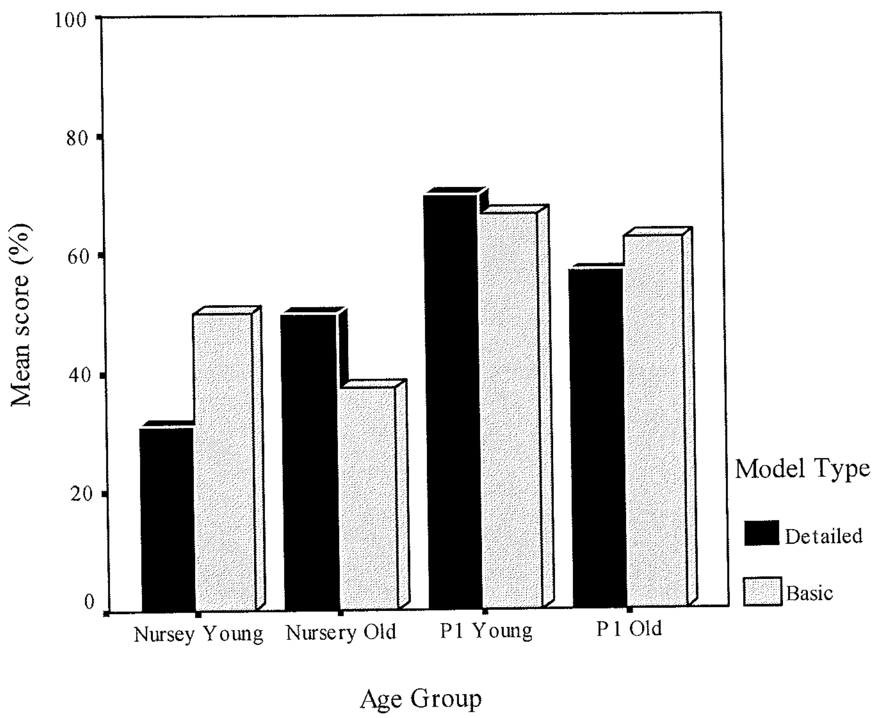


*Figure 1. Mean score for each Age Group, by Model Type.*

Time taken

Table 3 shows the mean time taken by children in each of the two Conditions, depending upon the type of model used. It appears that there was very little difference between the time taken in the Room-To-Model Condition, and that in the Model-To-Room Condition, nor does there appear to be any real difference between the time taken using the two different model types.

Table 4 shows the mean time taken by children depending upon their Level of Success, and Table 5 shows the time taken by children in each Age Group. It appears that in general children's time is less in the more successful groups. It also appears that the time taken by children is less in the older groups.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| Model Type | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Detailed (n = 19) | 14.85 | 7.97 | 11.89 | 7.37 | 13.37 | 6.83 |
| Basic (n = 20) | 14.60 | 5.55 | 12.57 | 7.52 | 13.59 | 4.95 |
| Total (n = 39) | 14.72 | 6.74 | 12.24 | 7.35 | 13.48 | 5.86 |

*Table 3. Mean time taken in each Condition, by Model Type.*

| | Condition | | | |
|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | |
| Number of correct responses | Mean time (secs) | SD | Mean time (secs) | SD |
| 0 | 23.09 (n = 7) | 7.49 | 17.75 (n = 10) | 8.12 |
| 1 | 15.19 (n = 20) | 4.55 | 13.51 (n = 12) | 5.75 |
| 2 | 9.04 (n = 12) | 3.26 | 8.11 (n = 17) | 5.51 |

*Table 4. Mean time taken in each Condition, by level of success.*

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| Age Group | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Nursery Young (n = 7) | 18.76 | 8.61 | 15.18 | 8.19 | 16.97 | 6.17 |
| Nursery Old (n = 7) | 15.46 | 7.87 | 15.80 | 8.97 | 15.63 | 6.14 |
| Primary One Young (n = 13) | 12.60 | 4.33 | 9.54 | 5.69 | 11.07 | 4.18 |
| Primary One Old (n = 12) | 14.39 | 6.96 | 11.55 | 7.01 | 12.97 | 6.50 |

*Table 5. Mean time taken in each Condition, by Age Group.*

A 2 (Model Type: Detailed vs. Basic) x 3 (Level of Success: 0 correct vs. 1 correct vs. 2 correct) x 4 (Age Group: Nursery Young vs. Nursery Old vs. P1 Young vs. P1 Old) ANOVA was carried out on the time data for each Condition. The analyses revealed a main effect of Level of Success in the Room-To-Model Condition ($F_{2, 19} = 16.223$, $p < 0.01$). A post-hoc Tukey test showed significant differences between all combinations of Level of Success. There was also a main effect of Level of Success in the Model-To-Room Condition ($F_{2, 18} = 4.823$, $p < 0.05$), and a post-hoc test revealed this difference to lie between the 0 correct and 2 correct groups. Figures 2 and 3 illustrate the times taken by children at each of these levels of success, and these show that the time taken by children was less as their scores increased. In these Figures the data for the group scoring one correct has been split to show the time taken by that group on their incorrect trial and on their correct trial. This provides further support for the idea that children take more time when they are incorrect, since the groups of children who scored one correct response took more time on their incorrect trial then their correct trial. Paired sample t-tests showed that these differences were significant in both the Room-To-Model Condition ($t_{19} = 3.563$, $p = 0.002$) and in the Model-To-Room Condition ($t_{11} = 2.813$, $p = 0.017$). There were no other significant effects or interactions.

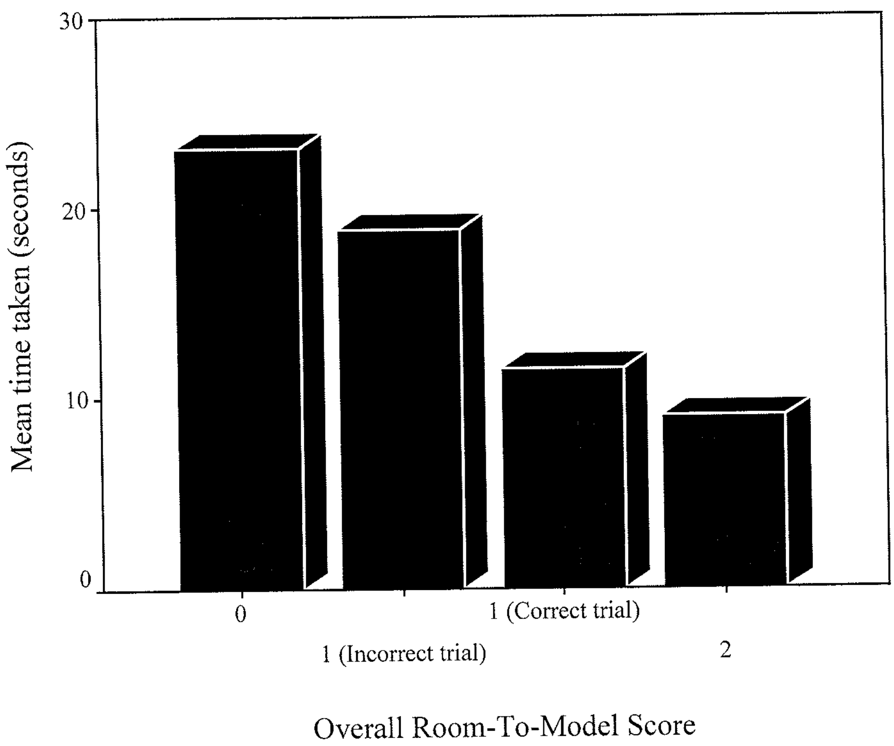


*Figure 2. Mean time taken, by score on Room-To-Model Condition.*

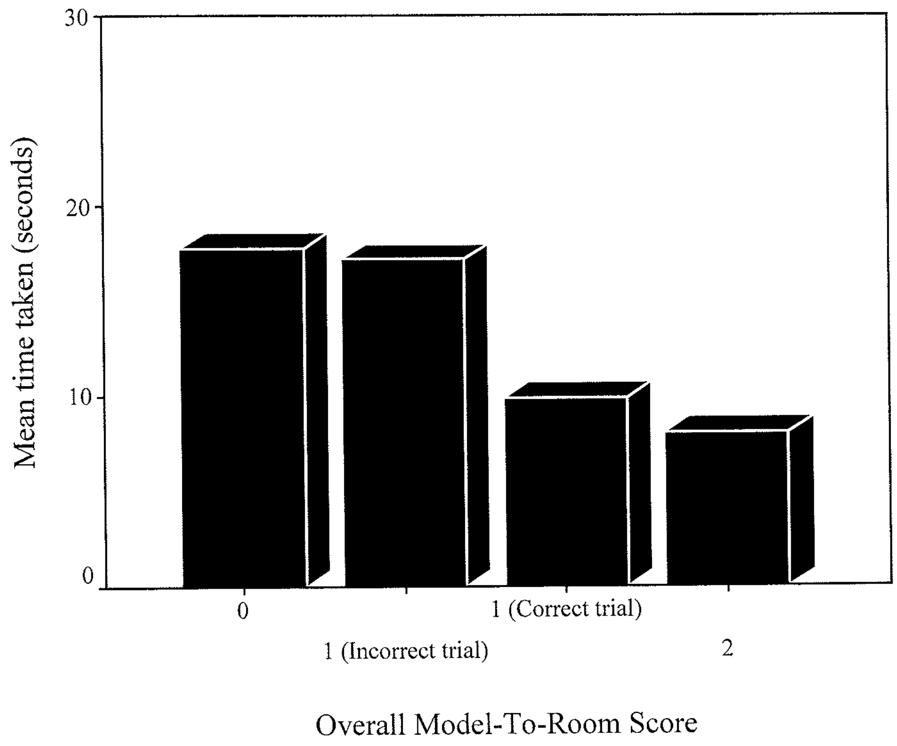


*Figure 3. Mean time taken, by score on Model-To-Room Condition.*

Error data

The errors that children made were classified into four categories, as in previous experiments. The number of each of the four errors types made using the detailed model and using the basic model, are shown in Table 6. From these results, it does not appear that there is any real difference between the two model types. The mean numbers of each of the four errors types overall are shown in Figure 4. This shows that the largest number of errors fell into the "Other" or "Identical location" categories, with Other errors making up the largest group overall. The number of each of the four error types made in each of the two Conditions are given in Table 7, and once again, there does not seem to be a different pattern of errors for the two Conditions.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| Model Type | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Detailed (n = 19) | 0.11 | 0.32 | 0.63 | 0.68 | 0.05 | 0.23 | 1.05 | 1.18 |
| Basic (n = 20) | 0.10 | 0.31 | 0.50 | 0.61 | 0.05 | 0.23 | 1.05 | 1.09 |
| Total (n = 39) | 0.10 | 0.31 | 0.56 | 0.64 | 0.05 | 0.22 | 1.05 | 1.12 |

*Table 6. Mean number of errors made, by Model Type.*

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.05 | 0.22 | 0.31 | 0.47 | 0.00 | 0.00 | 0.54 | 0.72 |
| Model-To-Room Condition | 0.05 | 0.22 | 0.26 | 0.44 | 0.05 | 0.22 | 0.51 | 0.72 |

*Table 7. Mean number of errors made in each Condition.*

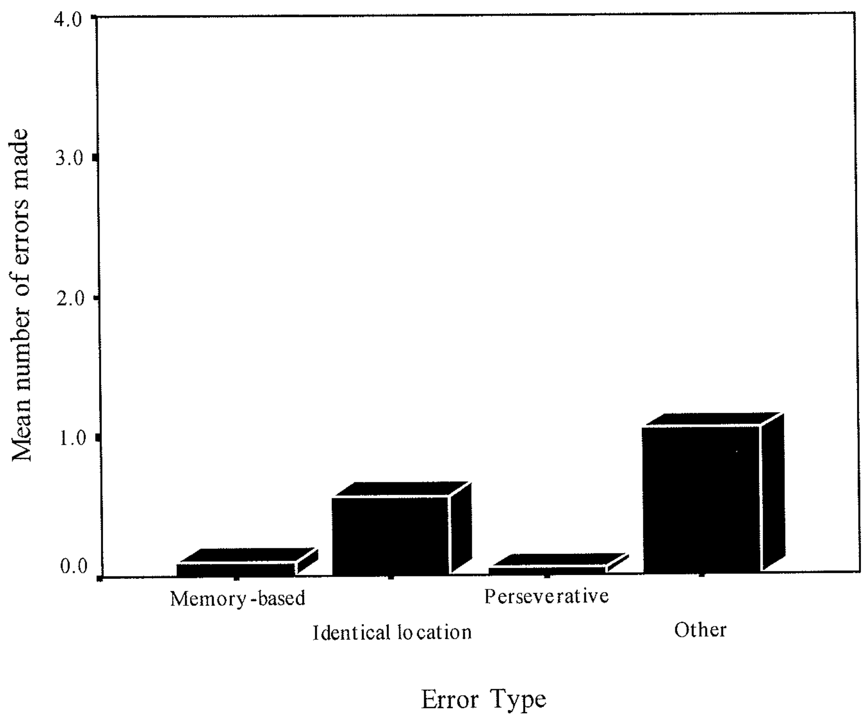


*Figure 4. Mean numbers of errors made.*

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Model Type: Detailed vs. Basic) x 4 (Age Group: Nursery Young vs. Nursery Old vs. P1 Young vs. P1 Old) mixed ANOVA was carried out on the data for each of the four error types. This revealed no significant effects or interactions. So, the numbers of each error type made did not differ using the two types of models.

Whilst the numbers of each error type did not differ significantly between the different Age Groups, nevertheless, the overall pattern of errors appears to alter slightly between the younger and the older children. As shown in Figure 5, the youngest group of children make the largest numbers of Other errors, then high numbers of Identical location and Perseverative errors. In the oldest group of children, though, children make similar numbers of Other and Identical location errors, and no Perseverative errors.

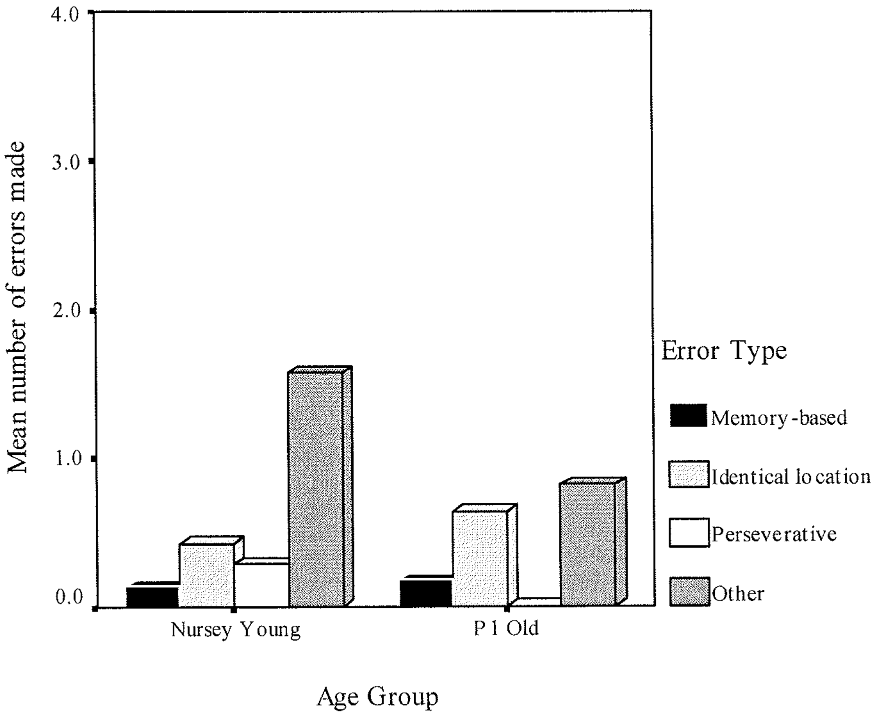


*Figure 5. Mean numbers of each error type made by the youngest and oldest age groups.*

***Discussion***

<u>Scores</u>

Experiment Four was designed to investigate the effect of the quality of the representation on children's ability to understand and to use that representation. The results here show that children were unaffected by the quality of the representation. Their scores, time taken and the types of errors that they made were similar when using both a detailed model and a basic, structural model. This, then, lends further support to the findings of Experiment Two, since the differences observed in children's performance between Experiments One and Two do not appear to be attributable to the different qualities of model that were used, but seem likely to be due to the complete novelty of the referent space in Experiment Two.

However, from Figure 1 we can see that the younger children appeared to do slightly better than the older children when using the basic model. This would fit with Piaget's (1962) suggestions that older children are more sensitive to the detail of a representation, whilst younger ones are unaffected by discrepancies between a representation and its referent.

As was the case in Experiment Two, children in this experiment scored higher overall in the Model-To-Room Condition than in the Room-To-Model Condition, and once again, this difference was most pronounced in the youngest group of children. This fits with the suggestions made previously that whilst younger children might find it easier to infer from a representation to the referent space, the abilities required to infer in both "directions" equally, develop with age.

Time taken

There was no difference between the time that children took when using the detailed model, as opposed to when using the basic model. Nor was there any difference between the time children took in the two Conditions. This fits with the findings of Experiment Two as well, in that using a smaller sized referent space means that children take equivalent amounts of time in the two Conditions.

In addition, main effects of Success on the time taken shows that children who score more highly take less time that those whose scores are lower. Further support for this comes from analysis of the times taken by children who made one correct response. Within these groups, children took more time on their incorrect trial than they did on their correct trial. This fits once again with the findings of previous experiments, and suggests that children who are confident about the correct response, respond quickly. When children are not sure of the correct target location, they appear to take more time in considering their responses.

Error data

The analysis of the error data suggests no differences between the numbers of each of the four error types made when using the detailed model and when using the basic model. Thus, the quality of the representation does not appear to affect the kinds of errors that children make.

An examination of the data reveals very similar patterns of errors to all of the previous experiments. Once again, children make the largest numbers of Other and Identical location errors overall. In addition, a comparison of the youngest and the oldest group of children, as shown in Figure 5, supports what has been found previously in terms of the strategies which children adopt at different ages in attempting these tasks. In the youngest group of children we observe a fairly random pattern of responding, with the large majority of errors being classed as "Other" errors, suggesting that these children have no appreciation of the overall representational relationship between the model and the room, or that they simply do not understand the task. Some Identical location errors are observed in this age group, suggesting the beginnings of an appreciation of object correspondences. However, there are also fairly large numbers of Perseverative errors, as has been observed in younger children from previous experiments.

The oldest group of children, however, make no Perseverative errors, and almost equal numbers of Identical location and Other errors. This suggests a much less random and more strategic form of responding from these children, who appear to have begun to grasp the representational relationship between the model and the room, and are utilising object correspondences in attempting to identify the correct target locations.

### *Conclusions*

In conclusion it appears that the quality of the representation has no discernible effects upon children's ability to understand and to use a representation of a referent space. Their scores, the time taken and the types of errors made were not significantly affected by the perceptual similarity between the model and the room, though younger children scored slightly higher using the more basic model.

Despite this, the pattern of performance in the two Conditions was not affected by the accuracy of the model, and it would therefore appear that the differences in children's performance which were observed between Experiments One and Two cannot be attributed to the different quality of the representations used in each. It seems that these differences in performance may be more likely to have been due to the complete novelty of the referent space in Experiment Two.

# CHAPTER EIGHT

## Selective Attention and Young Children's Understanding of Spatial Representations

## Experiments Five and Six

### *Introduction*

Representations, like maps or models, because of their very nature, tend to portray only the most salient features of that which they represent. Therefore the real world will generally contain much more than just that which is indicated by a representation. And as Ridderinkhof, van der Molen, Band & Bashore (1997) say,

> *"To develop the competence to interact efficiently with the sensory environment, children must learn to select relevant stimuli from the plethora of stimuli that impinge upon their senses." (p315)*

A number of studies have suggested, though, that children's ability to attend selectively to particular stimuli develops and improves with age. Young children may therefore perform more poorly on tasks which require irrelevant information to be ignored. In this case, when required to perform some task in the real world on the basis of a representation, young children might be expected to perform more poorly due to their inability to ignore the additional irrelevant material present in the real world which was not portrayed in the representation. Thus, young children's selective attentional abilities might explain their lower levels of performance in the Model-To-Room Condition in Experiment One, as opposed to their performance in the Room-To-Model Condition in that Experiment.

Developmental differences in attentional processes

In their review article on the development of selective attention, Lane and Pearson (1982) suggest three possible explanations for young children's difficulties in attending selectively to relevant information. Firstly, it is possible that younger children use more of their limited attentional capacities to process irrelevant information, whereas older children and adults have the ability to allocate attention more flexibly, which therefore enables them to allocate more attention to relevant information. Alternatively, it may be that the efficiency of younger children's capacities are less than those of older children and adults. A third possibility and one supported by Stroop (1935) is that interference from irrelevant stimuli occurs due to response competition rather than limited capacity, and that younger children may be more disrupted by this than older children or adults. Lane & Pearson (1982) conclude that much of the experimental evidence in this field suggests that as children get older they become less susceptible to distraction from irrelevant stimuli, although they admit that further research is required in order to determine what mechanisms underlie these developmental differences.

Pick, Christy and Frankel (1972) presented children with two dolls, and asked them to make same/different judgements on some dimension (size/shape/colour). Children were told the relevant dimension either prior to or following the stimulus presentation. Older children (sixth grade – precise ages not reported) were faster than younger children (second grade) on both types of task (relevant dimension given prior to or following stimulus presentation), but more so on the former. This, they conclude, suggests that older children are better then younger ones at not processing information which they know to be irrelevant to making a particular judgement. In a follow-up experiment, Pick and Frankel (1973) used the same dolls, but this time the relevant dimension was always either shape or size, and colour was always irrelevant. For one group of children the dolls' colour was varied between pairs, but for the other group colour was varied between pairs for the first part of the experiment and was then varied within pairs. This manipulation of colour within pairs should have no effect if children are able to focus their attention upon the relevant information. However, the results of this experiment showed that even the older children's responses were temporarily slowed by the variation of colour within pairs. Younger children's responses, though, were permanently slowed by the colour variation. This supports the results of their previous experiment, then, and further suggests that as children get older, their attention strategies become more flexible and are more capable of adapting to suit the demands of particular tasks. Taken together, the results of both of these experiments lend support to the notion that overall, younger children have more difficulties than older children at selectively processing information.

Further support for this comes from a study by Enns & Akhtar (1989). Children of four, five and seven years and adults of twenty years were required to respond to a target stimulus (a symbol of a particular shape), which was flanked by other symbols, which were either similar or dissimilar to the target. Results showed that all of the subjects, regardless of age, were unable to avoid processing stimuli that flanked a target, although older subjects were more capable than younger ones of inhibiting the processing of distracting stimuli.

Ridderinkhof et al. (1997) explored an alternative hypothesis – that younger children may not have difficulty in attending selectively to relevant stimuli, but that they instead have difficulties with the perceived structure of stimuli. That is, that younger children may be less able to perceive stimuli as being conjunctions of separate elements than their older counterparts. Therefore younger children may be unable to perceive relevant and irrelevant information as separate, whereas older children are able to separate them in their perceptions. A series of experiments in which children were asked to focus on relevant dimensions of a stimulus but ignore irrelevant elements showed that younger children were more affected than older children and adults by the presence of irrelevant stimuli. However, these differences were not accounted for by deficits in perceptual filtering, but instead the main difference was found in the speed or efficiency of processing, in the stage of translation from stimulus to response. These results once again support the view that younger children are more affected than older ones by the presence of irrelevant information, and further that this may be due to changes in processing speed, rather than in younger children's perceived structure.

Wohlwill (1962) supported the Piagetian distinction between perception and conception, and felt that development in attentional capacities can be thought of as resulting from the transition from perceptual to conceptual thought. However, rather than viewing these as two separate elements, he suggested that they are related and can be thought of as two opposite ends of a continuum, which can be specified along three dimensions – redundancy, selectivity and contiguity.

Since perceptual functions rely upon a high degree of redundancy in a stimulus input, Wohlwill felt that the transition from perception to conception entails a reduction in the amount of redundant information required. In terms of selectivity, the move from perception to conception means an increase in the amount of irrelevant information which can be tolerated without affecting the response. Finally, with regard to contiguity, the change from perception to conception leads to tolerance of greater spatial and temporal separation over which the information in the stimulus field can be integrated. Wohlwill carried out a study to illustrate these ideas, in which children and adults were presented with three stimuli and were asked to pick out the odd one from the three. The stimuli were geometric shapes which varied along one or more of four attributes – shape, colour, shading and size. "Criterial" attributes were those on which two of the three figures were the same, and one different. Each set of three stimuli varied either the amount of redundancy (where more than one attribute was Criterial) or the amount of noise (the number of attributes which varied). Wohlwill recorded errors and time taken for his subjects. He found that errors significantly decreased with age overall. In addition, although subjects made more errors on the sets of stimuli which varied noise than they did on the set varying redundancy, the younger children were affected more by redundancy than were the older children. Furthermore, the adults' times were greater on the sets varying noise than they were on those varying redundancy. Wohlwill took this to support the notion that these are separable dimensions, and that changes in levels of redundancy affect primarily perceptual processes. Increases in the amount of irrelevant information, however, mean that subjects must try out successive hypotheses with regard to the critical dimension. This supports the idea that the amount of irrelevant material which can be tolerated increases with age and is an important part of the transition from perceptual to conceptual processes.

Another study, by Day and Stone (1980) explored the effect of irrelevant visual information on a task in which children were shown pictures and asked to identify whether it was identical to a particular target picture. The pictures were shown to the child either alone, or were presented last in a series of six briefly presented drawings. These drawings are to be viewed as "visual noise", or non-target information which nevertheless falls upon the retina. The authors give an example of looking out from the window of a moving car. The visual noise in Day and Stone's experiment exemplifies all the irrelevant visual information in the successive scenes, which would fall upon the retina as one searched for a street sign. In Experiment One within the present study, this could be equivalent to all of the additional information present in the real room as the child identified the target location. Day and Stone (1980) assessed the abilities of five year olds, eight year olds and adults, and results showed that this type of visual noise reduced accuracy in all age groups, although children's accuracy was decreased more than adults'. This again supports the view that there may be a developmental trend in the ability to attend to a target stimulus when irrelevant information is also present.

Experiments Five and Six, then, were designed to assess whether children's performance on tasks using referent spaces and spatial representations, are affected by the presence of irrelevant information, as has been found in other areas. If so, this might account for the difference between performance in the

Model-To-Room Condition and the Room-To-Model Condition, in Experiment One.

### *Method*

Design

Two separate experiments were conducted at two primary schools in the Stirling area. Children in Experiment Five completed a Retrieval Task and those in Experiment Six completed a Positioning Task.

Participants

In Experiment Five, 48 children from a primary school took part in total, with 30 from the Nursery and 18 from Primary One class. The children were aged between 51 and 74 months (4;3 – 6;2), with a mean age of 62 months (5;2). The mean age of the Nursery children was 57 months (4;9) and of the Primary One children was 69 months (5;9). 30 of the children were boys, and 18 girls.

In Experiment Six, 50 children from a different primary school took part, with 31 from the Nursery and 19 from the Primary One class. These children were aged between 47 and 69 months (3;11 – 5;9), with a mean age of 60 months (5;0). The mean age of the Nursery children was 55 months (4;7), and of the Primary One children was 66 months (5;6). 27 of the children were boys and 23 girls.

An independent samples t-test showed that there was no significant difference between the ages of the children in the two experiments ($t_{96} = 1.451$, $p = 0.15$). Both schools were located in suburban, residential areas of Stirling.

Materials

As in previous experiments, the caravan served as the referent room, with the model of the caravan serving as the representation. See General Method (Chapter Three) for an overview of materials.

Procedure

All the children in Experiment Five completed Retrieval Tasks. All the children in Experiment Six completed Positioning Tasks. Children in both experiments were randomly allocated to one of four experimental groups:

1. Additional, irrelevant material present in both model and room.
2. Additional, irrelevant material present in neither.
3. Additional, irrelevant material present in the model only.
4. Additional, irrelevant material present in the referent room only.

Appendices Twenty-Two to Thirty-One show photographs of the model and the referent room in each of these configurations. Under configuration one (Both), all soft furnishings were left in the model and the room. In addition, books were placed on the shelves and on beds and cupboards. A plant was positioned on top of the chest of drawers and a toy train placed on top of one bed. A teddy bear was placed on another bed, and a doll on the third. Small-scale versions of all of these items were positioned in the analogous places in the model. Under configuration two (Neither), cushions and covers were removed from both model and room, and none of the aforementioned additional items were present. Under configurations three and four (Model only and Room only), these items were placed only in the model or only in the room, as appropriate.

Within their allocated experimental group, each child completed four trials – two of which were Room-To-Model and the other two of which were Model-To-Room. A memory check control trial was carried out after each Test trial. See General Method (Chapter Three) for an overview of Procedure.

***Results***

Scores

The overall score on Test trials was 56.4%. The mean score on Control trials, however, was 93.6%. This difference was highly significant ($t_{97} = -11.06$, $p < 0.001$). Table 1 shows the scores obtained in each Condition, by Task. There appears to be very little difference between children's performance in the two Conditions, nor on the two Tasks.

Table 2 shows the mean scores obtained in each Condition depending upon the location of the additional, irrelevant material (IM hereafter). Initial analyses revealed no significant difference between children's scores on the two Tasks (Retrieval vs. Positioning), so the data for Experiments Five and Six were combined for subsequent analyses. Preliminary analyses revealed no significant effects of gender, so this variable was omitted from subsequent analyses.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | %age correct | SD | %age correct | SD | %age correct | SD |
| Retrieval Ex. 5 (n = 48) | 61.5 | 37.5 | 50.0 | 37.2 | 56.3 | 30.3 |
| Positioning Ex. 6 (n = 50) | 59.0 | 41.3 | 54.0 | 38.9 | 56.5 | 35.6 |
| Total (n = 98) | 60.2 | 39.3 | 52.0 | 37.9 | 56.4 | 32.9 |

*Table 1. Mean score in each Condition, by Task.*

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| Location of irrelevant material | %age correct | SD | %age correct | SD | %age correct | SD |
| Both (n = 25) | 64.0 | 44.5 | 50.0 | 40.8 | 57.0 | 39.9 |
| Neither (n = 24) | 64.6 | 37.5 | 41.7 | 38.1 | 53.1 | 32.4 |
| Model (n = 24) | 60.4 | 41.6 | 62.5 | 33.8 | 61.5 | 28.5 |
| Room (n = 25) | 52.0 | 33.8 | 54.0 | 37.9 | 54.0 | 31.2 |

*Table 2. Mean score in each Condition, by Location of Irrelevant Material, collapsed across Task.*

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 Task (Retrieval vs. Positioning) x 4 (Location of Irrelevant Material: Room vs. Model vs. Both vs. Neither) x 3 (Age Group: Nursery Young vs. Nursery Old vs. Primary 1) mixed ANOVA was carried out on the data, with Condition as a within-subjects variable. The analysis revealed no significant difference between the scores in the two Conditions, nor any difference overall between the scores obtained with irrelevant material in each of the four different locations. The interaction between Condition and Location of Irrelevant Material was not significant, but nevertheless there does seem to be a slightly different pattern of performance in the two Conditions, as illustrated by Figure 1.

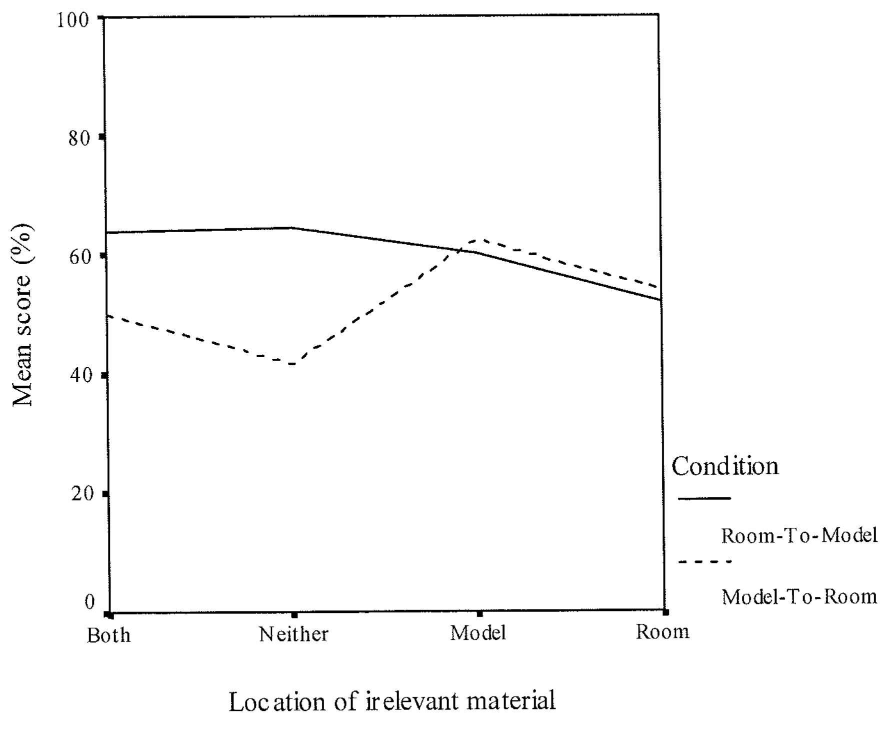


*Figure 1. Mean score in each Condition, by Location of Irrelevant Material.*

It appears from Figure 1 that children's scores in the Room-To-Model Condition change only slightly with the presence of irrelevant material in the different combinations. Children score equivalently in the Both and Neither configurations, but score slightly lower in the Model and Room only configurations. However, scores in the Model-To-Room Condition are higher when the irrelevant material is in the Model or the Room only, and much lower when it is in both or neither.

The only significant result to emerge from the analysis was a main effect of Age Group, as shown in Figure 2. Post-hoc Tukey tests revealed a significant difference between the Nursery Young and Primary One groups ($p < 0.01$), and a marginally significant difference between the Nursery Old and Primary One groups ($p = 0.069$).

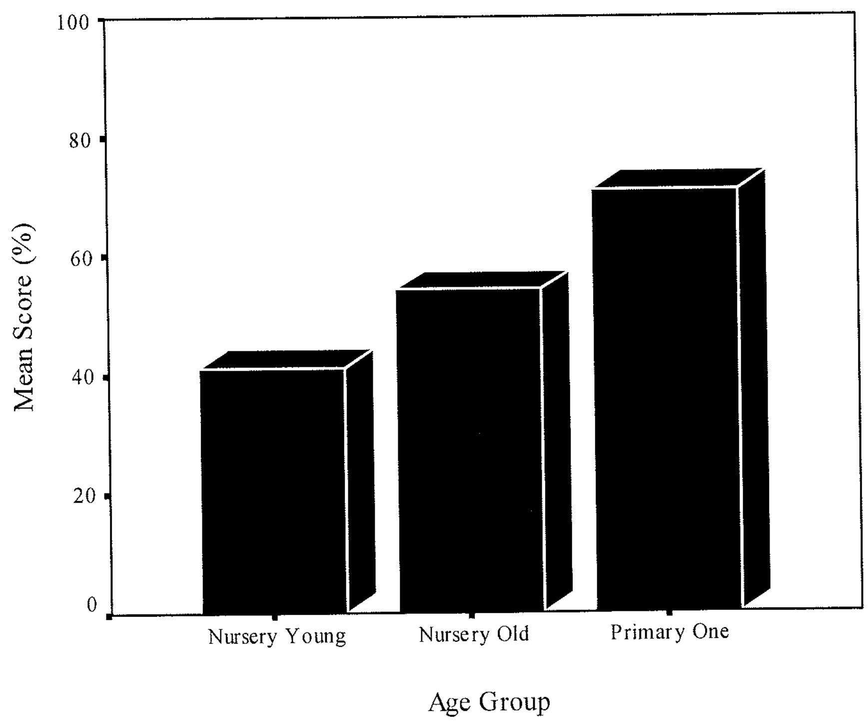


*Figure 2. Mean score for each Age Group.*

Figure 3 shows the scores obtained by children at each Age Group, by the location of irrelevant material. The interaction between these variables was not significant, but children seemed to perform similarly in the Model and Room only configurations, whilst the oldest group were better in the Both and Neither configurations.

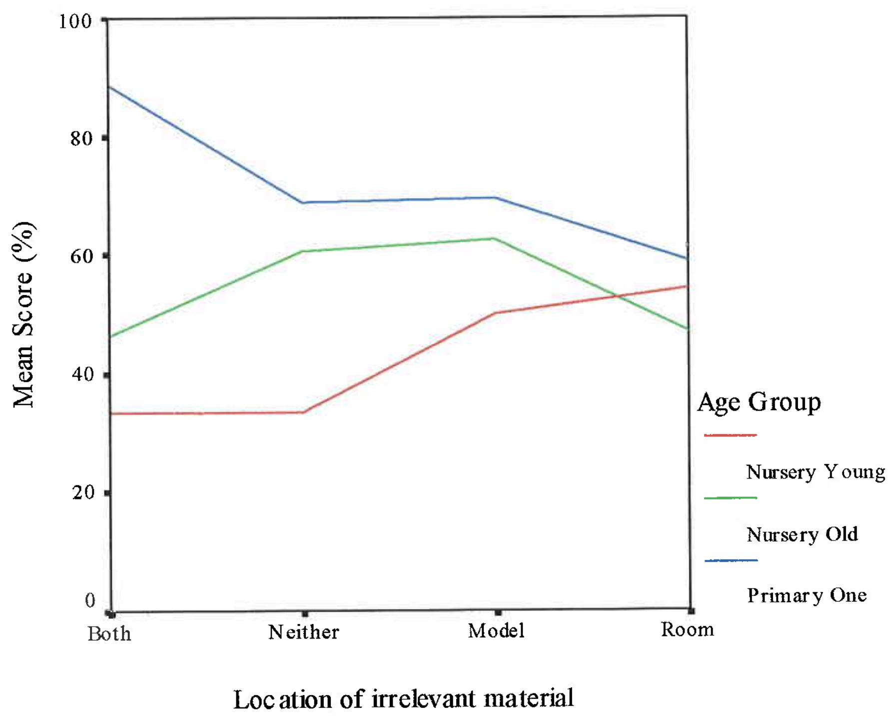


*Figure 3. Mean score for each Age Group, by Location of Irrelevant Material.*

Time taken

Table 3 shows the amount of time taken by children in each of the two Conditions depending upon the Task that they completed. Table 4 shows the amount of time taken in each Condition, depending upon the location of the additional, irrelevant material.

From Table 3, it appears that the Retrieval Task took longer than the Positioning Task, but there does not seem to have been any difference in the time taken by children in the two different Conditions. Table 4 suggests that there may be some differences in the time taken, depending upon the location of the irrelevant material, however. Children took longest in the "Both" and "Neither" configurations, then less in the "Model" and "Room" only configurations.

Table 5 indicates the time taken by children in each Condition, depending upon their level of success. These results suggest that in general children took less time with increasing success, although this is more pronounced in the Model-To-Room Condition.

| | Condition | | | | | |
|---|---|---|---|---|---|---|
| | Room-To-Model | | Model-To-Room | | Total | |
| | Mean time (secs) | SD | Mean time (secs) | SD | Mean time (secs) | SD |
| Retrieval Ex. 5 (n = 48) | 14.22 | 8.11 | 12.65 | 7.71 | 13.43 | 6.54 |
| Positioning Ex. 6 (n = 50) | 8.19 | 3.63 | 8.63 | 6.13 | 8.41 | 3.89 |
| Total (n = 98) | 11.14 | 6.91 | 10.59 | 7.20 | 10.87 | 5.89 |

*Table 3. Mean time taken in each Condition, by Task.*

| Location of irrelevant material | Condition: Room-To-Model Mean time (secs) | SD | Model-To-Room Mean time (secs) | SD | Total Mean time (secs) | SD |
|---|---|---|---|---|---|---|
| Both (n = 25) | 11.74 | 7.31 | 11.58 | 8.04 | 11.66 | 6.26 |
| Neither (n = 24) | 12.78 | 8.11 | 12.37 | 7.63 | 12.58 | 6.55 |
| Model (n = 24) | 10.85 | 7.03 | 9.81 | 7.96 | 10.33 | 6.39 |
| Room (n = 25) | 9.24 | 4.70 | 8.66 | 4.44 | 8.95 | 3.67 |

*Table 4. Mean time taken in each Condition, by Location of Irrelevant Material.*

| Number of correct responses | Condition: Room-To-Model Mean time (secs) | SD | Model-To-Room Mean time (secs) | SD |
|---|---|---|---|---|
| 0 | 13.71 (n = 22) | 9.05 | 16.08 (n = 26) | 8.89 |
| 1 | 12.85 (n = 34) | 6.62 | 10.04 (n = 42) | 5.53 |
| 2 | 8.41 (n = 42) | 4.69 | 6.62 (n = 30) | 4.29 |

*Table 5. Mean time taken, by score.*

A 2 (Condition: Room-To-Model vs. Model-To-Room) x 4 (Location of Irrelevant Material: Both vs. Neither vs. Model vs. Room) x 2 (Task: Retrieval vs. Positioning) x 3 (Age Group: Nursery Young vs. Nursery Old vs. Primary

One) ANOVA was carried out on the time data, to investigate whether the presence of IM in any of the four configurations, had an effect upon the time taken. Two separate 3 (Level of Success: 0 correct vs. 1 correct vs. 2 correct) x 4 (Location of IM) x 3 (Age Group) x 2 (Task) univariate ANOVAS were carried out on the time data for each Condition separately, to assess whether the children's success affected the time they took.

The results revealed main effects for Level of Success in the Room-To-Model Condition ($F_{2, 48} = 6.196$, $p < 0.01$) and in the Model-To-Room Condition ($F_{2, 44} = 4.788$, $p < 0.05$). As Table 5 suggests, the time taken was less in the more successful groups of children. Post-hoc Tukey tests show that in the Model-To-Room Condition the differences between the 0 correct and 1 correct groups, and the 0 correct and 2 correct groups, were highly significant ($p < 0.01$). The difference between the 1 correct and 2 correct groups was also significant, though less so ($p < 0.05$). In the Room-To-Model Condition the difference between the 0 correct and 2 correct groups, and the difference between the 1 correct and 2 correct groups, were highly significant (both $p < 0.01$).

There was a main effect of Task upon time taken overall ($F_{1, 74} = 26.112$, $P < 0.01$). As shown in Figure 4, children took longer on Retrieval trials in both Conditions. Task was also seen to significantly interact with Level of Success in the Room-To-Model Condition ($F_{2, 48} = 4.402$, $p < 0.05$). As illustrated by Figure 5, the amount of time taken on Positioning trials appears to remain relatively stable regardless of how highly children have scored. However, on Retrieval trials, the time taken drops in the more successful groups.

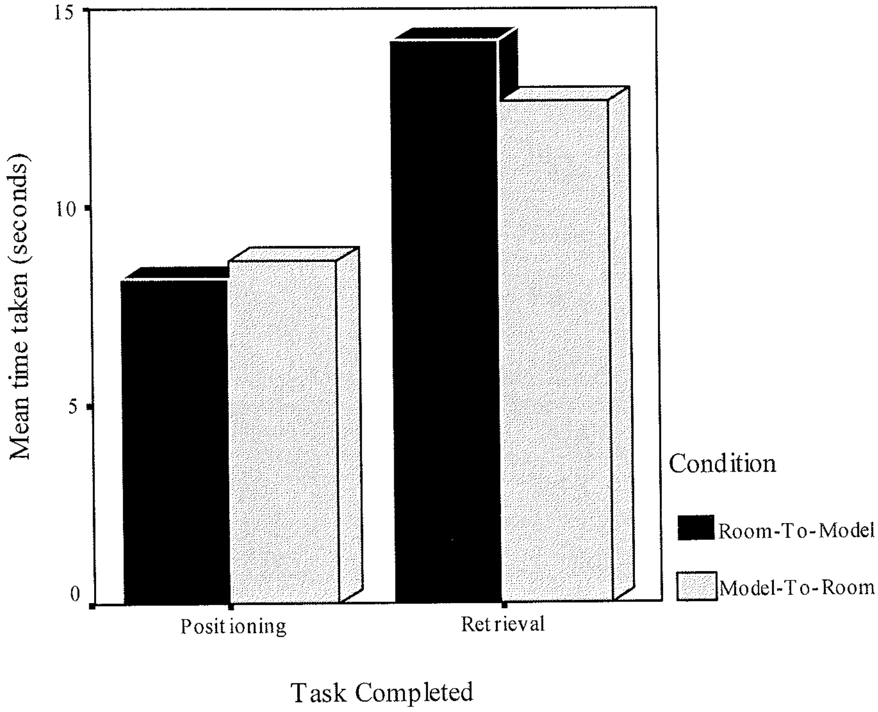


*Figure 4. Mean time taken in each Condition, by Task.*

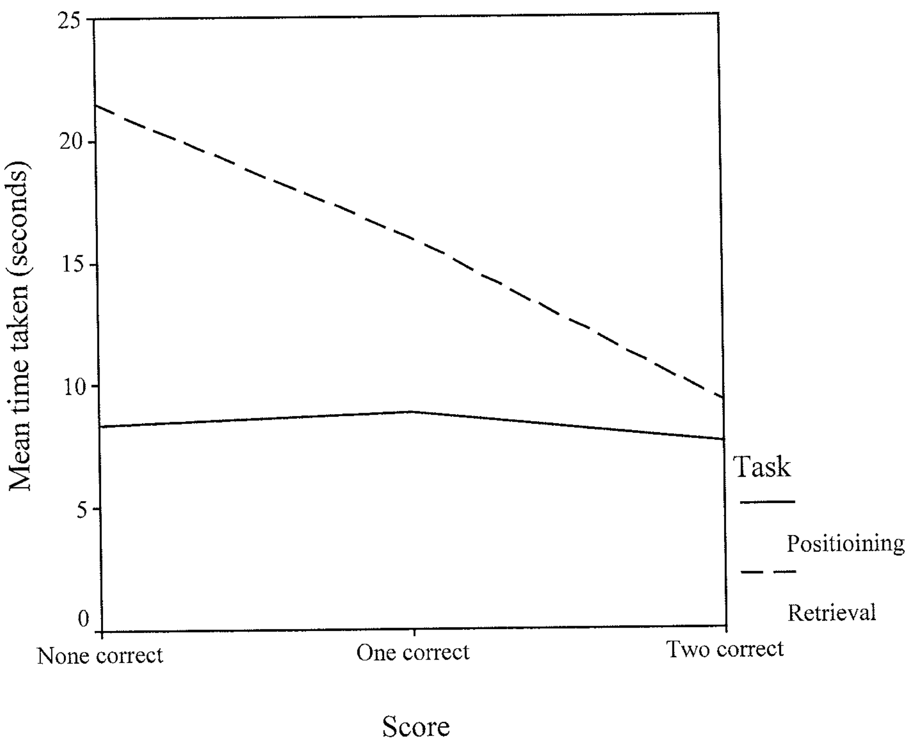


*Figure 5. Room-To-Model Condition: Mean time taken on each Task, by Score.*

There was also a main effect of Age Group upon time taken overall ($F_{2, 74} = 5.318$, $p < 0.01$). Figure 6 shows the amount of time taken in each Condition, by Age Group. In general, children in the older age groups took less time than the younger ones. This difference was only statistically significant in the Room-To-Model Condition ($F_{2, 48} = 4.635$, $p < 0.05$), and not in the Model-To-Room Condition.

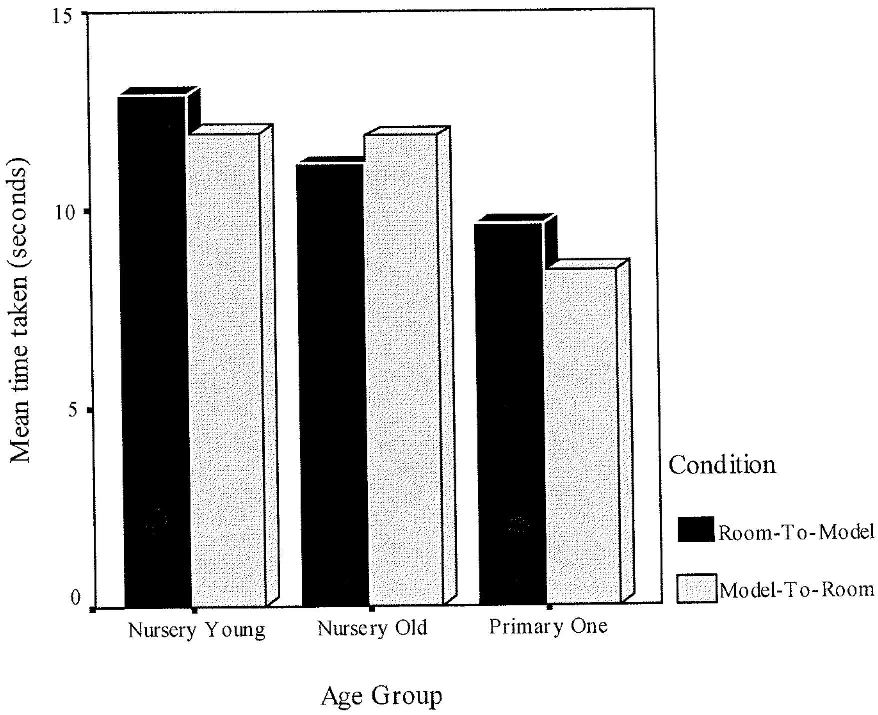


*Figure 6. Mean time taken in each Condition, by Age Group.*

This main effect of Age Group in the Room-To-Model Condition, was seen to significantly interact with Level of Success (see Figure 7. $F_{4, 48} = 3.752$, $p = 0.01$). From Figure 7 it appears that the oldest group of children take less time overall, even when they score poorly, but their time gets slightly less as their score improves. The youngest group takes most time overall, and even though their time is also less in the more successful group, they still take much more time than the other two groups even when highly successful. The middle group of children, however, take comparable amounts of time to the youngest children, in the less successful groups. However, their time drops dramatically in the most successful group, to a level similar to the oldest group of children.

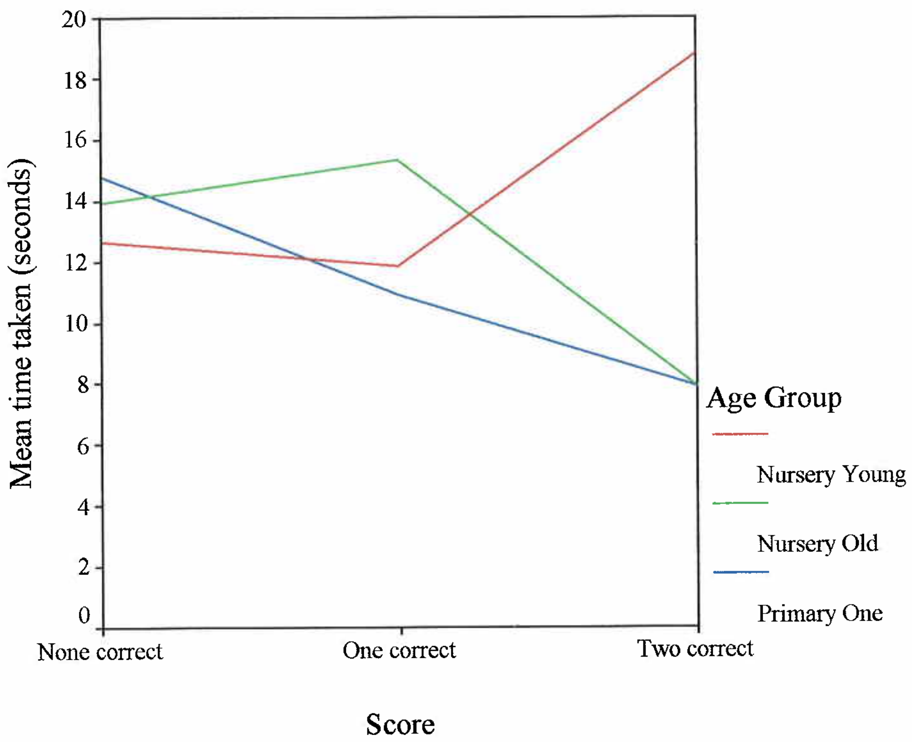


*Figure 7. Room-To-Model Condition: Mean time taken at each Age Group, by Score.*

There was an overall main effect of the Location of IM ($F_{3, 74} = 2.952$, $p < 0.05$). Post-hoc Tukey tests showed that the only difference lay between the group with irrelevant material in Neither, and the group with irrelevant material in the

Room. This effect of IM also interacted with Age Group in the Room-To-Model Condition, as shown in Figure 8 ($F_{6, 48} = 6.470$, $p < 0.01$).

From Figure 8 it appears that oldest group of children remains relatively unaffected by the presence or absence of irrelevant material, in terms of the amount of time they take. In addition, the amount of time taken when irrelevant material is present in the Model only or in the Room only, appears to be similar for all three Age Groups. When irrelevant material is present in Both spaces or in Neither space, however, the time taken by children is different at different Age Groups.

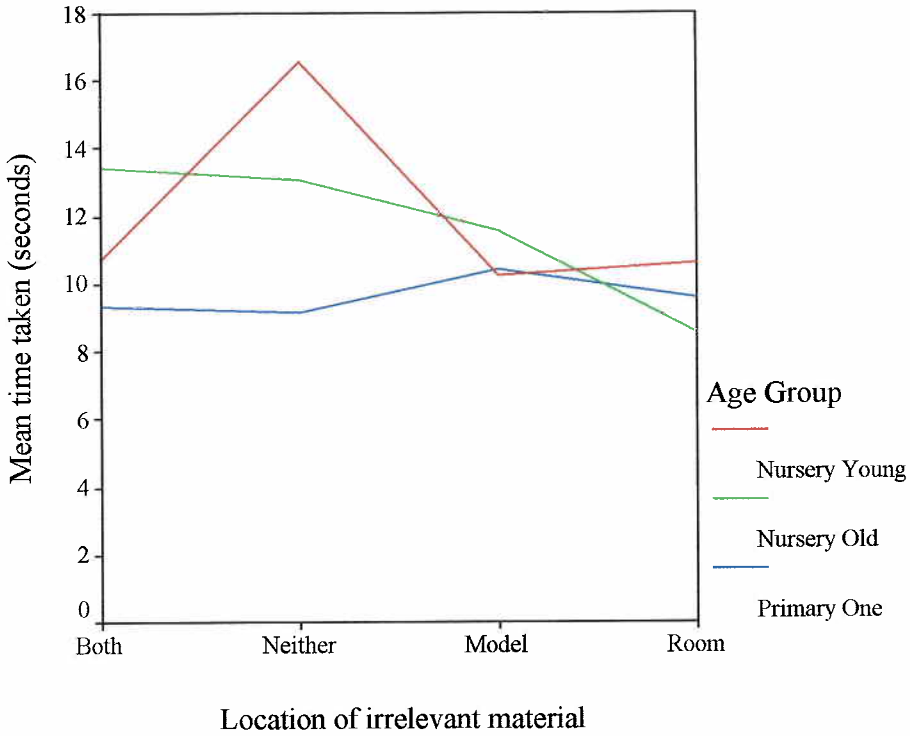


*Figure 8. Room-To-Model Condition: Mean time taken at each Age Group, by Location of Irrelevant Material.*

The middle group of children take most time when irrelevant material is present in Both, and less when it is present in Neither. But the time taken under both of these conditions is more than when there is IM in just the Model or just the Room. The youngest age group of children, however, take less time when IM is present in Both spaces and much more time when it is present in Neither.

Error data

The errors that children made were classified into four categories, as in previous experiments. The numbers of each of the four error types made under the four different combinations of Irrelevant Material, are shown in Table 6. The mean numbers of each of the four error types made in the two Conditions, are shown in Table 7. Figure 9 illustrates the overall pattern of errors being made.

It appears that the largest number of errors were "Other" errors, with Identical location errors comprising the second largest group. Only small numbers of Memory-based and Perseverative errors were made.

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| Location of Irrelevant Material | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Both (n = 25) | 0.28 | 0.54 | 0.24 | 0.44 | 0.08 | 0.28 | 1.16 | 1.43 |
| Neither (n = 24) | 0.13 | 0.34 | 0.50 | 0.72 | 0.17 | 0.64 | 1.08 | 1.18 |
| Model (n = 24) | 0.25 | 0.53 | 0.33 | 0.48 | 0.13 | 0.34 | 0.83 | 0.92 |
| Room (n = 25) | 0.12 | 0.33 | 0.76 | 0.72 | 0.00 | 0.00 | 0.96 | 1.39 |
| Total (n = 98) | 0.19 | 0.45 | 0.46 | 0.63 | 0.09 | 0.38 | 1.01 | 1.24 |

*Table 6. Mean number of each error type, by Location of Irrelevant Material.*

| | Number of errors made | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Memory-based | | Identical location | | Perseverative | | Other | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Room-To-Model Condition | 0.03 | 0.17 | 0.20 | 0.41 | 0.04 | 0.19 | 0.54 | 0.71 |
| Model-To-Room Condition | 0.16 | 0.39 | 0.26 | 0.44 | 0.05 | 0.26 | 0.50 | 0.71 |

*Table 7. Mean number of errors made in each Condition.*

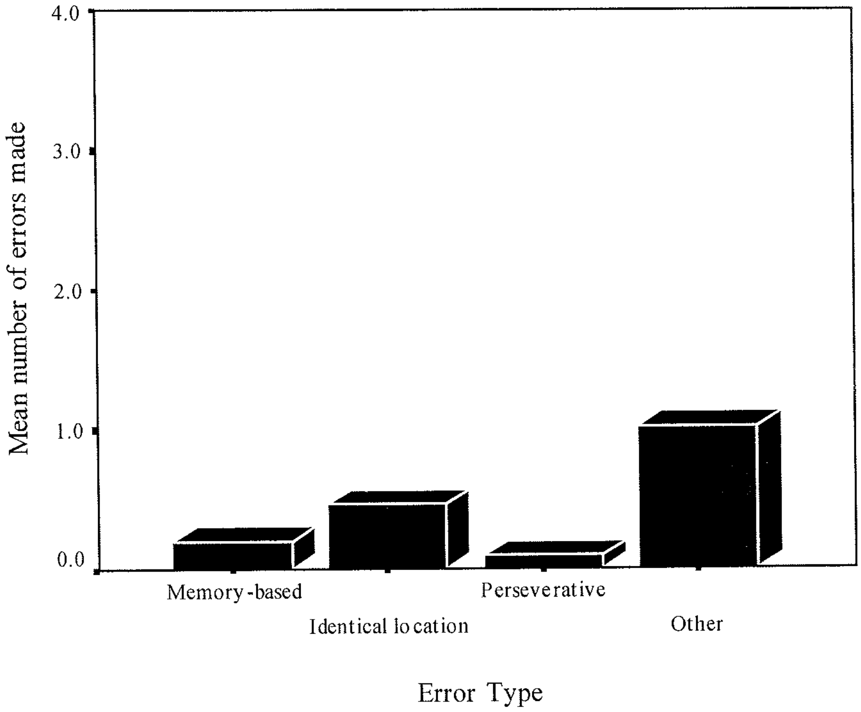


*Figure 9. Mean number of each error type made.*

Preliminary analyses revealed no effects of Task, so the data for Experiments Five and Six were combined for subsequent analyses. A 2 (Condition: Room-To-Model vs. Model-To-Room) x 2 (Task: Retrieval vs. Positioning) x 4 (Location of Irrelevant Material: Both vs. Neither vs. Model vs. Room) x 3 (Age Group: Nursery Young vs. Nursery Old vs. Primary One) ANOVA, with Condition as a within-subjects variable, was carried out on the data for each of the four error types. Previous analyses of the children's scores had already revealed no effects of Condition or Task, nor of Location of Irrelevant Material, on the overall number of errors which children made. Therefore, the concern of the present analysis was whether these variables affected any of the different error types in particular, in order to gain some insight into the kinds of strategies being adopted by children to approach the tasks, under varying conditions.

Whilst previous analyses had revealed no overall difference in children's performance in the two Conditions, the present analysis found a significant difference between the number of Memory-based errors in the two Conditions ($F_{1, 74} = 11.915$, $p < 0.01$). As shown in Table 7, children made more Memory-based errors in the Model-To-Room Condition than in the Room-To-Model Condition. None of the other error types differed between Conditions.

The analysis also revealed a significant main effect of Age Group, on "Other" errors ($F_{2, 72} = 5.608$, $p < 0.01$). Post-hoc Tukey tests suggest that the difference between the Nursery Young group and the Primary One group is significant ($p < 0.01$). Figure 10 shows the numbers of each type of error, that were made by children in each of the three Age Groups. Identical location errors appear to increase slightly with increasing age, whilst Perseverative and Memory-based errors decrease slightly with increasing age. The only type of errors which differ markedly with age, though, are "Other" errors. As Figure 10 shows, these decrease significantly as children get older.

No differences in the types of errors being made were observed in relation to the different configurations of irrelevant material.

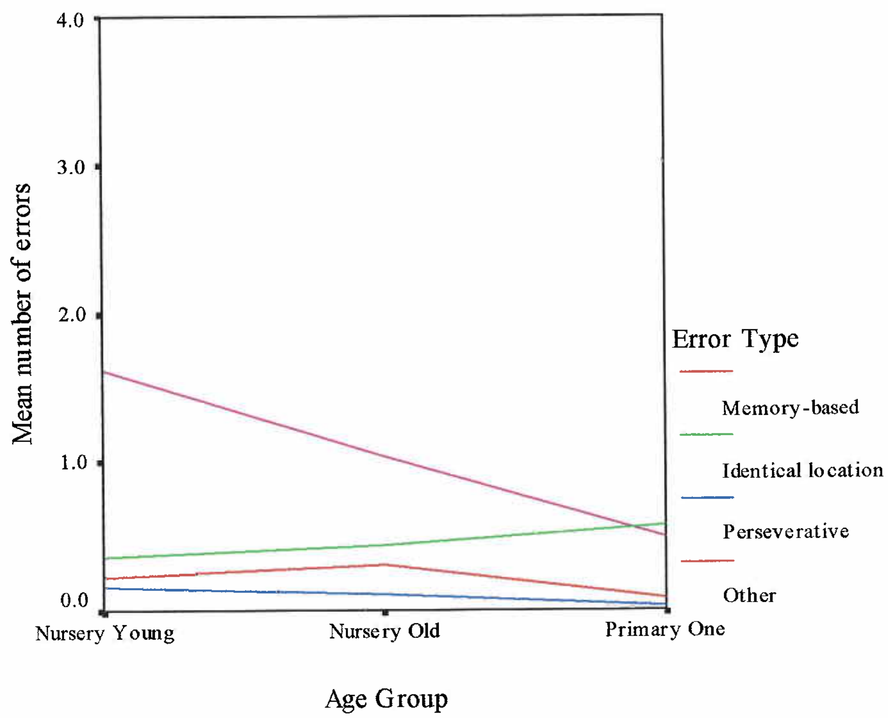


*Figure 10. Mean number of each error type made, by Age Group.*

***Discussion***

The experiments reported here were designed to assess whether the presence of additional, irrelevant material in a referent room or in a representation, might affect children's performance on these kinds of tasks. Experiment One found that children performed slightly worse in the Model-To-Room Condition. Experiment Two, however, found the opposite effect – that children performed worse in the Room-To-Model Condition. It has been suggested that this difference may be due to the subjects' familiarity with the referent room in Experiment One, and the converse novelty of the referent room in Experiment Two. However, it has also been suggested that since the referent space used in Experiment One was a genuine room, containing a large amount of additional and irrelevant material that was not represented in the model, this might have distracted children from the target location in the Model-To-Room Condition in that experiment, thus leading to poorer performance. Experiments Five and Six set out to explore whether this might be an explanation for the differences in performance observed previously.

Scores

As has been found before, there was a main effect of Age Group, with children increasing their overall scores as they got older. However, from the children's scores, it certainly did not appear to be the case that the presence of additional, irrelevant material in the referent space lowered performance in the Model-To-Room Condition. In fact, with additional, irrelevant material present in the Room only, performance was slightly higher in the Model-To-Room Condition. This is more consistent with the findings of Experiment Two than Experiment One. Overall, though, there was no significant effect of having irrelevant material in any of the four different configurations. This suggests that the presence of irrelevant material alone was not responsible for children's poorer performance in the Model-To-Room Condition in Experiment One.

Nevertheless, there were some slightly different patterns of performance between Conditions under the four configurations of irrelevant material. With additional material in the Model or the Room only, performance was slightly better in the Model-To-Room Condition, which is consistent with the results of Experiment Two. However, with additional material in Both or in Neither, performance was better in the Room-To-Model Condition.

When irrelevant material was present in either the Room or the Model only, the two spaces were different, and children performed in similar ways under these two configurations. But when irrelevant material was present in Both or Neither, the two spaces were very similar. Children again performed in similar ways under these two configurations, but differently to the way they performed under the other two configurations.

This might suggest that children's performance is affected by the level of similarity between the two spaces, irrespective of whether this similarity is due to a lot of additional material being included in both spaces, or whether it is due to all the superfluous material being removed from both spaces. Children might also perform similarly when the two spaces are different, irrespective of whether this difference arises from additional material being added to the representation, or whether it is due to additional material being added to the referent space.

Using a completely novel referent space, performance has previously been shown to be superior in the Model-To-Room Condition. This Condition characterises the way that a representation of space is typically used (see Chapter Two) – to assist with some task in the referent space. This continues to be the more successful Condition in the configurations under which the referent and the representation are different (IM in Model or Room only). However, it could be argued that when a representation and its referent are highly similar, the representational element of the task is no longer required, since the task then becomes more of a matching task. For example, DeLoache, Kolstad and Anderson's (1991) study used a representation and a referent which were actually very similar in scale. This elicited much improved performance in children, but in this situation it is difficult to view the task as one requiring representational abilities as such.

It is possible that in the present experiments, when the model and the room were highly similar (due to the presence of large amounts of additional detail in both, or due to the absence of any detail in either), the task was solved as a simple matching one by children, rather than a representational one. Thus, the counter-intuitiveness of the Room-To-Model Condition as a representational task may no longer have had an effect. DeLoache, Miller and Rosengren (1997) showed that children's performance is affected by the perceived nature of the task. When 2½ year old children were presented with a referent room and a model of the room in the standard experimental paradigm, they performed typically poorly. However, when the children were told that the smaller room was actually the same room, but had been shrunk, children's scores increased significantly. So, if children were required to think of the task as a representational one, they performed worse than if they could just think of it as a matching task. In the present experiments, instructions to children regarding the nature of the task remained the same throughout. However, perhaps the increased similarity of model and room in the present experiment had an effect similar to DeLoache's, of altering children's approaches to the task, and thus altering performance. Indeed, children of all age groups performed similarly when the two spaces were different, but the oldest children performed better than the other groups when the spaces were similar. This would again seem to support the notion that there is some advantage to the spaces having irrelevant material in either both or neither, which could be attributed to the older children being able to take advantage of a simpler "matching" solution to the task, rather than the more difficult representational solution.

In any case, the results do not support the notion that the additional material which was present in the referent room in Experiment One, would have in itself lowered performance in the Model-To-Room Condition.

Time taken

As has been observed consistently in previous experiments, children took longer to complete the Retrieval Task than they did to complete the Positioning Task. Once again, though, since there was no difference between scores on the two Tasks, it does not seem to be the case that the greater amount of time taken has any effect upon performance.

In addition, children who were more successful, consistently took less time than those who performed more poorly. Thus, it appears that children take longer in considering their responses when they are unsure of the correct response. When they are confident about the target location, children respond more quickly. This is also the case with increasing age. Children take less time as they get older, suggesting that the younger children, whose performance is poorer overall, take more time in considering their responses than their older, more successful counterparts. However, this difference in time taken was only statistically significant in the Room-To-Model Condition. In the Model-To-Room Condition, the time taken decreased with increased age, though not to the same extent as in the other Condition.

In relation to the effect of IM on the time taken, there was no difference between the two Conditions in the way that there was with the Score data. Therefore, if children were approaching the tasks differently under the four different configurations of IM, this did not have an effect on the time taken in the two Conditions. However, as with the Score data, once again there seems to be a slightly different pattern of performance for the "Both and Neither" configurations, as opposed to the "Model and Room only" configurations.

Firstly, the older children appear to be relatively unaffected by IM, and their time remains fairly stable under all four configurations. In addition, all three Age Groups take similar amounts of time when IM is present in the Model or the Room only. When IM is present in Both or Neither, though, different patterns emerge. It should be noted that post-hoc analyses revealed that a statistically significant difference lay only between the "Neither" and the "Room only" configurations. Thus, it appears that there is something which causes children to approach these two particular configurations of IM in very different ways.

Originally, it was thought that the presence of IM might cause a distraction to children. If this were the case, then children might take longer when IM was present. Therefore, in younger children at least, we would have expected the youngest group to take most time when IM was present in Both spaces; similar amounts of time when it was present in the Model or the Room only; and least time when it was present in Neither. In fact, what was observed was that the middle age group of children took most time when IM was present in Both, less time when it was present in Neither, but by far the least time when it was present in either one or the other only.

In the youngest group of children, the amount of time taken when IM was present in Both was almost comparable to that taken by the oldest group. However, when IM was present in Neither, this middle group took much, much longer to complete the tasks. Thus, whilst IM might prove distracting for younger children, it appears that a complete lack of any IM also causes them to take longer. Thus, it may not be the case that additional stimuli causes children to attend longer in these tasks.

Several authors have investigated the effects of landmarks on children's ability to understand and to use spatial representations (e.g. Blades and Spencer, 1987), and the importance of landmarks as unique identifiers for certain locations is well-documented (see, e.g. Blades and Spencer, 1990). An alternative explanation to the selective attention one, for the differences observed in different configurations of IM, could be that in these experiments it served as additional landmarks for children, providing extra cues as to the correct target locations in the two spaces. In that case, children would be expected to take most time with IM in Neither, which was exactly what was found. This would be because a complete absence of any additional cues whatsoever, would cause children in the "Neither" group to have to take additional time in picking out the correct location from the information that was available.

The problem with this explanation, though, is that under this hypothesis, children should have taken least time when IM was present in Both spaces, since then the identification of target locations through the use of landmarks would be most straightforward. What was actually observed, though, was that children took far more time in the "Both" configuration than they did with IM in Model or

Room only. In fact, the time taken with IM in "Both" was similar to that taken in "Neither". Therefore, this explanation does not seem to be convincing.

In addition, we would also have expected to see the highest scores when IM was present in both, due to the additional landmark cues. Model and Room only configurations would then have achieved the next highest scores. This pattern did not emerge.

One other possibility, then, is that the time children took was affected more by the novelty of the configurations than by the amount of additional material that was being attended to. In the Introduction to this chapter, it was suggested that referent spaces are typically more complex and contain more material than a representation of the space. However, representations themselves sometimes convey information not present in the referent space (e.g. gradients on maps). Perhaps it is most counter-intuitive, then, to be faced with an extremely simplified referent space, which matches precisely its representation. It might also be counter-intuitive to observe a very detailed referent space which matches precisely its representation. A more common situation would be for referent and representation to be different.

It is well-documented in many research domains, that novel objects or events receive more attention than familiar or common ones (see Ruff and Rothbart, 1996 for a review). Perhaps in this task, the unexpected configurations of having material in neither referent space nor representation, or the novelty of it appearing identically in both, was sufficient to cause the younger children at least, to spend more time attending to the stimuli under these circumstances than when the configurations were less novel.

Finally, in relation to the level of success, there was no overall match between the amount of time taken and the children's scores in the four configurations (Children scored lowest in the Neither configuration, in which they actually took most time. Yet they took least time in the Room only configuration, which obtained only the next highest score). Thus, whilst children overall took less time as they achieved higher levels of success, there does not appear to be any systematic relationship between their scores in each of the four configurations of IM, and the time they took in each configuration.

In summary, then, as shown in Figures 1 and 7, there does appear to be something similar about the "Both and Neither" configurations, which are different to the "Model and Room only" configurations, and this applies to both scores and time. Whether the former configurations lead to a different approach by children due to their novelty or to their suggesting a different strategy for solution, though, is unclear.

Error data

The overall pattern of errors was very similar to that found in previous experiments, with most errors being classified as "Other" or "Identical location" errors. The pattern of errors being made as children get older also supports the results of previous experiments, and several theories of spatial development as outlined in Chapter One. Memory-based errors and Perseverative errors decrease in number as children get older – a developmental trend which is typical in many domains.

Identical location errors are the only type of error which actually increase with age. This supports the notion that as children get older, they become increasingly aware of the correspondence between objects, which they become able to utilise more fully, although their lack of a full appreciation of spatial relations prevents them from being able to distinguish between two or more identical locations within the same space. "Other" errors, which are those attributable to a general lack of understanding in the representational domain, however, are the only error type to decrease significantly with increasing age.

The analyses revealed that children did not differ in the types of errors they made, under the different configurations of irrelevant material. Thus, any differences in children's perceptions of the novelty of the different configurations, or any attempts at alternative strategies for task solution, did not manifest themselves in the types of errors that were made.

### *Conclusions*

In terms of answering the question which these experiments set out to address, it does not seem to be the case that the presence of additional IM in the referent space was responsible for distracting children from their task in the Model-To-Room Condition in Experiment One.

Nonetheless, some differences between different configurations of IM have emerged from these studies, which might usefully be investigated further. No previous research has systematically addressed the issue of irrelevant material in the referent space, though several authors have acknowledged the differences of using a more genuine and complex real-world space, as opposed to a scant and contrived experimental space (e.g. Liben and Yekel, 1996). It would clearly be of use, then, to improve understanding of how children's performance or their strategies might alter under different conditions. However, given the similar patterns of performance observed in "Both" and "Neither" configurations, and the similar patterns observed in "Model only" and "Room only" configurations, it may be the case that these differences are eventually attributed to some level of physical similarity between a representation and its referent, rather than to do with strategies of selective attention, as was suggested previously.

# CHAPTER NINE

## General Discussion

The overall aim of this research project was to investigate how children's performance on tasks designed to assess their ability to understand and to use representations of space, changes when different tasks and methods are adopted. Chapter Two explored just some of the many experimental variations which researchers have used previously for investigating such understanding in children, giving an indication of just how diverse an area this is.

It has been implicitly assumed that these various tasks and methods are all essentially assessing the same underlying abilities. However, there has been very little in the way of any systematic investigation of how children's performance might be affected by the use of one task rather than another, which might support this assumption or enable a more thorough evaluation of precisely which abilities are being tapped under different circumstances.

In recent years this has led several researchers to point out the need for a fuller investigation of such differences, in order to reach any real understanding of children's underlying spatial representational capacities. For example, Golledge (1976) explains,

> *"Methodological issues consequently are of an importance almost equal to the theoretical issues raised in earlier segments of this book. Much of the information that we are collecting (and have collected) is of dubious value because of poorly designed experiments that yield low-value data. Much*

*more critical attention to experimental designs that are capable of yielding meaningful representations of cognitive knowledge appear to be essential if progress is to be achieved in this field." (p313)*

Liben (1997) further explains,

*"In the end, what is most important is that we recognise that many methods are available, that particular research questions are better answered by some methods rather than others, and that the answers we get are in part dependent upon the methods we use. In organising the coming decades of our collective work, we should continue to investigate phenomena by using a variety of methods. Unless we do so, we run the risk of concluding that children understand (or misunderstand) place representations in general on the basis of their skill at meeting (or not meeting) the demands of a certain kind of task in particular." (p60)*

So many different tasks and methods exist in the literature that a complete and thorough comparison of all of them would be outwith the capacities of the present project. Therefore, an initial investigation aimed at comparing just two tasks and two methods was carried out, and the results of that study then led to several follow-up experiments, aimed at expanding and building upon some of the findings of the first. At this stage it is useful to summarise the main findings of the studies which have been carried out.

***Summary of findings***

Scores

The initial investigation used two specific methods of assessment. The first required children to infer from a referent space to a representation, by observing some manipulation in a room, and on the basis of that manipulation, to themselves carry out some task in a small-scale model of that room. The second method required children to make the converse inference, by observing some manipulation in the small-scale model and on the basis of that manipulation to themselves carry out some task in the referent room. Apart from the comparison of these two methods, an additional comparison of two particular tasks was made. Children completed either a Retrieval task or a Positioning task. Retrieval entailed watching as a toy was hidden in a particular location in one space, then retrieving an analogous toy from the equivalent location in the other space. Positioning required the child to observe as one toy was placed at a particular location in one space, and then to themselves place the analogous toy at the equivalent location in the other space. The referent space used in this first experiment was the participants' own playroom.

The results of this initial study showed that children scored higher in the Room-To-Model Condition than the Model-To-Room Condition. These results contrasted with Liben's (1997) suggestions that inferring from Model-To-Room might be equivalent to a Comprehension-type task in this domain, and might therefore be expected to emerge developmentally prior to the more difficult Production-type task of inferring from Room-To-Model. These results also contrasted with intuitive notions about how representations are typically used, since inferring about a representation on the basis of its referent might be a less common activity than inferring about a referent on the basis of a representation. However, the results appeared to fit with the suggestions from Acredolo (1977; 1981) that since a representation can be observed from one viewpoint, and is easier to manipulate, performance when carrying out a task in a model might well be expected to be superior to that when carrying out a task in a large-scale room.

Several suggestions were made about factors which may have contributed to these observed differences. This first experiment utilised a referent space that was highly familiar to the participants. Whilst familiar referent spaces have been used in many studies (e.g. Liben & Yekel, 1996), others have used novel experimental spaces as the referent. Experiment Two therefore set out to replicate Experiment One, but using a completely novel experimental space. The results of that study suggested that when the referent space is completely novel, children may find it easier to infer from representation to referent, as suggested by Liben (1997).

Having compared the use of a highly familiar referent space with that of a completely novel referent space, Experiment Three set out to investigate how children's performance over the course of one school year altered as their experience of the referent space changed from being slightly familiar to being very familiar. The results indicated very little change in absolute levels of performance with increasing familiarity.

Having explored the effect that familiarity with the referent space had, it was suggested that differences between the results of Experiments One and Two might instead have be due to factors concerning the nature of the representation itself. The model used in the first experiment was fairly basic and structural, containing only the most salient items of furniture, and no soft furnishings, carpets, curtains etc. Experiment Two, however, used a more detailed model containing appropriately coloured carpet and curtains, as well as sofa coverings and cushions. It was therefore perceptually more similar to the referent room in terms of iconicity. Experiment Four set out to investigate whether this perceptual similarity might have affected the children's appreciation of the representational relationship between model and room. The results suggested that this extra detail had no effect, and that the differences in performance observed previously were not likely to have been due to the quality of the representation.

Experiments Five and Six addressed another issue emerging from the initial study, concerning not the quality of the representation, but the presence of additional, irrelevant material in the referent space. This builds upon the comparison of Experiments One and Two, which have already explored one factor resulting from the use of the children's own classroom as the referent space. As has already been mentioned, the use of the children's classroom meant that the participants were already highly familiar with the referent space. However, this also meant that the referent space contained a great deal of additional material in the form of books, toys, pictures, games, equipment etc. etc. which were not represented in the model of that room. Experiment Two, however, utilised an experimental, rather than a naturalistic space, in order that it should be completely novel to participants. As a result of this, though, the room in Experiment Two contained only its basic structural elements, with no additional contents.

Since children in Experiment One performed worse when required to carry out a task in the referent space, it was suggested that this might have been due to distraction from the additional material present, rather than a difficulty with appreciating the representational nature of a room already familiar to them as a "thing-in-itself". Therefore, Experiments Five and Six assessed children's performance when additional, irrelevant material was present in the room, as opposed to when it was present in neither room nor model. Apart from these two conditions, two others were included in which irrelevant material was present in the model only, or in both model and room. What was found overall was that children continued to score higher in the Model-To-Room Condition when there was irrelevant material present in the room only. Therefore, the additional material did not appear in itself to have been responsible for the children's poorer performance in this Condition in Experiment One.

In relation to the two different Tasks that were used, the initial study suggested that children were more successful on the Retrieval Task than they were on the Positioning Task. Several possible explanations for this difference were suggested, and Experiment Two was designed to assess whether simple methodological considerations might have been a factor influencing these results. To this end, only target locations which were completely hidden from the children's view were used. With these alterations, children no longer scored higher on Retrieval trials, and this was the case in all subsequent experiments in which such alterations were possible.

Time taken

Not only were absolute measures of performance recorded, but the time children took was also noted in order to gain some insight into how children might have been approaching different tasks and how they might have performed under different methods. It was thought that time might provide a more sensitive measure than just success or failure, by indicating more subtle differences in children's performance that were not reflected in their actual scores.

In Experiments One and Three children took consistently longer in the Model-To-Room Condition, which was unsurprising given the larger scale of the referent room. In all other experiments, however, children took comparable amounts of time in both Conditions. Therefore, that fact that it was the Model-To-Room Condition in which children scored lower in Experiments One and Three does not seem to have been related to the additional time taken in that Condition in those experiments, since Experiment Two showed that even when children took equivalent amounts of time in the two Conditions, they continued to score higher in one Condition than the other.

In general, the time taken by children was shorter in the groups of children who were more successful, although it should be noted that in several experiments, dividing children into groups according to their scores led to very small numbers in some of those groups. Thus, analyses should be interpreted with caution. Nevertheless, the time taken by children in all the studies in which the referent space was completely novel, was consistently less in the more successful groups. This was also the case in Experiment 3A, in which the referent space was only slightly familiar. In addition, where further examination was carried out of the groups of children scoring just one correct response, it was generally found that these children took longer on the trial on which they were incorrect than that on which they were correct. However, in Experiments One and 3B, when the referent space was very familiar, children's times decreased slightly with increased success, but then the time taken by the most successful children actually increased again. This may suggest a difference in performance which is related to familiarity with the referent space. However, examination of the groups who scored one correct response further supports the notion that children do generally taken more when they are incorrect than when they are correct, and that therefore, the sharp increase in time taken by the most successful children in Experiments One and 3B is reflective only of a small number of atypical outliers.

No difference in the amount of time taken was found when using a basic as opposed to a detailed model, in Experiment Four. Furthermore, the results of Experiments Five and Six suggest that the presence of irrelevant material in the referent space does not distract children from the task. In fact, children took least time in this configuration. They took longest when irrelevant material was present in neither model nor room. The time data from these experiments showed similar times being taken when irrelevant material was present in either the model only or the room only. Times appeared to differ, though, when irrelevant material was present in both spaces and in neither space.

Error data

The overall pattern of errors made by children was consistent throughout all the studies. The largest numbers of errors made by children were those classified as "Other" errors. These errors were thought to arise from a lack of understanding in the representational domain, or from a general misunderstanding of the task. The rate of these errors was generally found to decrease with age. Identical location errors comprised the next largest group, and were due to children's basic appreciation of object correspondences, but a lack of a full understanding of spatial relations. The rate of these errors was found to increase with age, in general. Perseverative errors and Memory-based errors were the two smallest groups, and like Other errors, the rate of these generally decreased with age.

As a general rule, this was the pattern found in all studies. However, it is interesting to note that in Experiment 3B, where children were highly familiar with the referent space, they made almost equivalent rates of Identical location and "Other" errors. This pattern is more consistent with older children in the later studies than with children of comparable age in the previous studies, despite the fact that the children in Experiment 3B scored no more highly than those in previous experiments. This suggests that whilst the strategies children adopt for dealing with representations of space improve with age, they also appear to improve with increased familiarity with the referent space.

The patterns of errors which children made were unaffected by altering the quality of the representation itself, in Experiment Four. Experiments Five and Six showed that children's strategies in general did not differ with irrelevant material in the different configurations.

### *Developmental issues*

In all of the studies within this project, two dependent measures were recorded for analysis – the children's success or failure on each trial, and the time taken on each trial. In addition, information about the errors which children made was recorded and explored. Developmental patterns were observed in all three of these areas.

Children in all of the experiments showed increased levels of absolute performance in the older age groups, thus showing that the ability to understand and use spatial representations in general is an ability which develops over the period three to six years of age. Even so, the oldest groups of children to take part in these studies were still showing a mean score of just 77% (Experiment Two) or 70% (Experiments Five and Six). Therefore, there would seem to be yet more development to occur after the age of six years, which would be interesting to address in further research.

The time that was taken by children also changed developmentally, with younger children generally taking longer than their older counterparts. However, some differences were observed between the times taken by the younger children as compared to the older children, in relation to their levels of success.

In general, children took less time as they got older, and as has been mentioned previously, children also took less time as their level of success increased. Thus, it could be argued that the two variables of age and success are confounded here, since older children were also generally the more successful ones. However, an examination of the data from the youngest groups of children in several experiments, suggests that younger children take more time as their level of success increases. This indicates that younger children may benefit in terms of taking extra time in responding, and that if they do not know the correct response they act quickly, rather than taking longer in consideration. Older children, in contrast, appear to be able to respond quickly when they know the right response, and take time in consideration when they are unsure, even though their final response may still be incorrect.

In order to gain an insight into developmental changes in the cognitive processes underlying performance, examination of the error data provides by far the most sensitive information. In order to succeed on these tasks, it is necessary for children to understand that the room and the model stand in a representational relationship to one another. Secondly, they must have the necessary spatial knowledge to be able to identify target locations in space with reference to their absolute position, or their position relative to other objects.

The consistent pattern of errors across all experiments showed that the majority of children's errors were classed as "Other" errors, and these appear to be due to a general lack of understanding of the task, and a lack of any appreciation of the representational relationship between the model and the room. The next most common error type was Identical location errors. These occur when children have a basic appreciation of the representational relationship between representation and referent, but do not yet have the necessary understanding of spatial relations to be able to distinguish between two or more locations which look the same, by taking into account their position within the space, or in relation to other objects. The other two error types occurred less frequently. Perseverative errors occurred when children placed or searched for the target object in the place where they had last seen it. Memory-based errors occurred when the child simply forgot where the original object was, and was therefore unable to successfully locate the analogous one.

Although this was the general pattern of errors across all children, some consistent differences were found in the patterns of errors made by children of differing age groups. The youngest children tended to make far more "Other" errors than any of the other four types. The next most common error types in younger children were Identical location and Perseverative errors. These occurred only in small numbers, though, and were usually about as frequent as each other in this age group. The middle age groups of children, however, made about equivalent numbers of "Other" and Identical location errors overall. Memory-based and Perseverative errors occurred only infrequently in these middle groups of children. In the oldest groups of children, Perseverative errors were virtually non-existent. "Other" errors and Identical location errors were the two most commonly occurring errors for the oldest groups of children, and in Experiment Two and Experiments Five and Six, Identical location errors actually outnumbered "Other" errors in the oldest children.

These differences in the kinds of errors being made as children get older allow for an insight into the cognitive processes underlying children's strategies in approaching these tasks. Even the youngest children appear capable of appreciating the overall relationship between the model and the room, and some of these children achieve reasonable levels of success on the tasks. However, many of them make typical errors of perseveration, and errors which suggest a general lack of understanding of what they are being asked to do. As children get older, errors due to a lack of representational understanding are fewer, and are almost equal in number to errors which suggest a good representational understanding, but poor spatial knowledge, since object correspondences are taken into account in responding, but identical objects cannot be distinguished through their spatial location. For the oldest children, this lack of spatial knowledge is what poses the largest problem, as representational understanding appears to a large extent to have been achieved.

The exception to this is seen in Experiment 3B, when children are highly familiar with the referent space. These children actually make errors more typical of an older group of children, with almost equal numbers of "Other" and Identical location errors being made. This suggests that an appreciation of the representational relationship between model and room may have been accelerated due to increased familiarity, enabling children to move on to a more sophisticated strategy of responding than would normally be found in their age group. However, in older children, this representational understanding would normally be accompanied by an increase in spatial skills. In younger children this spatial knowledge is still lacking, so they are unable to fully take advantage of this early onset of representational understanding, and absolute scores are not significantly improved.

In this way, the exploration of error data has been successful in exposing differences between groups of children, which simple measures of absolute success or failure were not sensitive enough to detect. The error patterns which have been observed provide support for several theories of spatial development outlined in Chapter One, and for more specific ideas about the development of understanding of spatial representations in particular. Firstly, it is clear that even the oldest children who took part in this project did not have a fully developed appreciation of spatial relations, which supports Piaget's views as to the development of the concept of space in children. It appears that a full Euclidean conception of space is still under-developed at age six, and this would fit with the Piagetian framework of spatial cognition. However, the partial success of even the youngest children in this project strongly indicates that the ability to understand and successfully utilise external representations of space is not necessarily one which emerges as late in development as Piaget suggests.

It appears that appreciating the representational relationship between a model and its referent space can be achieved as early as three years of age, although the lack of a full conception of space at this age prevents the representation from being used with complete success. Gentner's (1983) theory of analogical reasoning, as incorporated by DeLoache (1995) and Blades (1991b) all suggest that the development of the ability to understand and use a spatial representation begins with basic symbolic or representational understanding of the overall relationship between symbol and referent. It then extends to an appreciation of the correspondence between internal features of the representation and the analogous features to which they relate in the referent space. Even then, development is incomplete, due to a lack of spatial knowledge which enables the differentiation of two or more identical features. This appears to be the stage which the oldest children in the studies reported here have reached.

Thus, the results support Piaget's theory of the development of spatial cognition, but suggest that he may have under-estimated children's abilities in relation to appreciation of representations of space. The results similarly support DeLoache's findings with regard to the early emergence of representational understanding in children, but suggest she may have over-estimated children's abilities in relation to their understanding of spatial representations in particular.

***How best to assess children's understanding of spatial representations?***

Chapter Two explored some of the many different tasks and methods in this research domain, and this project investigated just a few of these. On the basis of the findings reported here, though, it may be possible to make some judgements about which of these might most usefully be adopted to assess children's abilities.

Tasks

The two tasks which were used within this project were a hide-and-seek type Retrieval task, as has been popularised by DeLoache amongst others, and a straightforward Positioning task. On each of these tasks, children viewed both a representation and a referent space, and carried out the task in one space on the basis of information gained from the other. This differs from tasks adopted by other researchers to assess understanding and use of spatial representations – some of whom have used other tasks entirely. For example, some researchers have asked children to produce a representation of their own (e.g. Liben & Downs, 1994). Others have required children to construct a representation from available materials (e.g. Siegel & Schadler, 1977).

Although the hide-and-seek task has become popular in recent years, it is not one which can be used in all circumstances. For example, if the representational medium is a map rather than a model, it is very difficult to imagine how an experiment could be designed that would enable a child to retrieve from the map, on the basis of information from the referent space. Thus, in studies where a manipulation of a map is required, researchers have often adopted a straightforward positioning task, whereby children place a sticker at the appropriate location on the map (e.g. Liben & Downs, 1993). In addition, though, DeLoache (1989) and Blades and Cooke (1994) have required children to carry out a straightforward placing task, as a kind of practise task, prior to a test phase involving a retrieval task. Thus, they are implicitly assuming that Positioning is an easier task than Retrieval. The results of this present project strongly suggest that this is not the case.

In Experiment One, for example, children actually found the Positioning task more difficult than Retrieval. It appears that this may have been due to methodological issues regarding how easily hidden objects could be viewed in their hiding places in a naturalistic referent space. However, following modifications to the methodology which ensured that all target locations were completely hidden, children then consistently scored comparably on Retrieval and Positioning trials. This strongly suggests that far from being a more straightforward "pre-test" type task, Positioning ought to be regarded as usefully equivalent to Retrieval in assessing children's absolute abilities. This has implications for further study, in that referent spaces and representations need not be constructed such that they contain locations that can easily conceal target objects, as these are not required when completing a Positioning task.

Despite the fact that Retrieval and Positioning tasks elicited comparable levels of absolute performance, nevertheless there was a consistent difference in the amount of time taken by children, to complete the tasks. The time taken on Retrieval trials was always longer than on Positioning trials, and this was the case regardless of whether children were scoring differently on the two tasks. This suggests, firstly, that in a general sense, the time taken by children to complete a task need not necessarily be indicative of their level of success. The additional time children took on the hide-and-seek task did not benefit them in terms of their scores. Secondly, this indicates that whilst children are not better or worse at one task or the other, nevertheless there is something about them which causes children to approach them slightly differently.

It does not intuitively seem as though there is anything in the nature of responding on these two tasks which would necessitate one taking longer than the other. On the Positioning task, children must take the target object, decide upon the correct location, move there and place the object. On a Retrieval task the child must decide upon the correct location, move there and retrieve the object. Therefore, the combination of necessary physical actions appears very similar, and it seems unlikely that this would be responsible for such marked differences in the amount of time taken.

On several occasions within this thesis, it has been suggested that the familiar nature of a hide-and-seek type task might contribute to differences in children's performance between the two tasks. Modifications to the methodology appear to have ruled this possibility out as a factor influencing children's scores in Experiment One, but the difference in time taken perseveres and may be due to children's perceptions of what they are being asked to do. Since the Retrieval task is conveyed to them in a familiar game format, they may feel more comfortable carrying out the task and considering where to search for the object, even when they are unsure of its precise location. Bridges and Rowles (1985) have previously suggested that presenting an assessment to children in an already familiar task paradigm may induce responding based more on children's previously established conceptions of the game than on the underling abilities which a researcher is trying to tap.

Alternatively, it may be that the Positioning task lends itself to a more rapid form of responding. Since the child is given the target object and is then holding it, aware that she is expected to put it somewhere, she may feel that a quick response is required. However, if this was the case then we might expect more incorrect responses by children on the Positioning task, which was not the case. Perhaps a combination of children's feeling of familiarity with the hide-and-seek paradigm, coupled with a feeling of pressure to place the object quickly on Positioning trials, was responsible for the time difference here. In any case, on the basis of these findings it would be of interest to pursue the suggestions of Bridges and Rowles more fully, and explore how children's performance is affected when an ability or process of interest is assessed using a familiar game format, as opposed to a novel game format.

Referent-to-representation versus representation-to-referent

This difference was of particular interest within this thesis, not least because it is one about which there is a distinct lack of previous research. As was indicated in Chapter Two, researchers generally tend to adopt one or other of these two methods, without any real justification for their choice. Those few who have used both methods within a study have done so as a counter-balancing procedure. Thus, experimenters appear to be assuming that these are just two forms of the same method, both assessing the same underlying abilities, rather than treating them as two different methods of assessment which may involve different cognitive processes. Those studies which have counter-balanced using these two methods report no differences between them.

However, traditional views on map use suggest that "using" a representation of space involves carrying out some task in the real world on the basis of information provided by the representation. Thus, the converse of that would appear to be counter-intuitive and might be expected to pose greater problems for young children. More recently, Liben (1997) has taken this further by suggesting that making an inference from a representation to a referent space requires comprehension on the part of a child, whereas the converse inference requires the child to actually externalise their understanding by manipulating the representation itself. This distinction between Comprehension and Production is one which exists in many other areas of child development, and Liben's suggestion is that it may exist within this area of spatial cognition as well. If this is the case, then it would lend further support to the notion that younger children should find it easier to go from a representation to a referent space than to do the opposite.

However, several researchers have suggested that there may actually be benefits for young children in carrying out a task within a small-scale space as opposed to carrying out a task within a large-scale space. For example, Acredolo (1981) suggests that the motor responses required when manipulating a model are much simpler than those required to carry out a task in a room. The child merely has to reach out in a model, whereas they must stand and move around within a room. In addition, a small-scale space can be viewed from one perspective, enabling a child to integrate all of the information at once. A large-scale space cannot usually be viewed in its entirety from one viewpoint, so a child must therefore co-ordinate several different perspectives. These factors suggest that perhaps young children might find it easier to work from referent space to representation and not the other way.

These conflicting ideas make it hard to decide which method should most usefully be employed in assessing children's understanding of spatial representations. This project therefore set about investigating just how children's performance differs using these methods, under a variety of different conditions.

The children in Experiment One performed better in the Room-To-Model Condition, which seems to support the idea that children find it easier to work in a small-scale space. However, Experiment Two replicated Experiment One, but using a completely novel space, and found performance to be superior in the Model-To-Room Condition. This contradicts the results of the first study, and suggests that making the intuitive inference from a representation to a referent space is easier.

Whilst it could be argued that the age of the children was responsible for this difference, a closer look at the data suggests otherwise. The children in Experiment One had a mean age of 43 months (3;7). The children in Experiment Two had a mean age of 57 months (4;9). Perhaps this is a developmental issue, then, in that younger children find it easier to infer from referent space to representation, and older children find it easier to do the opposite. In fact, though, the youngest group of children in Experiment Two had a mean age of just 49 months (4;1) – only 6 months older than those in Experiment One. And it was in this youngest group of children that the most striking difference between the two Conditions was observed. It therefore seems unlikely that such a radical turnaround in performance should occur within just six months.

The alternative argument is that it was the children's familiarity with the referent space which was responsible for performance differences in Experiment One, since Experiments 3A and 3B, which also used a familiar space, continued to elicit better scores in the Room-To-Model Condition. It may be that if young children are already familiar with a referent environment, understanding and using a spatial representation of that environment is an easier thing to do in general. Certainly, the overall mean scores achieved in Experiments One, 3A and 3B (all using a familiar space), were higher than the scores achieved by the youngest group in Experiment Two (novel space), despite the latter group being older than any of the former groups. Perhaps this advantage of using a familiar space enables children to benefit more from the other advantages to be gained from manipulating a small-scale space. When the referent space is completely novel, though, children have no baseline advantage, and perhaps the Comprehension/Production distinction or the intuitive nature of map use is what benefits them more.

In any case, the other factors investigated within this project as possibly contributing to the Room-To-Model / Model-To-Room differences did not appear to have any significant effects. What is clear from all experiments here, though, is that as children get older, they are able to operate in both directions equally, which suggests that if one is interested in absolute levels of performance, either method can usefully be employed. Only with very young children might this not be the case. In those cases, a familiar room might facilitate higher levels of performance, but particularly if the child is required to work from referent space to representation, and not in the opposite direction.

In relation to the time taken using these two different methods, Experiments One and Three unsurprisingly found that carrying out the task in the referent space took longer than in the model. At first it was suggested that perhaps the additional time required in the Model-To-Room Condition placed an increased memory demand upon children, thus leading to lower levels of performance in that Condition. However, the results of Experiment Two and the subsequent studies show children taking comparable amounts of time in both Conditions, yet we still observe differences between the two. Thus, it does not seem likely that additional memory load was responsible for the poorer performance in the Model-To-Room Condition in Experiment One.

It is actually relatively surprising, though, that the studies using the caravan did not result in more time being taken in the Model-To-Room Condition. If the size of the room alone is responsible for the amount of time children take, then we would still expect children to take slightly longer in the Model-To-Room Condition, even when the referent room is the caravan. This is not what has been observed, though. Perhaps the additional time taken in Experiment One, then, was not only due to the size of the room. Experiments Five and Six suggest that it was not the irrelevant material present in the referent room which affected the time taken, as this never significantly differed between Conditions, in any of the four configurations of IM in these studies. But perhaps the children's familiarity with the referent space played a part in the speed of their responses.

It is possible that feeling at ease within the referent environment may have led children to take longer about the task they were to complete, in the same way that playing the more familiar hide-and-seek game may also have led them to take longer in completing the task. Liben, Moore & Golbeck (1982) have previously commented on the fact that children's comfort within a referent space may lead to a different type of responding than if they are in an strange or unfamiliar environment. In addition, the results of Experiments 3A and 3B indicate that children took much longer overall when they were highly familiar with the referent space than they did when only slightly familiar with it. In any case, the time spent on the tasks never differed between Conditions in any of the experiments using a novel referent space, so from this perspective either method may be usefully employed.

Familiarity

As has already been suggested, it appears that some thought should be given to children's level of familiarity with the referent space before deciding upon which method to adopt. When the referent space is familiar, the results of this project indicate that we might expect children to perform better in a task requiring manipulation of a representation on the basis of a referent space, rather than the converse. With novel referent spaces, we might expect the opposite to be true, in that children perform better when manipulating the referent space on the basis of the representation. Having said all of this, though, the age of the children being studied also requires to be taken into account, since by five or six years, the children in this project appeared capable of performing equally using both methods. When children's strategies are of interest, though, it seems important to be aware that the use of a highly familiar referent space might elicit a more sophisticated approach than would otherwise be seen in children of a particular age.

Quality of representation and the presence of irrelevant material

Apart from familiarity, other factors investigated within this thesis as possibly affecting children's performance, were the quality of the representation itself, and the presence or absence of irrelevant material within either representation or referent space. The quality of the representation did not appear to significantly affect performance, suggesting that future research need not necessarily employ representations which look highly perceptually similar to their referent spaces. Nor did the presence or absence of additional material in the referent space, the representation, both spaces, or neither space, have any significant effect upon children's performance. However, some differences relating to absolute levels of success and to time taken, were observed. With additional material in model or room only, children's performance was very similar. With additional material in both spaces or in neither space, there were slightly different results. Thus, it has been suggested that what is important for children is the amount of detail in one space which is also represented in the other space. This may be due to the perceived similarity between representation and referent, or it may be due to the possibility of simply matching one space with the other when the two contain precisely the same items, rather than relying upon any notion of true representation. Nevertheless, as with the familiarity factor, the older children here were relatively unaffected by additional material in any configuration, and this variable, like familiarity, should therefore be taken into account with younger children in particular.

***Future research***

Liben (1982) indicated that there was a need within research into children's spatial cognition, to define more carefully precisely what it is that researchers are interested in measuring.

> *"There seems to be an assumption in much work on large-scale spatial cognition that what we are ultimately interested in is the content of the 'mind's eye'. From this perspective, we should use any possible avenue of reducing the cognitive manipulations of what is known about the space. Alternatively, we might well define the manipulations themselves as the competence of interest. From this perspective, the appropriate research*

> *strategy is to vary the manipulation demands systematically and observe the outcomes as developmental patterns."* *(p62)*

To a certain extent, this is what the research reported here set out to begin to do. A wealth of literature has emerged over recent years relating to children's understanding and use of spatial representations, resulting in many different hypotheses about the development of abilities in this domain. Yet there has been remarkably little systematic research to assess whether the many different methods used make the same demands of children, or rely upon the same cognitive processes. This project has at least begun to do so, but many more tasks and methods remain to be explored, as do many other factors to do with representations and referent spaces, which may affect children's understanding. Future research should usefully focus upon further systematic comparisons of particular tasks and methods of assessment.

Several allusions to other possible avenues of future research have already been made within this discussion. The oldest children in the present project were six years of age, and yet development in this domain was still not complete in these children. Further research could pursue the issues raised here with even older children. The tasks and methods investigated within this project elicited different patterns of performance in younger children in particular, but other variations might be observed in older children that were not identified here.

Another issue emerging from this project is that children may have performed differently when using a familiar, rather than a novel task paradigm. In addition, they may have performed differently when in a familiar rather than a novel testing environment. Whilst several researchers have touched upon this issue previously, more research might usefully assess precisely what it is that alters under these circumstances. The question of whether children just do better because they are more relaxed and at ease, or whether familiarity with a task or an environment actually changes the underlying cognitive processes should be more fully explored.

The overall concern of this thesis has been to compare and contrast different tasks and methods which have previously been used in the assessment of children's understanding of spatial representations. This was motivated by the diversity of research paradigms which have been adopted in the past, and the different results which have been reported in different studies. Previously, it has been difficult to make useful comparisons between studies which have obtained different results because of the differing methodologies. A suggestion for further research, then, would be that researchers concern themselves with the kinds of errors that children make, as well as just absolute measures of performance. This would enable us to gain some insight into what processes might be underlying differences between one method and another, rather than limiting us to simply reporting that children do better or worse using one method or another.

### *General conclusions*

In sum, this thesis set out to explore just how children's apparent understanding and use of spatial representations differs, if different tasks and methods are adopted. An initial experiment indicated that a Retrieval task might be easier for children to complete than a Positioning task, and therefore suggested that this type of hide-and-seek paradigm might be a more useful way of assessing such abilities. However, later studies indicated that provided all target locations are completely concealed, levels of success are actually similar on these tasks. Nonetheless, children do appear to take more time over the Retrieval task, which may indicate a difference in the way they approach tasks which are presented in a familiar game format. However, for the purposes of measuring absolute levels of success, it would seem that both of these two approaches are equally as valid. This has implications for future research, in that comparisons can more confidently be made between studies using either task. In addition, since the Retrieval task can be more difficult to implement methodologically, and is more time consuming, these findings now mean that researchers may adopt the more straightforward Positioning task instead, as an equivalent alternative.

The issue of whether to use an experimental method requiring inference from representation to referent space, or the converse – from referent space to representation, is one which should be given more consideration in future research, since the results of the experiments reported here suggest that they may not be equivalent. Certain other factors may particularly affect how children perform under these two methods – specifically the children's age, and their level of familiarity with the referent space.

The results of all of the present studies provide support for existing theories of developing spatial cognition, indicating that a full appreciation of spatial relations is a late developing skill. However, the results also support the notion that some representational understanding can be achieved very early in development, meaning that representations of space can begin to be used from just three years of age. Nevertheless, the ability to understand and use spatial representations does not fully emerge until late childhood due to the lack of a completely developed conception of space.

The use of several dependent measures within this project, as well as an examination of error data, has allowed for a more sensitive and complete assessment of children's abilities, as well as for some consideration of the processes underlying those abilities. This approach would be usefully employed in future research to add to our understanding of how and why children perform differently under different circumstances. Finally, further research is required to allow for a more complete evaluation of the many other tasks and methods of assessment which exist in this domain.

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Wohlwill, J. F. (1962). From perception to inference: A dimension of cognitive development. In W. Kessen & C. Kuhlman (Editors). Thought in the Young Child. Monographs of the Society for Research in Child Development, 27, 87-112.

# APPENDIX ONE

## Notice to Parents

Dear Parents,

I am a second year PhD student studying children's understanding of symbolic representations. I am currently working with the children in the playgroup, exploring the effect that familiarity with a room has on their understanding of a model of that room. This involves the children playing a game using a model of the playroom. A small toy is either hidden or positioned at a particular location in the model playroom and the children then retrieve or position an equivalent larger toy in the corresponding place in the actual playroom, or vice-versa.

If you would like any further information about this research then please do not hesitate to contact me (Room 3B103). Thank you for your co-operation in allowing your child to participate in this study.

Victoria L. Perry

*Postgraduate Research Student*

# APPENDIX TWO

## Application for Council Ethical Approval

**Stirling Council - Education Services**

Viewforth,
Stirling
FK8 2ET
(01786 442000)

**REQUEST FOR ACCESS TO SCHOOLS FOR THE PURPOSE OF EDUCATIONAL RESEARCH**

| |
|---|
| Your Name: MS VICTORIA L. PERRY |
| Your Post: POSTGRADUATE RESEARCH STUDENT |
| Your Employer: STIRLING UNIVERSITY |
| Title of your Project: AN INVESTIGATION INTO YOUNG CHILDREN'S UNDERSTANDING OF SYMBOLIC REPRESENTATIONS |
| Context and purpose of the research (e.g. M.Ed dissertation, personal study, project funded by SOEID): PH.D. RESEARCH |
| Give a brief outline of the research, indicating the kind of information you will be gathering and the main questions the research is trying to answer: THIS PROJECT IS CONCERNED WITH YOUNG CHILDREN'S (AGED 3 - 5) UNDERSTANDING OF SYMBOLIC SPATIAL REPRESENTATIONS (E.G. MAPS, MODELS). A SMALL CARAVAN WILL ACT AS A REFERENT SPACE AND CHILDREN WILL BE ASKED TO IDENTIFY TARGET LOCATIONS IN THE SPACE, ON THE BASIS OF A MAP OR A MODEL. THE RESEARCH IS PARTICULARLY INTERESTED IN HOW METHODOLOGICAL ISSUES MAY AFFECT CHILDREN'S PERFORMANCE, AND IN HOW SYMBOLS CAN HELP CHILDREN TO UNDERSTAND THE WORLD AROUND THEM. |

Ref: VE6A207R.sam

| |
|---|
| When do you intend to begin your work with schools/teachers?<br>JANUARY 1999 |
| When do you expect to complete your work with schools/teachers?<br>DECEMBER 1999 |
| When will the research as a whole be completed?<br>OCTOBER 2000 |
| What would you be asking schools or teachers to do? (e.g. fill in 6 page questionnaire, 40 minute interview, allow observation of six lessons). CHILDREN WOULD PLAY A SHORT 5-10 MINUTE GAME, INDIVIDUALLY, INVOLVING THE IDENTIFICATION OF LOCATIONS IN A ROOM USING A MAP OR A MODEL. TEACHERS WOULD NOT BE REQUIRED TO BE INVOLVED |

**(If you have a draft questionnaire or schedule for interview or observation, please attach a copy to this form)**

| |
|---|
| How many schools and teachers would be involved?<br>APPROXIMATELY 4 SCHOOLS |
| How much time would be involved for each individual during working hours?<br>5-10 MINUTES PER CHILD |
| How much time would be involved for each individual outside working hours?<br>NONE |
| Please state any way in which the research would involve pupils: EACH CHILD WOULD PLAY A SHORT "LOCATING" GAME, AS INDICATED ABOVE. |
| Is any organisation involved in any way?<br>NO |

RsE VE6A207R.sam

| To whom will you be reporting your research, and in what form? |
|---|
| IN THE FORM OF A THESIS TO BE SUBMITTED TO STIRLING UNIVERSITY. |
| Are you willing to provide Stirling Council Education Services with a summary of your findings? |
| CERTAINLY. |

| Please list any specific schools you plan to involve: |
|---|
| PRIMARY SCHOOLS ONLY, WITHIN THE STIRLING AREA. I WILL APPROACH VARIOUS SCHOOLS IN THE HOPE THAT 4 OF THEM AGREE. |

| Any other information you wish to add: |
|---|
| DR ROBIN CAMPBELL IS SUPERVISING THIS RESEARCH PROJECT, WHICH HAS BEEN APPROVED BY STIRLING UNIVERSITY'S INTERNAL ETHICS COMMITTEE. |

| **FOR AUTHORITY USE ONLY** | |
|---|---|
| This request for research access has the support of Stirling Council Education Services | |
| Signed: | Date: |

Ref: VEGA207R.sam

# APPENDIX THREE

## Ethical Approval From Stirling Council

02 November 1998

Ms Victoria Perry
Postgraduate Research Student
University of Stirling
Stirling
FK9 4LA

**Education Services**
Stirling Council
Viewforth
Stirling
FK8 2ET
DX. ST 28
Tel. 01786 442526
Fax. 01786 442782
Head of Service: Margaret Doran
Our Ref: MD/DS
Your Ref:

Dear Ms Perry

**Research Request**

Thank you for returning the pro forma seeking permission to approach four Stirling Council schools for the purposes of research.

I have no difficulty in authorising this research but would remind you that individual headteacher approval should be sought.

Yours sincerely

Margaret Doran

**Margaret Doran**
**Head of Services to Schools**

enc.

DS/rsch2

Director: Gordon Jeyes

# APPENDIX FOUR

## Example of Letter to School

UNIVERSITY OF STIRLING
STIRLING FK9 4LA SCOTLAND
TELEPHONE 01786 473171
FACULTY OF HUMAN SCIENCES
DEPARTMENT OF PSYCHOLOGY
Telephone 01786 467640
Facsimile 01786 467641
International Code +44 1786

16th November 1998
Direct Dial: 01786 466365

Dear Mrs Graham,

I am a second year PhD student in the Psychology Department at Stirling University, working under the supervision of Dr Robin Campbell. My research investigates young children's understanding of symbolic representations such as models and maps. Over the last year I have conducted research within the Department Playgroup here at the University. I anticipate that the next stage of this project will commence in the New Year, but require more children as participants. I have full approval from Stirling Council, and would be very interested in working with the children at St. Ninians Primary.

The tasks I play with the children involve them observing a real room as a referent space, and a scale model of that room as a representation. Using small toy dogs as target objects, the children observe a dog at a particular location in the model, and on the basis of that information are asked to locate another toy dog at the analogous location in the real room (or vice versa). This requires a referent room which must remain constant, which poses difficulties. To overcome this, Dr. Campbell and I are currently in the process of adapting a caravan to act as the referent room, which may then be brought to the schools. Thus it will not be necessary to bring the children to the University in order to participate in the study.

Ideally I would require between 20 and 30 children between the ages of 3 and 5, from the nursery and Primary One classes, to act as participants, although any number of children would be helpful. The tasks take only about 5 minutes for each child to play, and Parental consent would be sought for each child to take part.

Continuing research in Developmental Psychology depends upon the co-operation of schools and nurseries, and I would be very grateful if you would consider allowing me to work with the children at St. Ninians in order to further this project. Either myself or Dr. Campbell would be happy to provide you with more details of the study, and to discuss this further with you. I shall look forward to hearing from you in due course.

Yours sincerely,

Victoria L. Perry
*Postgraduate Research Student*

# APPENDIX FIVE

## Positive Consent Form

UNIVERSITY OF STIRLING
STIRLING FK9 4LA SCOTLAND
TELEPHONE 01786 473171
FACULTY OF HUMAN SCIENCES
DEPARTMENT OF PSYCHOLOGY
Telephone 01786 467640
Facsimile 01786 467641
International Code +44 1786

20th January 1999

Dear Parent/Guardian,

I am a PhD student studying Psychology at Stirling University. My supervisor is Dr Robin N. Campbell, Lecturer in Developmental Psychology. I will be visiting St. Ninians Primary shortly to carry out some research, and would like to involve your child in the study.

The topic of my research is the development of young children's understanding of symbols, such as models or maps. Your child would be seen individually by myself in a mobile laboratory at the school, and would first be shown a real room and a small-scale model of that room. A toy will be positioned somewhere in one of these rooms. At this point the child would be asked to do one of two things. They would either be asked to *position* another toy in the other room, in the same place as the toy they saw in the first room. Or they would be asked to *retrieve* a toy from the other room, from the same place as the toy they saw in the first room. The entire interaction would be audiotaped and would take between 5 and 10 minutes.

The only details that will be recorded for future use are whether the child is a boy or a girl, and their date of birth. The children's names will not appear in the study report.

Research in Developmental Psychology depends very much upon the co-operation of parents and children, so I hope that you will be happy for your child to take part. Please fill in the details requested below, stating whether or not you would be happy for your child to take part, and return the form to the class teacher as soon as possible. If you have any questions about the study then please do not hesitate to contact me at the University on (01786) 466365.

Thank you very much for taking the time to read this letter.

Yours sincerely,

Victoria L. Perry
*Postgraduate Research Student*

---

I DO/DO NOT* wish my child to take part in the above study. (* Delete as applicable)

Signed:____________________ Date:________________

Child's Name:________________ Date of Birth:__________

# APPENDIX SIX

## Negative Consent Form

UNIVERSITY OF STIRLING
STIRLING FK9 4LA SCOTLAND
TELEPHONE 01786 473171
FACULTY OF HUMAN SCIENCES
DEPARTMENT OF PSYCHOLOGY
Telephone 01786 467640
Facsimile 01786 467641
International Code +44 1786

20th January 1999

Dear Parent/Guardian,

I am a PhD student studying Psychology at Stirling University. My supervisor is Dr Robin N. Campbell, Lecturer in Developmental Psychology. I will be visiting Braehead Primary shortly to carry out some research, and would like to involve your child in the study.

The topic of my research is the development of young children's understanding of symbols, such as models or maps. Your child would be seen individually by myself in a mobile laboratory at the school, and would first be shown a real room and a small-scale model of that room. A toy will be positioned somewhere in one of these rooms. At this point the child would be asked to do one of two things. They would either be asked to *position* another toy in the other room, in the same place as the toy they saw in the first room. Or they would be asked to *retrieve* a toy from the other room, from the same place as the toy they saw in the first room. The entire interaction would be audiotaped and would take between 5 and 10 minutes.

The only details that will be recorded for future use are whether the child is a boy or a girl, and their date of birth. The children's names will not appear in the study report.

Research in Developmental Psychology depends very much upon the co-operation of parents and children, so I hope that you will be happy for your child to take part. If you DO NOT wish your child to take part then please complete the details below and return the form to the class teacher as soon as possible. If you have any questions about the study then please do not hesitate to contact me at the University on (01786) 466365.

Thank you very much for taking the time to read this letter.

Yours sincerely,

Victoria L. Perry
*Postgraduate Research Student*

---

I DO NOT wish my child to take part in the above study.

Signed:______________________ Date:_________________

Child's Name:_________________ Date of Birth:___________

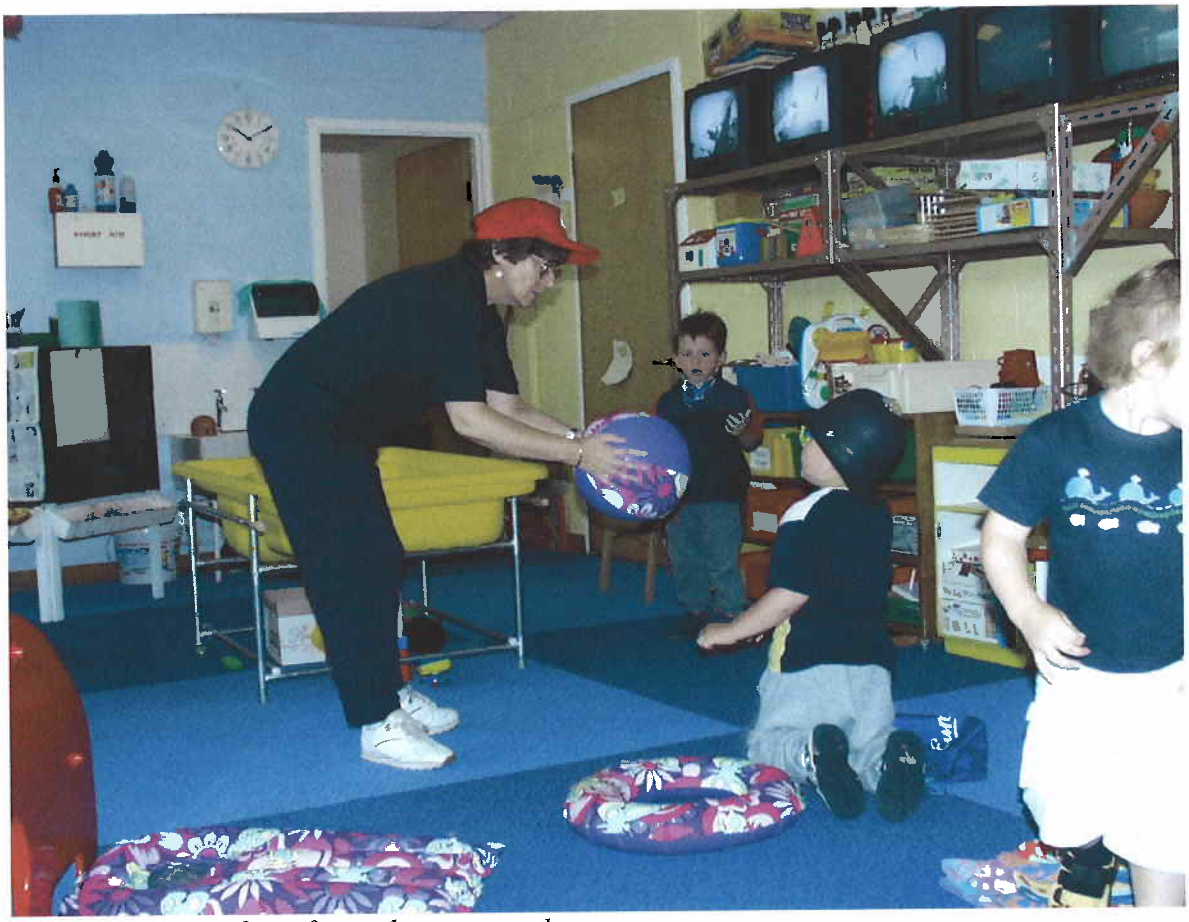
# APPENDIX SEVEN

## The Psychology Department Playroom

*The playroom from near end to far end.*

# APPENDIX EIGHT

## The Psychology Department Playroom



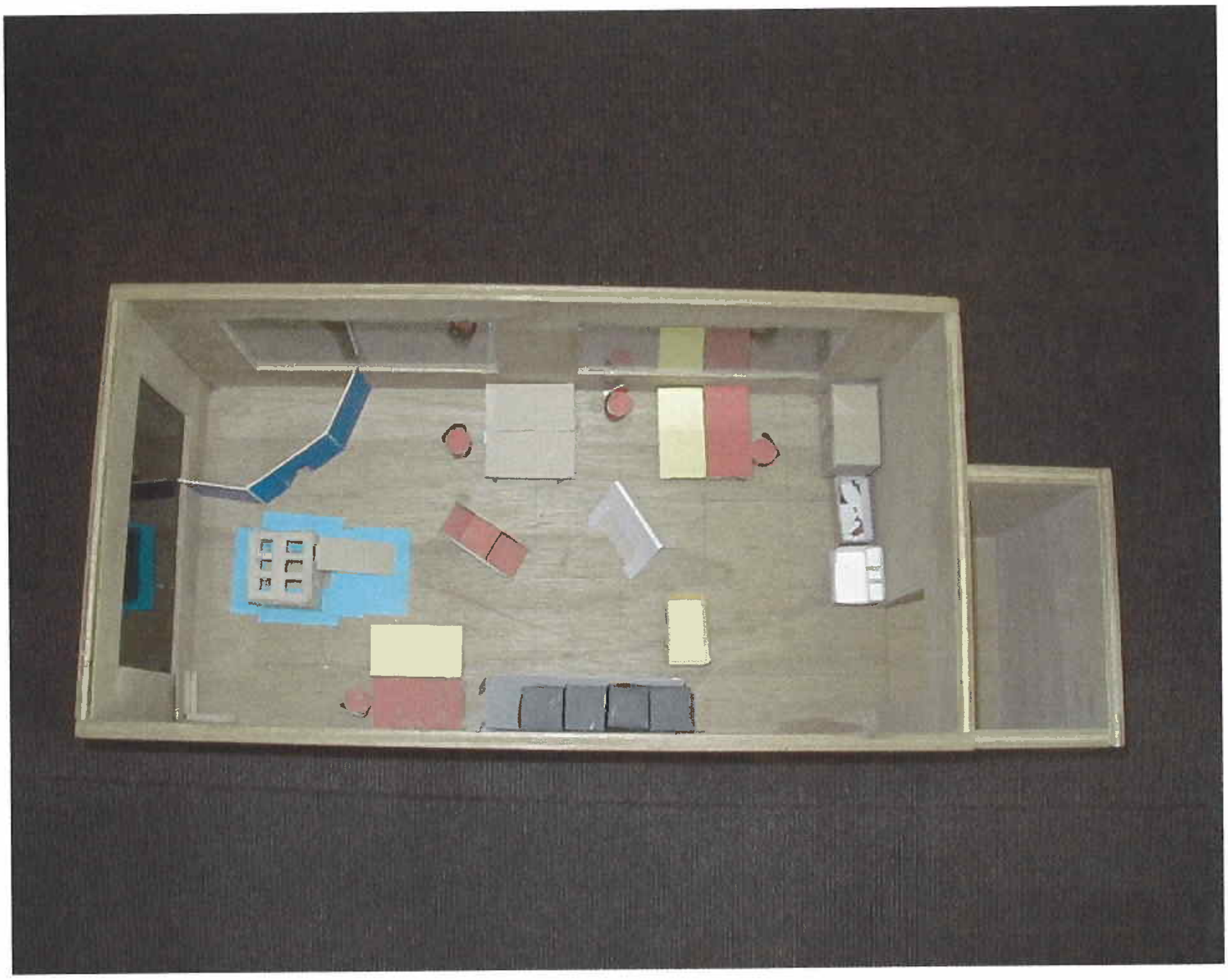
*The playroom from far end to near end.*

# APPENDIX NINE

## The Caravan

# APPENDIX TEN

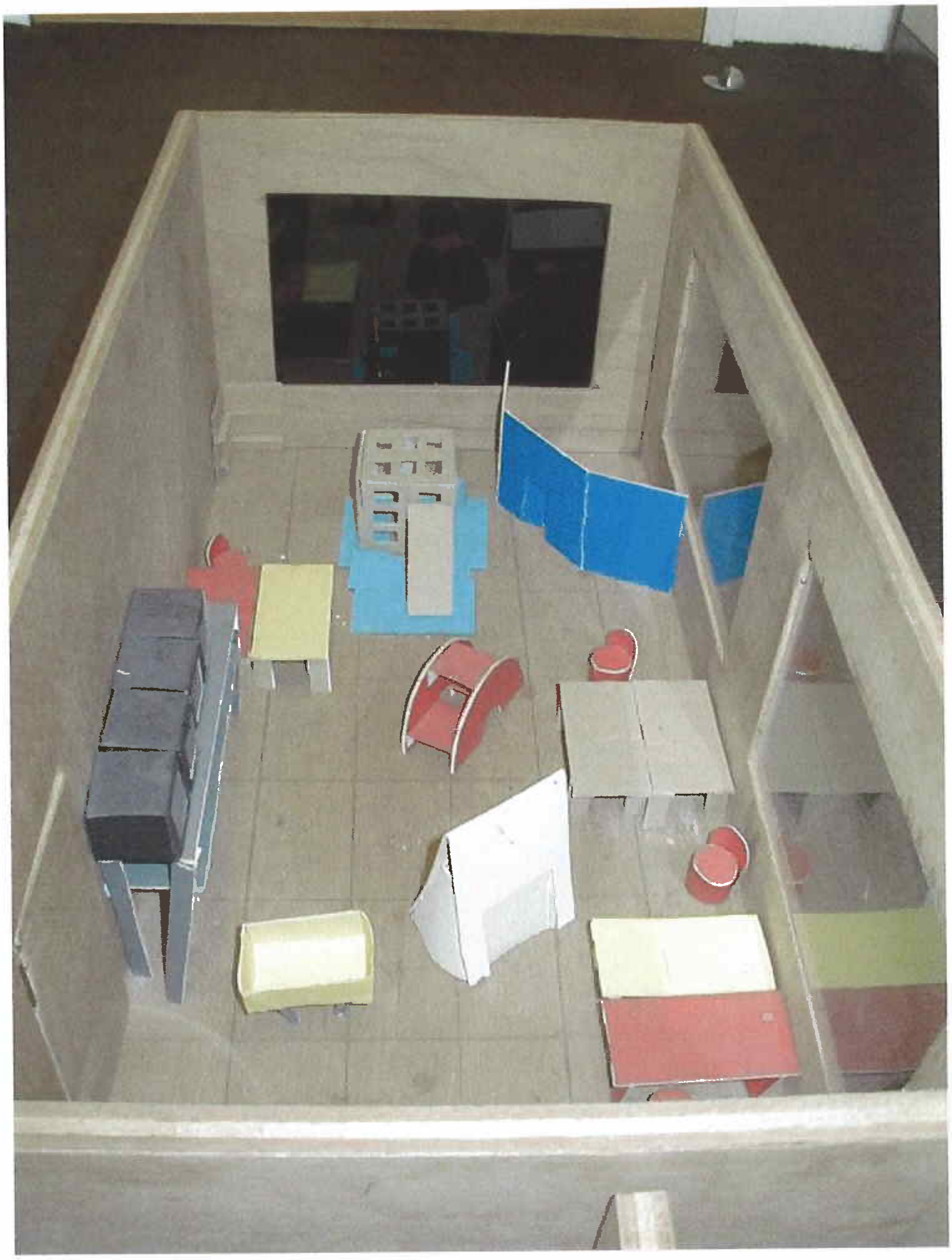
## The Playroom Model



*The playroom model from above.*

# APPENDIX ELEVEN

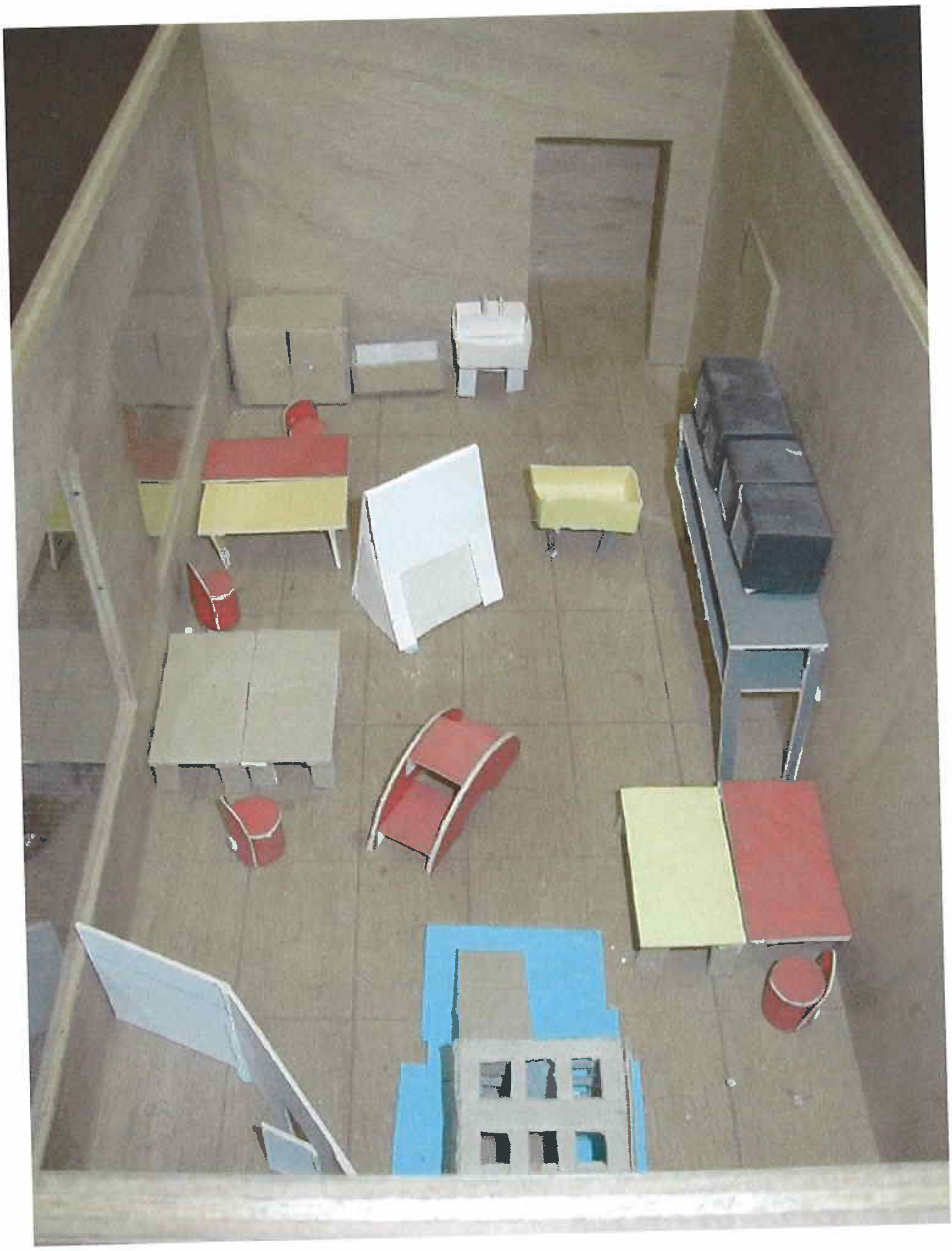
## The Playroom Model



*The playroom model from near end to far end.*

# APPENDIX TWELVE

## The Playroom Model



*The playroom model from far end to near end.*

# APPENDIX THIRTEEN

## Inside Caravan

*Inside caravan from near end to far end.*

# APPENDIX FOURTEEN

## Inside Caravan

*Inside caravan from far end to near end.*

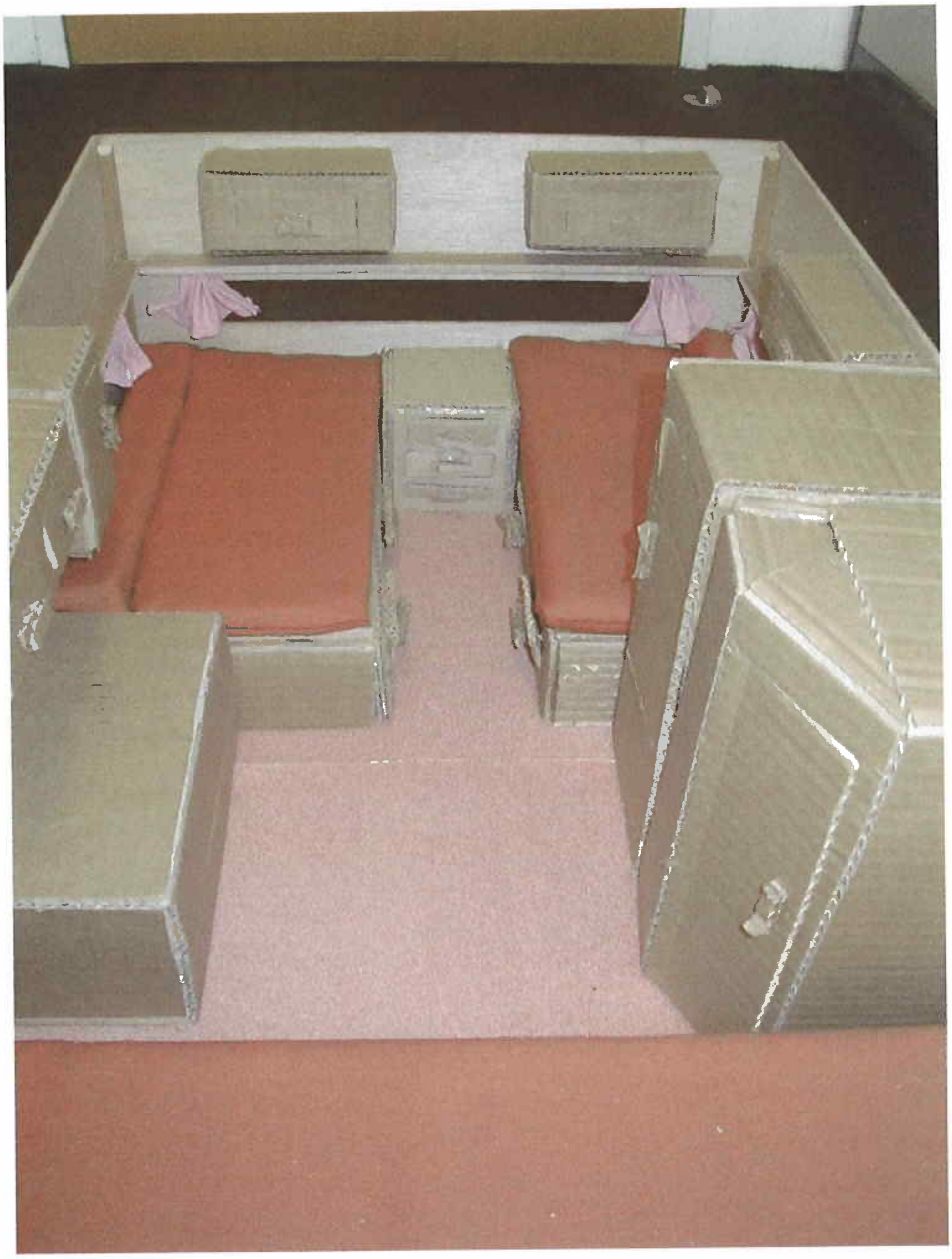
## APPENDIX FIFTEEN

## The Caravan Model

*The caravan model from above.*

# APPENDIX SIXTEEN

## The Caravan Model



*The caravan model from near end to far end.*

# APPENDIX SEVENTEEN

## The Caravan Model

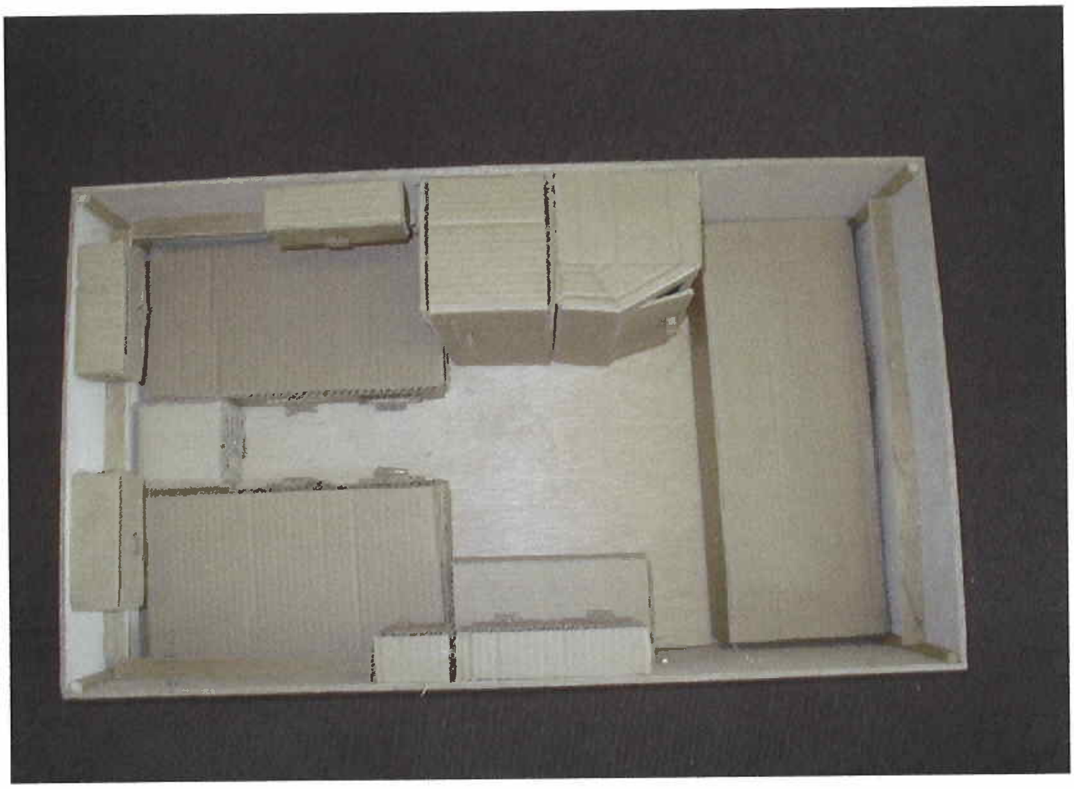
*The caravan model from far end to near end.*

# APPENDIX EIGHTEEN

## The Toy Dogs

# APPENDIX NINETEEN

## The Basic Caravan Model



*The basic caravan model, from above.*

# APPENDIX TWENTY

## The Basic Caravan Model

*The basic caravan model, from near end to far end.*

# APPENDIX TWENTY-ONE

## The Basic Caravan Model

*The basic caravan model, from far end to near end.*

# APPENDIX TWENTY-TWO

## The Caravan With Irrelevant Material

*The caravan with irrelevant material, from near end to far end.*

# APPENDIX TWENTY-THREE

## The Caravan With Irrelevant Material

*The caravan with irrelevant material from far end to near end.*

## APPENDIX TWENTY-FOUR

### The Caravan With No Irrelevant Material

*The caravan with no irrelevant material, from near end to far end.*

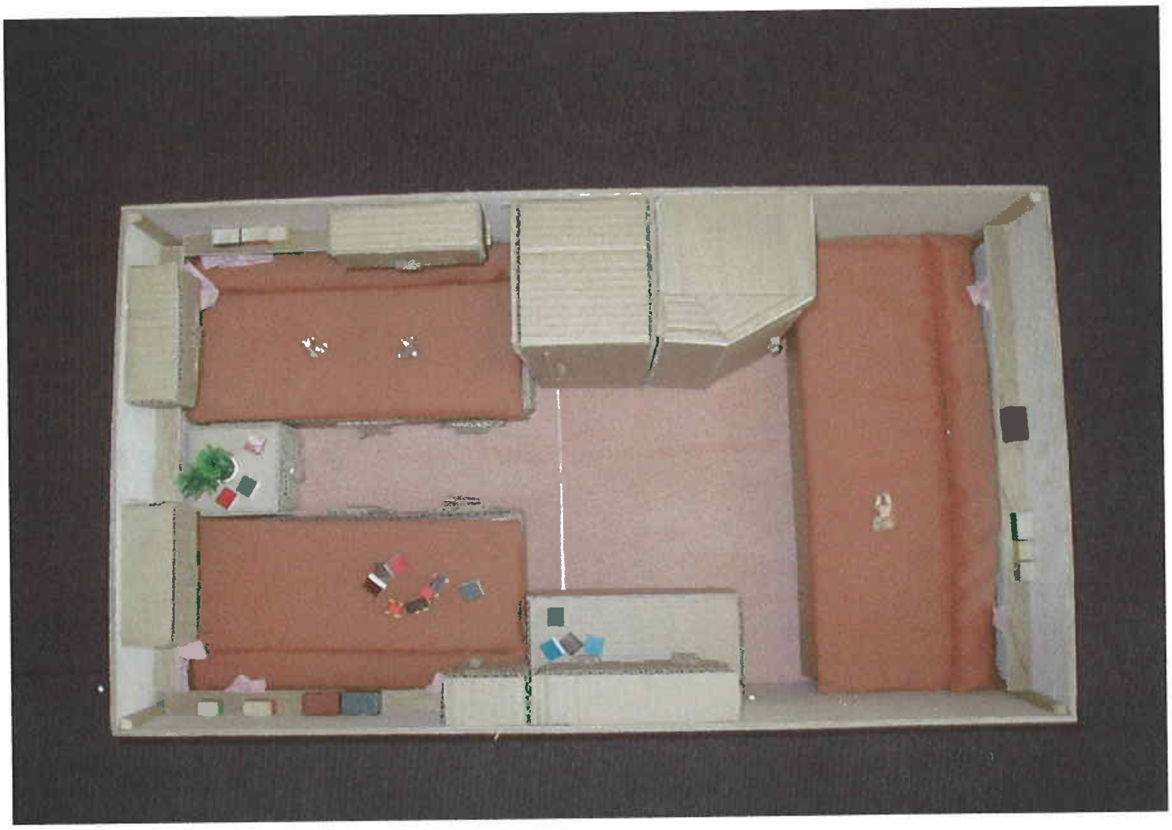
# APPENDIX TWENTY-FIVE

## The Caravan With No Irrelevant Material

*The caravan with no irrelevant material from far end to near end.*

# APPENDIX TWENTY-SIX

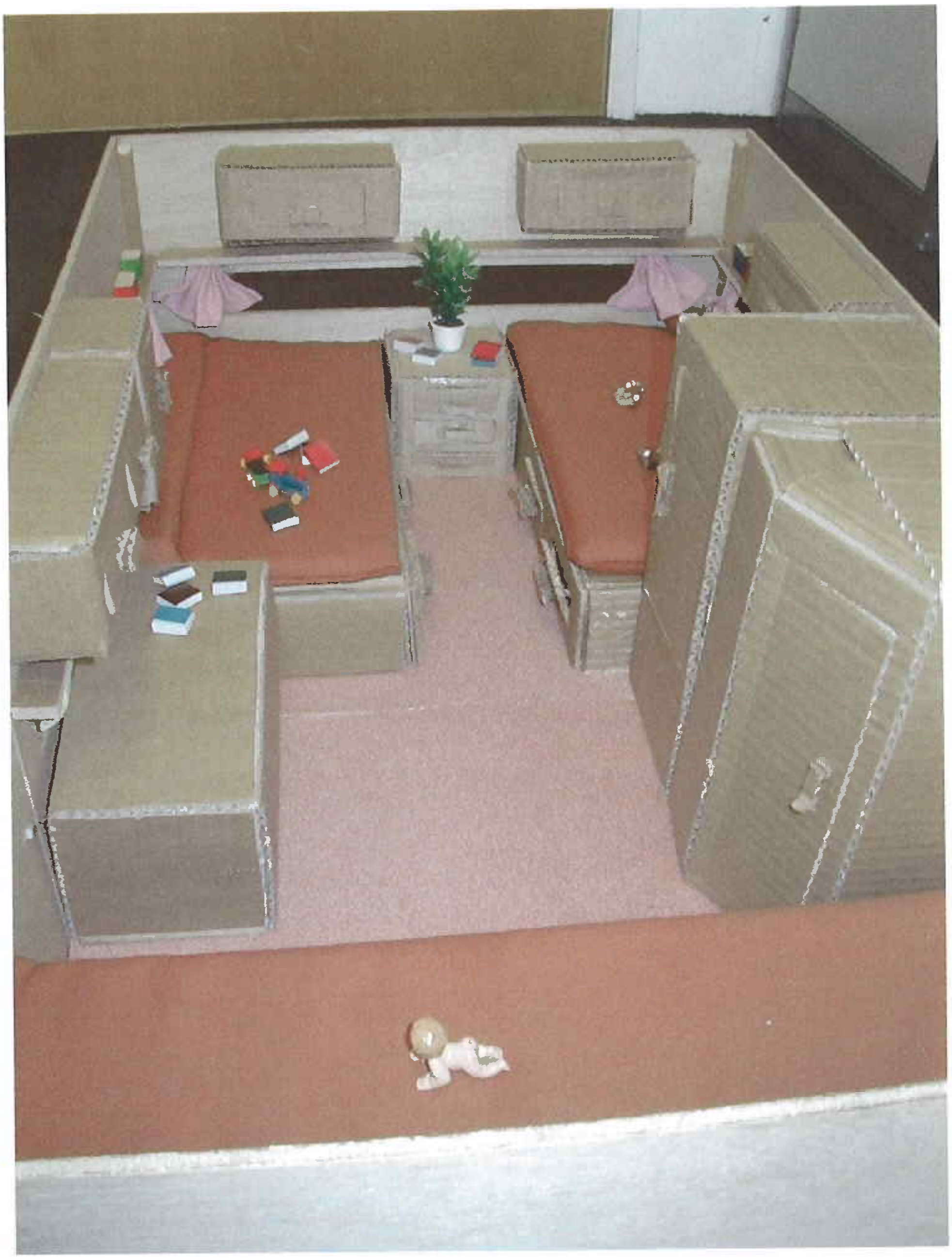
## The Caravan Model With Irrelevant Material



*The caravan model with irrelevant material, from above.*

# APPENDIX TWENTY-SEVEN

## The Caravan Model With Irrelevant Material



*The caravan model with irrelevant material, from near end to far end.*

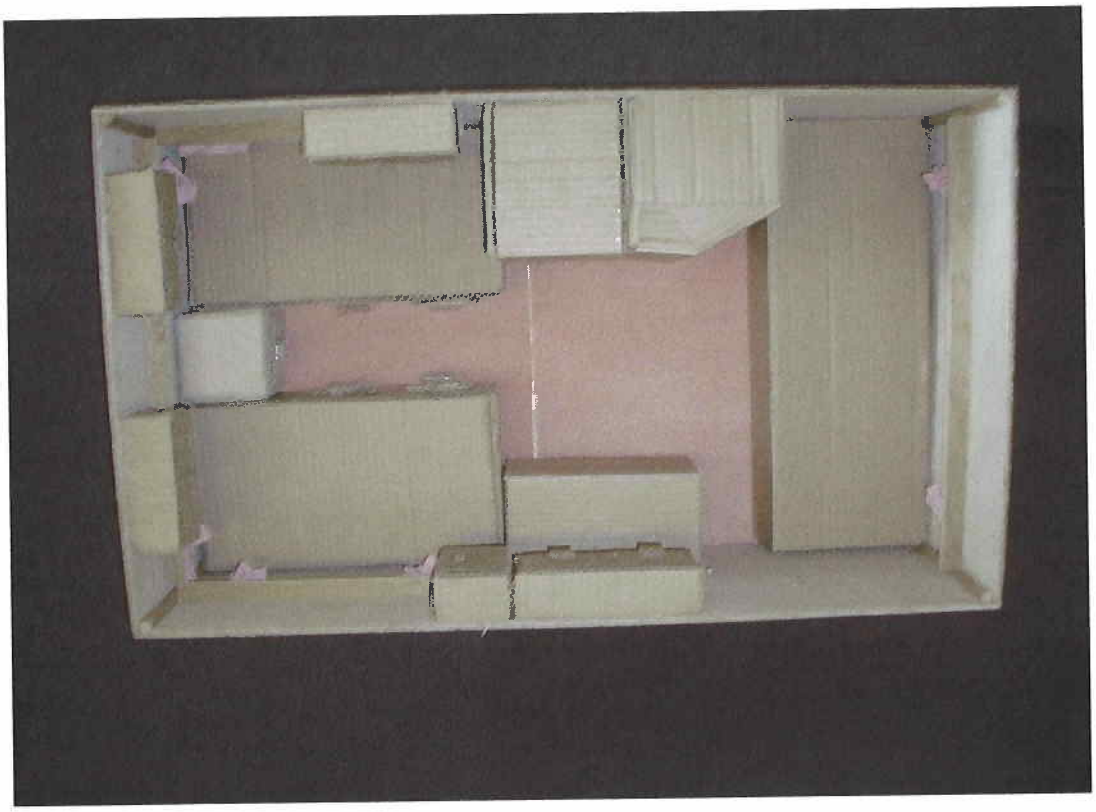
# APPENDIX TWENTY-EIGHT

## The Caravan Model With Irrelevant Material

*The caravan model with irrelevant material, from far end to near end.*

# APPENDIX TWENTY-NINE

## The Caravan Model With No Irrelevant Material



*The caravan model with no irrelevant material, from above.*

# APPENDIX THIRTY

## The Caravan Model With No Irrelevant Material

*The caravan model with no irrelevant material, from near end to far end.*

# APPENDIX THIRTY-ONE

## The Caravan Model With No Irrelevant Material

*The caravan model with no irrelevant material, from far end to near end.*