Measuring the Zone of Proximal Development: Studies of map-use in children with learning difficulties

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This thesis was submitted for the award of a Doctor of Philosophy, May 1993.

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Abstract

The value of measuring Vygotsky's 'zone of proximal development' (ZPD) is the main concern of this thesis. The theory and research described in the thesis examines the psychological and educational purpose of measuring the ZPD within the context of children's representational skills. The first chapter discusses the development of children's ability to understand and use spatial representations. Recent research in developmental psychology is criticised for measuring the ZPD and claiming that the ZPD corresponds to children's individual developmental level. The experiments in Chapter 2 show that previous research has overestimated the representational ability of young children and that a children's potential development is different from their actual development, as assessed by the ZPD. Chapter 3 examines the origins of Vygotsky's sociocultural theory and the ZPD within Soviet psychology and Hegelian philosophy. The next chapter presents contemporary interpretations of the ZPD which have to varying degrees attempted to extend this concept. The idea of dynamic assessment is introduced in this chapter and experiments using this notion are described in detail. Preliminary studies are described in Chapter 5, which examine the possible need for measurement of the ZPD and they also choose appropriate samples, methods and apparatus for future experiments which aim to measure the ZPD within a spatial task. The sixth chapter consists of three experimental studies, which all attempted to measure the ZPD using dynamic assessment techniques. These studies showed that measurement of the ZPD could provide important diagnostic information about children's spatial ability beyond that given by individual tests of intelligence. This was especially true in the case of children with learning difficulties. The results of all the experiments in the thesis are discussed in relation to measurement of the ZPD and its value within developmental psychology and educational psychology.

The unassisted hand and the understanding left to itself possess but little power. Effects are produced by means of instruments and helps.

Francis Bacon

Acknowledgements

I would like to thank my supervisors, Professor Ivana Markova and Robin Campbell for their support and guidance. Also special thanks to Joe McElroy for his assistance in gaining access to the schools and Ranald Macdonald who gave guidance with the statistical analysis. The work within this thesis was supported by a three year Research Studentship from the Economic and Social Research Council.

This thesis is the original work of the author. Though within Chapter 2 half of the data in Experiment 1 and a third of the data in Experiment 2 was collected by Debbie Custance for part completion of a BSc (Hons.) degree within the Psychology Department at the University of Stirling.

Thanks also to the staff, pupils and parents of the two schools that took part in the research, Dawson Park Special Needs School and Abercomby Primary School. In addition, thanks to the staff and children of the Playgroup in the Pyschology Department at the University of Sirling for their cooperation.

A very special thanks to my fiance Carol and the Logan Family for their support and interest, especially over the crucial final six months of the write up. Last, but not least, I am very much indebt to my mother, brother and father for their encouragement throught the last three and a half years.

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Introduction

This thesis is concerned with the psychological and educational value of measuring the ZPD in relation to children's ability to understand and use spatial representations. Theory and research is presented which attempts to escape from the notion of mind-body dualism and Cartesian philosophy which has dominated the majority of psychology in the twentieth century. The aim is to outline a dialectic theory of human development and demonstrate the relevance of such a theory through research. Vygotsky (1978) introduced the concept called the 'zone of proximal development' (ZPD) as a means of conceptualising the interaction between the mind and the environment, since he was influenced by Hegelian philosophy and the dialectical approach of Soviet psychology. The ZPD was defined by Vygotsky as:

"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with a more capable peer" (Vygotsky, 1978, pg. 86).

The experiments within this thesis are concerned with the development and measurement of children's representational ability. In line with a dialectic approach to human development the studies examine how external representation of the environment mediates the interaction between the mind and the social world which leads to cognitive development.

The questions under consideration are:

1. When do children develop metarepresentational ability?

2. Has previous research overestimated the representational ability of young children by measuring their ZPD and failing to differentiate between the actual developmental level and the potential developmental level?

3. What factors within a mapping task help determine children's ability to understand and use maps and can be used in devising tests to measure children's ZPD?

4. Can measurement of the ZPD improve upon and supplement the diagnostic information provided by individual standardised tests and I.Q. tests?

5. Is measurement of the ZPD a useful technique when assessing children's ability to understand and use different spatial representations?

6. What is the psychological and educational value of measuring the ZPD of children with learning difficulties?

Outline of chapters

Chapter 1 critically discusses theory and research in the area of children's ability to understand and use external spatial representations of the environment. It is argued that developmental psychologists need to be aware when they are measuring children's ZPD, so that they can avoid confusing children's actual level of development with their potential level of development. This is necessary in order to avoid exaggeration of young children's metarepresentational ability and the inaccurate attribution of cognitive skills within the very young to innate psychological mechanisms. Chapter 2 presents two experimental studies which investigate the ability of three to five year-old children to understand and use a map. These studies indicate at what age children actually develop unassisted representational ability and what external factors may be important in determining this skill.

Chapter 3 examines in depth the roots of Vygotsky's sociocultural theory in Soviet psychology and Hegelian philosophy. Attention is also drawn to the manner in which the ideas of Rubinstein complement and extend Vygotsky's theory. The chapter especially focuses on Vygotsky's use of the ZPD within psychology and paedological practice.

The fourth chapter critically examines contemporary interpretations of Vygotsky's ZPD. Initially, it discusses the inadequacy of 'scaffolding' as a concept to describe the ZPD. Then the chapter evaluates various attempts to extend Vygotsky's writings on the ZPD using the ideas of other psychologists like Leont'ev, Bakhtin and Rubinstein. Criticism is made of theories which have taken Vygotsky's idea of the ZPD and presented it using just a new combination of words without any theoretical advancement. Importantly, the chapter also includes a detailed description of theory and research on dynamic assessment as a technique aimed at measuring the ZPD and providing an aid to educational assessment. Special attention is given to the potential value of measuring the ZPD among children with learning difficulties and the implications of such an approach for the view of learning difficulty in psychology.

Chapter 5 includes a series of preliminary studies concerned with finding suitable samples of children, methods and apparatus for future studies aimed at measuring the ZPD. This chapter also includes an experiment which examined the diagnostic value of assessing children's individual ability to understand and use a map and their I.Q. scores. This experiment was particularly interested in determining whether such scores provided all relevant assessment information or whether measurement of the ZPD could possibly supplement these evaluation techniques.

The sixth chapter includes three experiments which attempt to measure the ZPD of children within the context of a spatial task. The aim of these studies is to test Vygotsky's assumption that measurement of the ZPD would provide diagnostic information in addition to that given by static, individual tests of intelligence. These studies improve upon previous research on dynamic assessment in two ways. Firstly, by examining the value of measuring the ZPD in relation to children's ability to understand and use spatial representations and not their performance on inductive reasoning tasks used within I.Q. tests. Secondly, these studies examine the relevance of measuring the ZPD among children with learning difficulties. The focus of the experiments is the concurrent validity with intelligence and predictive validity for improvements in performance of ZPD measures and individual tests.

The conclusion provides a summary of the findings within the experimental chapters and discusses the value of measuring the ZPD within psychology and education. It is argued that measurement of the ZPD is a useful exercise when examining the development of children's ability to understand and use spatial representations. This assessment technique can provide important diagnostic information additional to that given by I.Q. tests and individual tests, especially in the case of children with learning difficulties. However, in developmental psychology researchers must be alive to the possibility that the ability they are measuring is located within the children's ZPD, so they do not confuse children's potential development with their actual development. The result can be an overestimation of children's representational ability at a very young age.

Chapter 1

The development of children's ability to understand and use representations

The issue of human representation is a major concern of cognitive - developmental psychology. The major developmental theorists such as Piaget, Vygotsky and Bruner have all stressed the development of representational ability. They all view the process of "cognitive development as the accretion and expansion of representational powers" (Campbell & Olson, 1990, p. 208), though they may differ in their emphasis on how this development is achieved. There are two main ways in which the term representation has been used in psychology. Firstly, representation in its widest sense is comparable with knowledge. This means knowledge in itself and the manner in which it is structured internally in an individual's mind. The second use of the term representation refers to "words, artifacts or other symbolic productions that people use to represent (to stand for, to refer to) some aspect of the world or some aspect of their knowledge of the world" (Mandler, 1983, p. 420). These symbolic representations have a relationship to the referent which connects the individual's mind with the external world.

In recent years the focus of psychology has been on the first use of the term representation, as corresponding to knowledge and in particular the structures of the individual's mind (Astington et al, 1988; Liben et al, 1981). This prominence given to mental representations stems from the 'cognitive revolution' (Gardner, 1987), with a move away from the environmental determinism of behaviourism, with its disregard for mental events, and the development of cognitivism which directly focuses on the internal structuring of knowledge in mind. Cognitivists' thinking is based on a Cartesian philosophical framework which views the essence of mind as individualistic, separate from the body and external world (Markova, 1982). However, cognitivists have often not accepted the limitations of mental representations as an explanatory scheme (Costall & Still, 1991). They have not dealt with two main problems: solipsism, how are the individual's internal representations connected with the reality they supposedly represent ?; secondly, development, how can an innate mental representational ability be flexible enough to explain the mutual interaction between a growing human and complex external environment? I believe that in order to answer these questions psychology must also consider the second use of the term representation, namely external symbolic representations, in addition to a recognition of internal mental representations. It is these human symbols, for example words and maps, that link the individual with the external world and are the medium by which development occurs in the mutual interaction between mind - body and environment.

This chapter is primarily concerned with children's ability to understand and use external representations, in particular the emphasis will be on spatial representations which includes such cultural artifacts as models, maps and photographs. The research involving external representations has not tried to gain a direct insight into a child's mental representation of space, but instead has investigated a child's spatial development by considering how the child understands and uses spatial representations. Maps, models and photographs are productive areas to study because according to Vygotsky (1978, 1986) mental representations of space develop through the mind interacting with external representations which are based on a set of conventions and whose essential function is to render "the experience of space comprehensible" (Downs, 1985, p. 325). External representations can aid an individual form novel mental representation of space. However, an individual's prior mental representations of space are important in her ability to understand external representation. So an individual interprets an external representation with the assistance of existing mental representations and the result is a qualitively different mental representation of space. This new focus on external spatial representations is based on the premise that in order to comprehend the development of an individual's mental functioning the psychologist must go beyond the individual and seek the origins of conscious activity in the external world (Vygotsky, 1978 and Luria, 1976). Therefore, the study of how children use external representations, like maps and models, could indeed help explain how an individual child gradually begins to make sense of and encode space.

Children's ability to understand and use spatial representations is an area of psychology which has received scant attention. Only recently have psychologists placed importance on understanding how children begin to appreciate that a model, map or photograph can stand for part of the external world (Spencer et al, 1989; Blades & Spencer, 1991; Blades & Cooke, 1992; Uttal & Wellman, 1989). "Understanding an external representation is an important developmental achievement" (Blades & Cooke, 1992, p. 3). Piaget was the first to investigate children's ability to understand spatial representations, so I will begin by reviewing his contribution.

Piaget's theory of spatial development

Piaget wrote widely on the subject of child's developing spatial ability (Piaget & Inhelder, 1956; Piaget et al 1960). He offered a constructivist account of spatial development in which children's internal spatial representations are not just the outcome of sensation and reinforcement on a passive organism (empiricism), nor the product of innate structures present from birth (nativism). In Piaget's constructivist approach the children do not have a fixed mental copy of reality which constitutes their knowledge, but gradually children actively construct more complex mental representations through their assimilation and accommodation of environmental information.

Piaget was mainly concerned with internal mental representations and he only made a fleeting reference to external representations, since Piaget considered all use of external representations to be derivative of previously established mental representations. Piaget et al (1960) conducted a study which examined children's internal representations of space by asking children to draw or construct maps. This method has been criticised (Kosslyn et al, 1977; Siegel, 1981), because it failed to consider young children's poor constructional ability and the difficulty this could cause when assessing young children's mental representations of space. However, Piaget and his associates did report one experiment which tested children's ability to understand a spatial representation. Piaget & Inhelder (1956) describe a task which required children to recognize that a model represents a second model. The experiment used two identical models representing open country, including the following features a stream, a road, hills, fields, a bridge, trees, a path and houses with red and yellow roofs. Model A and model B were identical except that model B was rotated relative to model A 180 degrees. The children had to place a doll on fifteen different occasions in a position in model B that corresponded to a position in model A.

Three different stages of spatial development were described by Piaget & Inhelder (1956) from the results of their model landscape experiment. Stage 1 covers up to approximately 3 years, 6 months to 4 years of age and in this stage the child determines the position of the doll "solely by its relative proximity or the immediate surroundings and not through logical multiplication of other relationships or even several proximities taken together" (Piaget & Inhelder, 1956, p. 423). The child's understanding of the models is dominated by the topological relationships of proximity, surrounding and enclosure, so the child can only focus on one isolated feature at a time. For example, the doll was placed in a field in model A, so the child places the doll in a field in model B; but without considering which field and what objects are nearby, or even if the model is rotated and all the subsequent changes this causes. Stage 2 is between 4 and 7 years old and is a transitional period in which the child begins to show the signs of full spatial competence. In sub-stage 2A the child begins to place the doll relative to two or three features and develops a sense of projective space. However, the children's responses are still egocentric as they fail to co-ordinate the whole complex of spatial relationships in terms of a specific point of view, because the children can not deal with a rotated model. Then in sub-stage 2B the children become more effective in co-ordinating the differing relationships, as the child learns to cope with rotation and shows a gradual progression in co-ordination through a process of trial and error. Finally, in stage 3 (6 - 7 years old plus) the children can appreciate all the spatial relationships by logical manipulation using projective concepts (left-right and before-behind) and Euclidean concepts (distances in a straight line and angles).

These findings of Piaget & Inhelder (1956) led psychologists and educationalists to the assumption that children will not be able to understand any spatial representations, such as maps, before the age of seven (Spencer et al, 1989). This opinion was based on young children's supposed egocentric view of the world and their inability to understand space in terms of anything but topological relationships. Therefore, children below seven were considered spatially egocentric and very unlikely to understand and use any spatial representation effectively; as they consist of an artificial or unusual perspective of the world and a child would have no personal experience of such a viewpoint. Thus, the Piagetian theory of spatial development has been instrumental in reducing attention to young children's ability to understand and use spatial representations.

Recent research on young children's ability to understand and use spatial representations

There is now an expanding body of literature critical of Piaget's methods and of his theory of spatial development (Matthews, 1992; Spencer et al, 1989). Several studies have shown that young children do have some representational powers, though there is disagreement concerning the extent of these abilities. These experiments used different variations of the spatial representation employed by Piaget & Inhelder (1956) and created tasks with fewer extraneous demands - as suggested by Liben (1982) and Cohen (1985).

- Young children's ability to interpret aerial photographs

The interpretation of aerial photographs requires some but not all the cognitive ability necessary to use a map (Spencer et al, 1989). An aerial photograph involves a reduction of the referent in scale and it is an abstraction of the external world, but it does not contain the conventional symbols or labels of a map. Blaut et al (1970) asked 6 year-old American children to name and point out any features they could identify from either a oblique colour photograph of the countryside or a black and white photograph of a suburban area. They found that the majority of the children could recognise the correspondence between the two photographs and the external environments, as they identified at least six elements (roads, houses and trees) on both of the aerial photographs. Blades & Spencer (1987a) required 4-6 year old British children to recognise that a map corresponded with a possible urban environment by identifying that the symbols on the map represented features of reality. The study discovered that the majority of six year-old children could understand the symbols on the map and even half of the four year-old children were able to appreciate what the symbols stood for in the external world. Both the above studies suggest that young children are not necessarily spatial egocentric, as they can interpret aerial perspectives of the environment and understand conventional map symbols.

- Young children's ability to understand models and pictures as spatial representations

DeLoache (1987) studied young children's ability to use a small-scale model when finding a toy in an experimental room. She found that between the ages of two and half years and three years children rapidly developed the ability to recognise the correspondence between a model and a room. Three year old children, but not two and half year-old children, could observe a toy being hidden under or in different pieces of furniture (couch, dresser, chair etc) in a model and then find an analogous toy hidden in the same place within a room. DeLoache (1989) noted that in this experiment "undoubtedly these children understood the relation between the two spaces" (p. 15). This model task is basically an analogical reasoning problem. An analogy involves using knowledge in one domain to think about and solve a problem in a second domain through the process of inference. According to Gentner's (1983, 1988) structure-mapping theory a person draws an analogy between two objects by considering the "object attributes and the relations between objects" (1983, p. 156). DeLoache (1987) concluded that the successful three year old children used a representation of where the object was hidden, based on the relations between the objects, to infer where the analogous object was hidden.

The child's success at recognising the model-room correspondence, according to DeLoache (1989) and DeLoache et al (1991), is effected by two determinants. Firstly, the child must have an insight into the representational nature of the model, because the "model task is a symbolization problem" and "it requires that the child understand that the model represents or stands for the room" (DeLoache, 1989, p. 35). Comprehension of the model as a representation exists because the child has a dual orientation to the model. The child holds two understandings of the model: the model as a real object in its own right and secondly as a symbol of something else, a representation of the room. DeLoache contends that in the model-room task the younger children could not represent the model in two different ways, but the three year old children did posses a dual orientation to the model. She explains this by noting that young children do not usually use real objects, with their own functions, to symbolise other objects. In addition, DeLoache (1989) suggests that children below three years old may not have the cognitive capacity to understand that a model can be a real object as well as a representation of something else.

Secondly, physical similarity between two spaces can also promote access to an analogy (DeLoache et al, 1991). DeLoache and her associates offer an innatist position when they states that "the new situation may fail to activate or provide access to their (the child's) representation of the rule or the information" (DeLoache et al, 1991, p. 11). She is suggesting that the child has a natural representational ability, which could be demonstrated if the test situation was modified to allow the child express her inherent representational powers. DeLoache et al (1991) reports two experiments which investigated the influence on young children's representational ability of different types and different levels of physical similarity, between a scale model and a large room it represented. This study was based on the belief that two and a half year old children can form representations of the model and of the room, but the children cannot connect these two representations as they were unable to access the analogy. The first experiment examined the effect of two types of similarity on the ability of three year old children and two and a half year old children to find a toy in a room, after an analogous toy was seen being hidden in a model of the room: object similarity - the surface similarity of the furniture in the model and room; surroundings similarity - the surface appearance of the walls in the room and model. The children's performance with the high similarity model (same materials as the room, same coloured walls and furniture) was compared with their ability with a low similarity model (different material than the room, different coloured walls and furniture). The results showed that "perceptual similarity influences young children's ability to reason from a scale model to a larger space (or vice versa)" (DeLoache et al, 1991, p. 117). Object similarity (but not surround similarity) greatly improved both the younger and the older children's ability to solve the model task. DeLoache concluded that young children have the ability to create mental representations of both the model and the room, and increasing the perceptual similarity between these two spaces allowed the young children to draw on the analogy between these two representations.

The second experiment described by DeLoache et al (1991) investigated whether the two and half year-old children's understanding of the correspondence between the model and the room would become apparent if the two spaces where the same scale. This experiment used the same high similarity model as in Experiment 1, but instead of a large room another high similarity model was used. It was found that the two and half year old children's ability to appreciate the correspondence between the two similar scale models was significantly better compared to their performance with the small-scale and large-scale spaces. Thus, DeLoache asserted that two and half year old children do have the ability to understand the model as a representation, but this cognitive capability is fragile and only apparent in certain conditions. DeLoache et al (1991) concluded both the experiments outlined above by stating her belief that perceptual similarity helps young children to demonstrate their underlying ability to appreciate that a model can be an object in its own right and represent another space.

DeLoache (1991) reports a study which attempted to investigate further the dual orientation hypothesis; namely that the young children failed the initial model task (DeLoache, 1987) because they could not represent the model in two different ways. This study (DeLoache, 1991) tested whether two and half year old children would perform better in an equivalent task using a picture instead of a model. Though a picture is a real, physical object with two functions, its primary purpose is to represent something else. When examining a picture one is not chiefly concerned with it as an object, but one is interested in what it depicts. Thus, DeLoache argues that understanding a picture, unlike a model, does not require a dual orientation. Consequently, if young children can understand a picture as a representation, but not a model, this suggests that young children may have difficulty only with external representations which require a dual orientation. DeLoache (1991) describes three experiments, all with the aim of evaluating her dual orientation hypothesis.

The first experiment replicated an experiment initially reported by DeLoache (1987). This study found that young children showed superior performance when the task required them to understand that a picture (colour photograph), instead of a model, was a representation of a larger space. DeLoache (1991) examined whether the superiority of the picture was due to the different procedures involved with the model and the picture. In the model condition the child had to form a representation of the actual hiding event, whereas in the picture condition the experimenter only pointed at the hiding place. The dual orientation hypothesis would be in doubt if the variation between the test procedure was a valid explanation of the children's success with the picture. To test this explanation DeLoache's (1991) first experiment involved two and a half year-old children and it included four conditions. In the first condition the experimenter hid a toy in one model, then the child had to find an analogous toy in a room. The second condition just involved the experimenter pointing at the picture of the hiding place under or behind which the toy was hidden in the room. In the third condition the experimenter pointed at the appropriate piece of furniture in the model, explaining that the toy was hidden under or behind it in the room. Finally, in the fourth condition the experimenter hid a small toy behind a photograph of each piece of furniture in a room used as a hiding place, then the child was required to find an analogous large-scale toy in the room. The model used in each condition was identical to the high similarity model used by DeLoache et al (1991) and it also included different pieces of furniture (couch, armchair, coffee table etc.) as unique hiding places. The pictures used in this experiment showed individual hiding places separate from the rest of the large-scale room.

The results of the first experiment (DeLoache, 1991) supported the dual orientation hypothesis. The two and half year old children performed equally in condition 1 and condition 3, when a model and room were used, even though condition 1 involved a hiding event and condition 3 did not. Therefore, simplifying the test procedure by pointing at an object instead of a hiding event did not make the task easier for the children. The children found condition 4 harder than condition 2. DeLoache explains this finding as follows: - condition 4 the children had to form a dual representation of the picture as an object in itself and as a symbol for something else, whereas in condition 2 the child were only required to understand that the picture was a representation of the hiding place in the room. This experiment demonstrated that the difference in procedure between the model condition and the photographs condition (DeLoache, 1987) could not explain the children's superior performance with the picture. Additionally, it showed that young children have difficulty with tasks requiring a dual orientation to a two-dimentional symbol, just as they have problems with tasks demanding a dual orientation to a three-dimentional symbol.

The second experiment reported by DeLoache (1991) aimed to investigate the universality of the picture-superiority effect. This was achieved by using a wide angle colour photograph of the room and a line drawing of the room, instead of individual pictures of the four hiding places. The wide angle colour photograph and the line drawing both showed approximately two thirds of the room. DeLoache hypothesized that the children should not find these stimuli more difficult than the point-picture condition in Experiment 1, because none of these tasks required the children to form a dual representation. However, a variation in performance might be expected between the individual pictures and the wide angle photograph because the latter, like the model, contains more environmental information. The line drawing might also prove easier than both types of colour picture because it is less realistic as a physical object and less iconic. In this experiment one group of children were given a task in which the experimenter pointed at a piece of furniture in the wide angle picture and then required the children to find a toy hidden under or behind this item of furniture in a large-scale room. One or two days later this group of children were presented with a task in which a small toy was hidden in a model and then the children were told to find an analogous large-scale toy in a room represented by the model. The second group of children were taken through both parts of the same procedure but in an opposite order and a line drawing of the room was used instead of wide angle photograph. Initially this group of children performed the task with a model as the symbol of the room, then one or two days later they did the task with the line drawing as the representation of the room.

A replication of the picture-superiority effect was found in this second experiment, as the children performed well with both the wide angle colour photograph and the line drawing. Therefore, this picture superiority effect could not be explained by the simple and iconic nature of the individual pictures used in Experiment 1. DeLoache (1989) claimed that the young children's success with pictures, but not with models, was due to the fact that even by two and half years of age children are familiar with pictures as representation as they regularly interact with picture books in which pictures are used to represent something else in the external world.

DeLoache (1991) also discovered a transfer effect in the second experiment. The group of children who initially performed the picture task on the first day, later did better in the model task compared to the children who received the model task on day one. This result shows that if young children experience a symbolic medium which they can understand, later they can master a different representational medium which they did not at first comprehend. Thus, DeLoache argues that under certain circumstances even two and half year old children are capable of understanding a scale model as a representation.

Experiment 3 reported by DeLoache (1991) tested the generality of the transfer effect found in Experiment 2. The effect might be highly specific to the particular room and scale model used in the experiment. Alternatively, the transfer effect may be indicating a "very general heightening of symbolic awareness" (DeLoache, 1991, p. 747) between the picture task and the model task. Therefore, the third experiment investigated whether two and half year old children could transfer their representational ability from a picture task, in which the picture represents one room, to a model task with a model that symbolised a different room. The transfer effect was evident even in a different domain, since the children solved the model task involving one room after showing successfully that they understood the symbolism between a picture and a completely different room.

The picture task (DeLoache, 1991) and the high similarity model task (DeLoache et al, 1991) showed that understanding a real object in two different ways, as an object and a symbol, is within a young child's 'zone of proximal development' (Vygotsky, 1978). This potential development finally actualises after experience with different but relevant symbolic representations, as shown by Experiment 2 (DeLoache, 1991). However, the two and a half year old children's success in the picture task must not be interpreted as demonstrating young children's actual ability to understand an external representation. It is clear that their representational ability is not fully developed as they fail the original model-room task (DeLoache, 1987), a better test child's ability to understand and use a model as a spatial representation. Vygotsky introduced the 'zone of proximal development' as an explanatory and diagnostic concept, that could help explain the process of development and measure a child's potential ability. I am sure Vygotsky would not have wished the 'zone of proximal development' to be taken as an indication of a child's actual level of development.

There are other reasons why DeLoache (1987, 1989, 1991) and DeLoache et al, 1991) may have overestimated three year old children's actual understanding of spatial representations (Blades and Spencer, in press). This exaggeration of three year old children's representational competence results from two problems with DeLoache's experimental design, which make it hard to consider her experiments as true tests of young children's ability to understand and use spatial representations. Firstly, all the hiding places used in the experiment were unique, for example, there was only one couch and one table. Therefore, the children could perform well in the experiment by just matching the hiding place in the model with the hiding place in the room, without even considering the wider spatial relationships within the model and room. Recognition of the analogy between the model and room based just on such 'object attributes' (Gentner, 1983) shows that young children have only a partial understanding of the model as a spatial representation. Indeed, Gentner's (1983, 1988) structure-mapping theory states that complete recognition of an analogy between two spaces is "characterized by the mapping of relations between objects, rather than attributes of objects" (1983, p. 168). Secondly, in DeLoache's experiment the children could see the whole room at the same time as they were searching for the hidden toy. A room is not the type of space normally mapped or modelled. These aids are used for spaces which cannot be viewed from a single viewpoint. Therefore, DeLoache may have over-emphasized the ability of three year old children to use a spatial representation by using unique hiding places and a space much simpler than that normally mapped or modelled.

Research has been reported by Blades & Spencer (in press) and Blades & Cooke (1992) which demonstrates that young children have difficulty understanding and using a model as a spatial representation. DeLoache's experiments only required the children to understand the object attributes of the model and room, but true analogical reasoning "takes into account both object and relational attributes" and this implies the child has an "understanding that part or all the model represents part or all of the room" (Blades & Cooke, 1992, p. 6). Evidence that the children solving the model-room task purely used object attributes would not support the claim that young children appreciate that the model is a symbolic representation of the room. Blades and Cooke (1992) conducted two experiments aimed at discovering whether young children viewed the model as a representation of the room and understand the spatial relations with both of these spaces. Unlike DeLoache, they used hiding places with identical object attributes ('identical' hiding places) as well as unique hiding places in the model, forcing the children to encode the spatial relationships between the furniture in the model and room.

The first experiment described by Blades and Cooke (1992) used two identical model room layouts and tested the representational ability of three to five year old children. These rooms were exactly the same scale, plus they were of high object and surround similarity (DeLoache, 1991). Four items of furniture were used as hiding places: a blue and white bed, a green wardrobe and two identical white chairs placed against adjacent sides of the model and room. In one experimental condition the model was aligned relative to the room and in a second condition the model was rotated 180 degrees relative to the room. The procedure was adapted from DeLoache (1989), in which the child watched a toy hidden in or under a hiding place in one model and then the child had to retrieve an analogous toy hidden in the same location in another model. Each child experienced twelve trials, for six of the trials the toy was hidden in a unique target place and in the other six trials the toy was hidden under one of the identical chairs. If the children fully understood that the first model represented the second model, then whether the hiding place was unique or identical would not affect their performance.

This first experiment reported by Blades and Cooke (1992) found that three, four and five year old children were successful when the toy was hidden in a unique hiding place, but the three and four year old children failed the task when the toy was hidden in a identical target place. In addition, the young children performed better with the aligned model compared to the rotated model. Ninety eight percent of the three year old children's errors with the aligned model and one hundred per cent of their errors with the rotated model were choices of the wrong chair in the second model. These results suggest that the three year old children cannot appreciate the spatial relations between the objects in two models and they do not necessarily understand that the first model is a spatial representation of the second model. However, it is clear that three year old children have the ability to consider object attributes and this fact could explain their success with DeLoache's (DeLoache, 1989, 1991; DeLoache et al, 1991) model and picture tasks. It was not difficult, within DeLoache's experiments, for the children to recognise the correspondence between the pieces of furniture. Since in the familiarisation phase the experimenter actually took each item of furniture from the model into the room or the other model and held it up to its counterpart and stated that these two objects stood for the same item of furniture. DeLoache (1989) partly acknowledges the limitation of her experiments as tests of children's spatial representational ability as she states that "mapping spatial relations, may or may not be necessary for success in the model task" (p. 36).

Blades and Cooke (1992) provide evidence for a developmental progression in children's ability to understand external representations. Though the three year old children failed with the aligned model the four year old children were successful when the models were aligned but had problems when the first model was rotated. On the other hand the five year old children fully understood the model as a representation irrespective of its orientation or the existence of identical hiding places. This age related development in representational ability is consistent with the findings of earlier research, such as Piaget and Inhelder (1956). However, support for a gradual development in children's ability to understand external representations contradicts DeLoache's (1989) claim that young children experience an "abrupt developmental shift" in their representational powers around three years of age and that this suggests "the possibility of a strong maturational underpining" (p. 52). The results of the first experiment (Blades & Cooke, 1992) also challenges DeLoache's (1989) idea that young children's difficulty consists solely of the inability to grasp the dual orientation of the model, since they showed no ability to understand the model as a spatial representation.

The second experiment reported by Blades and Cooke (1992) investigated whether four year old children could actually understand the internal spatial relations of the model, even though though they failed to distinguish between the identical hiding places in Experiment 1. Thus in this experiment the spatial relationships in the model layout were altered possibly enabling the four year-old children to encode the spatial relations between objects. In Experiment 1 the identical chairs were in similar positions, namely at the mid-point of a side of the model and directly opposite one other item of furniture. This may have confused the four year old children and made it unnecessarily hard for them to solve the task by understanding that the model was a spatial representation of the room. The spatial relations within the model were changed in three ways: the chairs were moved nearer to a unique item of furniture; the chairs were positioned next to unique pieces of furniture and the chairs had completely different relationships to the other features of the room. However, the results of this experiment confirmed the findings of Experiment 1 and showed that the manipulation of the model's spatial layout did not improve four year old children's ability to distinguish between two identical chairs

Experiment 3 conducted by Blades and Cooke (1992) examined whether the exact similarity in scale between the two model caused the effects found in Experiment 1 and Experiment 2. Four year old children were presented with the same model layout used in the rotation condition within Experiment 1, but instead of finding a toy in a second model the children had to find an analogous toy in a real room. The four year old children performance in this experiment was compared with their ability demonstrated in the rotation condition within Experiment 1. This experiment discovered no significant differences between the children's performance when they had to appreciate a model as a representation of an model and their ability when using a model as a representation of an actual room. Therefore, the difficulty experienced by the four year old children in understanding the a rotated model as a representation of another space was not due to the similarity of the two spaces.

These three experiments reported by Blades and Cooke (1992) suggest that "preschool children have a limited understanding of spatial representations" (p. 18). Not until five years of age do children begin to show competent representational ability. This observation questions the conclusion of Piaget and Inhelder (1956), that children below the age of seven are spatially egocentric and can not understand external representations. Blades and Cooke's findings also contradicts DeLoache's (1989) claim that between two and half years and three years of age children rapidly acquire the ability to understand a model as a representation. It is suggested by Blades and Cooke (1992) that between three and four years of age children gradually begin to appreciate the correspondence between two spaces and understand that a space can represent another space. However, this process of development does not fully mature until around the child's fifth birthday.

DeLoache's interpretation of her research (1987, 1989) has also been criticised by Perner (1991). Perner considers that DeLoache was examining the development of children's understanding of correspondence, rather than representation, although he acknowledges that the understanding of correspondence is an essential component in developing an appreciation of representation. Perner (1991) is concerned with the fact that DeLoache initially argues that between two and half years old and three years old children develop the ability to understand the correspondence between the model and room, especially the items of furniture in the model and room. However, DeLoache also gives her results a wider interpretation, that by three years of age children realize that "an object can be understood both as a thing in itself and as a symbol of something else" (1987, p. 1556). Perner (1988) also equated the understanding of correspondence and the ability to infer from one space to another with the understanding of representation and symbolism, but now he (Perner, 1991) recognises this as a false belief. Correspondence is not the same as representation because it can not help explain the difference between what an object really stands for and how it could be interpreted to represent many different things. Here Perner (1991) is arguing that understanding correspondence is not so cognitively demanding as understanding a representation, since there are many ways to represent an object but only one way to correspond to an object.

Perner (1991) also notes that DeLoache's experiments (1989) used two corresponding models in a manner that makes it difficult to consider these experiments as tests of representational ability. This is because a representation usually has an asymmetric relationship with the object that it represents, but this is not the case in DeLoache's experiments. It is not absolutely clear what represents what in DeLoache's studies, as the first model could be seen to represent the second model though alternatively the second model might stand for the first model. Perner (1991) supports the idea that very young children have a dual orientation to the model, but only on the level of understanding correspondence; he believes, like Blades and Spencer (1989), that between three years old and four years old children begin to develop the ability to understand external representations.

- Young children's ability to understand and use maps as spatial representations

Bluestein and Acredolo (1979) were the first to test young children's ability to understand and use a map as a spatial representation. This experiment investigated three to five year old children's ability to use a map when finding a toy in either one of four indentical green boxes at the mid-point of each wall in a room. The corners of the room were distinguished by placing three differently coloured objects in them. Bluestein and Acredolo also examined whether young children could use a map as a representation of a room if the map was rotated 180 degrees relative to the room. This experiment found that three year-old children could "interpret cartographic symbols (maps) as representative of objects in space" (Bluestein and Acredolo, 1979, p. 695), but only when the map and the room were aligned. Only a few of the four to five year old children did not succeed in the task when the map was rotated relative to the room. Four to five year old children could understand the spatial relations between the objects in the room and appreciated the map as a representation of the room. The success of the four year-old children in this map task contrasts with their failure in Blades and Cooke's (1992) model-room task. These differing results could perhaps be explained by the dual orientation hypothesis (DeLoache, 1989), as a map is a less salient object in itself, so that understanding a map compared to a model does not require a dual representation of the map.

Research has shown that children understand and use maps in space by referring to nearby landmarks (Presson, 1982; Blades and Spencer, 1987a). Presson (1982) reported an experiment which investigated the map-reading skills of six to eight year old children and whether children use landmarks in locating objects in a space which is rotated relative to a map. The children had to find a tennis ball in one of four cardboard containers located in the corners of a school library using a rotated map of this space. The landmarks in the space were either fixed (windows) or moveable from trial to trial (chairs). It was found that a rotation of the map by 90 degrees relative to the room was an easier condition for the children compared to a condition with a rotation of the map by 180 degree relative to the room. The children extracted critical information (near or far) from the map concerning the target's location to landmarks when searching for the tennis ball.

The ambiguity of the landmarks in a space is an important factor in determining children's ability to navigate through space using a map, according to an experiment conducted by Blades and Spencer (1987b). This experiment required four to eight year old children to use a map while walking around the outside of an octagonal layout of paths, with cardboard boxes as hiding places at each of the vertices of the layout. The children had to use the map to choose the correct path in order to reach the centre of the layout. A large circle (landmark) was painted on each box. Some boxes had circles of the same colour whereas other boxes had different coloured circles. The boxes were arranged in the layout so that the coloured circles on the boxes made some boxes ambiguous landmarks and other boxes unambiguous landmarks. All the children could solve the task successfully when the correct path on the map was identified by a unique landmark. However, when the landmarks were ambiguous the younger children tended to fail the task by always choosing the first path in the layout marked by an appropriately coloured circle. By seven years of age the children realised the need to consider more than one landmark when the landmarks were ambiguous. This experiment supports the earlier criticism of experiments by DeLoache (1989, 1991) and DeLoache et al (1991), that they failed to consider the effect on the children's performance of using unique and unambiguous hiding places in the model task.

Blades and Spencer (1987c, 1987d) reported an experiment on young children's ability to use a map when following a route in a large-scale maze. The children had to use the map when making route choices at the three T-junctions in the maze. In one condition the decision points on the route were marked with different coloured landmarks and in a second condition these places were left unmarked, making each choice point in the second condition identical in appearance. The space used in this experiment was more complex in comparison to the room in DeLoache's experiment (1989), as screens were used to prevent the children from viewing the complete maze from any one position. Blades and Spencer found that all but the youngest group of children (mean age 3;11) performed much better than chance and could use the map effectively to navigate through the maze. This result suggested that three year old children could not use a spatial representation of a complex large-scale space. In addition, only the youngest group showed no effect of landmarks., whereas older children found the mazes with landmarks easier. This suggests that the three year-old children did not utilize the environmental information available from landmarks within the maze. However, this experiment is complicated by the fact that the children could use landmarks from outside the maze to aid their progress through the maze. This because the maze only consisted of a path drawn on a school playground, with screen only blocking the child's view ahead. Thus, this type of maze allowed the children to use landmarks outside the maze, possibly the school building or a nearby tree, to help their route following inside the maze. This might have made this task easier for the young children than other mapping tasks, such as Bluestein and Acredolo's (1979).

Uttal and Wellman (1989) investigated young children's ability to form mental representation of a map and then navigate through the space depicted by the map. They found that four to five year old children had substantial abilities to understand and use a spatial representation. The children could memorize a map and then demonstrate their knowledge by pointing out features of the map as they walked through a space containing six adjoining rooms. The children with prior experience of the map performed better in a later test, after all the children had walked through the rooms, compared to the children who were not exposed to the map. This study demonstrated that young children have the ability to use a map effectively when navigating through a space. Additionally, it was found, in line with Blades and Cooke (1992), that the children's acquisition of map-using ability was an extended developmental achievement.

- Related work on young children's metarepresentational ability with spatial representations

DeLoache's (1989) claim that very young children have the ability to form a dual representation of an object is equivalent to stating that these children have the ability to form a metarepresentation. A child capable of metarepresentation must construct a mental model consisting of two substructures and this model should describe the relationships between these structures (Perner, 1991). The first structure must represent the object, as a concrete entity. The second structure has to stand for what the picture depicts, namely its interpretation. Then the child has to understand how the first structure connects with the second structure. This description of metarepresentational ability, if one accepts DeLoache's interpretation of her experiments, allows one to claim that even two and half year old children have some metarepresentational ability.

Research on children's 'theory of mind' and false belief attribution has also addressed the issue of children's metarepresentational ability (Astington et al, 1988; Wimmer and Perner, 1983). These studies have examined a child's ability to understand another child's mind or belief system. This involves the child understanding that a person can have and act on a belief that differs from what the child knows to be reality. The child has to form a mental representation of reality and also create a mental representation of the other person's false view of it. Wimmer and Perner (1983) reported a number of experiments that tested young children's ability to correctly attribute a false belief to a deceived actor. They found that children could not correctly attribute a false belief until they were four years of age. Various explanations of this phenomena have been offered. Wellman (1988) and Leslie (1988) contend that children before four years-old are deficient in a 'theory of mind'; since these children can not conceive of the mind as an active, interpretive and analytic machine, making it possible for them to consider that another person can hold a false belief. Therefore, if the child's problem lies in their nonexistent theory of mind the problem must be restricted to mental representations. Indeed, Chandler and Boyes (1982) predicted that young children would not have a problem demonstrating their metarepresentational ability with non-mental representations. This may not be the case if one considers the findings of Blades & Spencer (1987c) and Blades & Cooke (1992), since they found that three year old children had problems understanding and using a model or a map as spatial representations of other spaces.

Zaitchik (1990) describes a collection of experiments which posed the same problem as Wimmer and Perner (1983), but a 'false' photograph took the place of the false belief. The first experiment involved three to five year old children observing the experimenter take a picture of an object with either a toy or a real camera. Once the picture developed, it was shown to the child and placed face down on a table. Then the object in front of the child was changed and the child was asked what was depicted in the picture on the table. This procedure was presented in a puppet skit, making sure the children were interested in and believed the events. The children were also required to perform a similar task, but instead of a false photograph the child had to understand a false belief. The results of this experiment showed that the picture task was no easier than the belief task, even though the picture was a non-mental representation of the reality.

Another experiment reported by Zaitchik (1990) investigated whether the children had an information-processing problem with the photograph task. The abstract operation of the camera in the picture task may have confused the children and effected their performance. Thus, the children in this experiment were presented with a non-representational analog to the camera description, which required the same level of information processing. The object was not represented in a picture, instead it experienced a change in location (it dropped down a tube which was part of a 'gizmo' machine). The children showed superior performance in this new non-representational task compared to the picture task. Therefore, the children's problem with the belief and photograph tasks is their representational nature. These experiments conducted by Zaitchik (1990) provide "evidence that the preschooler has an even harder time reasoning about photographs than beliefs" (p. 60). Young children's inability to correctly attribute a false representation may extend from mental representations to external or spatial representations. Failure in the false belief task (Wimmer and Perner, 1983) may have little to do with a child's lack of "an active cognitivist conception of the mind" (Zaitchik, 1990, p. 61), but have more to do with young children's poor metarepresentational ability.

Perner et al (1992) describes a series of experiments which tested the reliability of Zaitchik's findings. The 'gizmo' task within Zaitchik's (1990) study was in one way more complex compared to the camera task. In the 'gizmo' task unlike the camera problem one of the two objects was operated on directly, as the object went down the tube and in the picture task nothing happens to the object being depicted. Therefore, Perner et al (1992) tested three to four year old children on a colour transmission task. In one condition of this experiment the children were presented with the same task as described in Experiment 2 (Zaitchik, 1990). In another condition - the colour transmission task - the children observed the experimenter take a photograph of a coloured cloth on a screen, the picture was shown to the child and placed face down, then another coloured cloth was used to cover the screen and the child was asked to name the colour of the piece of paper that the camera produced. Perner et al (1990) considered the colour task a non-representational problem, as the camera did not develop a picture, but a coloured piece of paper. It was found that the children performed better in the colour transmission task compared to the photograph task. Experiment 2 reported by Perner et al (1992) found a corresponding difference in children's performance in a representational condition involving a drawing of a shape on a boy's tee shirt and a non-representational condition involving a copy of that shape on a friend's tee shirt. These results support Zaitchik's claim that young children have a problem with metarepresentations. Perner et al (1992) describe another experiment, with only sixteen three year old children, which showed that if the experimenter directed the child's gaze at the back of the picture while the child was questioned the children's performance drastically improves. Thus, it is claimed by Perner that young children do not have a problem with Zaitchik's picture task because it involves understanding a representation, but instead that children have a greater problem with context confusion. This is because in the picture task the children are required to think about two different temporal contexts, the reality they see and the past situation when the photograph was taken.

The criticism made of the experiments by DeLoache (1991) and DeLoache et al (1991) - see page 14 - can be made of this last experiment reported by Perner et al (1992). The experiment tested the children's 'zone of proximal development', because the experimenter's direction of the children's gaze helped them to recognize the distinction between reality and the photograph. This made it easier for the children to infer that the picture was a representation of a past situation and not connected with present reality. The process of marking the difference between the picture and the reality is similar to the procedure used by DeLoache (1991) and DeLoache et al (1991), which highlighted the correspondence between two spaces. In addition, the claim by Perner et al (1992) that the source of young children's difficulty in Zaitchik's (1990) picture task is not the fact that the photograph was a representation, but the children's context confusion is not supported by the findings of Blades and Cooke (1992) or Blades and Spencer (1987c). These studies indicated that young children had limited metarepresentational ability, even in situations with no contextual confusion.

Recent research has shown that young children develop the ability to understand and use both external and mental representations before seven years of age. This important developmental achievement begins to develop around the child's fourth birthday. However, before four years of age children have the ability to understand the correspondence or disassociation between two objects or events, when the experimenter helps them recognize the analogy or difference between such objects or events. Though this observation does not demonstrate that children below four years of age have metarepresentational ability, it indicates that representational competence is within their 'zone of proximal development'.

Chapter 2

Studies of map use in normal 3-5 year old children

Summary

Recent research has demonstrated that young children can use simple maps to find a location in an experimental room or follow a route in a large-scale environment. This chapter reports two experimental studies conducted as part of the thesis in order to investigate the ability of three, four and five year old children to use a map as a spatial representation. The aim of these two studies was to extend previous research by asking young children to use a map when finding an object in a large-scale maze. Four hiding places were used which varied in terms of their spatial relations to nearby landmarks and the degree to which the children had to re-orientate themselves within the maze. Data collected from thirty six and fifty four children revealed a significant improvement in the children's performance with age. Children's ability to use the map was dependent on the location of the hiding place inside the maze. The results are discussed in terms of the different external factors that contributed to the representational ability of the children. It is suggested that these criteria can be manipulated in future studies of map use in order to measure each child's ZPD.

Introduction

The experiments aimed to extend the research of DeLoache (1987) in two ways. Firstly, identical hiding places (boxes) were used, preventing solutions based on object attributes alone, and secondly the experiment improved upon DeLoache's work by testing the children in a large-scale maze, which prevented the children from viewing all the hiding places to be mapped from any one position.

These experiments also extend the research described by Blades and Spencer (1987) by examining two additional factors that might affect children's ability to use a map. The influence of external landmarks is investigated in this experiment by using a large-scale maze, which means that once the children have entered the maze external landmarks are no longer visible. If these landmarks are important in determining the children's ability to use a map one would expect the children to perform below the level shown in Blades and Spencer's experiment. Secondly, Blades and Spencer (in press) argue that the assumptions that children make when dealing with a spatial problem are an important influence on children's map-reading skills. If the children in this experiment do not make compensatory rotations of the map when they re-orientate themselves inside the maze, the children may not be able to capitalize on the correspondence between map and maze. Indeed, Bluestein & Acredolo (1979) and Presson (1982) both showed that the ability of young children to use a map in an small-scale environment depended on their decisions about the rotation of the map relative to the space. Therefore, in this experiment three of the four hiding places inside the maze required the children to re-orientate themselves to differing degrees.

Previous research has shown that girls and boys differ in their spatial competence. Matthews (1987a) found sex differences occurring in the children's environmental experience at the age of eight, with girls being more restricted in their spatial activity. He also discovered a corresponding difference in the children's quantitative accumulation of environmental knowledge and the qualitative manner in which the boys and girls externalized their mental representation of space. Matthews (1987b) reports that the more extensive movements of boys through the environment, compared to girls, led to better spatial abilities even in an unfamiliar environment.

The children in the following experiments had to use a map in order to find or hide an object within a simple large-scale maze (see Figure 1) on four trials. The position of the hiding place in the finding condition was varied between the trials. When the object was hidden in Box 1 the children were obliged to change their original direction of search by 45 degrees inside the maze: the walls around the hiding place were facing and to the right of of the line of approach. With Box 2, a 90 degree change of direction was needed: the surrounding walls were facing and to the left of the line of approach. Whereas, the box 3 trial did not require any shift in the children's original motion as they entered the maze: the walls around the box were facing and to the left of the line of approach. Finally, the box 4 trial required the children to change their direction 180 degrees inside the maze: the walls surrounding were facing and to the right of the line of approach. Experiments 1 and 2 will examine the variance in performance between different age groups across the four box trials, plus the difference in the children's ability between each box trial. These two experiments will also investigate whether sex differences exist in 3-5 year old children's ability to use and understand a map.

Experiment 1: The ability of 3-4 year-old children to understand and use a map.

Method

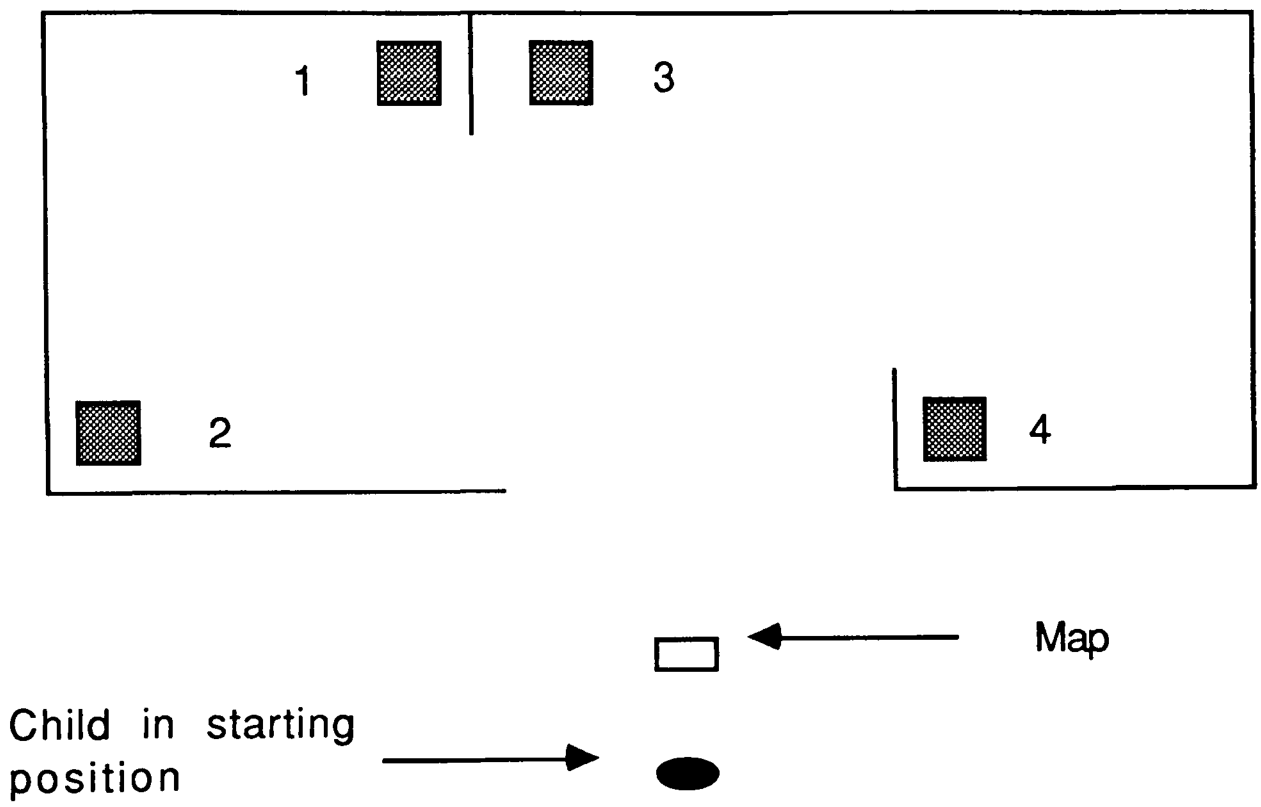
Subjects

Thirty six children took part in this experiment selected randomly from the University of Stirling Playgroup (Group 1, n = 18, mean age 3; 4, range 3; 0 - 3; 10; Group 2, n = 18, mean age 4; 4, range 4; 0 - 4; 9). The 18 children (8 girls, 10 boys) in the three year-old group and the 18 children (10 girls, 8 boys) in the four year-old group were tested in both the finding and hiding conditions.

Materials

The major piece of apparatus consisted of a 2.4m x 1.2m x 1.2m collapsible maze. Figure 1 below shows the plan of the maze, which was used in both the finding and hiding condition.

Figure 1: Plan of maze used in both the finding and hiding condition, indicating box 1, box 2, box 3 and box 4. (The map given to the children were the same as this plan, except that the map did not contain numbers by each box)



Four cardboard boxes were strategically placed in the maze. The cardboard boxes were identical, plain and measured 27cm x 22cm x 21cm. The walls of the maze were 1m high, so the children could not view the whole maze from one position. The children could only see box 3 as they looked at the maze from outside. The children had to find or hide an empty small multi-coloured box, called the 'present', in each of the four boxes in the maze in turn. Three soft toys were used to place in the boxes which were not the target within each trial. Thus this ensured all the boxes were approximately the same weight and prevented detection of the 'present' by shaking or lifting the box. A map of the maze (with a scale of 1:15) was drawn in thick black ink on white cartridge paper (see Map 1 in the appendix). The map for the finding condition was the same as the map for the hiding condition. Children or experimenter sat on a chair and covered their or his eyes while the 'present' was being hidden by the experimenter or child in the maze.

Procedure

- Finding Condition:

The subjects were tested individually. Initially, each child was encouraged to walk through the maze and the experimenter pointed out the location of each box. Then the child was told we would play a 'treasure hunt' game, in which the child must find the 'present' after the experimenter had hid it in a box. Next the child was shown the map. It was explained that the map was a picture of the maze and could be useful in locating the 'present' when it was hidden inside a box within the maze.

The experimenter placed the 'present' in box 3 (see Figure 1) and showed the child the position of box 3 on the map by drawing a cross on this box. Then the 'present' was put inside box 2 by the experimenter and the child was asked to identify box 2 on the map. If the child was incorrect, the experimenter showed the child the correct box on the map.

The child was taken back to the starting position (see Figure 1). The experimenter then hid the 'present' in one of the four boxes situated within the maze, while the child turned away and closed her eyes. Then the position, on the map, of the box containing the 'present' was pin-pointed for the child by marking it with a "X'. The child was asked to find the box with the 'present' inside and bring it back to the experimenter at the starting point. During her search for the correct box the child was allowed to take the map. If the child choose an incorrect box the experimenter replaced the wrong box and again showed the child on the map the box with the 'present' inside asking the child to try again. The child was allowed a maximum of four attempts in each trial. Overall, this procedure was repeated on three more occasion. Each child had to complete four trials, using a different box as the hiding place in each trial. The ordering of the hiding places across the trials was random. The number of attempts needed by each child to find the 'present' for each of the four hiding places was recorded.

- Hiding Condition:

In this condition the child was asked to hide the 'present' on four different occasions, while the experimenter closed his eyes and turned his back to the maze. Then the child had to identify on the map the box in which they hid the 'present' by marking this box on the map with a 'X'. The experimenter checked whether the child was correct, if not the child was requested again to identify the box on the map which contained the 'present'. The number of times the child needed to mark the map, in order to show the experimenter the location of the 'present', was noted. In both conditions the child was reminded to use the map, but no other help was given by the experimenter.

Results:

This results section focuses on the following areas: Firstly, the individual differences in spatial awareness within the finding and hiding conditions, resulting from the effect of age and sex. Secondly the differences, due to the interaction between age and sex, in the children's ability to find and hide the 'present' successfully in each box within the maze.

A series of analyses of variance with repeated measures assessed the effects of age and sex on differences in spatial performance within the finding and hiding conditions. These tests also considered the difference between the children's performance in the finding and hiding conditions. A test of cumulative probability using the binomial distribution was conducted to investigate whether overall the three year old children and the four year old children were performing above chance expectations in the finding condition.

Another set of analyses of variance with repeated measures examined whether children's spatial ability varied between the four box trials in the finding condition. The differences between the children's test scores in each of these four box trials will further analysed by post-hoc Scheffe tests. This set of ANOVAs also investigated the effect of age and sex on performance when the 'present' was hidden in each of the four boxes in the finding condition. The variation between the test scores of the two age groups within the four box trials was examined in more detail by post-hoc Scheffe tests. In addition, a test of cumulative probability using the binomial distribution was performed to examine whether the three year old children and the four year old children within the finding condition were scoring above chance expectations in each of the four box trials. Non-parametric correlations were calculated to investigate whether the children's performance varied between the four box trials in the hiding condition.

Table 1 contains a summary of the children's performances in both the finding and hiding parts of the experiment. It is evident from this table that certain prevalent patterns occurred in the children's test scores. The mean score in the finding session was 7.89, where as the mean in the hiding condition was 5.56. This suggests that the children found the hiding condition easier compared to the finding condition. Additionally, the children seemed to experience difficulty when certain boxes were used as hiding places. This seems very true in the finding condition, but not so evident in the hiding condition.

Table 1: Summary of children's performance scores

(a) Finding condition (for each box trial n = 36):

Trial	Mean (attempts)	Standard deviation	Min. (attempts)	Max. (attempts)
Box 1	2.33	1.12	1.00	4.00
Box 2	1.75	1.03	1.00	4.00
Box 3	1.33	0.68	1.00	3.00
Box 4	2.47	1.28	1.00	4.00

(b) Hiding condition:

Trial	Mean (attempts)	Standard deviation	Min. (attempts)	Max. (attempts)	N
Box 1	1.90	1.08	1.00	4.00	29
Box 2	1.52	1.00	1.00	4.00	29
Box 3	1.73	1.00	1.00	4.00	26
Box 4	1.64	0.96	1.00	3.00	33

(a) Finding and hiding conditions

The finding condition in this experiment had four trials. Each child was allowed four attempts to locate the 'present' successfully in every trial of the finding condition. Therefore, the child could score between 1 attempt and 4 attempts on each trial. When the child found the 'present' first time across all four trials, the score was perfect.

However, if the child failed to use the map and simply guessed the location of the 'present' there was a 0.25 chance of finding it on the first attempt at searching. Following the same procedure as Blades & Spencer (1987), the distribution of trials completed on the first attempt was compared to a binomial distribution based on the probability of 0.25. With such a distribution, the probability that an individual child searching randomly would succeed on the first attempt in 3 or more of the 4 trials is 0.0508. Overall, with a sample of 36, the probability that 5 or more of the children would succeed on 3 or more of the 4 trials at the first attempt is 0.0343. In the case of each age group the sample size was 18, therefore the probability that 3 or more children would finish 3 or more of the 4 trials using only one attempt is 0.0604 and the probability that 4 or more children would succeed on 3 or more of the 4 trials on the first attempt is 0.0115. Table 2 shows the number of children in each age group that solved 3 or more of the 4 trials on the first attempt.

Table 2: Number of children who completed 3 or more of the 4 trials in the finding condition using only one attempt (for each age group n = 18)

Condition	Ages (years) 3	4	Total (n = 36)
Finding	3	10	13

Thirteen of the children completed 3 or more of the 4 trials on the first attempt. On the whole, the children in this experiment performed significantly better than chance. Although it was the four year old group, that performed significantly better than chance. The first attempt at locating the 'present' among the three year-old group appeared to be random.

The test scores of every child, in each trial of the finding and hiding sessions, were added together giving a total score for all children in both conditions of the experiment. Analyses of variance with repeated measures were used to examine the age and sex effects on the children's scores in both test conditions. A 2 (age) x 2 (sex) x 2 (condition) ANOVA (equally weighted means) with the conditions as repeated measures, shown in Table 3, analysed the influence of the between-subject variables, the age and sex groupings, on the total number of attempts needed in the finding and hiding conditions.

It is apparent from Table 3 overleaf that the effect of conditions is significant - $F(1,32) = 23.96$, $p < 0.01$. Table 3 also demonstrates that there was a highly significant difference between the age groups in their test scores in both the finding and hiding conditions - $F(1,32) = 24.54$, $p < 0.01$. However, the interpretation of this analysis is problematic because it is based on an unbalanced design, which may be causing a partial confounding of effects (Macdonald, 1991a, 1991b).

Table 3: A 2 (age) x 2 (sex) x 2 (condition) analysis of variance with the conditions as the repeated measures, using sex and age as between-subject factors.

	df	F-factor	p
AGE	1,32	24.54	0.00**
SEX	1,32	0.44	0.51
AGE/SEX	1,32	0.13	0.72
CONDITION	1,32	23.96	0.00**
CONDITION/AGE	1,32	0.45	0.51
CONDITION/SEX	1,32	1.40	0.25
CONDITION/AGE/SEX	1,32	0.60	0.45

KEY: * $p < 0.05$; ** $p < 0.01$

The above key will apply to all other tables in this results section.

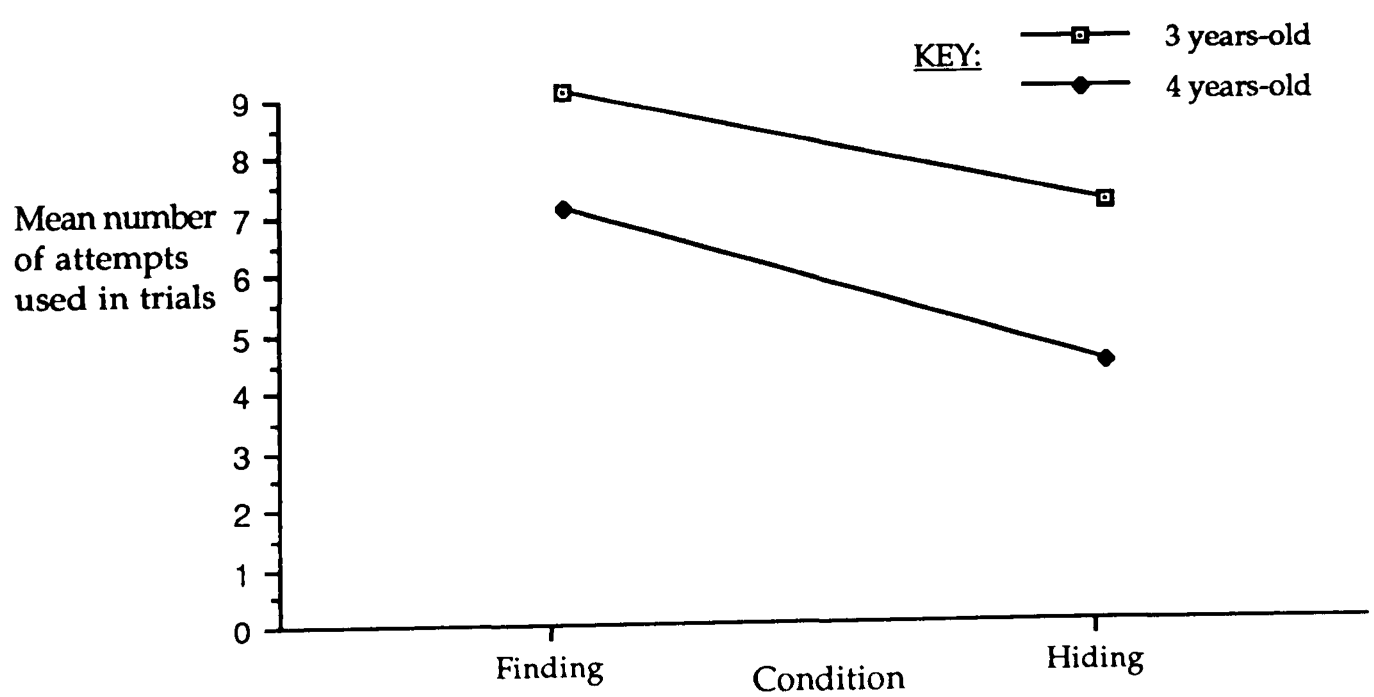
Thus, two 2 (age or sex) x 2 (condition) ANOVAs (equally weighted means) with the conditions as the repeated measures were conducted with the total number of attempts needed in both the finding and hiding conditions as the within-subject variables and either the age or sex grouping as the single between-subject factor. It is important to note that both these ANOVAs were executed on balanced designs, which present no problems to generalization.

The first 2 (age) x 2 (condition) ANOVA (equally weighted means) with the conditions as the repeated measures, with the age grouping as the between-subject factor and the total number of attempts required in both the finding and hiding conditions as the within-subject variables, calculated an effect of condition - $F (1, 34) = 23.42$, $p < 0.01$. The children found the finding condition appreciably more difficult compared to the hiding condition, as they required a mean number of attempts equal to 7.89 and 5.56 respectively. This first analysis also confirmed the significant difference between the age groups in the number of attempts they needed in the finding and hiding conditions - $F (1,34) = 25.18$, $p < 0.01$. Therefore, it is correct to state that three year old children used notably more attempts to complete all trials, in both the finding condition and hiding condition, compared to four year old children. The variation in performance between the two age groups can be seen in both Table 4 and Graph 1.

Table 4: Mean scores and standard deviations for the three year old children and the four year old children in both the finding and hiding conditions (for each age group in each condition n = 18).

	Ages (years)		
Condition	3	4	Total (n = 36)
Finding	8.89 (2.40)	6.89 (2.61)	7.89
Hiding	6.94 (1.77)	4.17 (0.92)	5.56
Total	7.92	5.53	6.72

Graph 1: Mean number of attempts needed across the four trials in the finding and hiding condition by the three and four year old children.



The second 2 (sex) x 2 (condition) ANOVA (equally weighted means) with the conditions as the repeated measures also found no effect of sex - $F(1,34) = 0.01$, $p = 0.93$.

(b) Position of the hiding place inside the maze.

(i) Finding condition:

A series of analyses of variance with the four box trials as the repeated measures and tests of cumulative probability examined whether children's ability to understand and use a map differed according to the box used to hide the 'present'. In addition, these analyses investigated whether any of the age or sex groups had special problems with the tasks when the 'present' was concealed in certain boxes.

If, on each box trial, a child ignored the map and just guessed the location of the 'present' the probability that the child would be successful on the first attempt is 0.25. With all the 36 children the probability that 14 or more children would find the 'present' on the first attempt in each respective box trial is 0.0461. In a group of 18 children the probability that 9 or more would find the 'present', in a given trial, using only one attempt is 0.0193 and the probability that 11 or more would complete that trial on the first attempt is 0.0012. Table 5 overleaf shows the number of children in each age group and box trial that completed the task using only one attempt.

Generally, the 36 children only achieved scores significantly better than chance in the box 2 and box 3 trials, not the box 1 and box 4 trials. The three year old group did not perform significantly better than chance in any of the box trials, except box 3. In addition, the four year old group performed significantly better than chance in all the box trials, apart from box 1.

Table 5: Number of children who completed each four box trials on the first attempt (each age group in each box trial n = 18)

Trial	Age (years) 3	4	Total (n = 36)
BOX 1	6	7	13
BOX 2	8	13	21
BOX 3	14	13	27
BOX 4	2	11	13

Table 6 contains the results of a 2 (age) x 2 (sex) x 4 (box trials) ANOVA (equally weighted means) with the box trials as the repeated measures, using the between-subject factors of the age and sex groupings. Generalizing from this analysis is difficult, because of its unbalanced design and the problems associated with such a design.

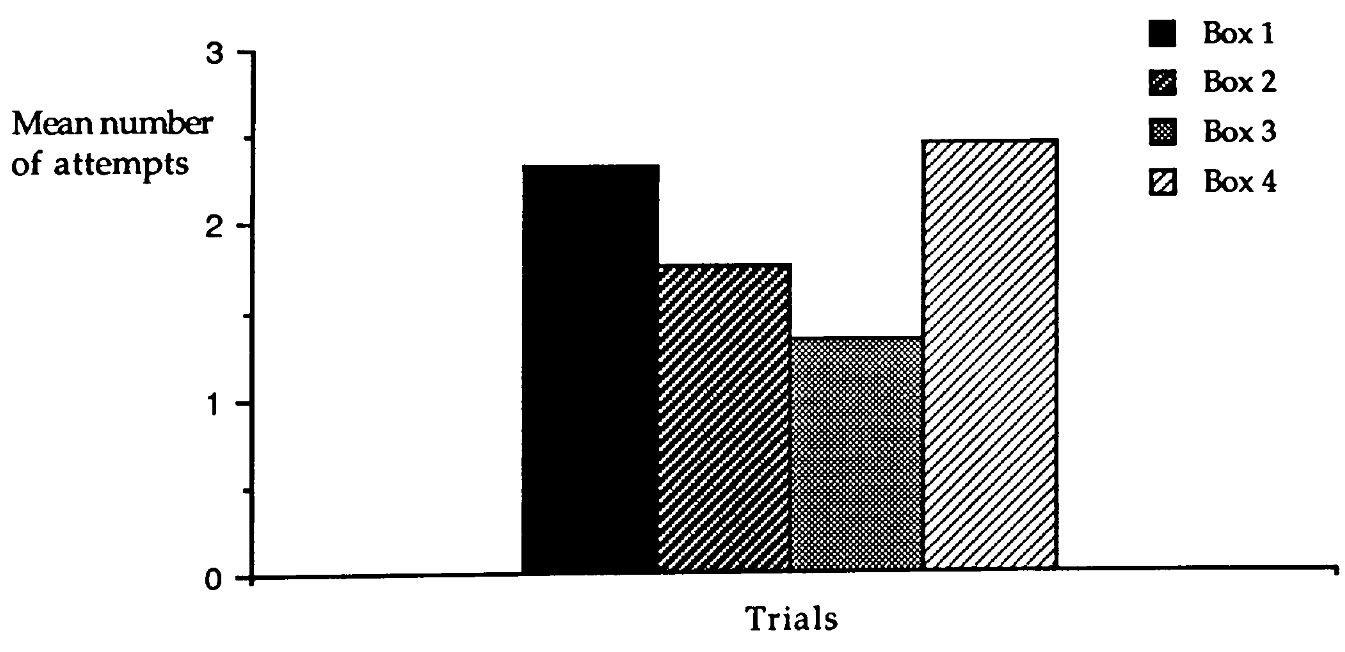
Table 6: A 2 (age) x 2 (sex) x 4 (box trials) analysis of variance with repeated measures, using the age and sex groupings as between-subject factors.

	df	F-factor	p
AGE	1,32	6.09	0.02*
SEX	1,32	1.12	0.30
AGE/SEX	1,32	0.06	0.82
BOX	3,96	11.44	0.00**
BOX/AGE	3,96	2.72	0.05*
BOX/SEX	3,96	0.51	0.68
BOX/AGE/SEX	3,96	0.12	0.95

Therefore, two 2 (age or sex) x 4 (box trials) ANOVAs (equally weighted means) with the box trials as the repeated measures were conducted, using either the age or sex groupings as the between-subject factor. Both these analyses were based on balanced designs.

The first 2 (age) x 4 (box trials) ANOVA (equally weighted means) with the box trials as the repeated measures, using the age grouping as the between-subject factor, revealed that generally the children's performance did vary significantly, depending on the box being used to hide the 'present' - $F(3,102) = 12.27$, $p < 0.01$. This is evident from Table 7. The children found the finding condition most difficult when the 'present' was hidden inside box 4 and box 1, with a mean number of attempts to finish the task of 2.47 and 2.33 respectively. The easiest locations in which to find the 'present' were box 2 and box 3, with a mean number of attempts required for success equal to 1.75 and 1.33 respectively. This can also be seen in Graph 2.

Graph 2: Mean number of attempts used by the children within the four box trials



It was also calculated that overall, irrespective of the box used as the hiding place in the finding condition, the age groups varied appreciably in their performance - $F(1, 34) = 5.73$, $p < 0.05$. This is clear from the total means contained in Table 7.

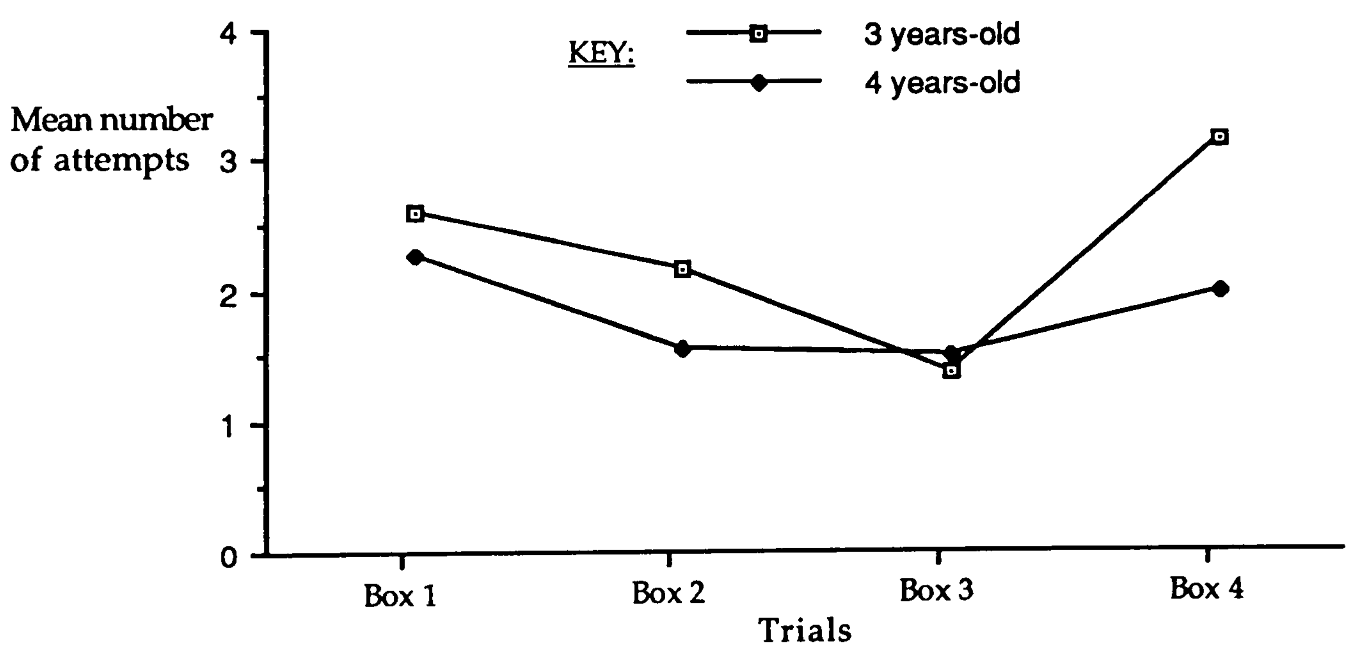
Table 7: The mean scores and standard deviations of the three year old children and the four year old children in the different boxes used within the finding condition (for each age group in each box trial n = 18)

Trial	Ages (years) 3	4	Total (n = 36)
Box 1	2.50 (1.25)	2.17 (0.99)	2.33
Box 2	2.06 (1.16)	1.44 (0.78)	1.75
Box 3	1.28 (0.58)	1.39 (0.78)	1.33
Box 4	3.06 (1.06)	1.89 (1.23)	2.47
Total	2.22	1.72	1.97

A post-hoc Scheffe test showed that the children needed significantly more attempts in the box 4 trial compared to all the other box trials - F (3,102) = 14.63, $p < 0.01$. The children used considerably less attempts to solve the box 3 task, in contrast to when the 'present' was hidden in all the other boxes - Scheffe test - F (3,102) = 24.54, $p < 0.01$. Another Scheffe test calculated that the children used significantly more attempts in the box 1 trial compared to the box 2 and box 3 trials - F (3,102) = 18.26, $p < 0.01$.

However, the performance of both age groups differed crucially depending on the which box was the hiding place - F (3, 102) = 3.14, $p < 0.05$. The biggest divergence in test scores between the two age groups occurred when the 'present' was hidden in box 4. The three year old children needed significantly more attempts to find the 'present' in box 4 compared to all the other box trails - Scheffe test - F (3, 102) = 40.81, $p < 0.01$. This was not true among the four year old children; there was no major difference between the number of attempts they used when the 'present' was hidden in box 4 and the number of attempts needed in the remaining box trials. It is apparent that the three year-old children experienced an important difficulty when the 'present' was hidden in box 4, which was not the case for the four year old children. The three year old children also needed significantly more attempts in the box 1 trial compared to the box 2 and box 3 trials - $F (3,102) = 20.16$, $p < 0.01$. However, the four year old children used significantly more attempts in the box 1 trial compared to all the other trials - $F (3,102) = 11.72$, $p < 0.01$. The variations between both age groups resulting from the exact box used as the hiding place are represented in Graph 3.

<u>Graph 3: Mean number of attempts used in the finding condition by the three and four year old children when the 'present' was hidden in each of the four boxes.</u>

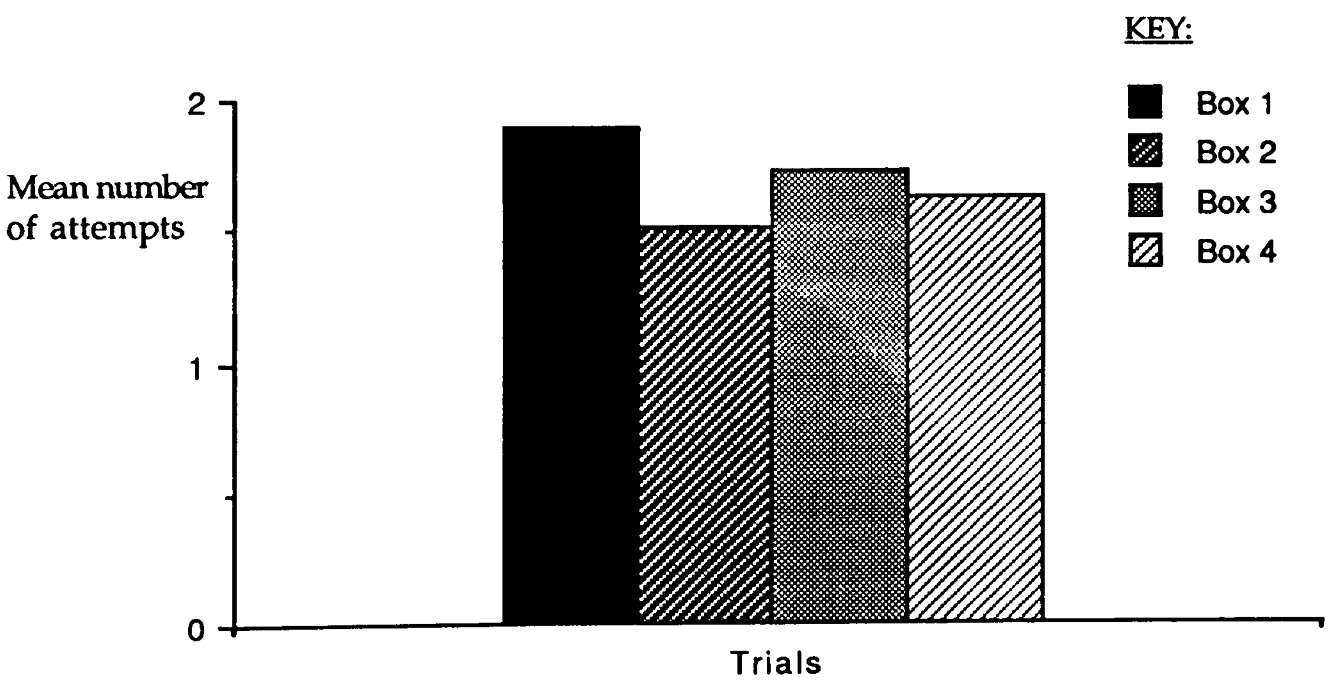


The second 2 (sex) x 4 (box trials) ANOVA (equally weighted means) with the box trials as the repeated measures, using the sex grouping as the between-subject factor, found that no significant difference occurred between girls and boys in terms of their performance in each box trial within the finding condition.

(ii) Hiding condition:

It was not possible to conduct a factorial analysis into whether the children's performance deviated according to the box used in the hiding condition or whether the age groups differed in their scores when the 'present' was hidden in each box. This was due to insufficient data, because in this part of the experiment the children were free to select the box which the 'present' was hidden in, thus not all boxes were used as hiding places. However, Table 1 (see pages 34-35) makes clear that the children's scores in this part of the experiment did vary according to the exact box used as the hiding location, but not with the same divergence as seen in the finding condition. Box 1 was the most difficult place to identify on the map after the 'present' was hidden, followed by box 3, then box 4 and box 2, with mean scores for the number of attempts used to solve the tasks being 1.90, 1.73, 1.64 and 1.52 respectively. This can be seen in Graph 4.

Graph 4: Mean number of attempts required in the hiding condition when the 'present' was hidden in each box.



Non-parametric correlations between the scores in each trial of the hiding condition and age revealed that the older the children the better their scores when they hid the 'present' in the following boxes: box 1 - r = - 0.55, significant at the 0.2 per cent level; box 2 - r = - 0.45, significant at the 1 per cent level; box 3 - r = - 0.61, significant at the 0.2 per cent level and box 4 - r = - 0.50, significant at the 0.2 per cent level.

Summary of results - Experiment 1

Firstly, no significant differences were found between the test scores of the boys and girls. Overall, the thirty six children performed significantly better than chance in the box 2 and box 3 trials, but not in the box 1 and box 4 trials. The three year old group performed at the chance level in the box trials, except for the box 3 trial. In contrast, the four year-old group achieved scores significantly better than chance in all box trials, except for the box 1 trial. Finally, in the hiding condition the older children required fewer attempts to hide the 'present', for all four boxes.

The results showed that overall the children found the finding condition appreciably more difficult than the hiding condition. It was clear that the three year-old children, compared to the four year-old children, needed significantly more attempts to complete both the finding and hiding conditions. Overall, in the finding condition, the children performed very significantly above chance expectations. In addition, the test scores of the four year-old group, but not the three year-old group, were very significantly better than chance. The initial search for the 'present' by the three year old group appeared to be random and based on no consistent strategy.

The results also revealed that children's mapping skills differed noticeably depending on the box used as a hiding place. This was particularly true in the finding session, since children used significantly more attempts when the 'present' was hidden in box 4 compared to all the other box trials. Furthermore, overall the children needed critically fewer attempts when the 'present' was hidden in box 3 compared to the remaining box tests. The box 1 trial was also significantly more difficult for the children compared to the box 2 and box 3 trials. The analyses also showed that, within the finding condition, three year-old children in contrast to four year-old children had serious difficulty finding the 'present' when it was hidden in box 4. The three year-old children also needed considerably more attempts in the box 1 trial in contrast to the box 2 and box 3 trials. However, the four year-old children had a noticeable problem with the box 1 trial compared to all the other trials.

Experiment 2 - The ability of 3-5 year old children to understand and use a map.

Method:

Subjects

The children in this experiment consisted of exactly the same groups of three year old children and four year old children as used in Experiment 1, plus another eighteen children with a mean age of 5 years 6 months (range 5:4 - 5:11). This made the total number of children in this experiment fifty four. These eighteen five year old children (9 girls, 9 boys) were randomly selected from a local primary school and they only took part in the finding condition.

The materials and procedure used in Experiment 2 was exactly the same as that used in Experiment 1 (see pages 30-33).

Results:

Experiment 2 investigated whether 3, 4 and 5 year old children differed in their ability to use a map. These experiment only included a finding condition, not a hiding condition. The focus was on the children's performance across the four trials in the finding condition, not the children's ability to find the 'present' in the four individual boxes within the maze. The aim was to find out if five year old children were better map users than three year old children and, like four year old children, could perform above chance levels in a task requiring them to understand and use of a map.

This results section explores the effects of age, sex and box on the finding performance. These group variations are investigated using a collection analysis of variance, post-hoc Scheffe tests and a test of cumulative probability based on a binomial distribution.

In experiment 1 cumulative probabilities were calculated for the three and four year old age groups, following the same procedure as Blades and Spencer (1987). Exactly, the same computation was undertaken with the five year old group in this experiment. Thus given 18 subjects, the probability that 4 or more children would succeed in 3 or more of the 4 trials on the first attempt is 0.0115. In fact, 13 of the 18 five year old children located the 'present' on the first attempt in 3 or more of the 4 trials. It is clear that the performance of the five year old children in this experiment is significantly better than chance.

A 2 (age) x 2 (sex) x 1 (finding condition) ANOVA (equally weighted means), shown in Table 8, using the between-subject variables of the age and sex groupings and the within-subject factor of the total number of attempts needed by each child to solve all trials within the finding condition. This analysis was based on an unbalanced design.

Table 8: A 2 (age) x 2 (sex) x 1 (finding condition) ANOVA (equally weighted means), with age and sex as the between-subject factors, and the total number of attempts used in the finding condition as the within-subject variable.

	df	F-factor	p
AGE	2, 48	5.47	0.01*
SEX	1,48	0.44	0.51
AGE/SEX	2,48	0.34	0.72

KEY: * $p < 0.01$

Table 8 shows that the test scores of the three age groups significantly differed in the finding condition - $F(2, 48) = 5.47$, $p < 0.01$. Again the interpretation of this ANOVA was hindered by the possibility of a partial confounding of effects. Therefore, two 2 (age or sex) x 1 (finding condition) ANOVAs (equally weighted means) were calculated on balanced designs, with either the age or sex grouping as the between-subject factor and the total number of attempts needed in the finding condition as the within-subject factor.

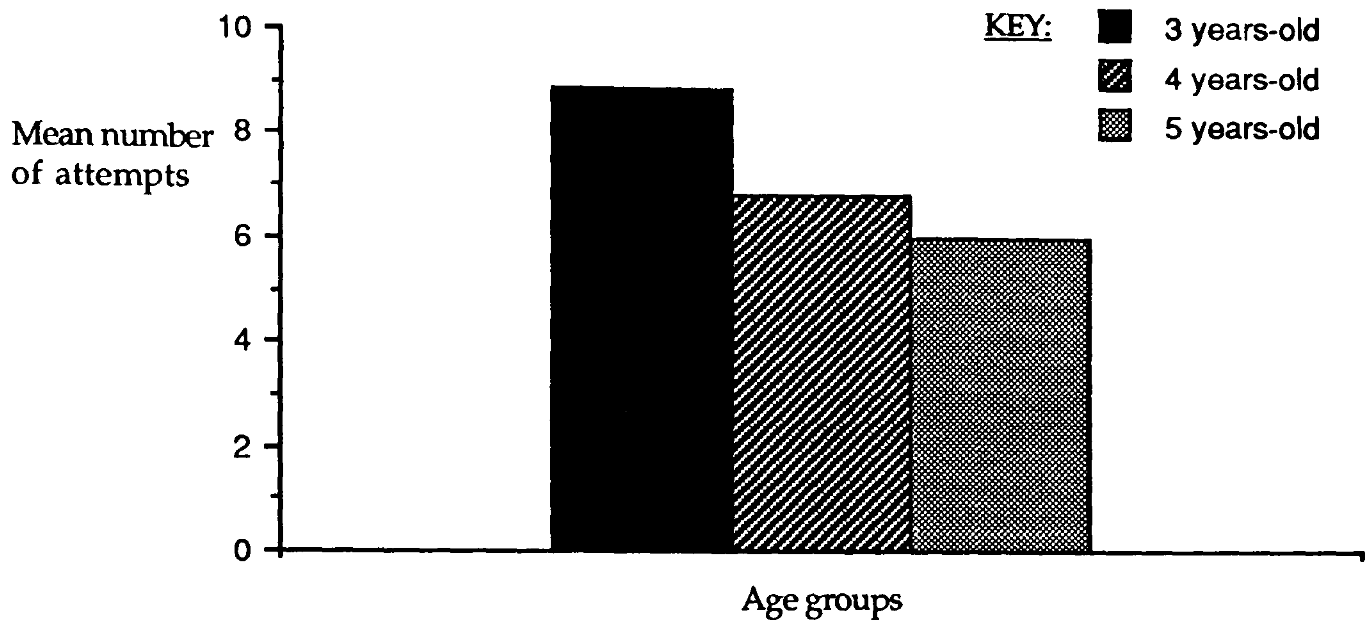
The 2 (age) x 1 (finding condition) ANOVA (equally weighted means), with the age grouping as the between-subject factor and the total number of attempts used in the finding condition as the within-subject variable, discovered that the three age groups varied significantly in their performance within the finding condition - F (2, 51) = 5.43, $p < 0.01$. This is evident from Table 9.

Table 9: Mean scores and standard deviations for the three year old children, the four year old children and five year old children in the finding condition (for each age group n = 18).

Condition	Age (years) 3	4	5	Mean (n = 54)
Finding	8.89 (2.40)	6.89 (2.61)	6.06 (2.92)	7.28

A Scheffe test was conducted on the data within Table 9. This test demonstrated that the three year old children needed significantly more attempts overall in the finding condition, in contrast to both the four year-old and five year-old children - F (2,51) = 29.87, $p < 0.01$. Thus the important difference in test scores between the age groups existed between the three year old children compared to the four and five year old children. The three year old children's competence was notably below that of the other age groups, as they averaged over two attempts for each of the four trials in the finding condition. The variation in test scores between the three age groups is pictured in Graph 5.

Graph 5: Mean number of attempts used by three, four and five year old children in all the trials of the finding condition.



The 2 (sex) x 1 (finding condition) ANOVA (equally weighted means), with the sex grouping as the between-subject factor and the total number of attempts required in the finding condition as the within-subject factor, found no significant differences between girls and boys in their experimental scores - $F(1,52) = 0.18$, $p = 0.67$.

Summary of results - Experiment 2

No important sex differences in the children's test scores were found in the experiment. The performance of the three age groups differed significantly in the finding condition. The three year old children needed considerably more hints in the finding condition, compared to both the four year-old and the five year old children. The five year old children performed above chance expectations. Their searching was not random and followed some consistent strategy.

Discussion

The findings of these two experiments extend previous research which has shown that young children can use a model or map to find an object in unique hiding spots within a room (DeLoache, 1987) or follow a route with identical choice points in a large-scale maze (Blades and Spencer, 1987). It has been shown in this experiment that young children can use a map to locate an object in corresponding hiding places within a large-scale maze, though this skill is dependent on the complexity of the spatial relations surrounding the hiding place and the assumptions that children bring to the task.

In experiment 1 there was a very significant improvement in the children's performance with age: three year old children used appreciably more attempts in the experiment than four year old children. Moreover, the performance of the three year old group, unlike the four year old group was consistent with chance expectations. These results suggest that the searching by the three year old group was purely random and based on no effective strategy.

However, the breakdown of the children's performance according to the nature of the four hiding places gives more insight into the spatial strategies employed by the children. Overall, the ability of the children to use a map when locating the object was strongly influenced by the particular box used as the hiding place. The children needed more attempts in the box 4 trial compared to all the other box trials, perhaps because in this trial the children were required to rotate themselves 180 degrees in the maze and they could not view the target box on entry in to the maze. Furthermore, the children used fewer attempts in the box 3 trial compared to the remaining trials, perhaps because they could see box 3 from outside the maze and this trial did not oblige them to re-orientate themselves inside the maze. These findings demonstrate that the children performed better when the target location was visible as they looked into the maze and the task did not require them to change their direction inside the maze.

The test scores of the three year old children and the four year old children differed noticeably depending on the box used as the hiding place. The only box trial successfully completed by the three year old children was box 3 (no rotation), showing that this age group could not use the map effectively when the hiding spot was obscured from their view and required them to change direction inside the maze.

In the box 4 trial, when the target location was not immediately visible, the three year old children used more attempts compared to the other box trials in which the hiding places could be viewed from one position. Therefore, the hiding location's degree of concealment may be an important influence on three year old children's map use. Although, three year-old children scored better than chance expectations on the box 3 trial, this result hardly suggests that the age group understood the correspondence between the map and maze. Since the children were told that the 'present' was hidden inside a box within the maze, it is not surprising that the children often looked inside box 3, since it was the first box clearly visible as they began their search.

Four-year old children could use the map successfully even when the task required them to change direction inside the maze. The box 4 trial did not prove difficult for the four year old children, suggesting that the visibility of the target box did not effect this group's performance. It is clear that the four year old children considered more than the analogy between the box on the map and the first box open to view, as they were successful in both the box 2 and box 4 trials. In these trials the four year old children may have considered the 'relational attributes' (Gentner, 1983) of the maze since they could differentiate between the identical boxes.

Four year-old performance with box 1 was consistent with random searching , and they use more attempts on this trial than in any other. The difficulty with box 1 for the four year old children may have resulted from the intricacy of the spatial relations surrounding this box. Box 1 and box 3 did share a common landmark, the wall to the right of box 1 and to the left of box 3. Thus, the children may have had a problem differentiating between these two boxes because they had the same spatial relationship with a landmark, or the difficulty of box 1 may be due to the fact that this box was partially concealed from the children's view as they entered the maze. This is plausible, since their performance with box 1 was not significantly different from box 4; on the other hand, performance with box 1 was significantly worse than with boxes 2 and 3, which were fully visible from the maze entrance. An additional possibility might be that the four year old children found it hard to solve the box 1 and box 4 trials without external landmarks. If the children had experienced difficulties in these trials such external landmarks would have helped them to orientate themselves within the maze. This was especially true in the cases of box 1 and box 4, since both these boxes were not always completely visible and box 1 was surrounded by complex spatial relations.

Experiment 2 demonstrates that five year year old children are significantly better than three year-old children at understanding and using a map. Like the four year old children they perform above chance expectations in this mapping task and it is clear that they are employing effective strategies when finding the 'present' in the maze with the help of the map.

The children required more attempts in the finding condition than in the hiding condition. However, the children's differing performance in the finding and hiding conditions possibly resulted from the nature of the hiding condition itself. In the finding trials the experimenter had complete control of were the 'present' was hidden, but in the hiding condition the children were free to select the hiding place of the 'present'. Therefore, in the hiding condition not all boxes were used by the children, as they tended to consistently hide the 'present' in a box they could successfully identify on the map. This may have made the hiding condition easier, compared to the finding condition, because the children were allowed to avoid difficult hiding places in the hiding condition. Subsequently, no general statement can be made about the relative difficulty of the finding and hiding conditions.

Both experiment 1 and experiment 2 found no important differences between the ability of girls and boys to understand and use the map. This result is not surprising considering previous research has shown that sex differences in spatial competence did not appear until around the child's eighth birthday. A absence of sex difference in these experiments may be because girls and boys do not differ in their environmental experience between three and five years of age.

This research extends the findings of previous experiments by showing that four and five year old children can use a map to locate an object in a large-scale maze. This ability, in the case of four year old children, is possibly dependent on 1) the need to make compensatory rotations of the map, 2) the degree of concealment of the hiding places, 3) the complexity of the spatial relationship between the hiding places and nearby landmarks and 4) the availability of external landmarks. It is possible that these external factors can be controlled in future studies, so alternating the level of assistance provided by the environment and providing a measure of each child's ZPD. However, further research is still needed to establish the importance of these various factors.

Chapter 3

The Origins of Vygotsky's Sociocultural Theory and the 'Zone of Proximal Development'.

In the majority of Anglo-American psychology, research and theory on cognitive development has focused on only one factor - either the individual or the environment - and simply assumed the other (Wertsch & Rogoff, 1984; Rogoff, 1990; Wertsch & Bivens, 1992). There has been a dominance of theories which have solely focused on the individual's role in constructing reality. The images of Rodin's thinker or the "stand-alone neural computer in its attractive dermal housing" (Gellatly et al, 1989) have been central to the study of mind and cognitive psychology. The metaphor may change, but the underlying theoretical direction remains the same. Recently, various writers have followed Luria's (1976) advice - that in order to understand higher mental functioning it is necessary to go beyond the isolated human organism. Psychologists have begun to question the idea that the individual is the only unit of analysis. There is an growing interest in the study of cognitive development on the "dialectical interaction between the social world and the changing individual" (Newman, Griffin & Cole, 1989).

Soviet Psychology and Hegelian Philosophy

Developmentalists and social psychologist in western Europe and America have increasingly looked to Soviet psychologists, like Vygotsky, Rubinstein, Luria, Leontjev and Bakhtin, for a dialectical theory of human development (Markova & Foppa, 1990; Wertsch, 1991; Moll, 1990; Newman et al, 1989). This has led to the development of theories like 'dialogism' which consider the "totality of human agency and conceive it as situated in socio-historical phenomena and in culture" (Markova, 1992, p. 1). British psychology has developed from seventeenth century thinking and the philosophies of rationalism and empiricism. However, the roots of Soviet psychology are in the dynamic ideas of eighteenth and nineteenth century philosophy. This means that Soviet psychology rejects the main presupposition of Cartesian philosophy, namely mind - body dualism which has dominated British psychology to date. The Cartesian framework views the nature of mind as ahistorical and individualistic, separate from the body and the external social world (Markova, 1982). Cartesian philosophy extends a long way back to the idea of innate inner sense introduced by Descartes and Kant. In contrast, Soviet psychology has emphasised that consciousness develops from the object-subject relationship (Markova, 1985). Consequently Soviet psychology has taken as its unit of analysis the constant interaction between humans and their social environment.

The origins of Soviet psychology can be seen in Hegelian philosophy and its objection to the formalistic laws of thought present in Cartesian thinking. There are two formal laws of thought, the law of identity and the law of non-contradiction. These laws are outside reality and are by nature abstract. The law of identity states that a certain object is always that same object and the law of non-contradiction argues that it is not possible to give something away and keep it at the same time (Markova, 1982). Hegelian philosophy does not believe that these laws are a true reflection of reality, the laws represent formal truth because they constitute the fixed end products of thought not the process of thought. Any attempt to study formal logic would be failing to recognise that "the approach of human beings towards objects is by nature reflexive and mediated through tools and instruments" (Markova, 1992 p. 7). These formal laws of thought assume an asocial mind separated from the content, meaning and context of the external physical and social environment. Hegel's conception of developing of mental functioning rested on the mutual relationship between the individual and his or her environment. His was a monistic theory of the embodied spirit, in which the mind and the body are dependent upon each other (Markova, 1982). To Hegel (1812) "organism-environment" are relational terms and one side of the dyad can not be understood in isolation from the other side. Thus it could be argued that Hegel saw a co-development of organism and environment (Markova, 1990b).

This chapter will examine the ideas of two Soviet psychologists, Vygotsky and Rubinstein who both based their psychological theories within the framework of Hegelian philosophy. The main focus of the chapter will be Vygotsky's socio-cultural theory and particularly his notion of the 'zone of proximal development' which has recently received a lot of attention in western psychology. The comparatively little known ideas of S. L. Rubinstein will be presented briefly as a second example of a Soviet psychologist who drew from Hegelian philosophy.

The Psychology of S. L. Rubinstein

"Rubinstein was one of the most creative Soviet psychologists" (Markova, 1985, p. 8). In 1945 Rubinstein first stated that psychology needed to be reconstructed (perestrojka) since psychology was in crisis (Payne, 1968). This crisis lies in the philosophical foundations of psychology which prevented the subject from solving the fundamental problem of psychology - the relationship between the psychic and the material world. Western psychology can not address this problem successfully because it is "either mechanistic, concerned with external factors, like behaviourism, or it was idealistic, spiritual, concerned only with internal factors" (Markova, 1985, p. 9). Consequently, psychologists can not agree on a common unit of analysis and the subject has disintegrated into a mass of competing schools of thought. Rubinstein explicitly accepted Hegel's criticism of Cartesian dualism. A real understanding of consciousness, according to Rubinstein, could only be obtained by studying the connection and relationship between the inner and the outer. This approach to psychology was based on one of Rubinstein's theoretical principles of Soviet psychology - the principle of psychological unity - which states that the "mind is not only a function of matter, but also a reflection of the external, material reality" (Rahmani, 1973, p. 50).

The development of knowledge, to Rubinstein, is neither an immediate nor a representative process but a reflective process (Markova, 1982). This places a clear emphasis on the active process of thought since it is a "penetration into the deeper levels of the essence of things" (Rubinstein, 1959, p. 57). Thus reflective thought becomes " an imaginative rehearsal, a comparison and evaluation of alternative routes to consummation" (Mead, 1938, p. 79). Rubinstein makes a unique contribution to Soviet psychology by claiming that reflective thought develops through practical activity. This is in contrast to theories which argue that specific cognitive structures are 'triggered off' by the social context (Markova, 1982). Both Marxist and Hegelian thinking is used by Rubinstein when he contends that labour or activity leads to social change and the development of consciousness which in turn determines the type of activity that is then taken on the environment. Rubinstein treats the mind as a dynamic whole in which thought, language, consciousness and activity are tightly interconnected.

"knowledge and action are mutually related. Knowledge is originally directly interwoven with practical activity; only then it detaches itself and forms itself into a special cognitive activity. It is not correct to oppose action and knowledge and treat them as external to each other" (Rubinstein, 1959, p. 59).

Cognitive development within a Hegelian framework is not represented by a linear model where knowledge is decomposed into component parts and formed in a hierarchy; but by a 'circle returning within itself' in which practical activity transforms the child's knowledge and the object for the child is also changed, because in the child's consciousness the object has a new functional existence. Thus knowledge acquisition to Rubinstein is an active and creative process in which humans create original realities through activity within the environment. Rubinstein's theory is in direct contrast to Cartesian thinking and mind-body dualism, since it offers consciousness in practical activity as the new unit of analysis for a reconstructed psychology.

Vygotsky's Sociocultural theory

Vygotsky based his ideas - like Rubinstein - on the dialectic epistemology of Hegel, though Vygotsky did not recognise this influence openly (Markova, 1990a; Wertsch, 1989a, 1989b). Vygotsky's cultural-historical theory is in contrast to the dominant individualistic and mechanistic approaches to the study of mind within psychology. He opposed those paradigms of psychology which are, often unconsciously, rooted in the philosophical presuppositions of Cartesian, mind-body dualism. Vygotsky attempted to escape from dualist thinking - as he viewed the development of mind as a process involving mutual interaction between the individual and his or her external social environment, in which people are active creatures engaged in giving meaning to their existence (Markova, 1990a; Rutland, 1991; Rogoff, 1990).

Vygotsky's theoretical framework has three general themes. Firstly, the use of a genetic or developmental analysis - as an understanding of any aspect of individual mental processes must involve an analysis of its origins and transitions. Secondly, Vygotsky argues that higher (uniquely human) mental functioning in the individual develops from social activity. Finally, Vygotsky focused on the tools and signs within the social environment that mediated individual human mental functioning.

The general genetic law of cultural development is the central tenet of Vygotsky's (1978, 1986) theory - mental functioning first occurs on the social level, interpersonally, then the person internalises these interactions in individual development.

"we could formulate the general genetic law of cultural development in the following way: every function in the cultural development of the child comes on the stage twice, in two respects; first in the social, later in the psychological, first in relations between people as an interpsychological category, afterwards as an intrapsychological category" (Vygotsky, 1960, p. 197-8).

The Zone of Proximal Development

Vygotsky used the zone of proximal development as a conceptual tool to capture the dialectic relationship between the interpsychological and intrapsychological levels of functioning. He recognised that "all development involves the construction of distance between the present and past, and overcoming the distance from the present to the future" (Valsiner and van der Veer, 1991), and Vygotsky noted how psychologists had problems explaining this latter process of development from present to future. This tended to result from the dominance of perspectives on cognitive development which focused exclusively on the role of the individual in constructing the future (Rogoff, 1990). Very few contemporary theories have offered concepts that have resolved this issue, or even addressed it, though many psychologists are now turning to Vygotsky's metaphoric concept of the 'zone of proximal development' to approach this theoretical 'no man's land'. Vygotsky, following Hegel's idea of the dialectic logic - in which opposites mutually determine each other - argued that the inner and outer interacted in the zone of proximal development resulting in internalisation and a future change in individual mental functioning.

Vygotsky (1978) argued that in order to find the true relation of the inner to the outer in development from present to future - one needs to determine two levels of psychological development. The first is the actual developmental level of the child. This involves mental functions that have been established by already completed developmental cycles. The second level is the level of potential development, which is what a child can achieve with the assistance of others. Vygotsky called the difference between these two levels the 'zone of proximal development' (ZPD):

"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with a more capable peer" (Vygotsky, 1978, p. 86).

An understanding of the history behind Vygotsky's use of the 'zone of proximal development' (Russian: 'zona blizhaishego razvitia' - the ZBR) would help in gaining a better understanding of the ZBR. The abbreviation ZBR will be used with reference to Vygotsky's writings on the 'zone of proximal development' - to distinguish his work from later interpretations of the concept, for which the abbreviation ZPD will be adequate. Vygotsky's development of the ZBR resulted from a combination of the cultural-historical theory of development, which recognises the inescapable social nature of human development, and theoretical paedology with its application in education.

In the 1930's as Vygotsky was actively involved in the organisation of paedology in the Soviet Union, the cultural-historical school needed to explain the developmental process involved in the present to future transformation of psychological functions. This school of thought claimed that people were 'free' to progress beyond their present level of development through sign-based mediation and instrumental action. Vygotsky linked cultural-historical theory and paedology with the idea of developing context-bound 'free will' which involves the internal re-construction of externally given social suggestions within the ZBR (Valsiner & van der Veer, 1991). Basically this means that people are free - within the context of their social world - to experience internal cognitive change. The ZBR was the arena which gave boundaries to the development of the individual. This shows the beginning of Vygotsky's attempt to develop a dialectical theory of cognitive development.

Vygotsky, as a paedologist, argued against the mere 'measurement of intelligence' by just noting down the mental functions that had already finished their course of development. He criticised traditional I.Q. testing methods existing in the 1930's, and up to the present day in America and Europe for ignoring the process of further intellectual development. Vygotsky explained the ZBR to paedologists in the language of 'difference scores' between assisted and individual achievement conditions (Vygotsky, 1933a/1935), which would give the tester an idea of the child's potential future development. The ZBR was a useful descriptive, but not explanatory concept in Vygotsky's arguments with fellow paedologists - who normally just used imported ideas of standardised testing from the West (Valsiner & van der Veer, 1991).

Within psychology it is traditionally assumed that children can not be taught certain abilities in school until they reach a set level of development. Individual tests of children's developmental stage provide a measure of the lowest possible starting point for future development. Vygotsky argued that there was also a upper level of development, which indicates the child's potential for instruction and this can be measured by examining his ZBR (van der Veer & Valsiner, 1991). Previous research by Terman, Burt & Blonsky was cited by Vygotsky as evidence that individual tests of intelligence were not true predictors of future school performance. Measurement of the ZBR was necessary in order to obtain a more accurate indicator of later development. Vygotsky did present ideas about the method by which the ZBR could be tested. If the child experienced difficulty with a task the experimenter needs to ask the child leading questions or demonstrate the task or provide other forms of hints, finally the child will be able to solve the problem in co-operation with the experimenter. This procedure will provide a measure of how far the child can be led by instruction, thus giving a estimate of the child's ZBR.

"In this way the investigation of the ZBR became one of the strongest instruments of paedological investigations, allowing (us) to enhance considerably their effectivity, utility and fruitfulness, the application of diagnostics of the intellectual development to the solution of the tasks raised by pedogogics, (and) the school (Vygotsky, 1933b/1935, p. 43).

The level of demands made by teachers - the ideal mental age - was introduced by Vygotsky as an important part of assessing future development. The distance between the ideal mental age of a certain school class and a child's real mental age, according to Vygotsky, was the "most sensitive measure established by paedologists yet" (van der Veer & Valsiner, 1991, p. 339). The ZBR was considered the best indicator of this phenomena. A child with a ZBR of two mental years should be placed in a class with an ideal mental age two years above the child's independent mental age. Thus the ZBR becomes a useful way of determining the structure of school classes.

Measurement of the ZBR according to Vygotsky was a means of predicting a child's independent development in the future (van der Veer & Valsiner, 1991). Therefore, the development of individual performance was viewed as fully predictable from co-operative levels of functioning. For example, if a four year-old child has an independent mental age of four and a half years and an assisted mental age of seven years, then over the next two and a half years the child's independent performance will progress to the level of her joint ability indicated at the age of four years. van der Veer & Valsiner (1991) are correct to note that this view is strange within the framework of an Hegelian approach. It seems that Vygotsky is representing the process of cognitive development in a linear manner, since he is assuming that after a certain time the difference between individual and joint performance will vanish. In addition, Vygotsky is presenting a picture of a dynamically developing child within a background of a static environment. The child's joint level of ability could change in the course of development. Moreover, Vygotsky fails to consider that the level of co-operative functioning may not be the peak of the child's individual development and children could possible exceed beyond the understanding shown by adults.

<u>Children with learning difficulties and the ZBR</u>

Vygotsky argued that the failure of traditional tests in to provide accurate measurements of intelligence is particularly pertinent in the case of children with learning difficulties. It seems that tests of cognitive ability, like the Binet system, are indication of children's innate psycho-physiological functions such as memory and attention. Naturally, these psychological characteristics are components of intelligence though it is also true "that a study of giftedness limited to the individual's natural, innate qualities would be far from complete" (Luria & Vygotsky, 1992, p. 163). Therefore, it would be false to doubt the intellect of children with poor memory or attentional ability. Though such children normally have low I.Q. scores and within the education system they are classified as 'children with learning difficulties' their deficiencies are not necessarily permanent. A non-dualist Vygotskian perspective allows for the possibility of compensation for children's natural endowments through external and cultural devices appropriated throughout life.

Psychologists need to do more than measure children's actual development or their 'point of departure'. An underestimation of a child with learning difficulties can be avoided by also examining his "ability to use the objects of the external world and primarily his ability to make rational use of his own psychological processes" (Luria & Vygotsky, 1992, p. 163). This can be achieved by measuring a child's ZBR. The result would provide an index of a child's cultural development, a dynamic phenomena which is a product of the constant interaction between the mind and the external world. Vygotsky's notion of the ZBR does provide an improved method for assessing the intellectual development of children with learning difficulties.

The Relationship between Education and Cognitive Development

Initially, Vygotsky introduced the ZBR narrowly within a critique of traditional intelligence testing and only later did he use the ZBR as a concept when discussing the relationship between education and cognitive development (van der Veer & Valsiner, 1991). The ZBR became an attempt by Vygotsky to "develop further Marx's idea of human psychology as a system of social relationships" (Valsiner, 1988, p. 140). The key to the Vygotsky's thinking was the notion of internalisation, which involves the transference of social relationships into new individual mental functions. Specifically, the ZBR concept was used by Vygotsky to integrate the influential role of the social environment (education) with the process of internalisation of social relationships by the individual (development).

Vygotsky was critical of the three main perspectives on the relationship between instruction and the development of higher mental functions (van der Veer & Valsiner, 1991). Firstly, Vygotsky rejected the organistic view that education should follow the lead of development. The role of instruction in such a view is minimised because the course of development is completely due to maturational (biological predetermined) processes. This hereditary determinist perspective is not interested in a child's potential development because the origins of individual psychological functions are not apparent in external reality and therefore they can not be measured. Secondly, the environmental determinist view also reduces the issue of the relationship between instruction and development to one of its sides. This perspective argues that instruction is the same as development, human development is a mere shadow of teaching. A child's development is solely influenced by the external environment and specifically the instructions of adults. Thirdly, Koffka and the Gestalt school attempted to form a compromise from the two theories presented above by arguing that both the organistic and environmentalist views were partially true. Koffka contended that a combination of maturational processes and external stimuli constituted cognitive development. Vygotsky lately recognised the value of Gestalt theory, though he always stated that a detailed explanation of the complex relationship between teaching and development was necessary and Koffka did not offer such an explanation.

The concept of the ZBR was first used by Vygotsky when addressing the relationship between the education and cognitive development on March 17th 1933 in a lecture to the Epstein Experimental Defectological Institute, Moscow (van der Veer & Valsiner, 1991). Vygotsky argued that cognitive development was not "the direct parallel or shadow of the educational process....but teaching enables a series of developmental processes that undergo their own development" (van der Veer & Valsiner, 1991, p. 331). Teachers can not directly install cognitive processes in children; but they can train children to engage in external activity, within periods of time when children are sensitive to development, so creating ZBRs which leads to internalisation and individual development.

<u>Is the Zone of Proximal Development a useful concept?</u>

The notion of a 'zone of proximal development' has been criticised by various psychologists. These challenges to the idea of a ZPD seem to result from differing basic presuppositions and questions in the study of human development. Bryant (1990) argues that many developmental theories assume that "one thing leads to another" (p. 35) and that this is caused by an external functional invariant. He contends that Vygotsky's theory of the ZPD can be put in this category - as Vygotsky and his followers assume that help given by parents today leads to cognitive changes tomorrow, but fail to prove this empirically.

It is the case that a paradox limits the empirical use of the ZPD. Vygotsky's theory refers to hidden processes of the present that lead development which can only become truly explicated in the future. This is because, remaining true to a dialectical view, any emerging psychological functions in present social interaction must result in different individual psychological functions in the future - as they are not direct imitations of social activity (Valsiner & van der Veer, 1991). Therefore, it is extremely difficult to prove that features of social interaction lead directly, through internalisation, to new levels of individual mental functioning. The ZPD should be seen as a general theoretical construct which both attempts to address the relationship between instruction and development and rests on the philosophical assumptions of Hegelian epistemology. Vygotsky's use of the ZBR clearly shows that the concept was not meant as a causal explanation of cognitive development.

The alternative offered by Bryant (1990) to Vygotsky's theory is both individualistic and reductionist, as he favours causal hypotheses which explain later development as products of some earlier measurable individual skill. He assumes that the abilities of individuals develop in isolation from the social world and are probably innate. Moreover, Bryant wishes to explain the development of higher complex mental functions with reference to only one simple measurable skill - this is like accounting for advanced mathematical ability by an innate understanding of basic counting principles.

It seems wise to accept the presuppositions of dialectic philosophy and refrain from concentrating on what makes people develop. The focus should be on how the interaction between the individual and the social worlds leads to development taking one course rather than another. Development seems inherent to human existence - as Newton said, matter not acted on by external forces continues in uniform motion (Rogoff, 1990). Psychologist need to examine why some people's development follows in one direction, while the development of other people takes another course. The ZPD seems a useful descriptive concept for this scientific enterprise.

The prediction of future lines of development can be enhanced by measurement of Vygotsky's zone of proximal development, since this procedure complements the scores obtained from individual tests of cognitive ability. This is particularly true in the case of children with learning difficulties who often have poor natural abilities, but might compensate for their limited innate powers through use of external artifacts present within social interaction. Measurement of the zone of proximal development will not provide a absolute indication of future individual performance, because of the dynamic development of both the individual and the environment but this procedure is a useful supplement to traditional tests of intelligence.

Chapter 4

Contemporary Interpretations of the Zone of Proximal Development.

Recently psychologists have extended three main lines of interpretation Vygotsky gave to the ZBR, which they call the ZPD or the Zo-ped (Winegar, 1988). The first is the use of the ZPD in settings of interactive learning and joint actions. Secondly, there have been various theoretical efforts to use the ZPD in developmental psychology. Psychologists have also focused on the relative measurement of children's performance by comparing assisted versus individual problem solving, commonly known as dynamic assessment. All scholars following these lines come under the 'umbrella' label of Vygotskian (or neo-Vygotskian). Initially, this chapter will critically examine the first two extensions of Vygotsky's thinking. However, the chapter will mainly consider the dynamic assessment of children's mental functioning since this use of the ZPD is particularly relevant to later experimental chapters.

'Scaffolding' and the ZPD

The first real elaboration of the ZBR in western psychology looks at interactive learning and introduces the notion of 'scaffolding' (Wood, 1980; Wood, Bruner and Ross, 1976) by the adult, while stressing the external-interactional nature of children's guided learning (Valsiner and van der Veer, 1991). The concept of "scaffolding" is that the adult structures the child's activity by reducing the degrees of freedom in task performance, then gradually introduces the children to each sub-routine required for task completion. The notion of 'scaffolding' was introduced by Wood et al (1976) without any explicit reference to Vygotsky, though clearly this concept is related to the idea of a ZPD.

The didactic nature of 'scaffolding' may reflect the fact that Wood et al (1976) never directly referred to Vygotsky's writings. As a concept 'scaffolding' does not appreciate the mutual construction of meanings given to objects and events within the ZPD - moreover it leaves open the question of the child's creativity in development (Rutland, 1991; Griffin & Cole, 1984). "Scaffolding" as a description of the ZPD seems to deny the roots of Vygotsky's theory in dialectic philosophy. This notion does not allow for the child going beyond the immediate scaffold within their development. It "suggests a rigid sequential structure to the process of cognitive change" (Rutland, 1991, p. 38) and assumes the maturational emergence of abilities, with the tutor providing a scaffold to those aspects of action that form the basis of unmaturated abilities (Valsiner and van der Veer, 1991). It can be argued that "scaffolding" fails to provide an adequate description of the ZPD in everyday social activity because it was a product of the special socio-cultural context of the experimental laboratory.

Theoretical extensions of the ZPD

Developmental psychologists have made few attempts to locate the ZPD in a structured theoretical context - a step which would aid the establishment of empirical studies. Despite this some contemporary work on the zone of proximal development has tried to use the ZPD as a component in new theoretical systems. There have been some notable efforts to go beyond a Vygotskian approach to a potentially new synthesis of ideas.

The first theoretical advancement of the ZBR into a new ZPD is the work of Wertsch (1984, 1985, 1989a, 1989b). Wertsch argues that some aspects of Vygotsky's ZBR need clarification and extension considering contemporary theoretical and empirical research. In particular Vygotsky never really gave an adequate account in his definition of the ZBR of what constitutes "problem solving under adult guidance or in collaboration with more capable peers". Wertsch makes two major extensions: towards a activity-theoretical (Leontievian) approach, with his notion of participants possessing situation definitions in an activity setting; and in the direction of a semiotic (Bakhtinian) domain, with a focus on semiotic mediation leading to internalisation of external dialogue (Valsiner and van der Veer, 1991). Wertsch cleverly synthesizes the ZPD with the idea of semiotic mediation of higher psychological functions in a way that Vygotsky never did.

Wertsch's first extension of Vygotsky's ZBR starts with Leont'ev's (1981) idea that human activity creates representations of a situation. It is never stated by Wertsch but his thinking owes much to Rubinstein's use of Leont'ev's idea, in particular Rubinstein's theory that through activity humans develop reflective thought. This type of thought then allows the actor to consider the various alternative forms of action and make a rational contextual judgment. Wertsch's (1984) focus is in contrast to the idea that people are passive recipients of representations, since he contends that in collaborative activity adults and children form different representations of objects and events, which he calls situation definitions. The differing situation definitions - which characterise the beginning of any ZPD - also include varying action patterns necessary to complete a task. This leads to a view of cognitive change in the ZPD which differs from that suggested by notion of "scaffolding" (Wood et al, 1976). Development in the ZPD is not seen as a gradual accumulation of task knowledge or the addition of a step to an existing action pattern: rather, it is viewed as a shift in a person's basic understanding of objects and events. According to Wertsch (1984, 1985), situation redefinition occurs during social interaction within the ZPD, resulting in intersubjectivity. This exists when interlocutors in a task situation share, and know that they share, the same situation definition. Normally there is an important asymmetry in caregiver-child interaction, with the only lasting situation redefinition occurring on the part of the child. These theoretical insights resulted from detailed empirical studies of adult-child joint action in novel situations (Wertsch et al, 1980; Wertsch and Hickmann, 1987). Wertsch's concern with how the negotiation of an intersubjective situation definition is achieved leads to his second extension of Vygotsky's ZBR.

Wertsch's second theoretical development of the ZBR recognises Vygotsky's original emphasis on semiotic mediation and internalisation. He notes that intersubjectivity is often created by the mediation of signs, especially linguistic signs. The adult within the ZPD regularly offers the child directives, with increasing explicitness: these are attempts to negotiate new levels of intersubjectivity. These directives either take the form of references, with the child's attention being drawn to specific events using certain signs - or they can be abbreviation, which use signs to implicitly require the child to compare their behaviour with the appropriate action (Wertsch, 1985; 1989b). The child can also make bids in the negotiation, as semiotic mediation is a process of mutual interaction. It is through semiotic mediation that the child internalises a new situation definition leading to improved task performance. Discourse in the ZPD can be characterised as "a kind of negotiation between teacher and student, in which teachers tend to use directives that require students to take on additional responsibility for regulating activity" (Wertsch, 1991, p. 112-3). These directives are 'semiotic challenges' and if they fail the teacher often returns to previous instructions, then with increasing success the teacher might attempt to 'up the ante' (Bruner, 1986) once more.

Wertsch (1989a, 1990) uses the ideas of Bakhtin to explicate further the theme of semiotic mediation. He considers 'social languages' as mediational means, which are tied to a particular socio-cultural context and stratum of society, like professional groups and generations or age groups. Development within the ZPD is viewed in terms of gaining mastery in a variety of social languages. Finally, Wertsch (1985) notes a problem with Vygotsky's formulation of the ZBR which is central to the next contemporary extension of the concept. Vygotsky concentrates on interpsychological processes while ignoring social institutional phenomena. He fails to appreciate fully that the sociohistorical context influences the type - for example, play, formal schooling or work - and the content of activity within the ZPD.

The second advancement of Vygotsky's theory places the ZBR within the activity-contextual approach, which emphasises the 'mutual construction of culture and person' inside the Zo-ped and draws heavily on Soviet 'activity theory' (Cole, 1985). This approach argues that the Zo-ped is a culturally organized activity with participants having differential responsibility and expertise. The influence of Soviet thinkers, such as Leont'ev and Luria, is seen in the emphasis on activity in the ZPD as a "functional system". This interpersonal system in the ZPD is considered the unit of analysis, in contrast to the focus on the individual in cognitivism. The functional system has a complex structure and its constituent parts or technologies - such as written language, task material, adults and children - have flexible roles in performing the function of development. Cole and Griffin (1984) argue that new functional systems or ZPDs are caused by new leading activities. This notion comes from Leont'ev's (1981) idea that some types of activity are significant for an individual's subsequent development, and these are called leading activities, while others are less important to development. Examples of leading activities are: play, work activity, peer interaction and formal schooling. The extension of Vygotsky's ideas presented by Cole and his associates has parallels with Rubinstein's emphasis on the development of consciousness through activity and the subsequent creation of new realities by active subjects, though the influence of Rubinstein is not recognised by Cole and his fellow workers.

Newman, Griffin and Cole (1989) introduce the notion of 'appropriation' to describe the constructive process of cognitive development. The Soviet psychologist Bakhtin initially used the notion of appropriation in relation to how people changed the meanings of words for use in different cultural contexts. Leont'ev (1981) originally used the idea of appropriation more generally to recognise the fact children actively construct their knowledge in a sociohistorical context. Appropriation involves the mutual negotiation of cultural meanings given to objects and events within the ZPD. The adult interprets the child's activities as if they had been produced with the teacher's goal in mind, while the child begins to internalise the culturally appropriate or acceptable actions within the task setting. The negotiation process can also lead to a transformation in the cultural meaning given to activity in the task setting. This notion of cognitive change suggests that development in the ZPD often contains discontinuity between past and new understandings - moreover it means that human development must be considered multidirectional. Appropriation, as a descriptive concept, captures the dialectical process involved in human development.

The third contemporary use of Vygotsky's notion of the ZBR is Rogoff's fusion of person and culture. Rogoff (1982, 1986, 1987 and 1990) consistently focuses on the cultural guidance of children's participation in social settings. She views the ZPD as guided participation with an active (goal orientated) child and a culturally more knowledgeable adult. The child is an active 'cultural apprentice' in a dynamic region of sensitivity. To Rogoff (1990), interaction in the ZPD is the crucible of development and culture. The ZPD is a place in time where cultural tools of a particular activity are passed on and transformed by new members of the culture.

Rogoff's theory does not extend Vygotsky's use of the ZPD by specifying the processes by which internalisation leads to individual development. Basically, she introduces new words such as 'guided participation' or 'apprenticeship' which fail to elaborate upon Vygotsky's use of the ZPD. Though she does make a valid criticism of Vygotsky lack of stress on the interrelatedness of the roles played by children and their caregivers or companions within the ZPD. Rogoff puts an emphasis on the role of the child as an active participant in their own development. The child seeks, structures and even demands assistance from others in solving problems. Rogoff (1990) also argues that Vygotsky should have focused on the importance of tacit and implicit as well as explicit face-to-face social interaction inside the ZPD. Vygotsky emphasised didactic verbal dialogue in his theory - to the virtual exclusion of tacit forms of communication in the verbal or nonverbal exchanges of everyday life and the assumed arrangements for organising children's activities. For Rogoff, a broader definition of language and communication in the ZPD would allow researchers to look at development in the early years, when words are not the main form of communication.

Vygotsky does not offer an internal dynamic in his theory of the ZBR, which would place a limit on the arbitrary high levels of actual and potential development a person could reach with extensive instruction (Wertsch, 1985). Rogoff (1984, 1990) offers possible precursors of the ZPD, which could internally drive the process of development. She found that young children appear to come equipped with ways to ensure their development. To varying degrees children ensure proximity to and involvement with experienced other, so becoming heavily involved in the physical and social environment. Adults also play their part in the mutual relationship by routinely, often unintentionally, adjusting interaction and the structure of the environment to provide support for learning. Rogoff seems to suggest that innate psychological factors determine the interaction within the ZPD and the effect of instruction is dependent on the developmental stage of the child. This view of the ZPD is very similar to organistic perspective on the relationship between education and development rejected by Vygotsky.

The final advancement of the ZBR into a theoretical system focuses on the co-construction of the future through 'bounded indeterminacy' (Valsiner, 1987). This means that 'free will', within limits, inside the ZPD leads the process of ontogeny. Valsiner's approach sees development by interpersonal (later intrapersonal) semiotic constraint systems: the zone of freedom of movement, which defines the possibilities at any one time; the zone of promoted actions, which is a set of possibilities encouraged by people in a setting. Valsiner offers these conditions on the use of the ZPD to clarify the 'umbrella' type use of the ZPD in contemporary psychology. These extensions to the notion of the ZBR are necessary because Vygotsky did not emphasise the fact that informal education and activity can lead to individual cognitive development. The ZPD is not only created by instruction but the "culturally structuring of the environment" (Valsiner, 1988, p. 147) by adults allows children at any time to interact with certain parts of the environment, creating new action possibilities and a different level of mental functioning. Basically, Valsiner stresses the point that explicit instruction is not always necessary for the creation of the ZPD and the children can achieve individual development through the active use of the available physical and cultural resources.

These theoretical extensions of Vygotsky's ZPD have provided new conceptual tools for interpreting the relationship between instruction and cognitive development. However, these contemporary interpretations of the ZPD do not provide concepts that lend themselves to quantitative empirical evaluation; though they are useful when attempting to interpret the complex interaction between the mind and the external world, which according to Hegelian philosophy drives human development. The next extension of the ZPD is not concerned with the process of development, but attempts to measure the ZPD with the specific aim of improving predictions of children future mental functioning.

Dynamic Assessment

Vygotsky used the ZBR to criticise traditional paedological testing in the U.S.S.R.. Researchers in America and Europe have developed the ZPD along similar lines to Vygotsky. This extension of the ZBR to the measurement of the ZPD is equated with the dynamic assessment of learning potential, leading to studies of individual and group differences and a focus on the different facets of the child's learning process (Brown and French, 1979; Brown & Ferrara, 1985; Campione and Brown, 1990). Campione and Brown (1990) wished to measure an individual's ZPD within specific domains, providing diagnostic information about their future performance beyond that provided by static estimates. They argue that the "fruits" of development are only captured by static measures, which fail to examine the "buds" or "flowers" of development. The aim of this line of research is to test Vygotsky's assumption that assessment of how children respond to socially structured instruction within specific domains provides important diagnostic information.

Standardised intelligence and ability tests usually require a student to provide information or solve a problem alone without any help from the tester. This method of testing gives an indication of the student's current level of competence. However, psychologists often use this measure of the student's independent ability as a basis for predicting that person's future development. An assumption lies behind this practice, namely that, all students have had equivalent opportunities to learn the knowledge being tested and they are similarly competent at explaining their knowledge in a test situation. It is possible that this assumption could be false, leading to a major underestimation of a student's potential development.

Some psychologists (e.g. Brown & Ferrara, 1985 and Brown & Campione, 1986), in line with Vygotsky's thinking, have suggested that this is particularly true among some people with learning difficulties, since they often lack the necessary experience to develop various abilities though they possess the underlying psychological processes for cognitive development. Traditionally, psychologists have conceptualised a learning difficulty as a general weakness in the different faculties of psychological functioning, such as memory and attention. It was argued that these deficits in cognitive ability were the cause of difficulties in academic subjects like reading and arithmetic (Woodrow, 1919). This approach to the issue of learning difficulties is based on the "medical model of diseased mental entities" (Brown & Campione, 1986, p. 1060).

There is a basic contradiction with dialectical philosophy in the underlying assumption of the medical model of learning difficulties. This medical model expects that there is a general and stable deficit in the child's psychological functioning. A dialectic approach to human development never regards a lack of cognitive ability as all encompassing and static over time. Dialectical thinking contends that any human dysfunctioning is not general to all social contexts and it can be remediated through activity in the environment. It is through interaction that the individual can appropriate external resources which can compensate for poor innate psychological qualities. However, even when psychologists have accepted the possible effect of the environment on human mental functioning they have argued that remediation of these general deficits would occur through the decontextualised practice of basic tasks, such as encoding and short term memory problems (Thorndike, 1913). Thorndike's approach fails to appreciate that learning is domain specific, the mind can not be detached from the external world and trained in an asocial manner. It seems that the medical model of learning difficulties and Thorndike's approach to instruction are basically rooted in a philosophy contradictory to the dialectic perspective on human development. Challenging this non-dialectical philosophy does led to a new psychology of learning difficulties.

"changing the mental model of academic delay from one focused on weak and diseased entities in the child to one that emphasizes partial knowledge that can be improved with guidance practice has important psychological consequences, as does changing the image of a child's learning potential from one that is static and general to one that is dynamic and domain specific" (Brown & Campione, 1986, p. 1065).

Dynamic assessment of children's cognitive development contributes to this shift in our psychology of learning difficulties and it provides instructional information that could be used within education. Measurement of the ZPD allows for the dynamic assessment of the children's cognitive ability, since this is a method of testing which examines as directly as possible the functioning of psychological processes, not the products of development. Dynamic assessment techniques can complement traditional intelligence and ability tests by gaining an insight into the efficiency with which students learn new knowledge and skills (Campione & Brown, 1990). Many early psychologists (Thorndike, 1926; Woodrow, 1921) claimed that learning and transfer efficiency are important elements in any definition of intelligence.

However, there is very little evidence showing a connection between I.Q. scores and measures of learning or transfer ability. This is primarily due to the belief that learning is an improvement in ability resulting from individual reinforced practice, which can be measured by static tests. Vygotsky's theory of cognitive development rejects this approach, since he argues that all psychological processes are originally develop in the social world and gradually become internalized through the mutual interaction between the individual and the social environment (Rutland, 1991). A neo-

Vygotskian perspective views learning as a social phenomenon, with the ZPD as a measure of a student's ability to learn and of her potential development.

Recent research (Brown & Ferrara, 1985; Campione & Brown, 1987; Campione & Brown, 1990) has examined the concurrent validity and predictive validity of learning and transfer measures. Concurrent validity is concerned with whether measures of learning and transfer are related to intelligence, while predictive validity addresses the issue of whether learning and transfer measures provide additional diagnostic information beyond that given by I.Q. tests. These studies have measured the ZPD by assessing the amount of instruction students have needed to reach a certain level of performance across a series of tasks. It has been suggested that these assessments of the ZPD render useful additional indications of children's future ability.

Ferrara et al (1986) examined the concurrent validity of learning and transfer measures in an inductive reasoning task. The experiments reported used two traditional tasks from standardised I.Q. tests: the letter series completion problems and progressive matrices problems. The subjects were eight to eleven year-old children from a normal school. Initially the children were given a difficult problem, so that the majority of the children required help. Help was given in the form of a standard sequence of hints which increased in their explicitness, as they proceeded from fairly general hints to concrete ones. Then the children were presented with a similar maintenance problem and if necessary help was provided by another graded series of abstract to explicit hints. Next the children had to solve two noticeably more difficult transfer problems and again if errors were made they were aided by a sequence of gradually more helpful hints. The results were concerned with number of hints the children required to reach a specific level of performance in the dynamic original, maintenance and transfer tasks.

The experiments described by Ferrara et al (1986) found a significant relationship between the children's I.Q. scores and the dynamic measure of learning efficiency obtained from the children's performance on the original problem. The dynamic maintenance and transfer scores also correlated significantly with the children's I.Q. scores. These results indicate that dynamic measures of learning and transfer efficiency have concurrent validity, as they are related to intelligence as assessed by I.Q. tests.

Bryant et al (1983) followed a similar procedure to Ferrara et al (1986), but they investigated the predictive validity of learning and transfer measures. This experiment added a posttest onto the method used by Ferrara et al (1986), it occurred after the transfer test and was a replication of the original task. The aim was to assess the improvement in the children's independent ability between the pretest and the posttest due to their experience with the maintenance and transfer problems. The results of this study suggested that dynamic measures of learning and transfer provided additional diagnostic information beyond the static measures of ability and intelligence. This is because the dynamic learning and transfer scores combined, on top of the I.Q. score and the measure of initial static ability, accounted for an extra forty per cent of the children's improvement in performance between the original problem and the posttest.

A study by Campione et al (1985) also investigated the concurrent validity of learning and transfer measures obtained by assessing the ZPD. The aim of this study was to examine whether there were intelligence related differences in children's ability to learn and transfer their skills. Therefore, dynamic assessment of the amount of help needed by children to learn and deal with transfer problems might provide important diagnostic information beyond that given by traditional individual tests. Campione et al (1985) designed a direct test of the notion that there are relative differences, between 'normal' children and children with learning difficulties, in the amount of hinting needed for learning and transfer to occur.

The experiment described by Campione et al (1985) required two groups each consisting of twenty five children, one group being 'normal' and the other group having learning difficulties, to learn three rules underlying problems taken from the Raven Progressive Matrices Test. These rules were rotation, imposition and subtraction. The two groups were matched approximately for mental age and initial task competence. Despite this the 'normal' children did have a slightly higher ability level at first compared to the children with learning difficulties. The 'normal' children' averaged thirty seven per cent correct in the initial pretest compared to twenty nine per cent correct for the children with learning difficulties. This matching procedure was necessary since a child's starting level in part determines their ability to learn and transfer skills. The children were provided with a series of hints if they made errors, until they reached a set criterion of performance. The hints were structured in a general to specific, weak to strong order, giving a index of the minimum amount of input needed for learning. Then the children were given a set of transfer tasks, which meant that they had to use the three rules they learnt within novel problems. Once again the children were given hints until they reached a certain ability level and this provided a dynamic measure of transfer propensity.

The results of the experiment conducted by Campione et al (1985) found no significant difference between the 'normal' children and the children with learning difficulties on the original pretest or their ability to learn from hints on this task. However, when the two groups were required to "make flexible use of the matrix rules (in the transfer problems) pronounced group differences were obtained" (Campione et al, 1985, p. 311). The 'normal' children showed more benefit from the hinting sequence than did the children with learning difficulties. This result lends support to the view that measurement of the ZPD in transfer tasks is a sensitive index of intelligence. Cronbach (1967) cautioned against the rejection of the idea that learning and transfer measures are related to cognitive ability.

"I shall not be satisfied until we get data on learning rates under instructional conditions; present studies have invariably measured learning rate under conditions of practice unguided save for knowledge of results" (Cronbach, 1967, p. 25-26).

It seems Cronbach was correct since the study presented by Campione et al (1985) indicates that measurement of the ZPD within a transfer task "provides important diagnostic information and deserves a central place in our views of intelligence" (p. 314).

The concurrent validity and predictive validity of measuring the ZPD was investigated in the context of a visuo-spatial task by Bishop (1991). In this study thirty four 'normal' children, aged between three and five years old, were required to find an object hidden in a box on a flat board with partitions. Initially, the children were given a black and white line diagram or map to help their search for the object. The children were given a series of hints if they made errors with the map. The hints consisted of a coloured diagram, a black and white map and a coloured photograph in that order. This sequence of hints was chosen in light of the findings of experiments by DeLoache (1989). The number of hints used by the children to reach a set level of performance provided a measure of their ZPD. Finally, the children were given a posttest, this involved a similar spatial task which was not appreciably more difficult than the first problem.

Bishop (1991) found that the dynamic measure of the ZPD correlated significantly with the children's score on the British Picture and Vocabulary Scale (BPVS). This correlation demonstrated that this method of assessment of the ZPD had concurrent validity, since it was related to intelligence as indicated by the BPVS test. The experiment also found that the dynamic measure was a significantly better predictor of the children's posttest performance than was their initial unassisted score. Measurement of the ZPD in this experiment had predictive validity beyond that provided by individual tests of ability. In addition, the nonsignificant correlation between the dynamic measure of the ZPD and the static measure of the individual performance found by Bishop suggests that these two scores are evaluating slightly different psychological abilities.

Newman, Griffin and Cole (1989) offers a criticism which applies to the work described by Campione and Brown (1990) and Bishop (1991). They contend that in the dynamic assessment technique the instructional situation is not interactive and thus lacks ecological validity. In everyday classroom interaction there is a mutual interaction between adult and child - with the goal of the task being jointly negotiated and the child being free to instigate various forms of assistance (Rogoff, 1990; Newman et al, 1989). This is not true of the interactional situation within the dynamic assessment procedures used by Campione and Brown or Bishop. Furthermore, Newman et al (1989) think that dynamic assessment techniques are unable to deal with complex mental functions, such as mathematical concepts, which cannot be decomposed into a "neat sequence of levels".

Assessment while teaching is offered by Newman et al (1989) as an alternative to dynamic assessment. This line of research bears closer resemblance to the work of Feuerstein (1979), who investigated the amount of improvement that followed guided instruction. Newman et al (1989) observed the instructional interaction in a "chemical indicator lesson" and coded the amount of help the children needed in two attempts at the task. They did not require the children to reach a set level of performance, but assumed a decrement in the amount of support given between the first and second attempt indicated a increase in independent ability.

There were serious problems with the technique used by Newman et al (1989). The teacher seemed to obscure the researcher's view of the children's competence, by giving unnecessary instruction. This resulted from the fact that giving too much help is not normally a critical problem in teaching. Newman et al (1989) noted that there was an "inherent ambiguity" in assessing while teaching, as the teacher's goals go beyond the immediate context. Needless instruction was given by the teacher in the form of: mini-lessons while helping; ensuring one phase is completed correctly so the next could continue and reinforcing actions which they presumed the child could carry out, but they knew were essential for the next phase. The dynamic assessment technique uses standardised hints and never assumes the child's ability, though it does have other limitations as already shown. It is also true that this elaboration of the paedological side of Vygotsky's ZBR concept does not extend the embryonic developmental theory behind it (Valsiner & van der Veer, 1991).

The studies of map use in the following chapter aim to develop and extend upon the research outlined above which measured the ZPD through dynamic assessment procedures. The specific purpose of the studies of map use is to test the concurrent and predictive validity of measuring the ZPD within the context of a mapping task and using both 'normal' children and children with learning difficulties.

Chapter 5

Preliminary studies

Summary

The experiments described in this chapter were preliminary studies to a series of experiments that would attempt to measure children's zone of proximal development (ZPD). These preliminary studies aimed to find appropriate samples of children, methods and apparatus for this future research. In addition, the final study examined the value of assessing children's individual ability to use a map. This would show whether measurement of the ZPD could be a useful additional educational procedure.

Experiment 1 suggested alterations to the scoring procedure, since it did not reflect accurately the child's mapping ability. The children's performance in the finding and hiding conditions were approximately equivalent. Therefore, the hiding condition was not used in the other experiments within this chapter and chapter 6. The apparatus used in Experiment 1 did perform as expected as it allowed for the fair representation of the child's ability to understand and use a map. Experiment 1 also examined whether children with learning difficulties had good mapping skills and if they could transfer these skills into new environments. The children with learning difficulties did not perform as well on the transfer task as on the initial non-transfer task. This result showed that children with a learning difficulty, aged between seven and nine years, have relatively good mapping abilities, but they had problems transferring these skills to modified environments.

Experiment 2 piloted a sequence of hints to assist the children in solving the mapping task and examined the difficulty of a series of task with different maze configurations. The aim was to test whether a sequence of hints proved gradually more useful to the children. The experiment also examined the difficulties children found when mapping a series of mazes. The results of this experiment showed the need to alter the sequence of hints, but the ordering of the mazes was unproblematic.

Experiment 3 investigated whether normal children could demonstrate mapping skills in increasingly more complex spaces. The results of this experiment showed that normal children, with a mean age of 7.2 years, had good mapping ability, and suggested that planned research should use a younger sample when measuring the children's ZPD on the spatial tasks used in this experiment.

Lastly, Experiment 4 demonstrated that static measures of children's mapping ability did not have concurrent validity with their BPVS (British Picture and Vocabulary Scale) scores. This experiment also found that the children's BPVS scores lacked predictive validity in relation to the children's individual map reading skills. These results suggested that measurement of the ZPD might prove a valuable additional way of assessing children's intelligence.

Introduction

The four experiments described in this chapter are investigations into the ability of children with learning difficulties and normal children to understand and use spatial representations. The mapping task used in the two experiments described in Chapter 2 was used in these preliminary experiments. The children had to use various spatial representations to find or hide an object in different hiding places within a maze. Some of the studies outlined in this chapter used variations of the maze that was the basis for Chapter 2 and the spatial representation used was not always a map.

The studies presented in this chapter were necessary precursors to a series of experiments intended to measure children's 'zone of proximal development' (ZPD). Before planning this research into the ZPD it was essential to identify appropriate samples and experimental designs. Measuring the ZPD involves assessing the amount of help children need to reach a new level of performance, their potential level of development. This would only be possible if an age group was matched with a mapping task with which children experienced some difficulties, so that they would actually need assistance. So some of the studies in this chapter were concerned with finding a group of normal children and a group of children with learning difficulties who would have problems with a mapping task, though they should not find the task impossible.

These preliminary studies also examined the children's relative difficulty with different spatial representations and various maze configurations. Measuring the ZPD involves assessing the number of hints required by children to reach a criterion level of performance (Campione & Brown, 1990) and the planned research into the ZPD aimed to use spatial representations of different quality as hints. It also aimed to investigate whether measuring the ZPD in transfer tasks had predictive value for the change in performance between a pretest and posttest. So it was necessary in these preliminary studies to identify a maze configuration which could be used as a transfer problem; that is, one noticeably more difficult than other maze tasks. The studies in Chapter 6 examined whether static and dynamic measures of map ability had concurrent validity with I.Q. scores. They also investigated the predictive validity of I.Q., static and dynamic measures for the improvement between a pretest and posttest. Experiment 4 attempts to assess the concurrent validity with BPVS scores of static measures of map use ability, plus the predictive validity for the static measures of the children's BPVS score, age and sex. This is a necessary preliminary study for the planned research because if static indicators of ability have excellent predictive power and have a strong relationship with measures of general development, such as the BPVS score, then measurement of the ZPD can not usefully supplement such static assessment.

The first study aimed to ensure that the apparatus used in the mapping task functioned correctly. This was taken to mean that the apparatus should provide a clear picture of the child's ability to use spatial representations; the experimental procedure should not allow the children to succeed through trial and error and the scoring procedure should fairly represent the children's ability. The other studies in this chapter were not concerned with the functioning of the apparatus as they chronologically followed the first experiment, and any methodological changes suggested by the conclusions of Experiment 1 were implemented in subsequent experiments within the chapter.

Another aim of the first experiment was to investigate whether children with a learning difficulty, aged between seven and nine years, have any problems with the spatial task. In order to measure these children's ZPD, as mentioned above, it was essential to find an age group of children with learning difficulties which could benefit from help on the mapping task.

The first experiment also examined the ability of children with learning difficulties to use a map in a second mapping task which included the same maze but provided with more hiding places. The intention was to investigate whether children with learning difficulties have problems transferring their mapping ability to a modified maze task. The importance of learning and transfer determining intelligence has been acknowledged for a long time in psychology (e.g. Binet, 1909; Thorndike, 1926). However, it is the case that for a major part of this century the centrality of learning and transfer processes to intelligence decreased because of unsuccessful experimental investigation (Campione, Brown and Ferrara, 1982). Some contemporary theories of intelligence, however, again focus on learning and particularly transfer mechanisms (Borkowski & Cavanaugh, 1979; Brown & Campione, 1978, 1981, 1984). These theories are supported by studies that have shown that young, inexperienced and especially children with a learning difficulty require detailed and explicit instruction in solving problem tasks (Butterfield et al, 1973; Campione and Brown, 1977). Moreover, these children were poor at transferring skills to different situations - once they had learnt a particular activity effectively in one situation, subsequent use in another was extremely limited. This was particularly dramatic for children with learning difficulties (Borkowski & Cavanaugh, 1979; Brown & Campione, 1978, 1981).

Further studies in a planned larger project would investigate the issue of transfer if this first study found that children with learning difficulties experienced problems in transferring their spatial awareness to modified environments. Research of this kind could prove useful in the field of psychological assessment. Transfer efficiency may be a useful measure of general intelligence if it can differentiate between children of various abilities. Measuring the ZPD in a transfer task may prove more useful than assessing it in only on a simple task.

The second experiment also involved children with learning difficulties. One aim of the experiment was to test the amount of help provided by a sequence of hints, consisting of different representations of the mapped space, within the task used in the first experiment. When measuring the ZPD the series of hints should gradually become more explicit, thus providing the children with increasing amounts of assistance. This was achieved by investigating how difficult the children found the mapping task using each hint. Bishop (1991) conducted research, with normal children, involving a visuo-spatial task in which he used a sequence of hints in the order of: coloured diagram; black/white photograph and coloured photograph. This study uses a similar order of hints. Bishop found that the coloured photograph was the most helpful hint, while there was no significant difference between the amount of assistance provided by the coloured diagram and the black/white photograph.

The other goal of the second study was to investigate whether children with learning difficulties found a series of tasks with different maze configurations increasingly more difficult spaces to map. The first mapping task involved the initial maze used in experiment 1. The next two mazes were proposed as maintenance tasks to be used in future research on the ZPD, since they were variations on the first task but not noticeably more difficult. The final maze configuration was supposed to be used in a transfer task, as it should prove significantly more difficult than the previous mapping tasks. It was necessary to correctly arrange the mapping tasks in order of difficulty so future experiments on the ZPD could examine the child's transfer of mapping skills across different mazes.

The third experiment examined whether six and seven year old normal children could use a map to find an object in series of increasingly more difficult maze configurations. Custance (1990) found that 6 year olds were relatively competent map readers, since they could generally find an object in a simple maze on the first attempt. Therefore in this experiment the children were presented with three different mazes. The first two mazes were slight variations of the maze used by Custance (1990), though not much more complex. The third and final maze was clearly more complex, since compared to the maze used by Custance (1990) it had an altered wall formation and a greater number of boxes as hiding places. This experiment was only concerned with assessing whether six to seven year-old children found the mapping task difficult enough.

The fourth experiment examines the concurrent validity of the static measures of mapping ability with the BPVS scores, plus the predictive validity of the children's BPVS score, age and sex for the static measures. Concurrent validity is considered by examining the relationship between the children's BPVS score and their ability to use a map to find an object in a simple maze. Predictive validity of the children's BPVS score, age and sex is assessed by considering whether any of these independent factors can predict the children's performance in a static test of their mapping skills. The main aim is to investigate whether children's BPVS scores are related to their ability to use a map when finding an object within a large-scale maze.

Four experiments are reported in this chapter. Experiment 1 (Condition 1) has two variants: variant 1 involves the subject using a map to find an object in a maze with four boxes as hiding places and variant 2 involves the subject using a map to hide an object in a maze with four boxes as target locations. Experiment 1 (Condition 2) required the children to use map to find an object in one of six boxes within a maze. It is predicted that the children with learning difficulties will perform better in Condition 1 than in Condition 2, but the children will not completely fail the later condition. In Experiment 2 the children with learning difficulties had to find an object in the maze with the help of a sequence of hints, supposedly increasing in their usefulness to the child. The children in this experiment were tested in a series of tasks with different mazes, with the last maze intended to be more difficult than the previous mazes. Experiment 3 also required the normal children to find a object in a sequence of mazes using a map. Measures of 'normal' children's BPVS scores were initially obtained in Experiment 4. Then the children had to find and hide an object using a map in just one simple type of maze.

Method

Experiment 1

Subjects:

Six children with learning difficulties from a local special needs school were used in this study. These six included three boys and three girls. The age of the children ranged from seven to nine years and their mean age was eight and a half years.

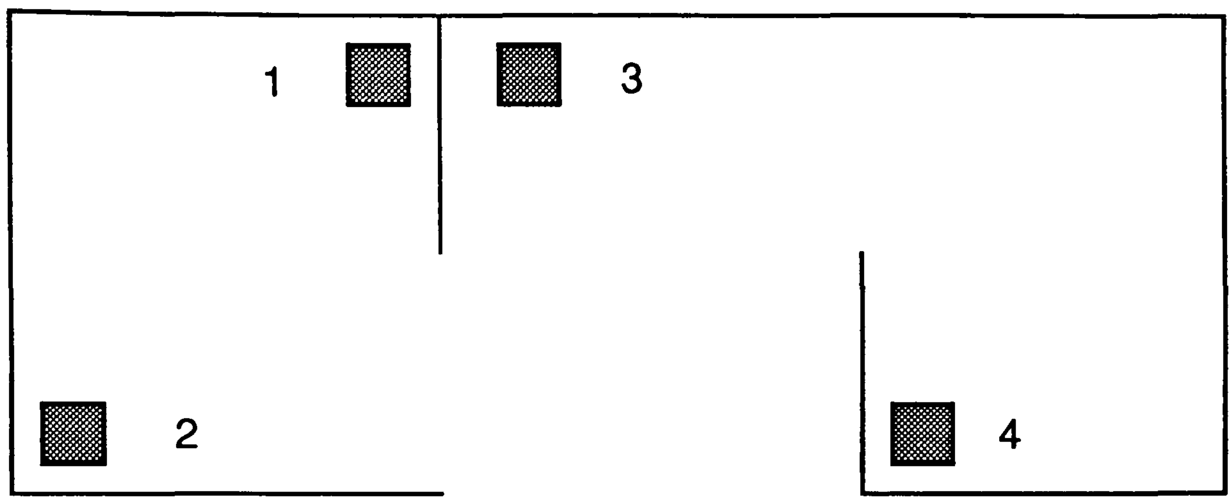
The six children were the subjects in both Condition 1 and Condition 2.

Condition 1

Apparatus:

The major piece of apparatus consisted of a 2.4m x 1.2m x 1.2m collapsible maze. The maze consisted of plain hardboard walls reinforced with timber frames. The walls were bolted together through the frames. There was a 0.6m wide entrance, and 2 partitions splitting the inside area into 3 sections with 0.45m entrance into the end sections. In the maze at strategic positions were placed four cardboard boxes (see Figure 1). The cardboard boxes were identical, plain and measured 27cm x 22cm x 21cm. A 6cm piece of wrapping tape sealed the boxes' lid-flaps together. The flaps were opened by pulling one side of the tape back. The children had to find or hide a chocolate bar in each of the four boxes within the maze in turn. Three soft toys were used to place in the boxes which were not the target within each trial. Thus this ensured all the boxes were approximately the same weight and prevented detection of the 'present' by shaking or lifting the box. Children or experimenter sat on a chair and covered their or his eyes while the 'present' was being hidden by the experimenter or child in the maze.

Figure 1: The maze used in Experiment 1 - Condition 1, with boxes 1 - 4 marked.



There were 8 maps of the maze per subject, with a scale of 1:15, drawn in thick black ink on white cartridge paper (see Map 1 in the appendix). The maps were marked with a felt tip pen.

Procedure:

Orientation Phase

The children were tested individually. Each experimental session began with an orientation phase. The experimenter showed the children a map and defined it as a picture that could help you find things'. Then the children were told they would be playing a game called treasure hunt in which three toys and the chocolate bar would be hidden in the maze and the chocolate bar was to be the object of the search.

The chocolate bar was then placed in box 3 (see Figure 1) while the child watched. Next a cross was drawn over box 3 on the map. The chocolate bar was then placed in box 2, and the child was asked to identify box 2 on the map.

Experimental Phase

Immediately after the orientation phase ended the main experiment began. There were two variants of condition 1 involving 4 trials each.

Variant 1: Finding the chocolate bar.

The toys and chocolate bar were hidden in different boxes, while the children remained in a chair with their eyes closed. The chocolate bar's hiding place for each session was randomly ordered. As a precaution against the children observing where the bar was hidden, it was always placed in the last box that the experimenter opened. Additionally, when the experimenter hid the bar he always opened the boxes in a standardized order.

The children were then told that they could open their eyes and the experimenter marked the box containing the chocolate bar with a 'X'. Then the children were told to find the box with the chocolate bar inside and bring it back to the experimenter. The children were allowed to take the map during the search. Only one chance was allowed to find the correct box. It was noted down on the map whether the child was correct or incorrect in each of the four trials.

Variant 2: Hiding the chocolate bar.

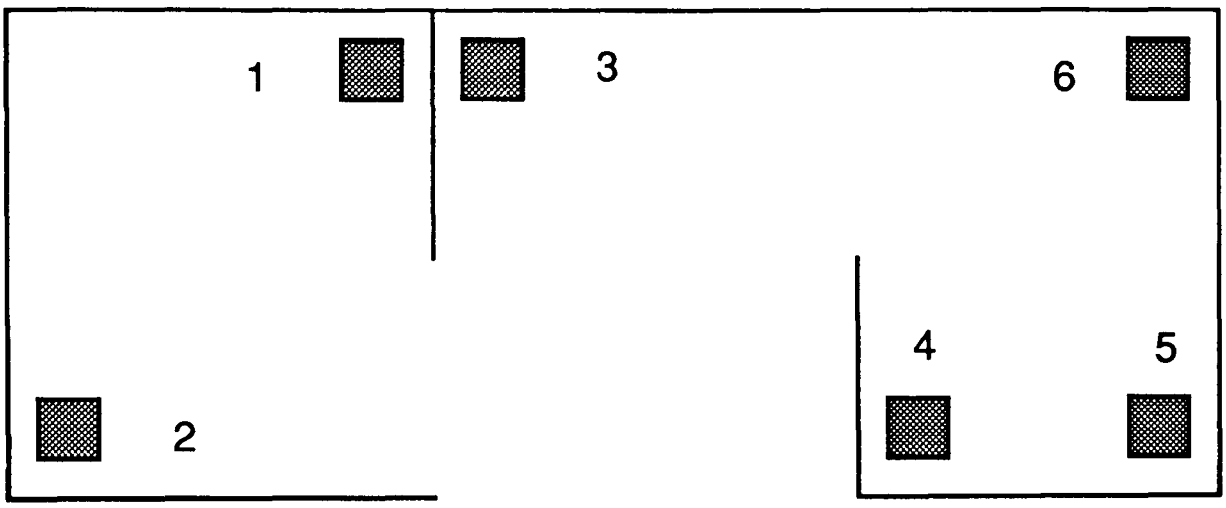
The children were required to hide the bar while the experimenter closed his eyes and turned his back to the maze. Once the bar had been hidden the children were presented with a map and asked to point to the box where they had hidden the bar. Then the experimenter pointed to the same box and asked whether it was the box they meant. The children were allowed to return to the maze and check where they had hidden the chocolate bar. The children had to hide the bar four times and they were only allowed one chance to identify correctly the box in the maze that contained the chocolate bar.

<u>Condition 2</u>

Apparatus:

The same apparatus was used as in Condition 1, except in this experiment six boxes where strategically placed in the maze (see Figure 2). Five toys and a chocolate bar were hidden in the six boxes. A new map was also used (see Map 4 in the appendix)

Figure 2: The maze used in Experiment 1 - Condition 2, with the boxes 1 - 6 marked.



Procedure:

The procedure in this experiment followed the procedure in Condition 1 (see page 87), with the same orientation phase and a same experimental phase, except only Variant 1 (Finding the chocolate bar) was completed in this condition. There were six hiding events in this condition, not four as in Condition 1.

Experiment 2

Subjects:

Five children with learning difficulties from a special needs school in Central region, Scotland were used in this experiment. Four of the subjects were boys and the other one was a girl. The children had a mean age of eleven years old.

Apparatus:

The mazes shown in Figures 1, 3, 4 and 5 (overleaf) were used in this experiment. Four or six boxes were used as hiding places for a chocolate bar, depending on which maze was used in each trial. Hints were used in this experiment which included a black/white photograph (see photographs 1-4 in the appendix), a coloured map (see maps 5-8 in the appendix) and a coloured photograph (see photographs 5-8 in the appendix) of each maze.

Figure 3: The maze used in Experiment 2 and Experiment 3

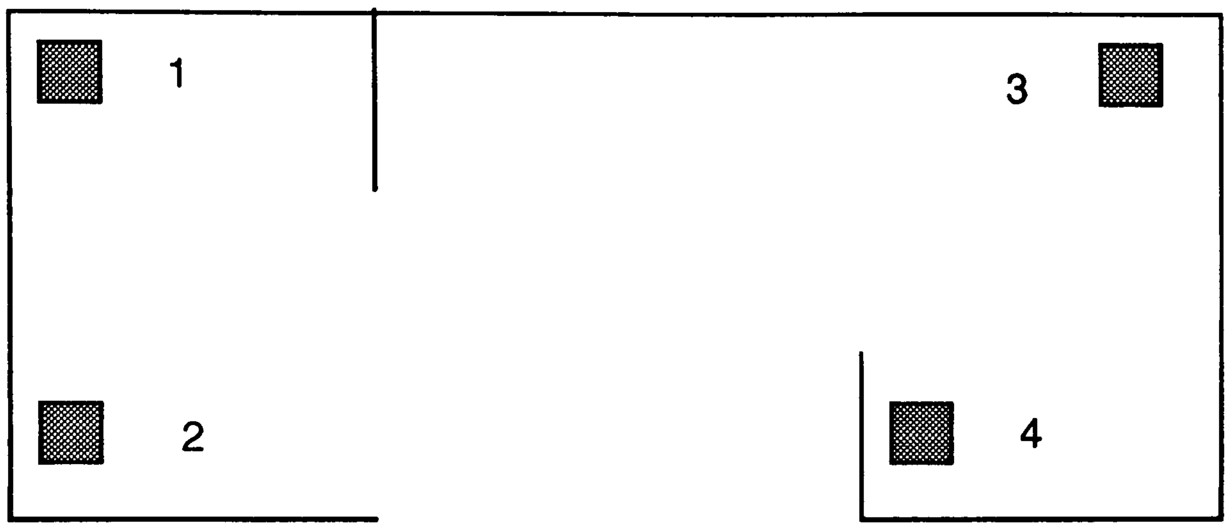


Figure 4: The maze used in Experiment 2 and Experiment 3

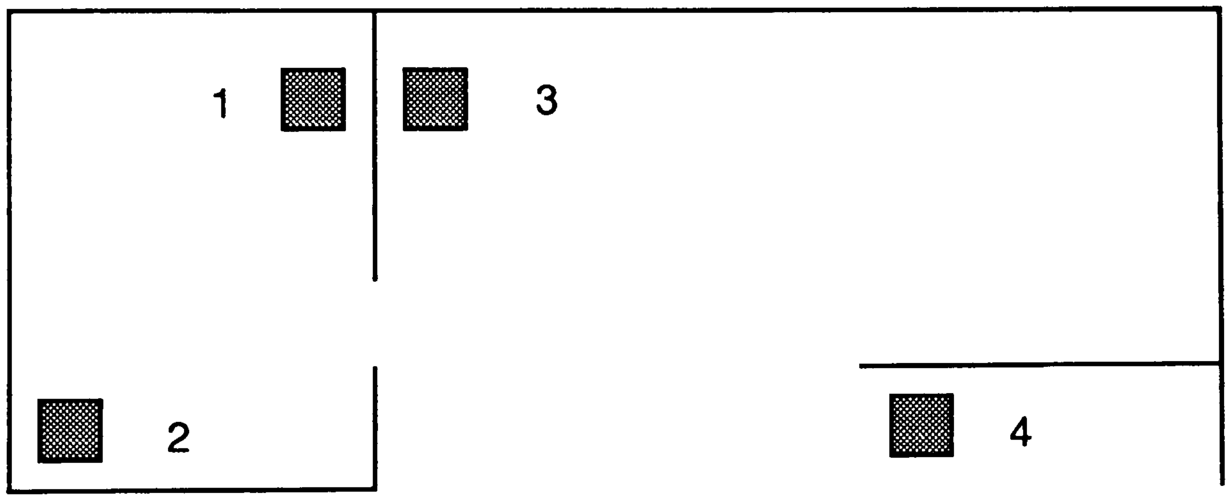
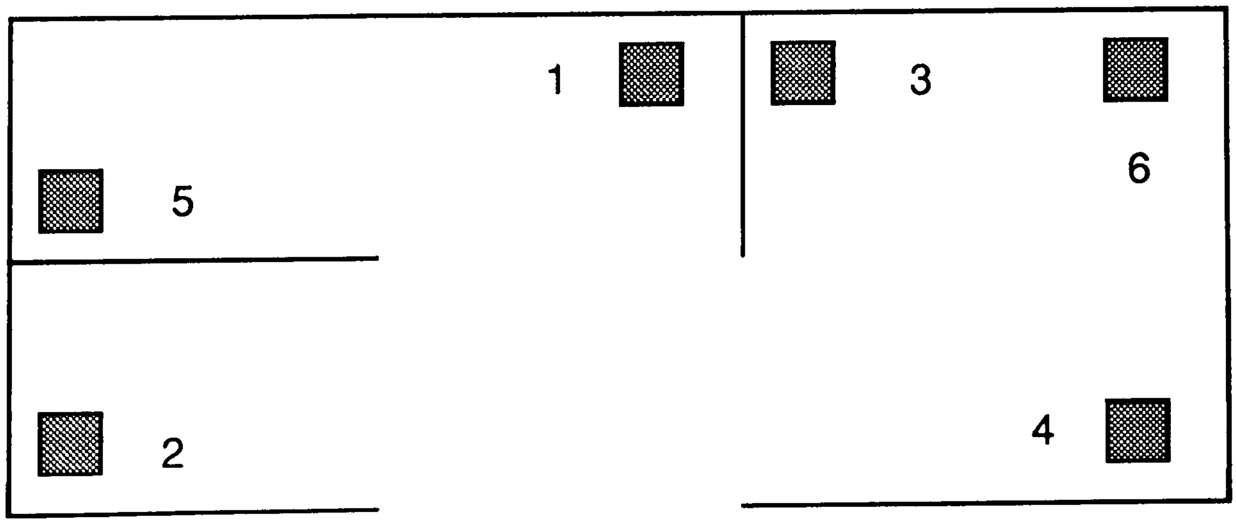


Figure 5: The maze used in Experiment 2 and Experiment 3.



Procedure:

The children followed the same procedure as used in the finding part of Experiment 1 - condition 1 (see page 87), except that the children were given a series of hints instead of a black/white map to assist them locate the chocolate bar inside the maze. The sequence of hints, in order of explicitness, can be seen in the Appendix. Another alteration in this procedure from the one used in Experiment 1 (Condition 1 - Variant 1) was that the children were also tested on the mazes shown in Figures 3, 4 and 5. Two children completed the maze in Figure 1, three the maze shown in Figure 3, two the maze in Figure 4 and three the maze shown in Figure 5. The number of attempts the child needed to find the box with the chocolate bar inside was recorded.

<u>Experiment 3</u>

Subjects:

Ten normal children from a local primary school were used in this study. These ten children included five boys and five girls. Their ages ranged from six years and ten months to seven years and eight months. The children had a mean age of 7;2 years.

Apparatus:

This experiment use the mazes shown in Figures 1, 3, 4 and 5. These mazes involved four or six boxes as hiding places, dependent on the particular maze being used in the trial.

Procedure:

The procedure in this experiment matched the procedure used in Experiment 1 (Condition 2) - see page 88, with an orientation and experimentation phase; except the children had more than one chance to find the object correctly. The experimenter noted down the number of attempts the child needed to find the object successfully, with the maximum number of tries depending on the number of boxes within the maze. One of the children completed the task with the maze shown in Figure 1, three the maze represented in Figure 3, three the maze in Figure 4 and three the maze in Figure 5.

Experiment 4

Subjects:

22 'normal' children were selected from the University of Stirling playgroup. Two groups of 11 children were formed from the 22 children. The first group had a mean age of 3 years 5 months (range 3;1 - 3;10) and the second group had a mean age of 4 years 3 months (range 4;0 - 4;9). The performances of the three year old group (4 girls, 7 boys) and the four year old group (7 girls, 4 boys) were investigated in both the finding and hiding conditions. The children had a mean score of 98.23 (range 72-115) on the British Picture Vocabulary Scale (BPVS). Two BPVS groups were created out of the 22 children: a low BPVS group with a mean of 88.18 (range 72 - 98) and a high BPVS group with mean of 108.27 (range 99 - 115).

Apparatus:

Figure 1 shows the plan of the maze, which was used in both the finding and hiding conditions of this experiment. The remaining apparatus was exactly the same as the material used in Experiment 1 - Condition 1 (see pages 86-87).

Procedure:

Initially scores for each of the twenty two children were calculated from the children's performance on the British Picture Vocabulary Scale (BPVS) test. The children's BPVS scores were obtained in an undergraduate practical class on mental testing.

- Finding Condition:

The subjects were tested individually. Each child was encouraged to walk through the maze and the experimenter pointed out the location of each box. Then the child was told a 'treasure hunt' game would be played, in which the child must find the 'present' after the experimenter had hid it in a box. Next the child was shown the map. It was explained that the map was a picture of the maze and could be useful in locating the 'present' when it was hidden inside a box within the maze.

The experimenter placed the 'present' in box 3 (see Figure 1) and showed the child the position of box 3 on the map by drawing a cross on this box. Then the 'present' was put inside box 2 by the experimenter and the child was asked to identify box 2 on the map. If the child was incorrect, the experimenter showed the child the correct box on the map.

The child was taken back outside the maze shown in Figure 1. The experimenter then hid the 'present' in one of the four boxes situated within the maze, while the child turned away and closed his or her eyes. The hiding place for the 'present' in each trial was randomly ordered. As a precaution against the children assuming that the 'present' was always hidden in the last box opened by the experimenter while hiding, the boxes were opened in a standardised order. The experimenter pin pointed for the child the position on the map of the box containing the 'present' by drawing a cross on the appropriate box. Then the child was asked to find the box with the 'present' inside. The child was allowed to take the map during their search for the correct box.

If the child chose the wrong box he or she was shown an exact copy of the same map and instructed to retrieve another box. This continued until the child found the correct box. Overall, this procedure was repeated on three more occasions; since each child had to complete four trials, each involving a different box as the hiding place. The number of attempts needed by each child to find the 'present' correctly in each of the four boxes was noted.

- Hiding Condition:

In this condition the child was asked to hide the 'present' on four different occasions, while the experimenter closed his eyes and turned his back to the maze. Then the child had to identify on the map the box in which they hid the 'present' by marking this box on the map. The experimenter checked whether the child was correct. If not the child was requested to identify the box which contained the 'present', on an exact copy of the initial map, . The number of times the child needed to mark the maps, in order to show the experimenter the location of the 'present', was noted. In both conditions the child was reminded to use the map, but no other help was given by the experimenter.

Results - Experiment 1 - The ability of children with learning difficulties to transfer their mapping skills.

The method for Experiment 1 can be seen on pages 86-89. Experiment 1, Condition 1 (Variant 1 and Variant 2) and Experiment 1, Condition 2 were scored according to whether the subject correctly identified the box inside the maze which contained the chocolate bar. The results of Experiment 1 are presented in Table 1 overleaf.

Table 1: The number of correct and incorrect searches in Experiment 1 Condition 1 - (Variant 1 and 2) and in Experiment 1 Condition 2

		EXPERIMENT 1 CONDITION 1				EXPERIMENT 1 CONDITION 2	
AGE (YEARS)	SEX	VARIANT 1 (FINDING)		VARIANT 2 (HIDING)		(FINDING)	
		C	I	C	I	C	I
9	G	2	2	1	3	2	4
9	G	4	0	3	1	2	4
8	B	2	2	3	1	2	4
7	B	4	0	4	0	3	3
9	B	2	2	3	1	2	4
9	G	2	2	2	2	2	4
TOTALS		16	8	16	8	13	23
PERCENTS (%)		67	33	67	33	36	64

KEY: C = correct search B = boy
I = incorrect search G = girl

The above key applies to the remaining tables in this chapter.

Table 1 shows that overall the children found Experiment 1 - Condition 2 more difficult than Experiment 1 - Condition 1 (Variant 1 and 2), with a 67% success rate and a 33% success rate respectively. As expected the children with learning difficulties in this experiment showed relatively good understanding of the map in one task context, but in a subsequent modified environment their understanding diminished.

The children's performance in Experiment 1 - Condition 1 was not different in variant 1 (finding) compared to variant 2 (hiding) according to Table 1. Evidently, these two different experimental methods had no effect on the child's ability to understand and use a map.

Table 2: The percentage of correct and incorrect searches among girls and boys in Experiment 1 - Conditions 1 (Variants 1 and 2) and in Experiment 1 - Condition 2.

		EXPERIMENT 1 CONDITION 1				EXPERIMENT 1 CONDITION 2	
SEX	N.	VARIANT 1 (FINDING)		VARIANT 2 (HIDING)		(FINDING)	
		C	I	C	I	C	I
Boys	3	67	33	83	17	39	61
Girls	3	67	33	50	50	33	67

Table 2 shows that the percentage of correct searches is greater for both sexes in all variants of Experiment 1 - Condition 1 than for Experiment 1 - Condition 2. It also shows that the majority of searches for both sexes in Experiment 1 - Condition 1 were correct, with boys slightly out performing the girls in the hiding condition.

The apparatus within Experiment 1 performed as expected. The boxes remained well sealed so the children could not see inside without opening the boxes. The large-scale nature of the maze prevented the children from gaining an overall view of the experimental space without physically moving around the maze. This made the maze similar to the kind the space normally mapped.

Results - Experiment 2: The selection of appropriate hinting and maze sequences

The method for this experiment can be seen on pages 89-91. The sequence of hints used in this experiment gradually become more explicit; since the ordering of the hints meant that increasingly more help was not provided to the children. This can be seen in Table 3.

Table 3: The mean number of attempts needed by the children with five hints in tasks involving the mazes shown in Figures 1, 3, 4 and 5 (for each maze condition n = 5)

MAZE	HINT					TOTAL
	1	2	3	4	5	
FIGURE 1	1	1	1	2.5	1	1.3
FIGURE 3	1	1	1.7	1.3	1	1.2
FIGURE 4	1	1	1	1.5	1	1.1
FIGURE 5	2.3	2	1	2	1	1.6
TOTAL	1.3	1.2	1.2	1.8	1	

The overall score for hint 4 was greater that the overall scores for hints 1, 2 and 3. This shows that hint 4 did not give more help than the hints that preceded it. The first, second and third hints seem to be in the correct order, as does the fifth hint. It is the fourth hint that breaks the sequential order of the hints.

Table 4 also shows the maze in Figure 5 proved the most difficult for this sample of children with a learning difficulty. The table does not suggest the children found any major difference in difficulty between the mazes in Figures 1, 3 and 4.

Results - Experiment 3: The mapping ability of 7 year old 'normal' children

The method for Experiment 3 can be seen on pages 91-92. Table 4 shows that the children in Experiment 3 had no difficulty in finding the object, irrespective of the configuration of the maze.

Table 4: The mean number of attempts needed by children to find the chocolate bar in the different mazes shown in Figures 1, 3, 4 and 5 (for each maze condition n = 10)

MAZE	TRIAL				TOTAL
	1	2	3	4	
FIGURE 1	1	1	1	1	1
FIGURE 3	1	1	1	1	1
FIGURE 4	1	1	1	1	1
FIGURE 5	1.3	1.3	1	1	1.15

The children found the chocolate bar at the first attempt in all but one of the mazes. This result suggests that seven year-old normal children have a good ability to understand and use a map in this experiment, no matter how the maze is altered. The maze shown in Figure 5 did prove slightly more difficult since the children required a mean of 1.15 attempts to solve the task involving this maze. This finding is similar to the result found in Experiment 2, involving children with learning difficulties.

Results - Experiment 4: The concurrent validity of static measures with BPVS and the predictive validity for static measures of BPVS, age and sex.

The method for Experiment 4 can be seen on pages 92-94. Concurrent validity is considered by examining the relationship between the children's BPVS score and their ability to use a map to find an object in a simple maze (static measures). Predictive validity, for the children's static abilities, of the children's BPVS score, age and sex is assessed by considering whether any of these independent factors can predict the children's static mapping skills. The main aim is to investigate whether children's BPVS scores are related to their ability to use a map when finding an object within a large-scale maze.

The results presented for Experiment 4 are concerned with two areas: Firstly, the effect of the BPVS score and condition (finding and hiding) on static performance and secondly, the predictive ability of the BPVS score, sex and age in relation to the children's experimental scores in the finding and hiding conditions.

The effect of the children's BPVS score and condition on experimental performance were examined in a series of analyses of variance with the condition as a repeated measure (equally weighted means). The predictive validity of BPVS, sex and age was examined by a combination of multiple stepwise regressions and nonparametric correlations.

A summary of the children's BPVS scores and experimental performance within both conditions is presented in Table 5. The overall mean score in the finding condition was 8.27 attempts and in the hiding condition 5.72 attempts. This suggests that the children found the hiding task easier than the finding task. However, these differences between conditions could have resulted from the nature of the hiding condition itself. In the finding trials the experimenter had complete control of where the 'present' was hidden, but in the hiding trials the children were free to select the hiding place of the 'present'. Therefore, in the hiding condition not all boxes were used by the children, as they tended to hide the 'present' in a box which they could successfully identify on the map. This could have made the hiding condition less difficult than the finding condition, because the children seemed to prefer certain boxes as hiding places. Indeed, Table 5 shows that certain boxes in the finding task, such as box 2 and box 3, proved easier hiding places than others. Consequently, no general statement can be made about the relative difficulty of the finding and hiding conditions.

Table 5: Summary of children's performance scores

	Mean	Standard deviation	Min.	Max.	N
BPVS	98.23	12.48	72.00	115.00	22

(a) Finding condition (for each box trial n = 22):

Trial	Mean no. (attempts)	Standard deviation	Min. no. (attempts)	Max. no. (attempts)
Box 1	2.55	1.06	1.00	4.00
Box 2	1.86	1.04	1.00	4.00
Box 3	1.27	0.63	1.00	3.00
Box 4	2.41	1.30	1.00	4.00

(b) Hiding condition:

Trial	Mean no. (attempts)	Standard deviation	Min. no. (attempts)	Max. no. (attempts)	N
Box 1	2.00	1.11	1.00	4.00	19
Box 2	1.35	0.86	1.00	4.00	17
Box 3	1.83	1.10	1.00	4.00	18
Box 4	1.58	0.84	1.00	3.00	19

<u>Concurrent validity: the relationship between the children's I.Q. score and their static ability.</u>

The children's scores in each trial of the finding and hiding conditions were examined using an analysis of variance with the condition as a repeated measure and the BPVS group as the between-subject factor.

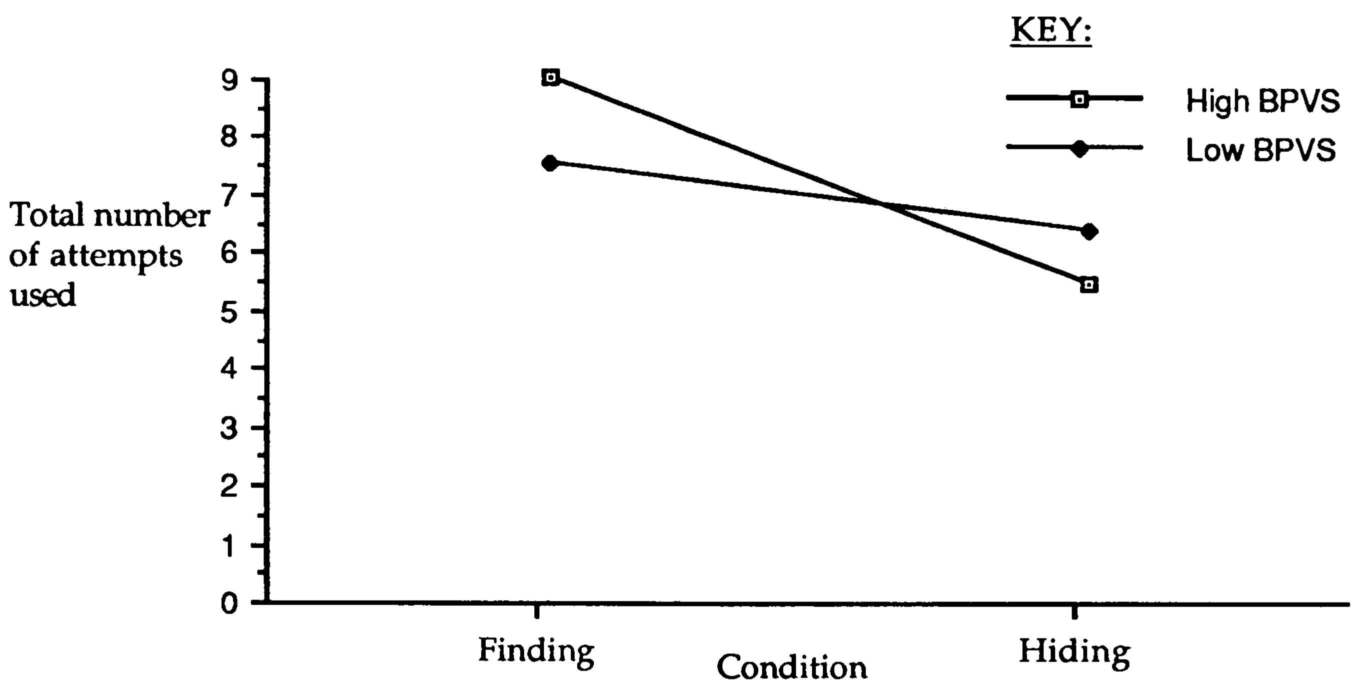
This 2 (BPVS) x 2 (conditions) analysis of variance yielded a main effect of condition - $F(1, 20) = 15.67$, $p < 0.01$ - but no effect of BPVS score group. The finding condition proved appreciably more difficult than the hiding condition; the mean number of attempts used in each condition were 8.09 and 5.73 respectively.

There was also a significant interaction between condition and BPVS score group - $F(1,20) = 4.86$, $p < 0.04$. In the finding condition the high BPVS group needed more attempts than the low BPVS group. However, in the hiding condition the high I.Q. group used noticeably fewer attempts than the low BPVS group (see Table 6 and Figure 6).

<u>Table 6: Mean scores and standard deviation for the high BPVS group and the low BPVS group in the finding and the hiding conditions (for each age group in each condition n = 11).</u>

	BPVS		Total
	High	Low	(n = 22)
Finding Condition	8.82 (2.99)	7.36 (2.46)	8.09
Hiding Condition	5.27 (1.79)	6.18 (1.89)	5.73
Total	7.05	6.77	6.91

Figure 6: Mean score for both BPVS groups in the finding and hiding conditions.



Predictive validity

(i) Finding condition:

The relative importance of the BPVS score, age and sex in predicting the number of attempts used in the finding condition (a static measure) was examined by non-parametric correlations and a stepwise multiple regression. Table 7 indicates that the BPVS score and sex were poor predictors of this static measure of mapping ability. The BPVS score could account for only 4.41 per cent and sex for only 11.56 per cent of the variance in the finding condition. It is clear from Table 7 that age was the best predictor of the children's spatial ability, explaining 20.25 per cent of the variance. The relative significance of each factor is represented in Figure 7.

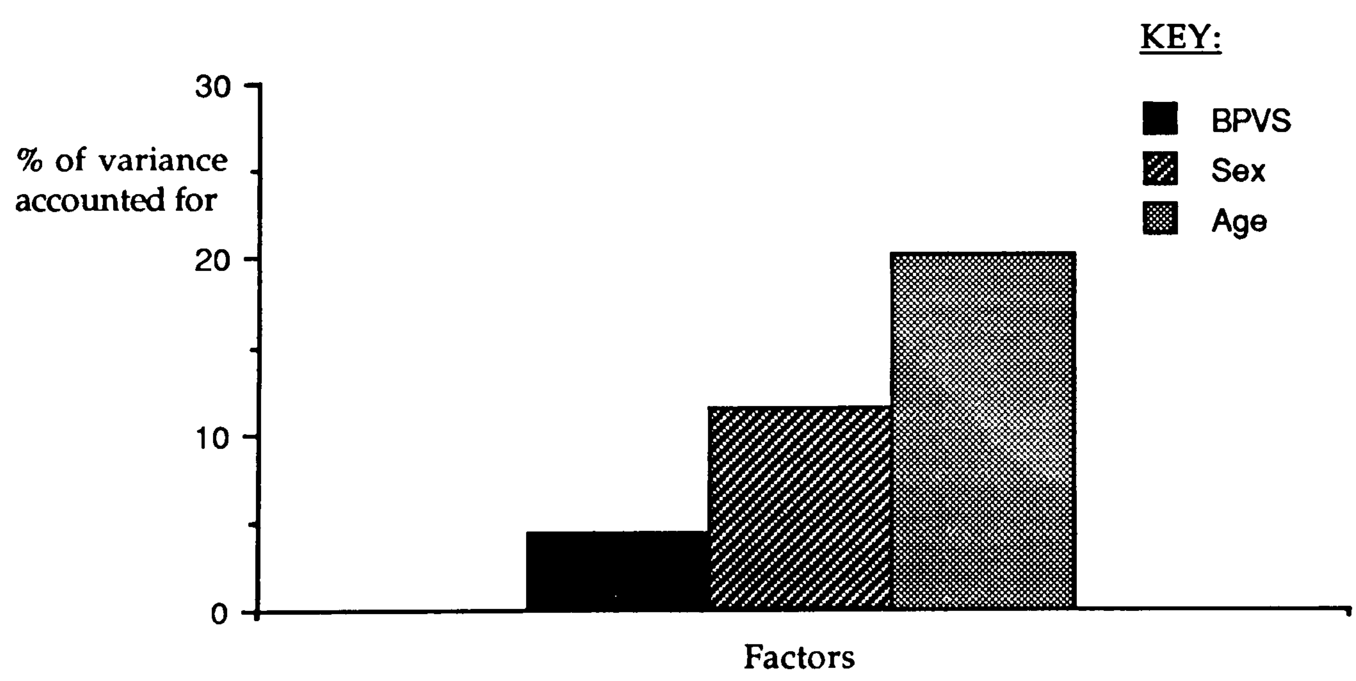
Table 7: The importance of the BPVS score, age and sex in predicting the number of attempts needed in the finding condition.

Factor	r	% reduction in errors of prediction	% variance accounted for
BPVS	0.21	2.00	4.41
AGE	-0.45*	11.00	20.25
SEX	-0.34	6.00	11.56

KEY: * $p < 0.05$; ** $p < 0.01$

The above key will apply to all other tables in this chapter.

Figure 7: Percentage of variance in the children's scores within the finding condition accounted for by their BPVS score, age and sex.



The stepwise multiple regression shown in Table 8 supports the findings above. The BPVS score and sex together could only explain 7.90 per cent of the variance, thus the regression equation they formed was non-significant -

$p = 0.18$. However, when age was added to the regression equation the prediction became significant - $p < 0.01$ - accounting for 34.60 per cent of the variance.

Table 8: Stepwise multiple regression on the number of attempts used in the finding condition using the BPVS score, sex and age as variables.

Variable	F	Multiple R	Rsq.	Increase Rsq.	p
BPVS	0.91	0.00	0.00	0.00	0.35
SEX	1.90	0.28	0.079	0.08	0.18
AGE	4.70	0.59	0.346	0.27	0.01*

(ii) Hiding condition:

The predictive power of the children's BPVS score, age and sex in relation to their performance within the hiding condition was investigated by a set of non-parametric correlations and a stepwise multiple regression.

Table 9: The importance of the children's BPVS score, age and sex in predicting their score within the hiding condition.

Factor	r	% reduction in errors of prediction	% variance accounted for
BPVS	-0.19	2.00	3.61
AGE	-0.59**	19.00	34.81
SEX	0.30	5.00	9.00

The BPVS score and sex proved even worse predictors of the variance in the children's hiding condition scores than in their finding condition scores. Age again was the best factor at explaining the children's mapping ability. Table 9 indicates that the BPVS score and sex accounted for little of the variance, whereas age could explain 34.81 per cent.

The respective importance of the factors in predicting the children's differing test scores is shown in Figure 8.

Figure 8: Percentage of variance in the children's score within the hiding condition accounted for by their BPVS score, age and sex.

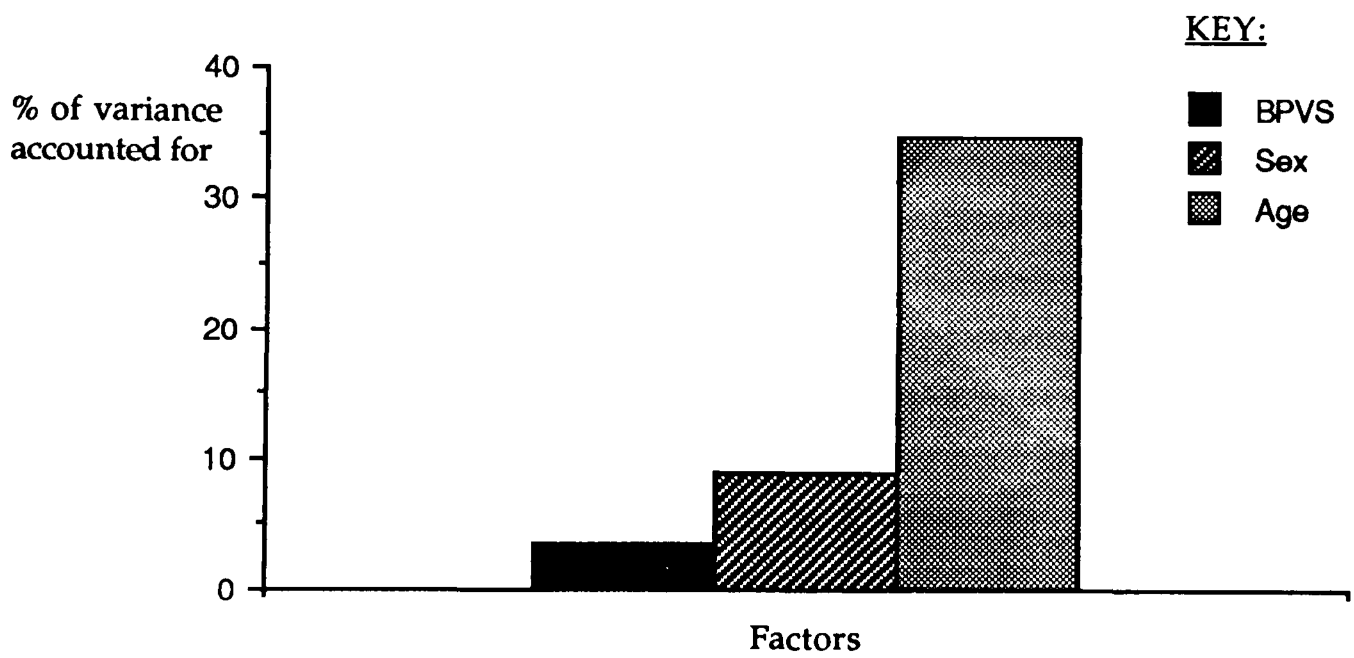


Table 10 presents a stepwise multiple regression on the number of attempts needed in the hiding condition, using the BPVS score, sex and age as factors. This analysis reinforces the findings shown in Table 9, that the BPVS score and sex together were poor predictors of the variance, accounting for only 4.40 per cent of the variation in the children's mapping ability. The regression equation became significant - $p < 0.05$ - with the addition of age as a factor and together these three variables could explain 33.60 per cent of the variance.

Table 10: Stepwise multiple regression on the total number of attempts required in the hiding condition, using the BPVS score, age and sex

Variable	F	Multiple R	Rsq.	Increase Rsq.	p
BPVS	0.75	0.00	0.00	0.00	0.40
SEX	1.49	0.21	0.044	0.04	0.25
AGE	4.53	0.58	0.336	0.30	0.02*

Summary - Experiment 4

Firstly, the children's scores were higher in the finding than in the hiding condition. The finding condition was appreciably more difficult than the hiding condition. No overall effect of BPVS grouping on performance was found, although the high BPVS group performed better in the hiding than in the finding condition. These results suggest that static measures of the children's mapping ability do not have concurrent validity with their BPVS score.

Age proved to be the best predictor of the children's performance in both conditions. The children's BPVS score and sex accounted for very little of the variance. Therefore the BPVS score seems not to possess predictive validity in relation to children's static ability to understand and use a map in a maze.

Discussion

There was a problem with the experimental procedure in Experiment 1. The scoring procedure used in this experiment did not reflect in enough detail the children's ability to understand and use a map. This procedure required the children to complete four or six trials and on each trial the child was told whether they were correct. A different scoring procedure which provided a more thorough measure would be better in future planned experiments. This procedure would note the number of attempts a child needs to find the treasure correctly in each trial. Therefore, if the child makes an incorrect selection of the box the experimenter should tell the child and again identify the correct box on the map. This should continue until all the boxes have been used.

The apparatus used in the experiments requires no alterations, as it performed according to expectations and will be used in future studies. Overall, the experimental procedure of the first experiment proved successful, but certain parts need changing for use in the planned larger series of experiments. The results showed that the children performed equally well in both the finding and hiding variants in Experiment 1 - Condition 1. In future studies, as with Experiments 2 and Experiment 3, children's mapping ability will be assessed by finding tasks as above.

The children with learning difficulties in the Experiment 1 performed fairly well at locating objects in the four box maze, but made many errors with the six box maze. The findings of Experiment 1 add support to previous research (e.g. Borkowski & Cavanaugh, 1979; Brown & Campione, 1978, 1981) which showed that children with learning difficulties have problems transferring their ability to a modified context. Therefore, this experiment suggests that children with learning difficulties have a transfer problem with understanding and using a map, which is worthy of further investigation.

Forthcoming experiments in this thesis which measure children's ZPD will focus further on the transfer problem experienced by children with learning difficulties. These experiments will involve testing the children's transfer skills in various maze environments. The amount of assistance the children needs in solving a transfer task will be examined; since Campione and Brown (1990) suggest that children with learning difficulties require more instruction in problem solving compared to 'normal' children. An insight into the quantity and type of instruction required by children with learning difficulties, when learning to understand and use a map might provide useful information on their potential mapping ability. This type of dynamic assessment will focus on the leading edge of the child's development (Vygotsky, 1978) and could provide practitioners with knowledge beyond that given by static tests of ability and intelligence.

The children found the second maze used in Experiment 1 a significantly more difficult space to map than the first maze. It seems that the addition of two more hiding places in the second maze task made it difficult for the children to understand the spatial relationships. The transfer task in future experiments - which will measure the ZPD - will therefore include six boxes making this task relatively difficult.

Experiment 2 showed that the order of hints used by Bishop (1991) does not gradually increase the assistance given to the children. Bishop's study found no difference between the degree of help provided by the coloured map and the black/white photograph. Experiment 2 suggests that the coloured map is more useful to the children than the black/white photograph, with the coloured photograph providing the most help. Therefore, in the planned larger project the hinting sequence will be altered, with hint 4 (see Appendix) being administered before hints 1, 2, 3 and 5. The findings of Experiment 2 also showed that the children with learning difficulties found the six box maze the most difficult space to map. Future research will examine the value of measuring the ZPD with this six box maze forming a transfer task.

Experiment 3 showed that normal children aged about seven years have relatively good mapping skills. Changing the maze configuration in this experiment did not cause problems for these normal children. This age group is not appropriate for future planned experiments on measurement of children's ZPD, since they they would not require much or any help to reach a perfect level of performance. Therefore, in these future studies the sample of normal children will be drawn from a younger age group, allowing the present spatial task to be retained.

The concurrent validity of static measures with the BPVS scores was questioned by the results of Experiment 4. The children's static measures of mapping ability in both conditions were not significantly related to their general developmental level as indicated by their BPVS scores. The children's BPVS score did not show predictive validity for their mapping skills. The children's age proved to be the best indication of the their map reading ability. This result was in line with the experimental findings of Chapter 2, that age was a significant predictor of children's ability to understand and use a map.

Experiment 1 showed children with learning difficulties have problems transferring their mapping ability from one context to another. This experiment demonstrated the need to investigate further the transfer problems faced by children with learning difficulties when using a map. The second experiment showed that seven year old normal children are not suitable subjects for the planned studies on the measurement of the ZPD. The third study suggested that the sequence of hints used by Bishop (1991) needs alteration, to achieve increasing explicitness in the hinting order for planned research. Experiment 3 also demonstrated that the six box task would be a good transfer task in future research. The final study, Experiment 4, showed that investigation of the concurrent validity of ZPD measures with the children's I.Q. score (as a measure of general intelligence) and the predictive validity of static and dynamic measures for the children's improvement between a pretest and posttest, all within a spatial task, might be a fruitful exercise.

The experiments in this chapter have helped clarify: the details of the method, such as apparatus and procedure; the choice of sample age; the choice of transfer task and the hinting sequence for planned research. In addition, the final study suggested that the children's static measures do not have concurrent validity with their general developmental level and BPVS scores do not show predictive validity for the static measures of mapping ability. Future research should involve: a larger sample; a slightly altered method, sample and order of hints. This research should examine the value of measuring the ZPD within tasks that require the transfer of mapping ability.

Chapter 6

Measuring the Zone of Proximal Development

Summary

The object of the studies reported in this chapter is to test Vygotsky's assumption that the assessment of a child's response to instruction provides important diagnostic information, beyond that obtained by static intelligence tests. Previous research has shown that measurement of the ZPD is a useful technique when assessing the intelligence of children. The aim of this chapter is to improve upon this research in two ways. Firstly, by evaluating Vygotsky's theory in a task not found in traditional I.Q. tests, namely a mapping task. Secondly, to investigate the relevance of Vygotsky's assumption to children with learning difficulties. Analysis found that Vygotsky's point was also pertinent in a less scholastic mapping task and applicable in the case of children with learning difficulties. This study shows that a Vygotskian approach could help improve the ability of educational psychologists to predict the future development of children with learning difficulties and of 'normal' children.

Introduction

Vygotsky (1978) criticized traditional paedological testing for only examining the products of development, while failing to capture children's potential ability. He proposed that one should measure the child's 'zone of proximal development' (ZPD), the difference between what a child can do independently and while receiving assistance. Assessing the ZPD as opposed to applying standardised tests would allow an insight into the "buds or flowers of development rather than the fruits of development" (Vygotsky, 1978, p. 86).

Previous research has used dynamic assessment techniques to measure the ZPD (Campione & Brown, 1990; Campione et al, 1985 ; Ferrara et al, 1986). However, the tasks used in these studies, namely inductive reasoning problems, were sub-scales of I.Q. tests. This may have led to the relative importance of I.Q. being overestimated when predicting the children's potential performance. In addition, no study has examined the value of measuring the ZPD in children with learning difficulties. Therefore, the studies in this chapter specifically aimed to investigate whether Vygotsky's assumption about the usefulness of the ZPD in assessment was also relevant in the following cases: firstly, when 'normal' children solved a mapping tasks appreciably different from those found in standardised I.Q. tests; and secondly when children with learning difficulties had to complete the same mapping task tackled by the 'normal' children. A preliminary study presented in Chapter 5 has shown that static measures of children's mapping ability lack concurrent validity with indicators of general developmental level (BPVS scores) and BPVS scores show no predictive validity for children's mapping skills. The focus of the experiments in this chapter, like those described by Campione & Brown (1987), will be: the concurrent validity of static and dynamic measures with the children's I.Q. and the predictive validity of static measures, dynamic measures and I.Q. for the children's improvement between pretest and posttest. The first experiment will examine these two forms of validity among children with learning difficulties and the second experiment will do the same with 'normal' children. The final experiment will evaluate the concurrent validity of static and dynamic measures with the children's intelligence as indicated by the school which they attend.

Method

- Apparatus

The major piece of apparatus consisted of a 2.4m x 1.2m x 1.2m collapsible house-like maze. Each wall in the maze was covered with different coloured paper as shown in Figures 1, 2, 3 and 4. Four or six cardboard boxes were placed in various positions inside the maze. The cardboard boxes measured 27cm x 22cm x 21cm and each box was covered in different coloured paper: red, blue, yellow, orange, green and peach. Figures 1, 2, 3 and 4 show the colour of the boxes inside each maze.

The children were given black and white maps and coloured maps (both with a scale 1:15) - see maps 1-8 in the appendix - of all the mazes shown in Figures 1, 2, 3 and 4. In addition they could also use, if necessary, black and white photographs and coloured photographs (both with a scale 1:15) - see photographs 1-8 in the appendix - of the mazes in Figures 1, 2, 3 and 4. The black and white photographs, the coloured maps and the coloured photographs were used as hints within the experiment (see hinting sequence in the appendix). There were three toys and a small multi-coloured box called a 'present' to hide inside the boxes in the mazes shown by Figures 1, 2 and 3. When the maze in Figure 4 was used five toys and the 'present' were hidden. The children used a chair to sit on while the experimenter hid the 'present'.

- Subjects

EXPERIMENT 1:

Twenty six children with learning difficulties (14 boys, 12 girls) were selected from a special needs school in Central Region, Scotland. The older children had a mean age of 12; 8 (n = 13, range 14; 5 - 12; 1) and the younger children had a mean age of 11;7 (n = 13, range 12; 0 - 11; 0). The children were also divided into two I.Q. groups: those with a high I.Q. (n = 13, mean I.Q. = 71, range 86 - 65) and those with an average I.Q. (n = 13, mean I.Q. = 58, range 62 - 51) - * see Appendix. The I.Q. score was estimated from two subtests, Block Design and Vocabulary, of the WISC-R (Scottish Edition). The subjects were also split into two more groups; the children with a high block design score (n = 13, mean score = 25, range 43 - 15) and the children with a low block design score (n = 13, mean score = 9, range 14 - 0). In addition, another two groups of children existed; those children with a high vocabulary score (n = 13, mean score = 19, range 26 - 16) and those children with a low vocabulary score (n = 13, mean score = 10, range 15 - 3)..

EXPERIMENT 2:

Twenty six mainstream children (14 boys, 12 girls) were involved in this experiment. They came from a primary school in Central Region, Scotland. The older children had a mean age of 5; 10 (n = 13, range 5; 6 - 6; 3) and the younger children had a mean age of 5; 4 (n = 13, range 5; 3 - 5; 5) The high I.Q. group of children had a mean I.Q. of 106 (n = 13, range 115 - 97), while the average I.Q. children showed a mean I.Q. of 86 (n = 13, range 96 - 64) - ** see Appendix. The I.Q. score was calculated from two subtests, Block Design and Vocabulary, of the WIPPSI. There were children with a high block design score (n = 13, mean score 16, range 19 - 14) and children with a low block design score (n = 13, mean score 9, range 13 - 4). Additionally there were children with a high vocabulary score (n = 13, mean score 21, range 28 - 15) and children with a low vocabulary score (n = 13, mean score 12, range 14 - 6).

EXPERIMENT 3:

Fifty two children took part in this experiment: twenty six mainstream children and twenty six children with learning difficulties. These two groups of children had differing I.Q. scores and ages, but were approximately equivalent in initial task performance. The mainstream children came from a primary school in Central Region, Scotland. They had a mean age of 5; 7 (range 6; 3 - 5; 4) and a mean WIPPSI I.Q. score of 96.3 (range 115 - 64). The children with learning difficulties attended a special needs school in Central Region, Scotland. This group had a mean age of 12; 1 (range 14; 5 - 11; 0) and a mean WISC-R (Scottish Edition) I.Q. score of 64.6 (range 86 - 51).

- Procedure

The procedure described below was used in all three experiments within this chapter.

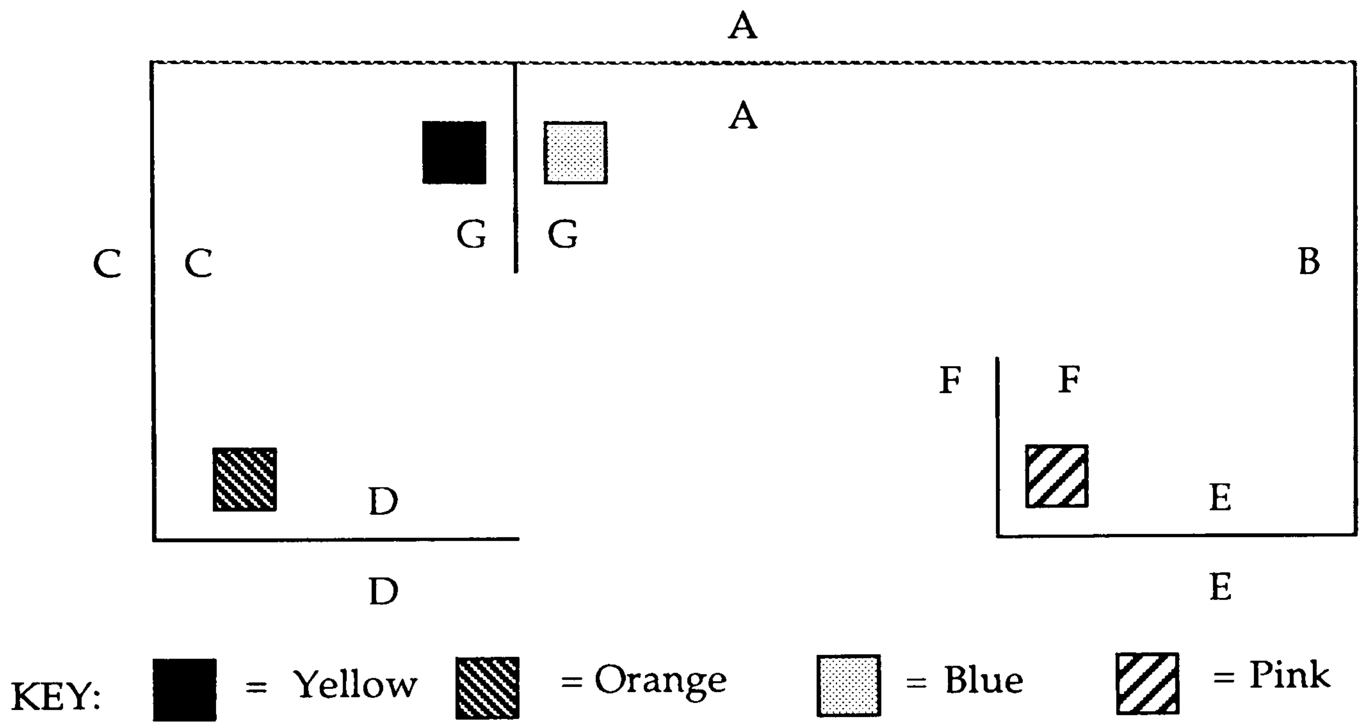
Initially all children were administered a short form I.Q. test, involving two subtests, the block design and the vocabulary, of either the WISC-R (Scottish Edition) or the WIPPSI (American Edition). Each child's I.Q. score was obtained by partialing out his or her age. The block design and vocabulary scores were not norm measures like I.Q, but raw scores. The children were tested individually and each session took approximately twenty minutes.

ORIENTATION PHASE

Every experimental session began with an orientation phase. The toys and the 'present' were shown to the child, and it was emphasised several times that she would have to find the 'present' inside the maze after the experimenter had hid it in a box. This was called a treasure hunt. The experimenter described a black and white map (see maps 1-4 in the appendix) as a picture that could help the child find things within the maze.

Then the experimenter placed the 'present' in box 3 (see Figure 1) and showed the child the position of box 3 on the map by drawing a cross on this box. Then the 'present' was put inside box 2 by the experimenter and the child was asked to identify box 2 on the map. If the child was incorrect, the experimenter showed the child the correct box on the map.

Figure 1: Maze used in the static pretest, posttest and dynamic training phase



A = Red; B = Blue; C = Green; D = Brown; E = Orange; F = Purple; G = Black

The above key also applies to Figure 2 and Figure 3.

THE EXPERIMENTAL PHASE

Immediately after the orientation phase ended the main experiment began. The experiment was run in five phases: pretest, training, maintenance, transfer and posttest. Each phase took approximately a week and they were completed one after the other; except there was a seven week gap between the pretest and training phases, due to a school holiday and the testing of the hinting sequence (see appendix) in Experiment 1 and the school summer holiday in Experiment 2. The children were initially given a black and white map (see maps 1-4 in the appendix) at the beginning of each static stage of the experiment.

(a) Static pretest

The child received no hints within this test. This was a simple standardised test in which each child was provided with a black and white map. The experimenter hid the 'present' in one of the four boxes and the toys in the other boxes, then he showed the child the box on a map (see map 1 in the appendix) where the 'present' was hidden by marking it with a 'X'. The child was asked to find the box with the 'present' inside and bring it to the experimenter. The child was allowed to take the map during the search. If the child choose an incorrect box the experimenter replaced the wrong box and again showed the child on the map the box with the 'present' inside asking the child to try again. The child was allowed a maximum of four attempts in each trial. Overall, this procedure was repeated on three more occasions as each child had to complete four trials. Each trial used a different box as the hiding place. The ordering of the hiding places across the trials was randomised. The number of attempts needed by each child to find the 'present' correctly for each of the four hiding places was noted. The maze used in this phase is shown in Figure 1.

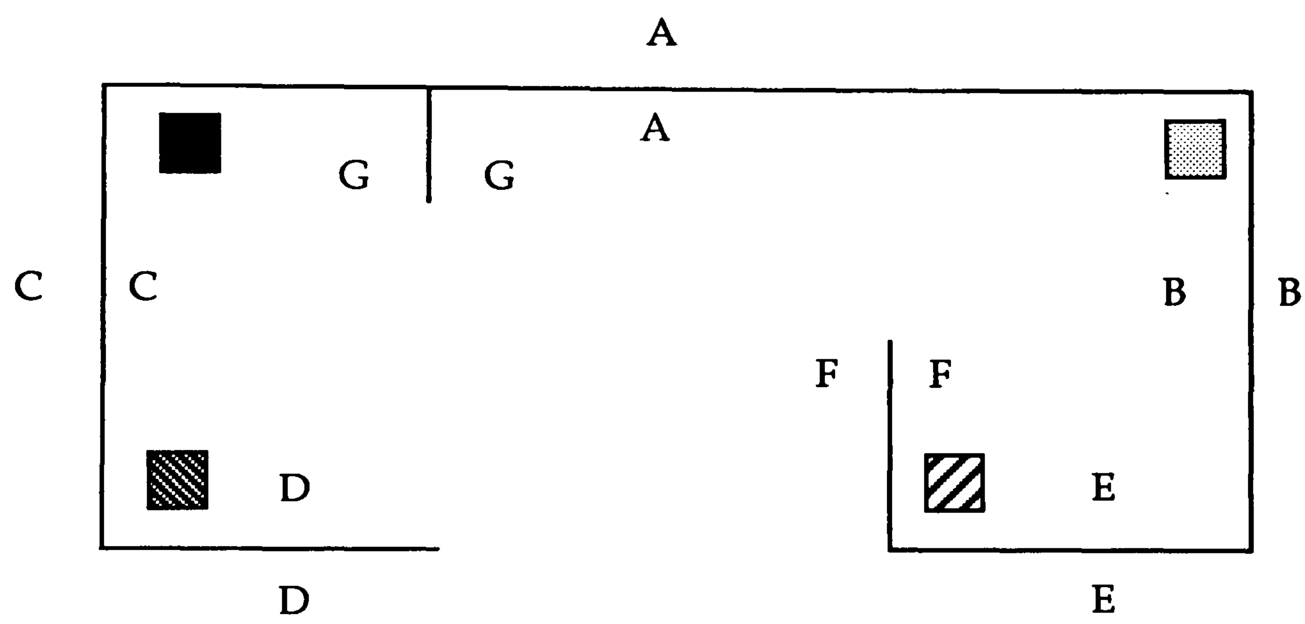
(b) Dynamic training phase

The procedure used in this session was exactly the same as in the pretest, except that the children were given hints if they made an error in any of the four trials in the pretest. This help was given according to a pre-planned hinting procedure. However, it was emphasised that they should try to do the task with the least number of hints. A series of five hints, ranging from general to specific, was administered in a predetermined order. The collection of hints used in this phase can be seen in the appendix. When the subject correctly found the 'present' after receiving a hint, the 'present' was put in a different box and the same hint was re-administered; this was a double check against the possibility that the success of the hint might be due to the specific location of the box in the maze and the hint used in the first attempt. The children had to correctly find the 'present' in each of the four boxes consecutively without receiving any extra hints before reaching the criterion level of this stage. The experimenter noted the number of hints used by each child. Figure 1 show the maze used in this phase.

(c) Static and dynamic maintenance phase

This phase of the experiment contained both a static and dynamic task. The static task was the same as the pretest (see page 115) in as much as no hints were given to the children, but the children were required to find the 'present' inside a box within the novel mazes shown in Figure 2 (maintenance-1) and Figure 3 (maintenance-2). The children who made errors in this static task were then given the dynamic task.

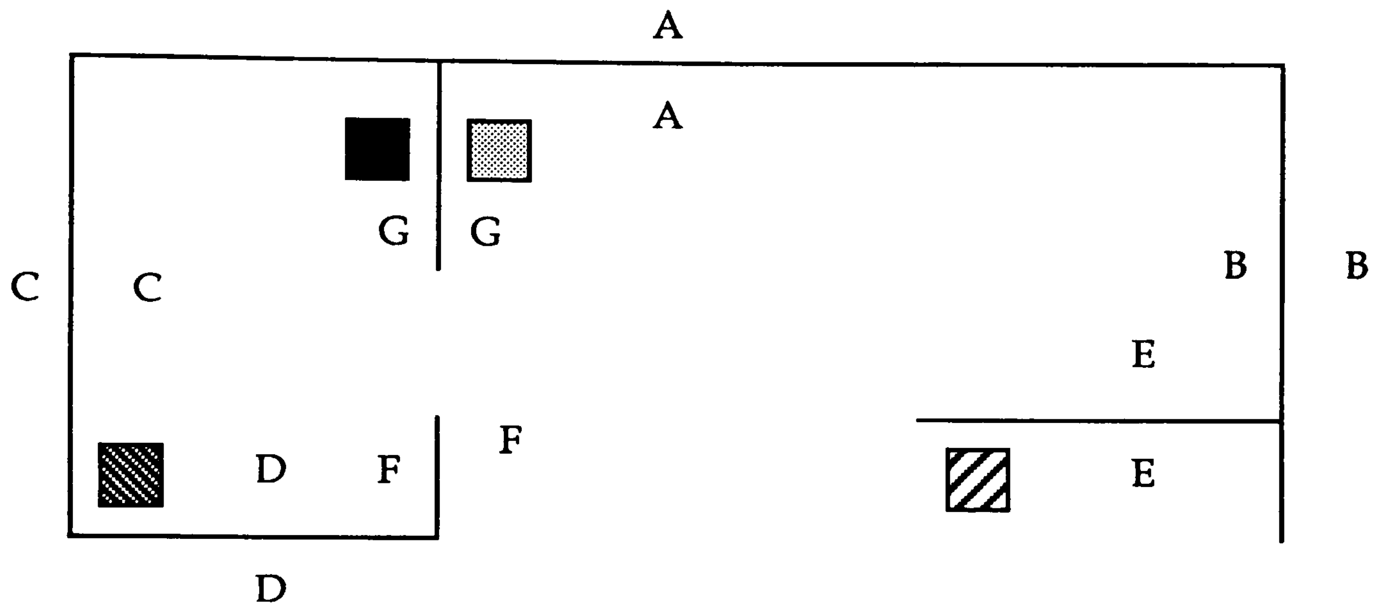
Figure 2: Maze used in the maintenance-1 phase



The use of the term 'maintenance-1' and maintenance-2' in future tables refers to the first and second maze tasks used in the maintenance phase.

The dynamic task was the same as the training stage (see page 115), in as much as the children were given hints, but the task was conducted using the unfamiliar mazes shown in Figure 2 and Figure 3. The hinting sequence used in their dynamic task can be seen in the appendix. The experimenter noted the number of hints the child needed to reach the criterion which was to find the 'present' correctly in the four boxes without receiving additional hints.

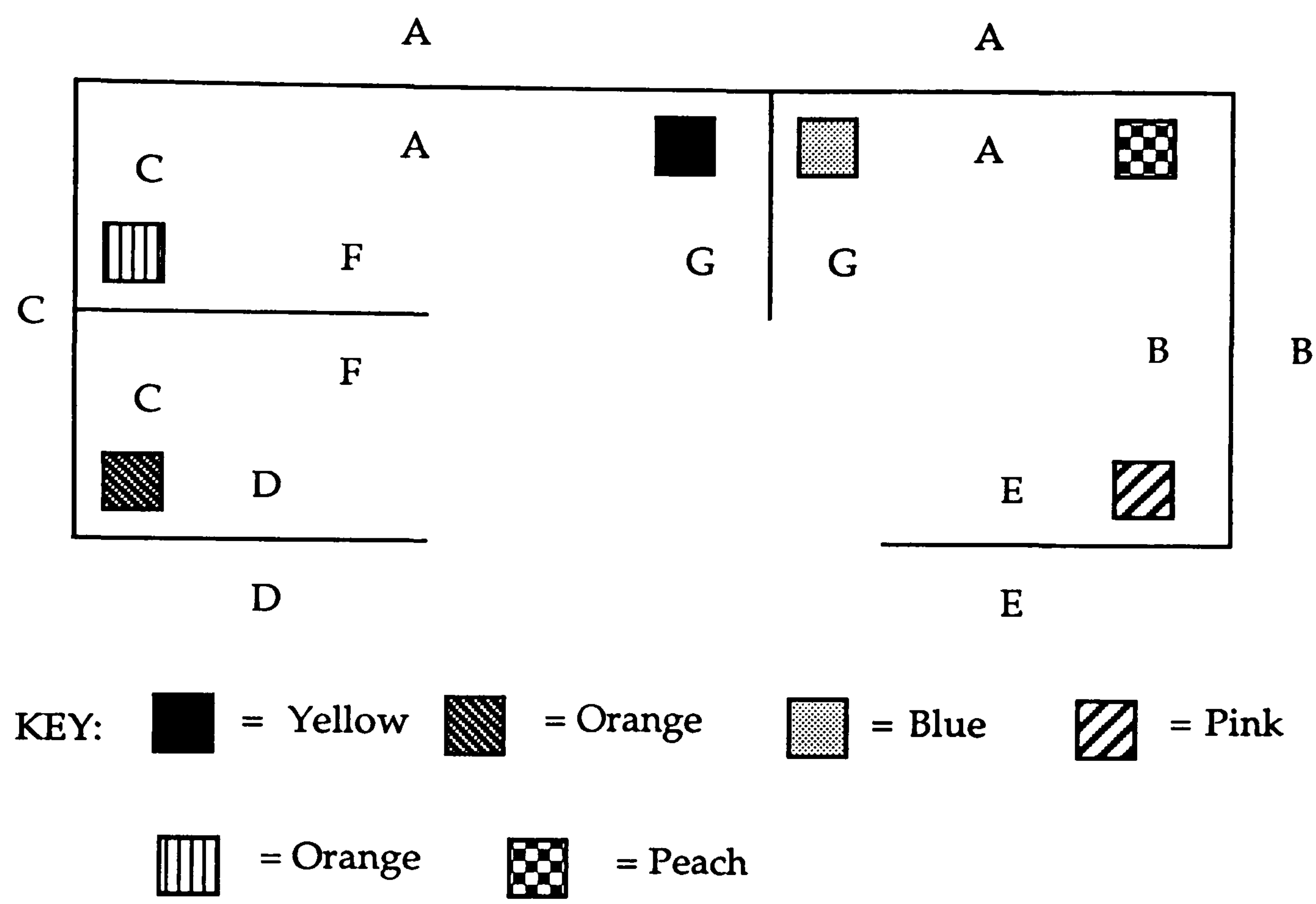
Figure 3: Maze used in the maintenance-2 phase



(d) Static and dynamic transfer phase

The transfer phase involved static and dynamic tasks and the maze in Figure 4 was used during the whole phase. The procedure in the static task was the same as the pretest (see page 115): the children were not given help and had to find the 'present' inside a box in the maze with only the use of a black and white map (see map 4 in the appendix). Children who made errors in the static task were then given the dynamic task, in which they were given hints. The hints were given in a predetermined sequence which is shown in the appendix. The number of hints a child needed to locate the 'present' successfully four times consecutively without any new hint was noted.

Figure 4: The maze used in the transfer phase



A = Red; B = Blue; C = Green; D = Brown; E = Orange; G = Black

(e) Static posttest:

This test involved a repetition of the pretest (see page 115).

All sessions were video-recorded to help the recording of data.

Results - Experiment 1: Measuring the ZPD among children with a learning difficulty

The method for Experiment 1 can be seen on pages 111-118.

This experiment is interested in the concurrent validity of the static and dynamic measures with indicators of the children's general developmental level and the predictive validity of I.Q., the static and dynamic measures for the improvement between pretest and posttest. Concurrent validity is investigated by considering the relationship between the ability indices of

I.Q. and age and the following measures: (1) the number of attempts needed in the pretest; (2) the number of attempts required across the maintenance and transfer phases; (3) the number of hints used to reach criterion in the training session; (4) the number of hints needed across the dynamic maintenance and transfer phases. Predictive validity is examined by assessing the relative importance of the I.Q. score, the static measures and the dynamic measures in predicting the change in performance between the pretest and posttest sessions.

A series of analyses of variance investigated the effect of I.Q. and age on: (1) the number of attempts needed in the pretest; (2) the number of hints required to reach criterion in the training session; (3) the number of attempts needed in the static maintenance, transfer phases; (4) the number of hints required to reach criterion in the dynamic maintenance, transfer phases; (5) the number of hints needed individually in each test of the maintenance phase and the transfer phase. Stepwise multiple regressions and nonparametric correlations are examined to see whether I.Q. alone could predict the changes between pretest and posttest, or whether the static and the dynamic measures were useful in accounting for the changes between pretest and posttest.

A summary of the children's performance at each stage of the experiment is given in Table 1 overleaf. The children in the static and dynamic parts of the maintenance phase needed fewer attempts and fewer hints than in the static pretest and the dynamic training phases respectively. However, in the static and dynamic parts of the transfer stage the children required more attempts and hints than in the static and dynamic tests of the maintenance phase. The children showed an improvement between the pretest and the posttest, with means of 6.46 attempts in the pretest and 5.12 attempts in the posttest. This is a decrease in the mean number of attempts between the pretest and the posttest of 1.35.

Table 1: Summary of the children's performance measures

	Mean	Standard Deviation	Min.	Max.
I.Q.	64.62	8.51	51.00	86.00
Block design Subtest	17.08	10.94	0.00	43.00
Vocabulary Subtest	14.58	5.70	3.00	26.00

Static measures (number of attempts):

	Mean	Standard Deviation	Min.	Max.
Pretest	6.46	3.72	4.00	16.00
Maintenance-1	6.12	3.35	4.00	15.00
Maintenance-2	5.58	3.67	4.00	16.00
Transfer	6.27	3.41	4.00	16.00
Posttest	5.12	2.85	4.00	16.00

Dynamic measures (number of hints to criterion):

	Mean	Standard Deviation	Min.	Max.
Training	1.00	1.17	0.00	4.00
Maintenance-1	0.77	1.11	0.00	4.00
Maintenance-2	0.42	0.70	0.00	2.00
Transfer	0.92	1.02	0.00	3.00

Concurrent validity: the relationship between learning, transfer and intelligence.

(1) Static measures

(a) Pretest:

The pretest was a test of the children's initial performance before the learning session. It measured the number of attempts needed across four trials. This dependent variable was examined by a 2 (I.Q.) x 2 (age) x 1 (pretest) analyses of variance (equally weighted means), with the I.Q. grouping and age grouping as the between-subject variables. This can be seen in Table 2.

Table 2: A 2 (I.Q.) x 2 (age) x 1 (pretest) analysis of variance with I.Q. grouping and age grouping as the between-subject variables.

	df	F-Factor	p
I.Q.	1,22	5.47	0.03*
AGE	1,22	0.05	0.83
I.Q./AGE	1,22	0.00	0.97

KEY: * $p < 0.05$; ** $p < 0.01$

The above key is applicable to all the other tables in this results section.

An effect of I.Q. is evident in Table 2. The average I.Q. children needed significantly more attempts in the pretest than the high I.Q. children - $F(1,22) = 5.47$, $p < 0.05$. There was no age effect, as the younger children did not need significantly more attempts in the pretest compared to the older children. Generalising from this 2 (I.Q.) x 2 (age) x 1 (pretest) ANOVA is difficult, because it was based on an unbalanced experimental design which could result in some factors being partially confounded (Macdonald, 1991a, 1991b).

Therefore, two 2 (I.Q. or age) x 1 (pretest) analyses of variance (equally weighted means) were calculated on balanced designs. The I.Q. grouping or age grouping was used as the between-subject variable in each of these ANOVAs and the pretest score was the within-subject variable in both the ANOVAs.

The first 2 (I.Q.) x 1 (pretest) ANOVA, with the I.Q. grouping as the between-subject variable found an I.Q. effect. The average I.Q. children required significantly more attempts in the pretest than the high I.Q. children - $F(1, 24) = 6.57$, $p < 0.05$. This is clear from Table 3.

Table 3: Mean number of attempts and standard deviations for the high I.Q. and average I.Q. children in the pretest (for each I.Q. group n = 13)

	I.Q. group		Total
	High	Average	(n = 26)
Pretest	4.77 (1.54)	8.15 (4.51)	6.46

The second 2 (age) x 1 (pretest) ANOVA, with the age grouping as the between-subject variable, found no significant difference between the performance of the older and younger children - $F(1, 24) = 0.53$, $p = 0.47$.

Analyses of variance (equally weighted means) were conducted using either the block design raw score or vocabulary raw score grouping as the between-subject variable and the pretest score as the within-subject variable. The first 2 (block design) x 1 (pretest) ANOVA, with the block design grouping as the between-subject factor, found no significant difference between the pretest performances of the high block design and the average block design groups - $F(1, 24) = 0.27$, $p = 0.61$. The second 2 (vocabulary) x 1 (pretest) ANOVA, with the vocabulary grouping as the between-subject variable, found no significant difference in pretest score between the high vocabulary and average vocabulary groups - $F(1, 24) = 0.22$, $p = 0.65$. Therefore, the raw scores from the block design and vocabulary subtests of the norm referenced I.Q. score were not significantly related to the children's performance in the pretest.

(b) Static maintenance and transfer:

The effect of I.Q. and age on the number of attempts needed in the maintenance and transfer phases was examined in a series of analyses of variance, with the static scores in the two maintenance tests and the one transfer test as the repeated measures. A 2 (I.Q.) x 2 (age) x 3 (maintenance-1, maintenance-2 and transfer) ANOVA (equally weighted means) was performed, with the I.Q grouping and age grouping as the between-subject variables and the number of attempts needed the maintenance and the transfer phases as the within-subject variable (see Table 4). The within-subject variable in this ANOVA had three levels, the two tests in the maintenance phase and the one test in the transfer phase.

Table 4: A 2 (I.Q.) x 2 (age) x 3 (maintenance and transfer tests) ANOVA with the tests in the maintenance and transfer phases as the repeated measures, using the I.Q. grouping and age grouping as the between-subject variables.

	df	F-Factor	p
I.Q.	1, 22	4.91	0.04*
AGE	1, 22	0.02	0.90
I.Q./AGE	1, 22	0.48	0.50
TESTS	2, 44	0.72	0.49
TESTS/I.Q.	2, 44	0.01	0.99
TESTS/AGE	2, 44	0.11	0.90
TESTS/I.Q./AGE	2, 44	0.62	0.54

The above ANOVA shows that the two I.Q. groups differed significantly in their performance across the maintenance and transfer phases - $F(1, 22) = 4.91$, $p < 0.05$. No other effects are evident in this analysis. However, interpretation of this ANOVA is complicated because it was a based on an unbalanced design, so allowing for the possibility of a partial confounding of effects.

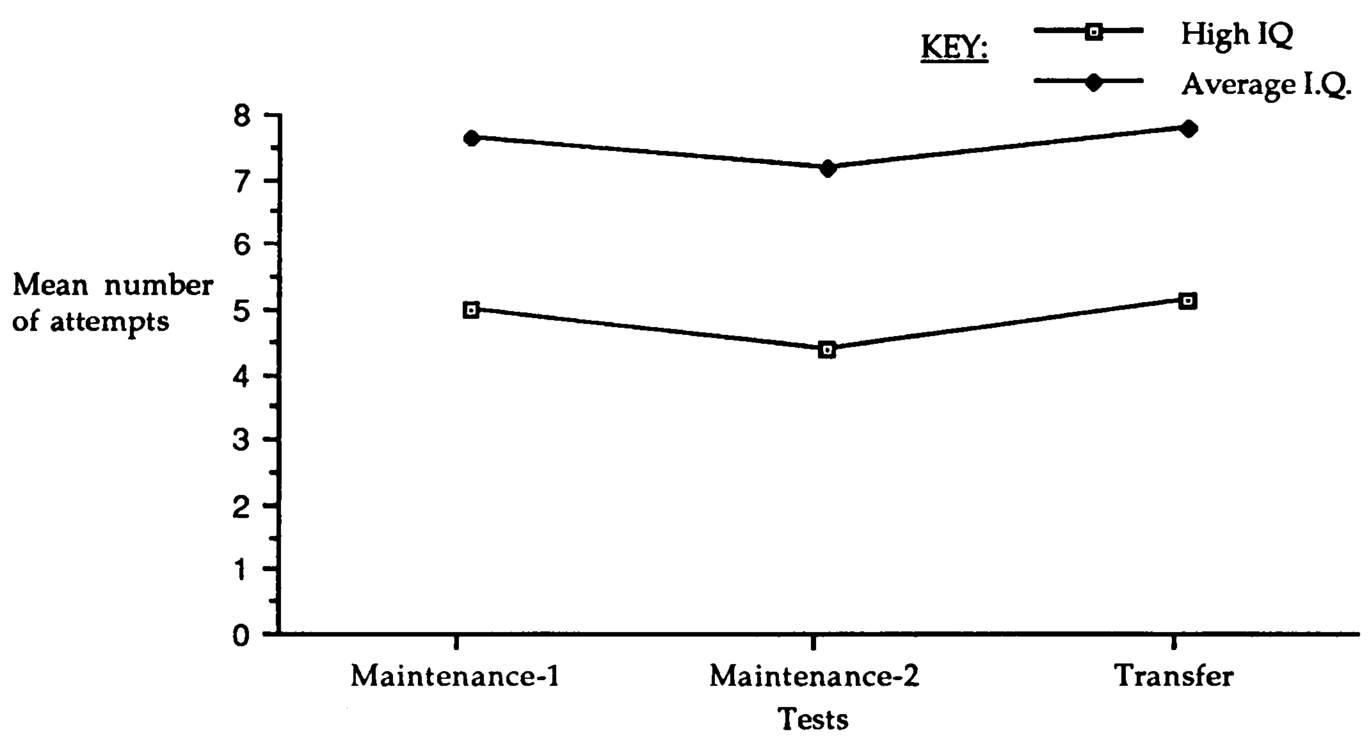
To avoid the above problem two 2 (I.Q. or age) x 3 (maintenance-1, maintenance-2, transfer) ANOVAs (equally weighted means) were calculated on balanced designs. These ANOVAs used the number of attempts needed in the static tests of the maintenance and transfer phases as the repeated measures and either the I.Q. grouping or the age grouping as the between-subject factor. The first 2 (I.Q.) x 3 (maintenance and transfer tests) ANOVA with the I.Q. grouping as the between-subject variable, found that the two I.Q. groups differed in their performance across the maintenance and transfer phases - $F(1, 24) = 5.70$, $p < 0.05$. The average I.Q. children needed significantly more attempts in maintenance and transfer phases than the high I.Q. children. This is shown in Table 5.

Table 5: Mean number of attempts used and standard deviations for the high I.Q. and average I.Q. children in two maintenance phase tests and the one transfer phase test (for each I.Q. group in each test n = 13).

Test	I.Q. group High	Average	Total (n = 26)
Maintenance-1	4.77 (1.36)	7.46 (4.20)	6.12
Maintenance-2	4.15 (0.38)	7.00 (4.85)	5.58
Transfer	4.92 (1.85)	7.62 (4.11)	6.23
Total	4.62	7.36	5.99

The differences between the I.Q. groups in the maintenance and transfer phases were examined in more detail by some univariant analyses of variance. A 2 (I.Q.) x 1 (maintenance-1) ANOVA, with the I.Q. grouping as the between-subject variable and the number of attempts needed in the first test of the maintenance phase as the within-subject variable, found a significant difference between the two I.Q. groups - $F (1, 24) = 4.84$, $p < 0.05$. Table 5 shows that in this test the average I.Q. children used significantly more attempts than the high I.Q. children. Another 2 (I.Q.) x 1 (maintenance-2) ANOVA, with the I.Q. grouping as the between-subject variable and the number of attempts required in the second test of the maintenance phase as the within-subject variable, also found a significant difference between the I.Q. groups - $F (1, 24) = 4.45$, $p < 0.05$. Again the average I.Q. children used significantly more attempts in this test than the high I.Q. children. A significant I.Q. effect was also evident in the transfer phase - $F (1, 24) = 4.63$, $p < 0.05$. This was calculated by a 2 (I.Q.) x 1 (transfer) ANOVA, with the I.Q. grouping as the between-subject factor and the number of attempts needed in the static transfer phase as the within-subject factor. The average I.Q. children used significantly more attempts in the transfer phase than the high I.Q. children. The difference in performance across the maintenance and transfer phases between children with a high I.Q. children and average I.Q. children can be seen in Graph 1.

Graph 1: Mean number of attempts needed in the maintenance and transfer phases by high I.Q. children and average I.Q. children



A 2 (age) x 3 (maintenance and transfer tests) ANOVA was calculated, with the two tests in the maintenance phase and the one test in the transfer phase as the repeated measures and the age grouping as the between-subject variable. This ANOVA found no significant differences between the older and the younger children - $F(1, 24) = 0.39$, $p = 0.54$.

Two 2 (block design or vocabulary) x 3 (maintenance and transfer tests) analyses of variance were calculated with the two tests in the maintenance phase and the one test in the transfer phase as the repeated measures and the block design or the vocabulary groupings as the between-subject variable. A 2 (block design) x 3 (maintenance and transfer tests) ANOVA using the block design grouping as the between-subject variable, found no significant differences between the high block design children and the average block design children - $F(1, 24) = 0.39$, $p = 0.54$. A 2 (vocabulary) x 3 (maintenance and transfer tests) ANOVA using the vocabulary grouping as the between-subject variable found no vocabulary effect - $F(1, 24) = 0.25$, p =

0.62. Therefore, the block design and vocabulary measures are not significantly related to the maintenance and transfer measures.

(2) Dynamic measures

(a) Learning efficiency:

The number of hints needed by each child to reach criterion in the training phase served as an index of each child's efficiency of learning. This dependent measure was examined by a 2 (I.Q.) x 2 (age) x 1 (dynamic training score) analysis of variance (equally weighted means), with the I.Q. and age groupings as the between-subject variables. This is shown in Table 6.

Table 6: A 2 (I.Q.) x 2 (age) x 1 (dynamic training score) analysis of variance, using the I.Q. and age groupings as the between-subject variables.

	df	F-Factor	p
I.Q.	1, 22	12.88	0.00**
AGE	1, 22	0.19	0.66
I.Q./AGE	1, 22	0.00	1.00

The above ANOVA found an I.Q. grouping effect - $F(1, 22) = 12.88$, $p < 0.01$. The average I.Q. children required significantly more hints to satisfy criterion in the training phase than the high I.Q. children. However, drawing conclusions from this ANOVA is problematic because it used an unbalanced design.

Therefore, two 2 (I.Q. or age) x 1 (dynamic training score) ANOVAs were conducted using balanced designs, so eliminating the possibility of any partial confounding of effects. The first 2 (I.Q.) x 1 (dynamic training score) ANOVA, using the I.Q. grouping as between-subject variable and the number of hints to criterion in the training phase as the within-subject variable, found a significant I.Q. effect - $F(1, 24) = 13.89$, $p < 0.01$. The average I.Q. children used significantly more hints to obtain the criterion level in the training phase than the high I.Q. children. This is shown in Table 7.

Table 7: Mean number of hints to criterion in the training phase and standard deviations for high I.Q. children and average I.Q. children (for each I.Q. group n = 13)

	I.Q. group		Total
	High	Average	(n = 26)
Training phase	0.31 (0.48)	1.70 (1.25)	1.00

The second 2 (age) x 1 (dynamic training score) ANOVA, with the age grouping as the between-subject factor and the number of hints to criterion in the training phase as the within-subject factor, found no significant age effect - $F(1, 24) = 0.11$, $p = 0.74$.

Two analyses of variance were conducted, using either the block design or the vocabulary groupings as the between-subject variable and number of attempts to criterion in the training phase as within-subject variable. The first 2 (block design) x 1 (dynamic training score) ANOVA, with the block design grouping as the between-subject factor, found no significant difference between the high block design group and the average block design group - $F(1, 24) = 1.87$, $p = 0.18$. There was also no vocabulary effect - $F(1, 24) = 0.11$, $p = 0.74$ - according to a 2 (vocabulary) x 1 (dynamic training score) ANOVA, with the vocabulary grouping as the between-subject variable.

(b) Dynamic maintenance and transfer:

A collection of analyses of variance with the two dynamic tests in the maintenance phase and the one test dynamic test in the transfer stage as the repeated measures examined the effect of I.Q. and age. Initially, a 2 (I.Q.) x 2 (age) x 3 (dynamic maintenance and transfer measures) ANOVA (equally weighted means) was calculated with the I.Q. and age groupings as the between-subject variables. This ANOVA can be seen in Table 8 overleaf.

Table 8: A 2 (I.Q.) x 2 (age) x 3 (dynamic maintenance and transfer scores) analysis of variance using both tests of the maintenance phase and the test of the transfer phase as repeated measures, with the I.Q. and age groupings as the between-subject factors.

	df	F-Factor	p
I.Q.	1, 22	6.47	0.02*
AGE	1, 22	0.00	1.00
I.Q./AGE	1, 22	0.16	0.69
TEST	2, 44	3.09	0.05
TEST/I.Q.	2, 44	0.56	0.58
TEST/AGE	2, 44	0.10	0.90
TEST/I.Q./AGE	2, 44	0.23	0.80

The ANOVA in Table 8 calculated a significant difference between the performance of the two I.Q. groups in the maintenance and transfer phases - $F(1, 22) = 6.47$, $p < 0.05$. The average I.Q. children needed significantly more hints to satisfy the criterion in the maintenance and transfer phases compared to the high I.Q. children. There was no significant difference between the children's performances in both tests of the maintenance phase and the test of the transfer phase - $F(2, 44) = 3.09$, $p = 0.05$. However, the ANOVA in Table 8 was based on an unbalanced design so making the interpretation of this analysis difficult.

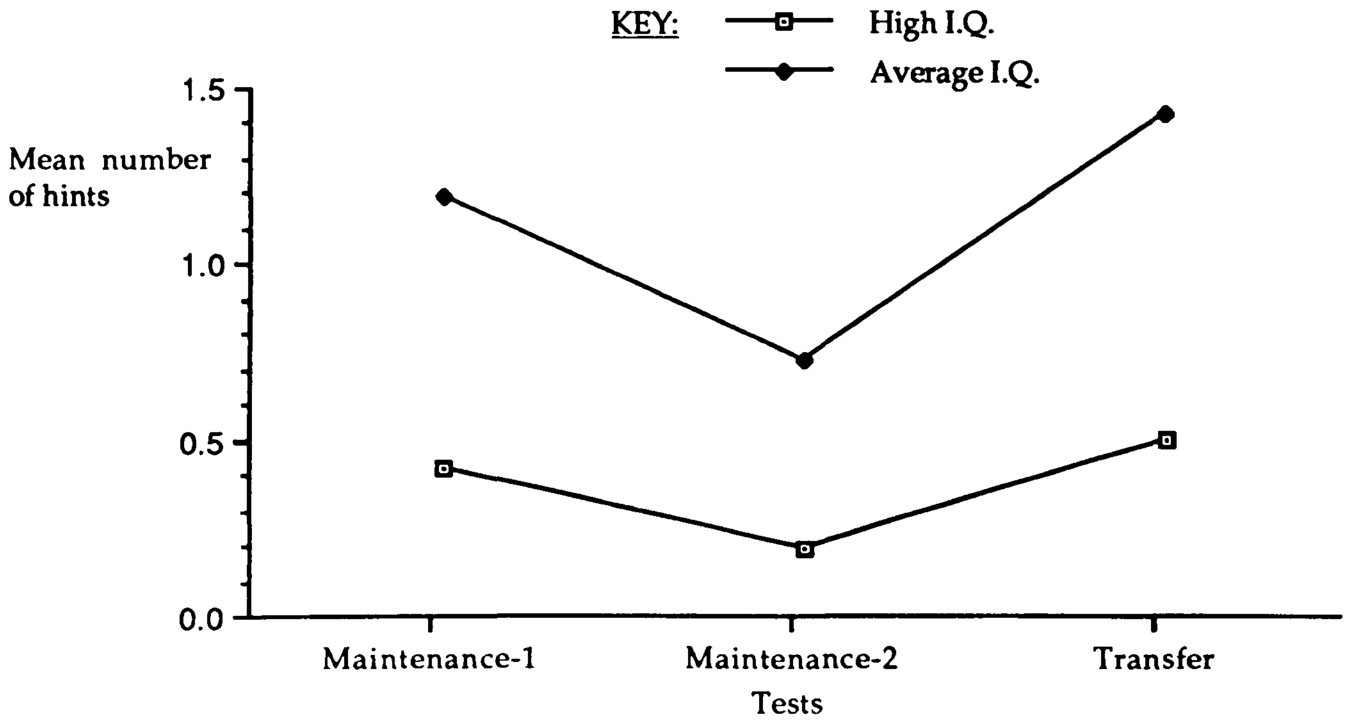
Therefore, two 2 (I.Q. or age) x 3 (dynamic maintenance and transfer scores) ANOVAs with the two measures in the dynamic maintenance phase and the one measure in the dynamic transfer phase as the repeated measures were computed on balanced designs, using either the I.Q. or age grouping as the between-subject variable. The first 2 (I.Q.) x 3 (dynamic maintenance and transfer scores) ANOVA with the I.Q. grouping as the between-subject variable, found a significant I.Q. effect - $F(1, 24) = 7.44$, $p < 0.01$.

The average I.Q. children used significantly more hints to satisfy the criterion in the maintenance and transfer phases than the high I.Q. children. This difference is shown in Graph 2 and Table 9.

Table 9: Mean number of hints to criterion and standard deviations in both tests of the maintenance phase and the test of the transfer phase for the high I.Q. children and the average I.Q. children (for each I.Q. group in each test n = 13)

Test	I.Q. group High	I.Q. group Average	Total (n = 26)
Maintenance-1	0.39 (0.65)	1.15 (1.34)	0.77
Maintenance-2	0.15 (0.38)	0.69 (0.86)	0.42
Transfer	0.46 (0.78)	1.39 (1.04)	0.92
Total	0.33	1.08	0.71

Graph 2: Mean number of hints needed to reach criterion by the high I.Q. children and the average I.Q. children in the two maintenance phase tests and the one transfer phase test.



Three 2 (I.Q.) x 1 (maintenance-1 score or maintenance-2 score or transfer score) ANOVAs investigated the performances of the two I.Q. groups in each test within the two dynamic maintenance tests and the one dynamic test in the transfer phase. No significant difference was found in the scores of the high I.Q. children and the average I.Q. children in the first test within the maintenance session - $F (1, 22) = 3.45$, $p = 0.08$. However, the performance of the high I.Q. children and the performance of the average I.Q. children did vary significantly in the second test of the maintenance phase - $F (1, 22) = 4.32$, $p < 0.05$. The scores of the two I.Q. groups also differed significantly in the transfer phase - $F (1, 22) = 6.55$, $p < 0.05$. Therefore, the difference in performance between the two I.Q. groups increased gradually between the maintenance and transfer phases.

The 2 (I.Q.) x 3 (dynamic maintenance and transfer) ANOVA with the two dynamic maintenance tests and the one dynamic transfer test as the repeated measures, using the I.Q. grouping as the between-subject factor, also found a significant difference between the children's scores across the maintenance and transfer phases - $F (2, 48) = 3.59$, $p < 0.05$. The variation in the children's scores between both tests in the maintenance phase and the transfer phases can be seen in Table 9. A post-hoc Scheffe test found that the children needed significantly more hints to reach criterion in the transfer phase than in the maintenance phase - $F (2, 48) = 3.90$, $p < 0.05$.

A 2 (age) x 3 (dynamic maintenance and transfer) ANOVA with the dynamic scores in the two maintenance tests and the one transfer test as the repeated measures, using the age grouping as the between-subject factor found no significant age effect - $F (1, 24) = 0.34$, $p = 0.57$. The older children did not need significantly more hints in the maintenance and transfer phases compared to the younger children.

Two 2 (block design or vocabulary) x 3 (dynamic maintenance and transfer) ANOVAs with the dynamic scores in the two maintenance tests and the one transfer test as the repeated measures were calculated, using either the score the block design or the vocabulary groupings as the between-subject factor. The 2 (block design) x 3 (dynamic maintenance and transfer) ANOVA with the block design grouping as the between-subject variable, found no significant difference between the high block design children and the average block design children - $F(1, 24) = 0.85$, $p = 0.37$. The second 2 (vocabulary) x 3 (dynamic maintenance and transfer) ANOVA with the vocabulary grouping as the between-subject variable, found no significant variation in the performance of the the high vocabulary children and the average vocabulary children - $F(1, 24) = 0.17$, $p = 0.68$. Therefore, the children's performance in the maintenance phase and transfer phase was not significantly related to their scores in the block design and vocabulary subtests of the I.Q. test.

The relationship between learning and transfer:

The children all learnt to the same criterion level in the training phase of the experiment, with varying degrees of hinting. A correlation between the number of hints needed in the training stage and the number of hints required in the maintenance and transfer stages proved significant, $r = 0.57$ - $p < 0.01$. Therefore, though the children reached the same level of performance in the training session, their subsequent performance in the rest of the stages was significantly related to the number of hints they required in the training phase. This meant that the children who learnt with a lot of help in the training session had difficulty transferring their demonstrated ability to the later maintenance and transfer phases.

Predictive validity - the ability of I.Q., static measures and dynamic measures to predict the proportion of change between pretest and posttest

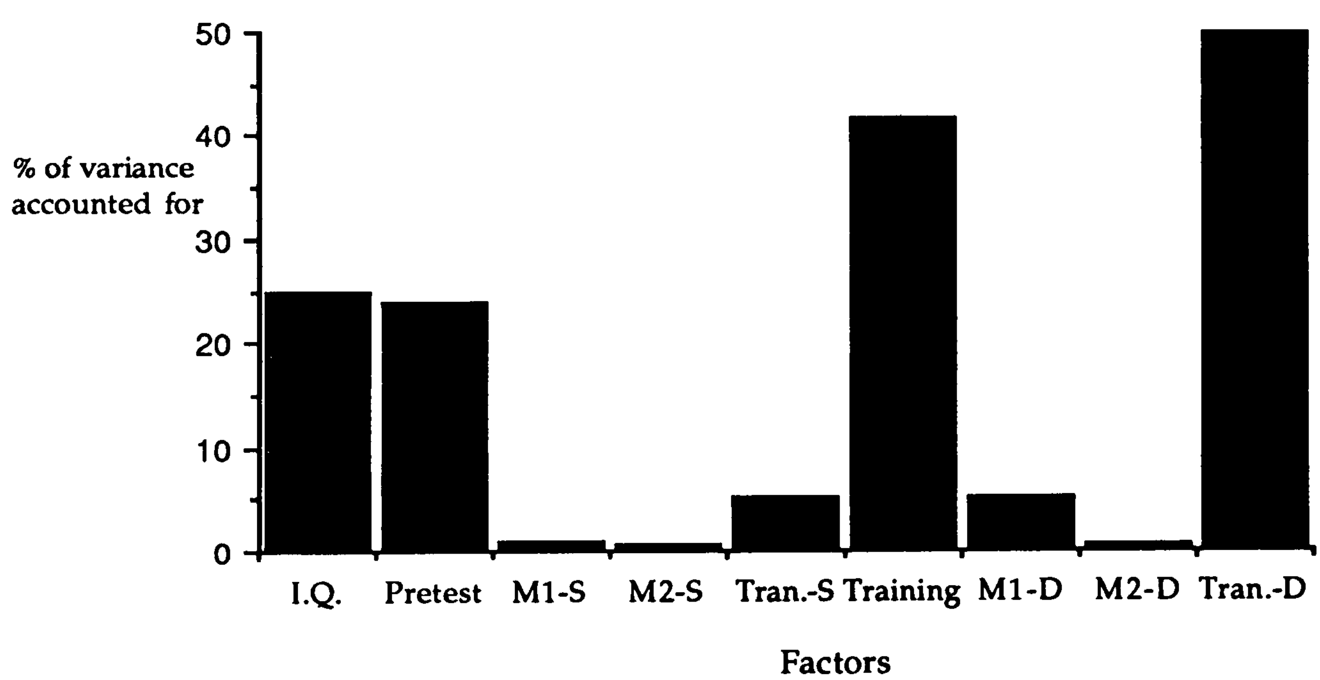
The children experienced a significant improvement in their performance between the pretest and posttest - Wilcoxon signed rank test, $p < 0.01$. This section examines various measures which could be useful in predicting this change in score between the pretest and posttest, adjusted for the initial pretest score. Table 10 on this page and overleaf shows the importance of different variables in predicting the proportion of variance between the pretest and posttest.

Table 10: The importance of I.Q., block design, vocabulary, static measures and dynamic measures in predicting the proportion of change between pretest and posttest.

Factor	r	% reduction in errors	% of variance accounted for
I.Q.	-0.50**	13.2	24.70
Block Design	-0.34	6.0	11.56
Vocabulary	-0.18	2.0	3.24
Static Measures:			
Pretest	0.49*	12.8	24.01
Maintenance-1	0.10	0.0	1.06
Maintenance-2	0.08	0.0	0.67
Transfer	0.22	2.5	4.97
Dynamic measures:			
Training	0.65**	23.6	41.60
Maintenance-1	0.23	2.6	5.20
Maintenance-2	0.09	0.0	0.72
Transfer	0.71**	29.3	49.99

I.Q. alone could only account for 24.70 per cent of the change in performance between pretest and posttest and it only reduced the possibility of errors in the prediction by 13.2 per cent. The raw scores from the block design and the vocabulary subtests of the I.Q. test were bad predictors of the change between pretest and posttest compared to the overall I.Q. score. The dynamic training score and the dynamic transfer score could each account for a significantly large proportion of the variance between the pretest and posttest, 41.60 per cent and 49.99 per cent respectively. The static score were especially poor in explaining the proportion of change between pretest and posttest, apart from the pretest itself. This can be seen in Graph 3.

Graph 3: Percentage of variance between pretest and posttest scores accounted for by I.Q., the static measures and the dynamic measures.



KEY:

Static measures:

M1-S = First test in the static part of maintenance phase.

M2-S = Second test in the static part of the maintenance phase.

Tran.-S = Only test in the static part of the transfer phase.

Dynamic measures:

M1-D = First test in the dynamic part of the maintenance phase.

M2-D = Second test in the dynamic part of the maintenance phase.

Tran.-D = Only test in the dynamic part of the transfer phase.

A stepwise multiple regression was conducted to further investigate the importance of the children's I.Q. score, pretest score and dynamic measures in predicting the variance between the pretest and posttest. The result of this analysis is presented in Table 11.

Table 11: A Stepwise multiple regression on the proportion of change between the pretest and the posttest accounted for by I.Q., the pretest score and the dynamic measures.

Factor	F	Multiple R	Rsq.	Increase in Rsq.	p
I.Q.	7.89	0.46	0.216	0.22	0.**
Pretest	5.13	0.50	0.248	0.03	0.**
Training	5.74	0.60	0.362	0.11	0.**
Maintenance-1	4.66	0.61	0.369	0.01	0.**
Maintenance-2	5.41	0.69	0.469	0.10	0.**
Transfer	6.29	0.75	0.560	0.09	0.**

Table 11 shows that I.Q. and the pretest score combined could only explain 24.8 per cent of the variance in performance between the pretest and posttest. When each dynamic score was gradually introduced into the regression equation the amount of variance accounted for increased by 31.2 per cent to 56.0 per cent. Thus, an important improvement in predictability occurred with the addition of the dynamic training, maintenance-2 and transfer scores. Table 16 shows that consideration only of I.Q and the static pretest does not fully explain the variance in performance between the pretest and posttest. The introduction of the dynamic measures to the analysis provided additional information that helped in the prediction of the change in performance between the pretest and posttest.

Nonparametric correlations between each static and dynamic score supported the view that some dynamic measures were useful predictors of performance compared to static scores. It was found that static pretest score did not significantly correlate with the dynamic training score - r = 0.26 and the static transfer score did not significantly correlate with the dynamic transfer score - r = 0.34. This suggests that these dynamic scores were measuring a different factor compared to the static scores, which could be important in explaining the improvement between the pretest and posttest. In addition, the static and dynamic scores in the maintenance -1 and maintenance -2 stages did correlate significantly - r = 0.79 and r = 0.99 respectively. This significant relationship between the static and dynamic measures in the maintenance phase suggests that the dynamic scores in this phase were not measuring any ability beyond that shown in the static tests.

Table 10 shows that the block design score is slightly better compared to the vocabulary score in explaining the variance in performance between the pretest and posttest, with 11.56 per cent against 3.24 per cent. Two stepwise multiple regressions were conducted on the change in score between the pretest and the posttest, using either the block design or the vocabulary scores as factors and the pretest, all the dynamic measures as other factors. These multiple regressions demonstrated the marginal superiority of the block design score over the vocabulary score in explaining the shift in score between pretest and posttest. Since the multiple regression which used the block design score as an independent factor accounted for 57 per cent of the change in performance between the pre and post tests, whereas the multiple regression that used the vocabulary score as an independent factor accounted for 55.7 per cent of the variance between the pretest and the posttest.

Summary - Experiment 1

The children's static pretest score, plus their static maintenance and transfer scores all had concurrent validity with their level of intelligence, because they were significantly related to the children's I.Q. score but not their age. The average I.Q. children needed appreciably more attempts in the pretest, maintenance phase and transfer phase than the high I.Q. children. The children's performance in all the static maintenance and transfer tests did not differ significantly. The scores from the two subtests of the I.Q. score, block design and vocabulary, were not significantly related to any of the static measures.

The measure of learning efficiency - the training score - had concurrent validity with the children's intelligence because it was significantly related to the their I.Q. score, but not to their age. The average I.Q. children required notably more hints in the training phase than the high I.Q. children. The dynamic maintenance and transfer scores also had concurrent validity with the children's intelligence, since they were significantly connected with the children's I.Q. but not their age. Average I.Q. children needed considerably more hints to reach criterion in the dynamic maintenance and transfer phases than the high I.Q. children. However, the score from the first test in the dynamic maintenance phase, unlike the second test in the maintenance phase and the test in the transfer phase, did not demonstrate concurrent validity with the children's intelligence. The children's performance in the maintenance and transfer sessions did vary significantly. More hints were needed to satisfy criterion in the transfer phase than the maintenance stage. The raw scores from the two subtests of the I.Q. score were not significantly related to any of the dynamic measures.

Those children who required more hints in the training phase of the experiment subsequently had problems transferring their demonstrated ability to the later tests in the maintenance and transfer sessions. The number of hints needed to reach criterion in the training stage was significantly related to the number of hints to criterion in the maintenance and transfer stages.

The dynamic scores, especially the training and transfer scores, proved better predictors to the variance between the pretest and posttest than either the I.Q. score or the static measures. In addition, the I.Q. score and the static pretest combined could not explain a large proportion of the change between pretest and posttest, but if the dynamic scores were considered too, over half of the variance between the pretest and posttest could be predicted. The dynamic training score and the static pretest score were did not correlate significantly, neither did the dynamic transfer score and the static transfer score. Finally, the block design subtest score was slightly better against the vocabulary subtest score in accounting for the shift in ability between the pretest and the posttest.

Results - Experiment 2: Measuring the ZPD among 'normal' school children

The method for Experiment 2 can be seen between pages 111-118.

Experiment 2 is interested in the concurrent validity of the static and dynamic measures with indicators of the children's general developmental level and the predictive validity of I.Q., the static and dynamic measures for the improvement between pretest and posttest. Concurrent validity is investigated by considering the relationship between the ability indices of I.Q. and age and the following measures: (1) the number of attempts needed in the pretest; (2) the number of attempts required across the maintenance and transfer phases; (3) the number of hints used to reach criterion in the training session; (4) the number of hints needed across the dynamic maintenance and transfer phases. Predictive validity is examined by assessing the relative importance of the I.Q. score, the static measures and the dynamic measures in predicting the shift in performance between the pretest and posttest phases.

A collection of analyses of variance investigate the effect of I.Q. and age on: (1) the number of attempts needed in the pretest; (2) the number of hints used to reach criterion in the training session; (3) the number of attempts needed in the static maintenance, transfer phases; (4) the number of hints required to reach criterion in the dynamic maintenance, transfer phases; (5) the number of hints needed individually in each test of the maintenance phase and the transfer phase. Stepwise multiple regressions and nonparametric correlations are used to see whether I.Q. alone could predict the changes between pretest and posttest, or whether the static and the dynamic measures were useful in explaining the change in performance between pretest and posttest.

A summary of the children's performance in each stage of the experiment is contained in Table 1. The children in the maintenance phase needed fewer attempts and hints than in the static pretest and dynamic training phase respectively. However, in the transfer stage the children needed slightly more attempts than in the second test, but not the first test, of the maintenance session. The children used the same number of hints in the dynamic transfer test as in the second dynamic test of the maintenance phase, but fewer than in the first dynamic test of the maintenance session. An improvement occurred in performance between the pretest and the posttest, as the mean score on the pretest was 7.12 attempts and in the posttest it was 4.65 attempts. This was a decrease in the mean number of attempts between the pretest and the posttest of 2.47.

Table 1: Summary of children's performance scores

	Mean	Standard Deviation	Min.	Max.
I.Q.	96.31	12.57	64.00	115.00
Block design Subtest	12.27	4.64	4.00	19.00
Vocabulary Subtest	16.65	5.57	6.00	28.00
Static measures (number of attempts):				
Pretest	7.12	3.73	4.00	16.00
Maintenance-1	6.15	3.25	4.00	15.00
Maintenance-2	5.46	1.94	4.00	11.00
Transfer	5.62	1.77	4.00	12.00
Posttest	4.65	1.67	4.00	11.00

Dynamic measures (number of hints to reach criterion):

	Mean	Standard Deviation	Min.	Max.
Training	1.31	1.16	0.00	4.00
Maintenance-1	1.00	0.99	0.00	3.00
Maintenance-2	0.89	1.03	0.00	4.00
Transfer	0.89	0.82	0.00	3.00

Concurrent validity: the relationship between learning, transfer and intelligence.

(1) Static measures

(a) Pretest:

The children's initial mapping ability was assessed by the pretest. This dependent variable was investigated in a 2 (I.Q.) x 2 (age) x 1 (pretest) analysis of variance (equally weighted means), with the I.Q. and age groupings as the between-subject factors. The results of this ANOVA are seen in Table 2.

Table 2: A 2 (I.Q.) x 2 (age) x 1 (pretest) analysis of variance with the I.Q. and age groupings as the between-subject factors.

	df	F-factor	p
I.Q.	1, 22	2.11	0.16
AGE	1, 22	0.15	0.70
I.Q./AGE	1, 22	0.30	0.59

No significant effects existed in the ANOVA shown above. The average I.Q. children did not need significantly more attempts in the pretest than the high I.Q. children. Moreover, the older children did not use fewer attempt in the pretest than the younger children. However, interpretation of the above ANOVA is problematic, since it was based on an unbalanced design and this could have caused a partial confounding of effects.

Thus, two 2 (I.Q. or age) x 1 (pretest) analyses of variance (equally weighted means) were performed on balanced designs. The first 2 (I.Q.) x 1 (pretest) ANOVA, with the I.Q. grouping as the independent variable and the pretest score as the dependent variable, found no effect for I.Q. - $F (1, 22) = 2.10$, $p = 0.16$. The second 2 (age) x 1 (pretest) ANOVA, with the age grouping as the independent factor and the pretest score as the dependent factor, found no effect for age - $F (1, 22) = 0.00$, p 0.96.

The block design or the vocabulary raw score groupings were used as between-subject variables in two analyses of variance, with the pretest score as the within-subject variable in both ANOVAs. The first 2 (block design) x 1 (pretest) ANOVA, with the block design grouping as the between-subject factor found no significant difference between the pretest scores of the average block design children and the high block design children - $F (1, 24) = 0.02$, $p = 0.88$. The second 2 (vocabulary) x 1 (pretest) ANOVA, with the vocabulary grouping as the between-subject factor, found no significant variation between the pretest scores of the high vocabulary children and the average vocabulary children - $F (1, 24) = 2.10$, $p = 0.16$. Therefore, the raw scores from the block design and vocabulary subtests were not significantly related to the children's pretest performance.

(b) Static maintenance and transfer phases:

A series of analyses of variance with the two measures in the static maintenance tests and the static score in the transfer test as the repeated measures examined for the effect of I.Q. and age. The first of this series, a 2 (I.Q.) x 2 (age) x 3 (static maintenance and transfer) ANOVA (equally weighted means), with the I.Q and age groupings as the between-subject factors, is shown in Table 3 overleaf.

Table 3: A 2 (I.Q.) x 2 (age) x 3 (static maintenance and transfer) ANOVA with the two static maintenance tests and the static transfer test as the repeated measures, using the I.Q. and age grouping as the between-subject variables.

	df	F-factor	p
I.Q.	1, 22	5.43	0.03*
AGE	1, 22	0.06	0.80
I.Q./AGE	1, 22	0.10	0.75
TEST	2, 44	1.49	0.24
TEST/I.Q.	2, 44	2.82	0.07
TEST/AGE	2, 44	1.79	0.18
TEST/I.Q./AGE	2, 44	1.20	0.32

KEY: * $p < 0.05$; ** $p < 0.01$

The above key applies to all other tables in this results section.

The ANOVA in Table 3 shows that the high I.Q. children and the average I.Q. children differed significantly in their scores across the maintenance and transfer phases - $F (1, 22) = 5.43$, $p < 0.05$. No other significant effect were found in the above ANOVA. Generalising from the ANOVA shown in Table 3 was difficult because it was based on an unbalanced design, making the ANOVA prone to a partial confounding of effects.

Thus, two 2 (I.Q. or age) x 3 (static maintenance and transfer) ANOVAs (equally weighted means) were calculated on balanced designs, with two measures in the static maintenance tests and the one score in the static transfer tests as the repeated measures. The I.Q. or age groupings were used as the between-subject factors in these two ANOVAs. The first 2 (I.Q.) x 3 (static maintenance and transfer) ANOVA with the I.Q. grouping as the between-subject factor, found that the I.Q. groups varied significantly in their performance across the maintenance and transfer phases - $F (1, 24) = 5.90$, $p < 0.05$. The average I.Q. children used significantly more attempts within the maintenance and transfer phases than the high I.Q. children. This is evident in Table 4.

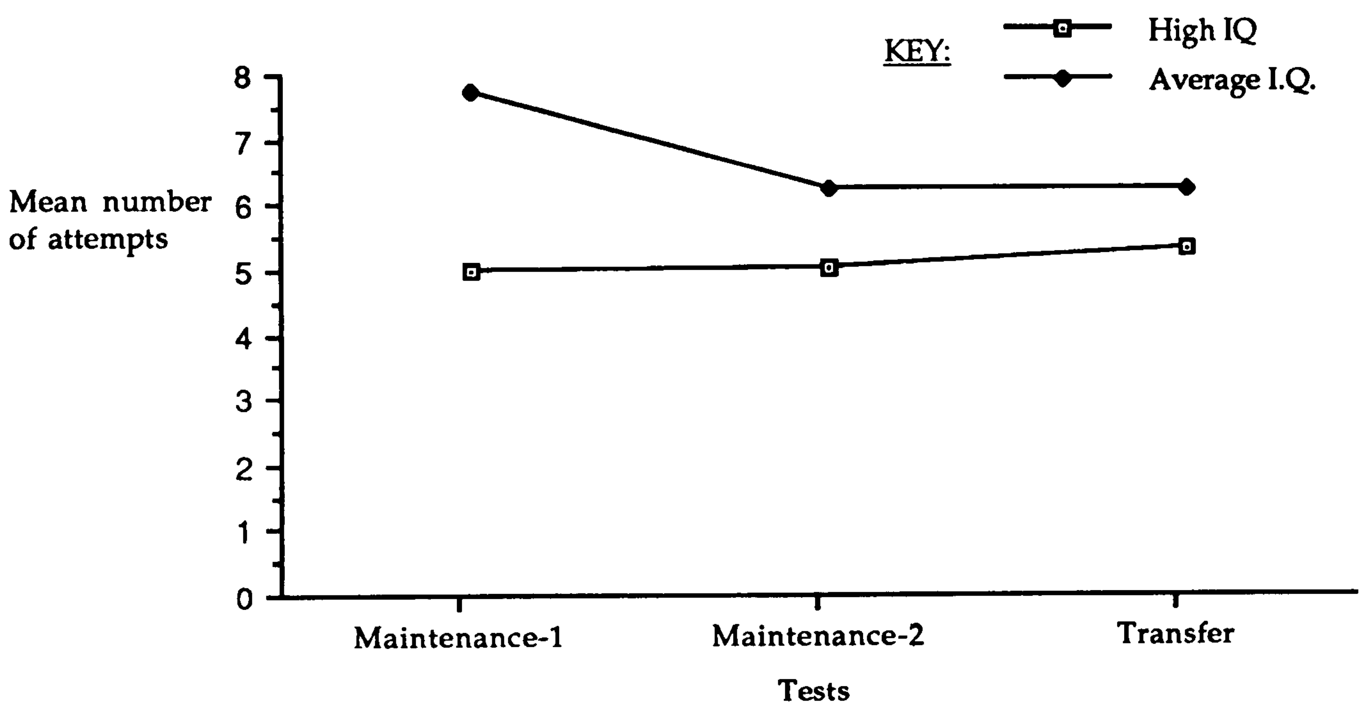
Table 4: Mean number of attempts needed by the high I.Q. children and the average I.Q. children in both tests in the maintenance phase and the test in the transfer phase, plus the standard deviations (for each I.Q. group in each test n = 13).

Test	I.Q. group High	I.Q. group Average	Total (n = 26)
Maintenance-1	4.77 (0.93)	7.54 (4.12)	6.15
Maintenance-2	4.85 (0.80)	6.08 (2.53)	5.46
Transfer	5.15 (1.14)	6.08 (2.18)	5.62
Total	4.92	6.56	5.74

Univariant analyses of variance were performed to investigate the I.Q. effect in each test of the maintenance phase and the test in the transfer phase. A 2 (I.Q.) x 1 (maintenance-1) ANOVA, with the I.Q grouping as the independent factor and the number of attempts used in the first test of the maintenance phase as the dependent factor, found a significant difference between the high I.Q. children and the average I.Q. children - $F(1, 24) = 5.60$, $p < 0.05$. It is clear in Table 4 that the average I.Q. children needed significantly more attempts in the first test of the maintenance phase than the high I.Q. children. A second 2 (I.Q.) x 1 (maintenance-2) ANOVA, with the I.Q. grouping as the independent factor and the number of attempts required in the second test of the maintenance phase as the dependent factor found no significant difference between the two I.Q. groups - $F(1, 24) = 2.79$, $p = 0.11$. A third 2 (I.Q.) x 1 (transfer) ANOVA, with the I.Q. grouping as the independent factor and the number of attempts used in the static transfer test as the dependent factor, found no significant variation between the two

I.Q. groups - F (1, 24) = 1.83, p = 0.19. Therefore, the average I.Q. children and the high I.Q. children did not differ significantly in the second test of the maintenance phase and the test in the transfer phase. The difference in performance between the two I.Q. groups in maintenance and transfer phases can be seen in Graph 1.

Graph 1: Mean number of attempts needed across the maintenance and transfer phases by the high I.Q. children and the average I.Q. children.



A 2 (age) x 3 (static maintenance and transfer) ANOVA with the two tests in the static maintenance phase and the one test in the static transfer phase as the repeated measures, using age as the between-subject factor was also performed, found no significant difference between the older children and the younger children - F (1, 24) = 0.07, p = 0.79.

The 2 (I.Q) x 2 (age) x 3 (static maintenance and transfer) ANOVA with repeated measures and the two 2 (I.Q. or age) x 3 (static maintenance and transfer) ANOVAs with repeated measures reported above all found no significant difference between the children's overall scores in the two tests of the maintenance phase and the transfer test.

The block design and vocabulary raw score groupings were each used as between-subject variables in one of two 2 (block design or vocabulary) x 3 (static maintenance and transfer) analyses of variance. The two tests in the static maintenance phase and the one test in the static transfer phase were used as the repeated measures in these ANOVAs. The first 2 (block design) x 3 (static maintenance and transfer) ANOVA with repeated measures, using the block design grouping as the between-subject variable, found no significant difference between the performances of the high block design children and the average block design children in the maintenance and transfer phases - $F(1, 24) = 0.23$, $p = 0.64$. The second 2 (vocabulary) x 3 (static maintenance and transfer) ANOVA with repeated measures, using the vocabulary grouping as the between-subject factor, calculated no significant variation in the performances of the two vocabulary groups throughout the maintenance and transfer phases - $F(1, 24) = 2.23$, $p = 0.15$. Thus, the block design and the vocabulary scores were not significantly related to the maintenance and transfer measures.

(2) Dynamic measures

(a) Learning efficiency:

The children's efficiency of learning within the map task was measured by the number of hints needed by them to reach criterion in the training phase. A 2 (I.Q.) x 2 (age) x 1 (training) analysis of variance (equally weighted means) investigated this dependent variable, using the I.Q. and age groupings as the independent variables. This is presented in Table 5.

Table 5: A 2 (I.Q) x 2 (age) x 1 (training) analysis of variance, with the I.Q. and age groupings as the between-subject variables.

	df	F-factor	p
I.Q.	1, 22	3.03	0.10
AGE	1, 22	0.16	0.69
I.Q./AGE	1, 22	0.00	0.98

The ANOVA shown in Table 5 found no significant effects for I.Q. or age. The I.Q. groups and the age groups did not differ significantly in their performances within the training phase. However, this ANOVA was based on an unbalanced design and this makes it difficult to draw conclusions from this analysis.

Thus, two 2 (I.Q. or age) x 1 (training) analyses of variance were calculated on balanced designs. The first 2 (I.Q.) x 1 (training) ANOVA, with the I.Q. grouping as the independent factor and the number of hints to satisfy criterion level in the training phase as the dependent variable, found no significant I.Q. effect - $F(1, 24) = 3.11$, $p = 0.09$. The scores of the high I.Q. children and the average I.Q. children did not vary significantly in the training session. The second 2 (age) x 1 (training) ANOVA, with the age grouping as the independent factor and the number of hints to criteria in the training phase as the dependent factor, found no significant age effect - $F(1, 24) = 0.00$, $p = 1.00$. The younger children and older children did not differ noticeably in their performance within the training session.

The block design subtest and the vocabulary raw score groupings were used as the independent variables in two 2 (block design or vocabulary) x 1 (training) analyses of variance, with the number of hints to satisfy the criterion level in the training phase as the dependent variable. The ANOVA with the block design grouping as the independent variable, found no significant difference between the high block design children and the average block design children in the training test - $F(1, 24) = 1.90$, $p = 0.18$. The second 2 (vocabulary) x 1 (training) ANOVA with the vocabulary grouping as the independent factor and the training score as the dependent variable, indentified no significant variation in performance between the high vocabulary children and the average vocabulary children in the training stage - $F(1, 24) = 0.45$, $p = 0.51$. Therefore, the children's measure of learning efficiency is not significantly related to the block design or vocabulary raw scores.

(b) Dynamic maintenance and transfer:

The effect of the I.Q. and age groupings on the number of hints needed to reach criterion in the maintenance and transfer phases was investigated in series of analyses of variance with repeated measures. The two tests in the dynamic maintenance phase and the one test in the dynamic transfer phase were used as the repeated measures in these ANOVAs. Firstly, a 2 (I.Q) x 2 (age) x 3 (dynamic maintenance and transfer) ANOVA (equally weighted means) with the I.Q. and age groupings as the between-subject variables was performed. This analysis is shown in Table 6.

Table 6: A 2 (I.Q.) x 2 (age) x 3 (dynamic maintenance and transfer) analysis of variance with repeated measures, using the I.Q. and age groupings as the between-subject factors.

	df	F-factor	p
I.Q.	1, 22	0.28	0.60
AGE	1, 22	0.07	0.79
I.Q./AGE	1, 22	0.07	0.79
TEST	2, 44	0.11	0.90
TEST/I.Q.	2, 44	0.20	0.82
TEST/AGE	2, 44	0.17	0.85
TEST/I.Q./AGE	2, 44	0.08	0.93

The above ANOVA found no significant effects. The performances of the I.Q. groups and the age groups did not differ significantly in the maintenance and transfer phases. Overall, the children did not vary significantly in their scores within the maintenance and transfer sessions. Accurate interpretation of the ANOVA shown in Table 6 is difficult, because this analysis was based on an unbalanced design.

Two 2 (I.Q. or age) x 3 (dynamic maintenance and transfer) analyses of variance with the two tests in the dynamic maintenance phase and the one test in the dynamic transfer phase as the repeated measures were calculated on balanced designs. The first 2 (I.Q.) x 3 (dynamic maintenance and transfer) ANOVA with repeated measures, using the I.Q. grouping as the between-subject factor, found no I.Q. effect - $F (1, 24) = 0.40$, $p = 0.53$. The second 2 (age) x 3 (dynamic maintenance and transfer) ANOVA with repeated measures, using the age grouping as the between-subject factor, found no age effect - $F (1, 24) = 0.18$, $p = 0.68$. Therefore, the performances of the I.Q. groups and the age groups did not vary significantly across any of the tests in the maintenance and transfer sessions.

Two 2 (block design or vocabulary) x 3 (dynamic maintenance and transfer) analyses of variance with the two tests in the dynamic maintenance phase and the one test in the dynamic transfer phase as the repeated measures were computed. These ANOVAs used either the block design or the vocabulary raw score groupings as the between-subject factor. The first 2 (block design) x 3 (dynamic maintenance and transfer) ANOVA with repeated measures, using the block design grouping as the between-subject variable, found no significant effect for block design - $F (1, 24) = 4.14$, $p = 0.05$. The average block design children did not use significantly more hints to reach the criterion across the two tests in the maintenance phase and the test in the transfer phase than the high block design children. The second 2 (vocabulary) x 3 (dynamic maintenance) and transfer ANOVA with repeated measures, using the vocabulary grouping as the between-subject factor, indentified no significant vocabulary effect - $F (1, 24) = 2.35$, $p = 0.14$. Therefore, the scores from the block design subtest and the vocabulary subtest are not significantly related to the dynamic measures of maintenance and transfer.

The relationship between learning and transfer

The children all learnt to the same level of achievement in the training session, but with differing levels of help. A correlation between the number of hints required in the dynamic training phase and the quantity of hints used in the dynamic maintenance -1 stage proved significant - $r = 0.41$ - at the 5 % level of confidence. This meant, though all children reached the same performance level in the training stage, their score in the next phase of the experiment was critically related to the degree of hinting needed in the training phase. The children who had problems in the training session had difficulty transfering their ability to the first test in the maintenance phase. However, the training score did not significantly correlate with the dynamic measures in the maintenance -2 and transfer stages. This showed that the children had little trouble transfering their proven ability in the second test of the maintenance stage and the transfer stage.

Predictive validity - the ability of the I.Q. score, static measures and dynamic measures to predict the proportion of change between the pretest and posttest

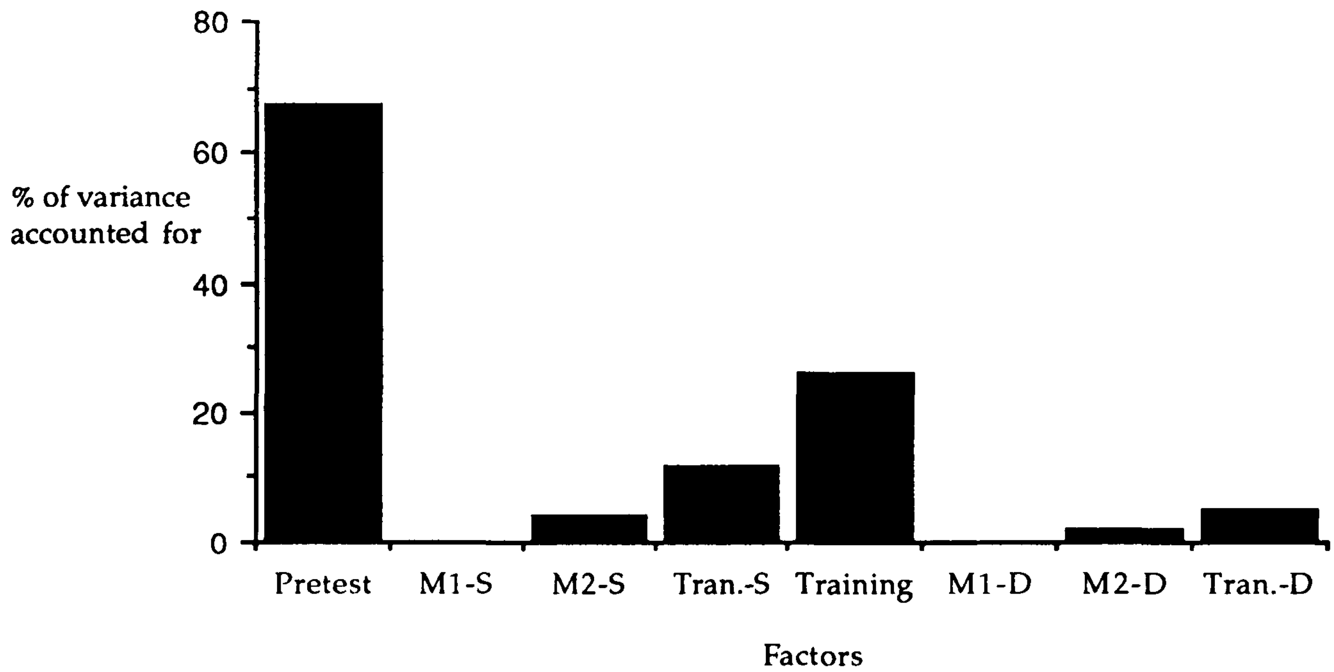
The children showed an improvement in performance between the pretest and posttest - Wilcoxon signed rank test, $p < 0.01$. The following analyses aimed to discover the best predictor of this change in performance. Table 7 shows the importance of different measures in predicting the variance in score between the pretest and posttest.

Table 7: The importance of the I.Q. score, static measures and dynamic measures in predicting the proportion of change between the pretest and posttest.

Factor	r	% reduction in errors	% of variance accounted for
I.Q.	0.00	0.00	0.00
Block Design	-0.02	0.00	0.04
Vocabulary	-0.17	0.99	2.89
Static measures:			
Pretest	0.82*	43.00	67.24
Maintenance-1	0.01	0.00	0.01
Maintenance-2	-0.20	2.00	4.00
Transfer	-0.34	6.00	11.56
Dynamic measures:			
Training	0.51*	14.00	26.01
Maintenance-1	0.02	0.00	0.04
Maintenance-2	-0.14	1.00	1.96
Transfer	-0.23	3.00	5.29

I.Q. alone could not account for any of the change in score between the pretest and posttest.

Graph 2: The percentage of variance between pretest and posttest accounted for by the static measures and the dynamic measures.



KEY:

Static measures:

M1-S = First test in the static part of maintenance phase.

M2-S = Second test in the static part of the maintenance phase.

Tran.-S = Only test in the static part of the transfer phase.

Dynamic measures:

M1-D = First test in the dynamic part of the maintenance phase.

M2-D = Second test in the dynamic part of the maintenance phase.

Tran.-D = Only test in the dynamic part of the transfer phase.

Table 7 and Graph 2 show that the pretest score is the best predictor of the change in scores, accounting for 67.24 per cent of the variance in performance between the pretest and posttest and reducing the possibility of an error in prediction by 43 per cent. However, the training score was the next best factor in predicting the improvement in performance, accounting for 26.01 per cent of the variance score between the pretest and posttest. The other static and dynamic measures were very poor at explaining the change in ability between the pretest and posttest.

Three stepwise multiple regression were calculated to further investigate the importance of the children's I.Q. score, pretest score and dynamic score in predicting the improvement between the pretest and posttest. The first stepwise multiple regression is shown in Table 8.

Table 8: Stepwise multiple regression on the proportion of change in score between the pretest and posttest accounted for by the I.Q. score, the pretest score and the dynamic measures.

Factor	F	Multiple R	Rsq.	Increase in Rsq.	p
I.Q.	0.00	0.00	0.0	0.00	0.99
Pretest	27.12	0.82	0.676	0.67	0.*
Training	20.09	0.84	0.698	0.03	0.*
Maintenance-1	16.76	0.85	0.716	0.02	0.*
Maintenance-2	15.11	0.86	0.738	0.02	0.*
Transfer	13.62	0.87	0.752	0.02	0.*

Table 8 shows that the I.Q. score is very bad at accounting for the change in the children's performance between the pretest and posttest. However, a major advance in predictability occurs with the addition of the pretest score to the regression equation. Then when the dynamic scores are gradually added to the equation 7.6 per cent more of the fluctuation in performance between the pretest and posttest could be answered for. The second stepwise multiple regression is shown in Table 9.

Table 9: Stepwise multiple regression on the proportion of change in score between the pretest and posttest accounted for by the I.Q. score and the dynamic measures.

Factor	F	Multiple R	Rsq.	Increase in Rsq.	p
I.Q.	0.00	0.00	0.00	0.00	0.99
Training	5.75	0.52	0.275	0.27	0.**
Maintenance-1	4.38	0.54	0.289	0.02	0.*
Maintenance-2	3.31	0.52	0.270	-0.02	0.*
Transfer	4.46	0.64	0.409	0.14	0.**

Table 9 shows that all the dynamic scores, with no assistance from the I.Q. score, could explain 40.9 per cent of the variance in ability between the pretest and the posttest. The static scores combined were worse than the dynamic measures in explaining the shift in performance between the pretest and posttest, with only 2.5 per cent of the change in score explained by the static measures, as shown by a stepwise multiple regression presented Table 10.

Table 10: Stepwise multiple regression on the proportion of change in score between the pretest and posttest accounted for by the I.Q. score and the static measures.

Factor	F	Multiple R	Rsq.	Increase in Rsq.	p
I.Q.	0.00	0.00	0.00	0.00	0.99
Maintenance-1	0.00	0.00	0.00	0.00	1.00
Maintenance-2	0.46	0.00	0.00	0.00	0.71
Transfer	1.16	0.16	0.25	0.03	0.36

Nonparametric correlations between each static and dynamic variable suggested that the static and dynamic scores were measuring different abilities. The static pretest score did not correlate significantly with the dynamic training score - r = 0.14. The static and dynamic score in the first test of the maintenance phase did not correlate significantly - r = 0.26. Furthermore, the static and dynamic scores in the second test of the maintenance stage did not correlate significantly - r = 0.29. Finally, the static transfer score did not significantly correlate with the dynamic transfer score - r = 0.01. These non-significant correlations suggest that the dynamic scores were measuring additional information, not already provided by the static scores.

The predictive validity, for the improvement between the pretest and posttest, of the block design and vocabulary scores was examined in two stepwise multiple regressions. These two analyses showed that a regression equation including the vocabulary score, the pretest score and the dynamic measures was just better in accounting for the improvement in ability between the pretest and posttest than another regression equation with the same factors, except the block design score was substituted for the vocabulary score. Table 7 also demonstrates that the vocabulary subtest score was marginally better than the block design subtest score in predicting the variance in the performance between the pretest and posttest, accounting for 2.89 per cent compared to 0.04 per cent respectively. However, generally there was no important difference in the predictive validity of the block design score and the vocabulary score.

Summary - Experiment 2

The children's pretest score did not have concurrent validity with their general developmental level, because it was not significantly related to their I.Q. score, block design score, vocabulary score or age. However, the children's performance across the static maintenance and transfer phases did posses concurrent validity with their intelligence, since this measure was significantly correlated with I.Q. The average I.Q. children needed appreciably more attempts within the maintenance and transfer phases combined than the high I.Q. children. The significant difference in performance between the average I.Q. children and the high I.Q. children was in the first test of the maintenance stage.

The dynamic measures of learning efficiency, maintenance and transfer did not show concurrent validity with the children's general developmental level, since no significant relationship existed between these dynamic scores and the children's I.Q. score, block design score, vocabulary score or age. The children who had problems in the training phase experienced difficulty transfering their demonstrated ability to the first test of the maintenance phase, but not to the second test of the maintenance stage and transfer stage.

The pretest was the best predictor of the children's change in performance between the pretest and posttest, though the training score was the best truly independent predictive factor. The stepwise multiple regressions showed that when the pretest was excluded from the analysis the dynamic measures were better than the static measures at predicting the change in ability between pretest and posttest. The non-significant correlations between the static and dynamic scores in each phase suggest that these measures were testing different abilities. Neither the block design or vocabulary measures were good at accounting for the shift in scores between the pretest and posttest.

Results - Experiment 3: Measuring the ZPD among both children with learning difficulties and mainstream school children

The method for Experiment 3 can be seen between pages 111-118.

This results section focuses on the concurrent validity, with the children's general developmental level, of the static and dynamic measures of children's ability to understand and use a spatial representation. Concurrent validity was examined by investigating the effects of school membership (mainstream or special needs) on the following measures: (1) number of attempts needed in the pretest; (2) the number of hints required to reach the criterion level in the training phase; (3) the number of attempts and hint to criterion across the maintenance and transfer phases; (4) the change in the number of attempts used in the posttest compared to the pretest. The children who attended the special needs school were defined as having learning difficulties and the children who went to a mainstream school were classified as 'normal'.

A series of analyses of variance, some with repeated measures, was carried out on the static and dynamic dependent variables. The aim was to investigate whether the mainstream children and the special needs children varied in the number attempts or hints they required across the experimental phases. In addition post hoc Scheffe tests were performed to investigate further differences between the mainstream children and the special needs children in each phase of the experiment.

A summary of all the childrens' I.Q. scores and performance measures in both the static and dynamic phases is presented in Table 1. The results for Experiment 1 and Experiment 2 contain a summary of the performance scores and I.Q. scores relevant to the special needs children and mainstream children respectively. The mean I.Q. score for all the children was 80.46 and the children had very similar scores in the block design and vocabulary components of the I.Q. test. In the pretest the mean number of attempts required was 6.79, but in both the static and dynamic tests of the maintenance phase the children used gradually fewer attempts and hints than in the pretest and training phase. However, in the transfer stage the children needed more attempts and hints than in the maintenance session; though the children did perform better in the transfer phase than in the pretest and training phases. The children did show an improvement between the pretest and posttest, because the childrens' mean score in the posttest was only 4.89. This was a decrease in the mean number of attempts to complete the task between the pretest and posttest of 1.90.

Table 1: Summary of children's performance scores

	Mean	Standard Deviation	Min.	Max.
I.Q.	80.46	19.21	51.00	115.00
Block design Subtest	14.67	8.67	0.00	43.00
Vocabulary Subtest	15.62	5.68	3.00	28.00

Static measures (number of attempts):

	Mean	Standard Deviation	Min.	Max.
Pretest	6.79	3.71	4.00	16.00
Maintenance-1	6.14	3.27	4.00	15.00
Maintenance-2	5.52	2.91	4.00	16.00
Transfer	5.94	2.71	4.00	16.00
Posttest	4.89	2.32	4.00	16.00

Dynamic measures (number of hints to reach the criterion level):

	Mean	Standard Deviation	Min.	Max.
Training	1.15	1.16	0.00	4.00
Maintenance-1	0.89	1.02	0.00	4.00
Maintenance-2	0.65	0.91	0.00	4.00
Transfer	0.90	0.91	0.00	3.00

(1) Pretest

A 2 (school) x 1 (pretest) analysis of variance using the children's school grouping as the independent variable and the number of attempts needed in the pretest as the dependent variable, found no significant difference between the number of attempts used in the pretest by the mainstream children and the special needs children - $F (1, 50) = 0.40$, $p = 0.53$. The mainstream children needed a mean of 7.12 attempts across the four trials of the pretest and the special needs children required a mean number of 6.46 attempt in the four trials of the pretest.

(2) Training

The number of hints to satisfy the criterion level, the dependent variable, was examined in a 2 (school) x 1 (training) analysis of variance with the school grouping as the independent variable and the number of hints to criterion in the training session as the dependent variable. This ANOVA found no significant difference between the mainstream children and the special needs children in the training phase - $F (1, 50) = 0.91$, $p = 0.34$. A mean of 1.31 hints was needed by the mainstream children in the training phase, compared to a mean of 1.00 hints for special needs children. Therefore, there was no evidence of differences during the first learning phase of the study between groups of mainstream and special needs children approximately equated for starting competence.

(3) Static maintenance and transfer measures

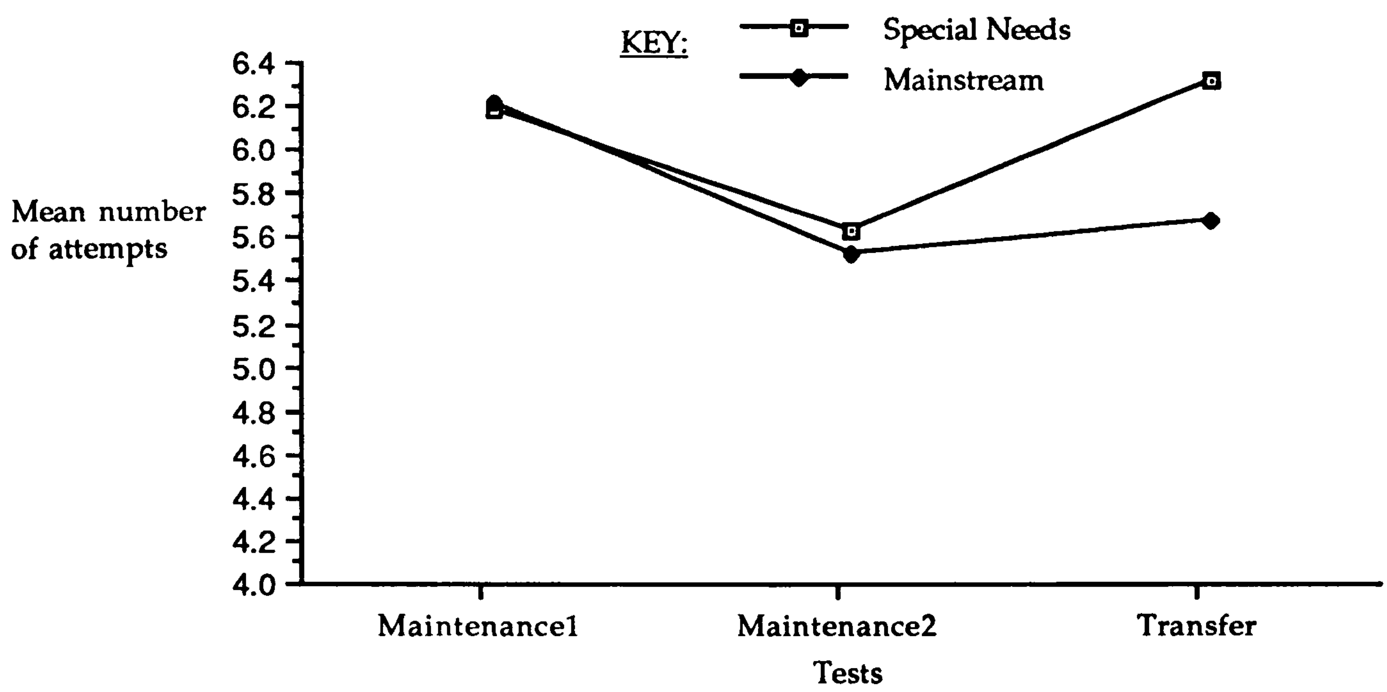
A 2 (school) x 3 (static maintenance and transfer) analysis of variance with the two static test scores in the maintenance phase and the one test score in the transfer phase as the repeated measures was computed. This ANOVA used the school grouping as the between-subject factor and is shown in Table 2.

Table 2: A 2 (school) x 3 (static maintenance and transfer) analysis of variance with repeated measures using the school grouping as the between-subject variable.

	df	F-factor	p
SCHOOL	1, 50	0.11	0.74
STATIC	2, 100	1.65	0.20
SCHOOL	2, 100	0.55	0.58

Table 2 shows that the performance of the mainstream children and the special needs children did not differ significantly in the static tests of the static maintenance and transfer tests. The mainstream children and the special needs children used an equivalent number of attempts in the first static test of the maintenance phase. The special needs children required gradually more attempts in the subsequent second static test of the maintenance phase and the one static test in the transfer phase. However, the difference in performance between the two groups of children never became significant. Table 2 also shows that there was no significant difference between all the children's scores in the static tests of maintenance and transfer phases. The variation in ability between the mainstream children and the special needs children across the two static tests of the maintenance phase and the one static test of the transfer phase can be seen in Graph 1.

Graph 1: Mean number of attempts used by the mainstream children and the special needs children across the tests in the maintenance and transfer phases.



(4) Dynamic maintenance and transfer measures

The number of hints required to reach criterion in both maintenance phase tests and the transfer phase test were the dependent variables in a 2 (school) x 3 (dynamic maintenance and transfer) analysis of variance. The two dynamic test scores in the maintenance phase and the one test score in the transfer phase were the repeated measures in this ANOVA and the school grouping was the independent variable. This ANOVA with repeated measures is shown in Table 3.

Table 3: A 2 (school) x 3 (dynamic maintenance and transfer) analysis of variance with repeated measures using the school grouping as the between-subject factor.

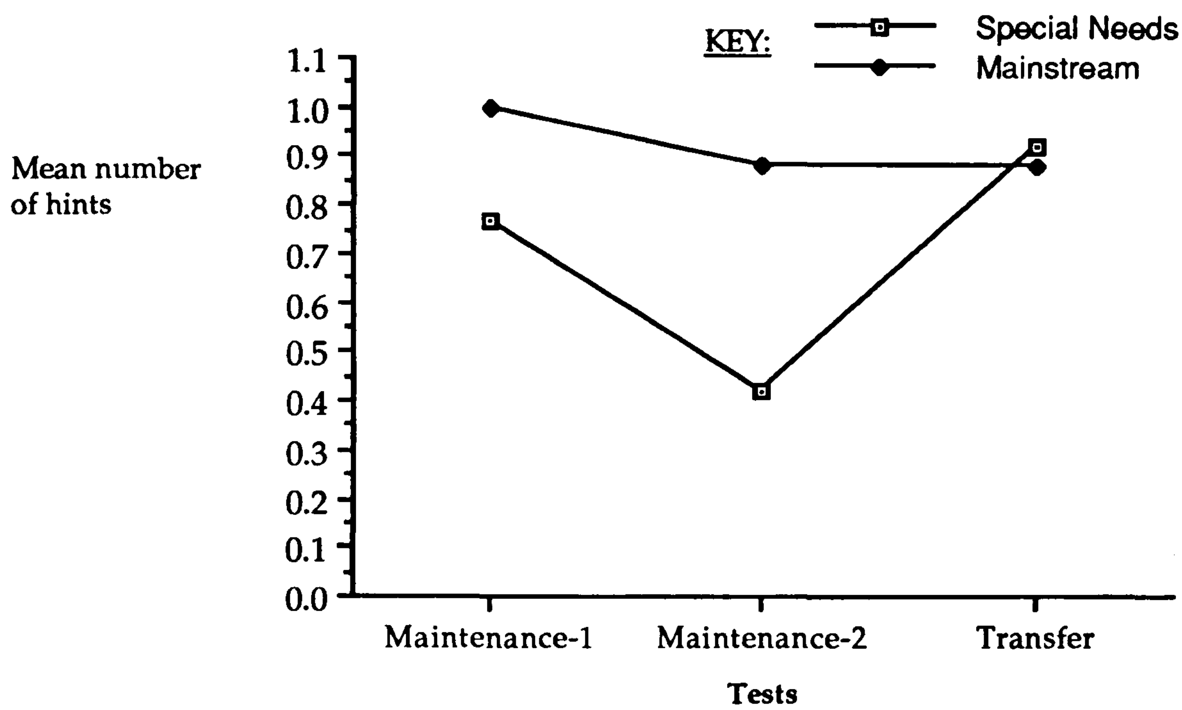
	df	F-factor	p
SCHOOL	1, 50	1.26	0.27
DYNAMIC	2, 100	1.67	0.19
DYNAMIC/SCHOOL	2, 100	1.35	0.26

The ANOVA with repeated measures in Table 4 demonstrates that overall the children's performance did not vary significantly throughout the dynamic tests of the maintenance and transfer phases - $F (2, 100) = 1.67, p = 0.19$. The mainstream children and the special needs children did not differ significantly in the number of hints needed to satisfy the criterion level across the maintenance and transfer phases. The differences between the number of hints used by the mainstream children and the special needs children across all the dynamic tests of the maintenance and transfer phases can be seen in Table 5 and Graph 2.

Table 5: Mean number of attempts (and standard deviations) needed by the mainstream children and the special needs children in the dynamic tests within the maintenance and transfer phases (for each school group n = 26)

	School		Total
Test	Mainstream	Special Needs	(n = 52)
Maintenance-1	1.00 (0.94)	0.77 (1.11)	0.89
Maintenance-2	0.89 (1.03)	0.42 (0.70)	0.65
Transfer	0.89 (0.82)	0.92 (1.02)	0.90
Total	0.92	0.71	

Graph 2: Mean number of hints needed to criterion across the dynamic tests of the maintenance and transfer phases by the special needs and mainstream children



Initially, in the first dynamic test of the maintenance phase the mainstream children needed slightly more hints to reach criteria than the special needs children. Then in the second dynamic test of the maintenance session both groups of children showed an improvement as they used fewer hints, with the special needs children requiring marginally fewer hints than in the first test of this phase. The special needs children needed significantly more hints in the dynamic transfer test compared to the tests in the maintenance phase - Scheffe test - $F (2, 100) = 6.10$, $p < 0.01$. Whereas the mainstream children required approximately the same number of hints in the transfer phase as in the two tests within the maintenance phase. There was no significant difference between the number of hints used by the mainstream children in the tests of the maintenance and transfer phases - Scheffe test - $F (2, 100) = 0.21$.

(5) Posttest

Following the transfer phase the children were re-administered the pretest and this test was called the posttest. A 2 (school) x 2 (pretest and posttest) analysis of variance with the pretest and posttest scores as the repeated measures was conducted, using the school grouping as the independent variable. The results of this ANOVA with repeated measures is shown in Table 6.

Table 6: A 2 (school) x 2 (pretest and posttest) analysis of variance with pretest and the posttest scores as the repeated measures, using the school grouping as the between-subject factor

	df	F-Factor	p
SCHOOL	1, 50	0.02	0.90
TEST	1, 50	17.12	0.00*
TEST/SCHOOL	1, 50	1.47	0.23

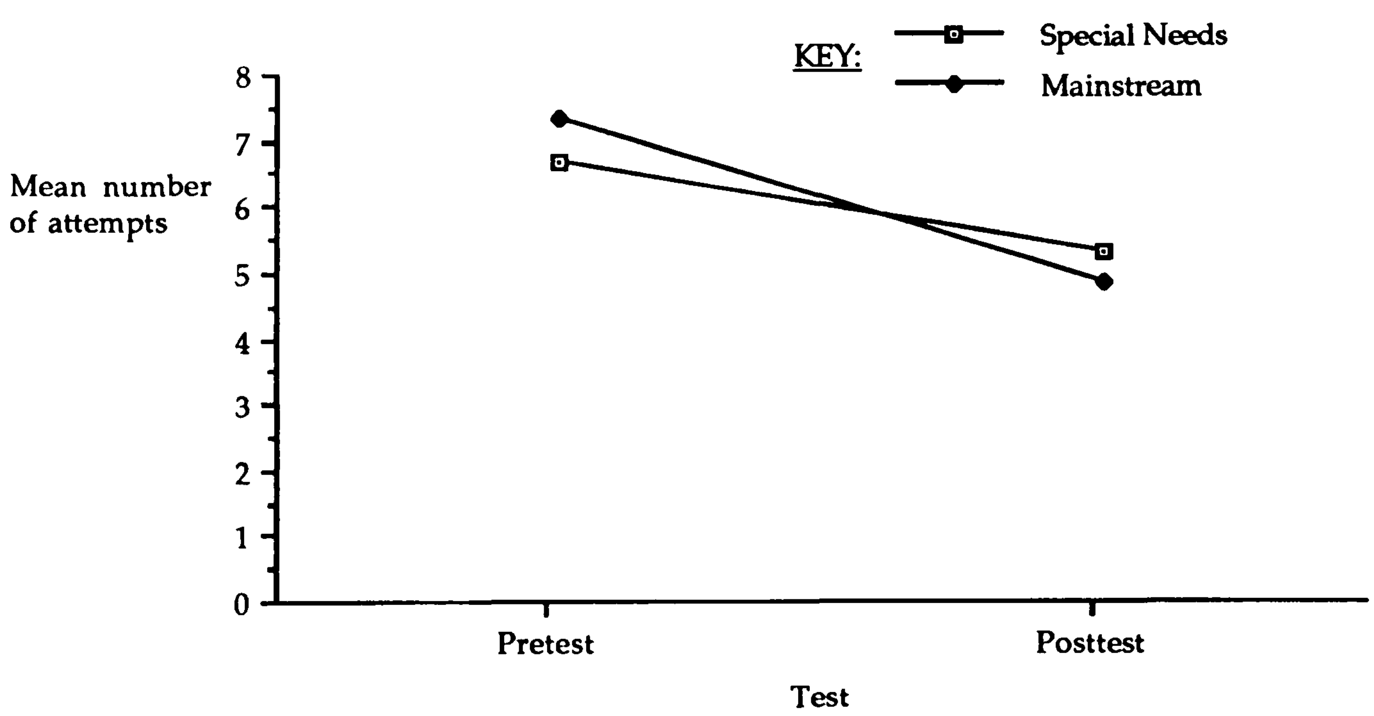
KEY: * $p < 0.01$

The above ANOVA with repeated measures reveals that overall the children showed a significant improvement in their ability to understand and use the map between the pretest and posttest - $F (1, 50) = 17.12$, $p < 0.01$. The children needed on average 6.79 attempts in the pretest and in the posttest the children used on average 4.88 attempts. Table 6 also shows that the number of attempts needed in the pretest and posttest by the mainstream children and the special needs children was not significantly different. The change in score from the pretest and posttest did not vary significantly between the mainstream children and the special needs children. The mainstream children required more attempts in the pretest than the special needs children. However, in the posttest the special needs children used more attempts on average than the mainstream children. The shift in performance between the pretest and posttest for both the mainstream children and the special needs children can be seen in Table 7 and Graph 3.

Table 7: Mean number of attempts (and standard deviations) required by the special needs children and the mainstream children in the pretest and posttest (for each school group n = 26)

Test	School: Mainstream	School: Special Needs	Total (n = 52)
Pretest	7.12 (3.73)	6.46 (3.72)	6.79
Posttest	4.65 (1.67)	5.12 (2.85)	4.88
Total	5.88	5.79	

Graph 3: Mean number of attempts used by the mainstream children and the special needs children in the pretest and posttest



<u>Summary of results - Experiment 3</u>

The mainstream children and the special needs children did not differ significantly in their static pretest score and their dynamic training score. This is not surprising considering the two groups of children were matched according to their initial competence. The special needs children needed slightly fewer attempts and hints in the pretest or training phase respectively, compared to the mainstream children.

The static measures in the maintenance and transfer phases did not possess concurrent validity with the children's intelligence as indicated by their school grouping. The mainstream children and special needs children did not vary in the number of attempts they needed across the maintenance and transfer phases; although a divergence between the two groups of children began to appear in the transfer phase.

The dynamic maintenance and transfer measures also did not display concurrent validity with the children's intelligence as indicated by their school grouping. The mainstream children and the special needs children did not differ appreciably in the number of hints to criterion they used across the maintenance and transfer phases. Initially, the mainstream children required marginally more hints in the first test of the maintenance phase than the special needs children. However by the time of the dynamic transfer phase the special needs children used more hints to reach criterion than the mainstream children. Indeed, the special needs children needed significantly more hints in the transfer phase than in the maintenance session. This was not true of the mainstream children, since they used slightly fewer hints between the first test of the maintenance phase and the test in the transfer phase.

Overall, the children showed a significant improvement in ability between the pretest and posttest. The mainstream children and the special needs children did not vary significantly in their shift in performance between the pretest and posttest. Interestingly, in the pretest the mainstream children required more attempts than the special needs children, but in the posttest the special needs children were using more attempts than the mainstream children. Therefore, the mainstream children experienced a marginally better improvement in performance between the pretest and posttest compared to the special needs children.

Discussion

The studies in this chapter extend previous research by demonstrating that dynamic measurement of the 'zone of proximal development' is useful in the context of a mapping task, especially among children with learning difficulties. The first experiment examined the concurrent validity with the general developmental level of both static measures and dynamic measures of the ZPD among children with learning difficulties. Experiment 1 also investigated the predictive validity for the improvement between pretest and posttest of the I.Q., static measures and dynamic measures among children with learning difficulties. The second experiment investigated the concurrent validity with the general developmental level of both static measures and dynamic measures of the ZPD among 'normal' children. Experiment 2 also examined the predictive validity for the improvement between pretest and posttest of the I.Q., static measures and dynamic measures among 'normal' children. The third experiment investigated the concurrent validity, with intelligence according to the children's school grouping, of static scores and measurements of the ZPD.

The first experiment, involving children learning difficulties, found that the dynamic learning and transfer measures of the ZPD showed concurrent validity with the children's intelligence, since they correlated significantly with the I.Q. test scores. The transfer score was noticeably better than the maintenance measures in differentiating between the I.Q. groups, indicating that the transfer score had more concurrent validity with intelligence than the maintenance measures. The children showed a significant improvement in ability between the pretest and posttest. The dynamic measures of the ZPD in the learning and transfer tasks demonstrated more predictive validity for this improvement between the pretest and posttest than the I.Q. score and the initial static measure; since they could account for appreciably more of the variance in performance between the pretest and posttest. The addition of the dynamic measures to the I.Q. score and the static score meant that over fifty percent of the improvement in performance between pretest and posttest could be explained.

The finding that measurement of the ZPD is valuable in a mapping task domain corresponds with results of the study by Bishop (1991). This experiment also shows that assessing the ZPD of children's ability to use spatial representations is particularly relevant among a group of children with learning difficulties. Bishop found that the static and dynamic measures of mapping ability were not significantly related. This was also the case in Experiment 1, which suggests that measurement of the ZPD is providing a different indication of psychological functioning than static scores. The results from the first experiment also matches the findings of Ferrara et al (1986), which involved 'normal' children within the context of a inductive reasoning task.

The introduction of dynamic assessment in the area of learning difficulties could possibly improve the current ability of educational psychologists to predict the future development of children with learning difficulties. This alternative method of assessment would provide a clearer diagnosis of each child's expected competence in different task settings. A child with a learning difficulty could have their ZPD assessed in various academic areas within school. This would be made easier by the help of computers in conducting dynamic assessment within certain task domains. Indeed, Campione et al (1985) have already undertaken the dynamic assessment of inductive reasoning ability using computers.

Assessing the potential development of children with learning difficulties helps one escape from the negative view that these children will always have a general deficit in cognitive ability as identified by I.Q. tests (Brown & Campione, 1986). Measuring the ZPD provides a dynamic and domain specific diagnosis of children with learning difficulties. This alternative approach to assessment allows for a focus on the particular problem each child has in a specific domain, without implying that this child is generally or permanently mentally handicapped.

The dynamic measures of the ZPD, in Experiment 2, did not show concurrent validity with the 'normal' children's intelligence, since they were not related to the 'normal' children's intelligence as assessed by an I.Q. test. This was also the case with the initial static test of the children's mapping ability. Experiment 4 in Chapter 5 found exactly the same result with a slightly younger sample of 'normal' children. These results suggest that young 'normal' children's I.Q. scores are not closely related to their ability to use a map or any other spatial representation. Therefore, the fact that the dynamic measures of the ZPD within a spatial task are not correlated with the children's I.Q. scores is not surprising. Measures of children's ability to use spatial representations do not have concurrent validity with their intelligence if one accepts that I.Q. scores are a complete reflection of intelligence. It is clear that spatial tasks require very different intellectual skills among 'normal' children compared to the tasks used within I.Q. tests.

Evidence supporting the notion of measuring the ZPD was found in the second experiment. Dynamic measures of learning and transfer in this experiment did improve upon the predictive power of I.Q. scores and static scores of transfer ability, when accounting for the change in performance between the pretest and posttest. Indeed, the I.Q. scores could not explain any of the variance in scores between the pretest and posttest. This result does contradict the findings of Bryant et al (1983) who found that I.Q. did have some predictive validity within an inductive reasoning type task. The difference in results between this experiment and one conducted by Bryant et al (1983) is probably due to the close similarity between the tasks they used and the subtests within the I.Q. tests themselves. The second experiment also found non-significant correlations between the static measures and the dynamic assessments of the ZPD across all phases of the experiment. This implies that these two different measurement techniques are actually appraising different psychological abilities, namely children's actual developmental level and their potential to learn from instruction. Thus if assessment of the ZPD is indicating the children's potential mapping ability this could explain the fact that dynamic scores had better predictive validity, for the improvement between pretest and posttest, than the I.Q. scores and the static measures in the maintenance and transfer problems.

Experiment 3 examined the concurrent validity with the children's intelligence of static and dynamic measures by comparing the performance of 'normal' children and children with learning difficulties on a mapping problem. The ability of the two groups did not vary significantly across any of the static and dynamic tests of the experiment. This result would suggest that neither the static or dynamic measures had concurrent validity with the children's intelligence. However, a closer examination of the results shows that the transfer problem had a significant effect on the dynamic performance of the children with learning difficulties but not the dynamic ability of the 'normal' children. Measurement of the ZPD within the transfer task did demonstrate an appreciable difference in mapping ability between the two groups of children, which was not apparent in the static assessment of these children.

Campione et al (1985) found that 'normal' children and children with learning difficulties had noticeably different ZPDs within a transfer task. They found a significant difference between the number of hints needed by the two groups on the transfer problem. This reflects the manner in which they approximately matched their groups; since in their pretest the 'normal' children were already out performing the children with learning difficulties and by the transfer phase this difference had become significant. The two groups in Experiment 3 were matched in a different way than that by Campione et al (1985), since the children with learning difficulties had marginally better pretest scores than the 'normal' children. This may explain why the third experiment did not find a significant difference between the two group's abilities in the maintenance and transfer phases, though the children with learning difficulties gradually began to perform below the standard of the 'normal' children. Importantly, a similar shift in dynamic scores between the maintenance and transfer for both groups of children was found by Experiment 3 and Campione et al (1985). The results of this Experiment 3 do indicate that measuring the ZPD on transfer problems within a mapping task is a useful exercise, because it can help identify transfer difficulties experienced by children with learning difficulties.

The nature of dynamic assessment, unlike traditional static tests, allows for the development of instruction for remediation in many different task domains. Each child will probably find a particular hint in the assessment procedure which enables them to reach a new level of potential development. This form of help could be used as a basis to design effective individualised intervention in various domains. The results from these studies suggest that generally children's ability to use maps could be improved by allowing the children to experience a variety of spatial representations and helping them to realize the correspondence between the landmarks on the map and those in real space.

The studies presented in this chapter show that Vygotsky's assumption about the value of measuring the 'zone of proximal development' is appropriate within the context of a task requiring the understanding and use of spatial representations. Measurement of the ZPD is particularly useful when examining the ability of children with learning difficulties. The introduction of dynamic assessment techniques in the field of learning difficulties could help educational psychologists identify these children's potential development, so providing a basis for intervention and a more positive conception of learning difficulties. Dynamic measures of learning and transfer efficiency have both concurrent validity with children's intelligence and predictive validity for improvements in ability among children with learning difficulties. The assessment of the ZPD could also improve upon the predictive power of I.Q. scores and static measures among 'normal' children too.

Chapter 7: Conclusion

Vygotsky attempted to develop a dialectic theory of human development and escape from the Cartesian straight jacket that has surrounded psychology since its birth. In his endeavours Vygotsky provided us with various intellectual tools, including the zone of proximal development, that could be useful in generating psychology's own zone of proximal development. Psychology needs such intellectual tools if it is to truly explain the process of interaction between mind, body and environment that creates new psychological functioning, for "it is by the instruments and helps that the work is done, which are as much wanted for the understanding as for the hand. And as the instruments of the hand either give motion or guide it, so the instruments of the mind supply either suggestions for the understanding or cautions" (Bacon, 1620/1960, p. 39). Or as the contemporary psychologist Jerome Bruner explains "even the strongest causal explanations of the human condition cannot make plausible sense without being interpreted in the light of symbolic world that constitutes human culture" (1990, p. 138).

The value of measuring the 'zone of proximal development' (Vygotsky, 1978) was the main issue of this thesis. The ZPD as a concept was framed within the context of Vygotsky's dialectical theory of human development which emphasised that the mind, the body and the external environment are interdependent. This sociocultural approach to development draws on the influence of Soviet psychology and Hegelian philosophy. In line with Vygotsky's thinking the measurement of the ZPD in this thesis occurred within tasks which required children to understand and use external spatial representations. Vygotsky's sociocultural theory contends that it is through the interaction between external artifacts, the body and the mind that cognitive development occurs.

The chapters within this thesis offer theory and research which indicate that Vygotsky's concept of the ZPD is both a useful descriptive tool within psychological theory and, importantly, a valuable criteria upon which to base predictions of children's future cognitive development.

Recent research in developmental psychology has been critical of Piaget's theory of spatial development which argued that children below the age of seven years can not understand and use both external and mental representations. This research (Blades and Spencer, in press; Blades and Cooke, 1992) has shown that children develop representational ability around their fourth birthday. Research by DeLoache (1989) and Perner et al (1992) has demonstrated that children below the age of four years can understand the correspondence or dissociation between two objects or events; if the experimenter assists them in recognising the analogy or difference between such objects or events. These researchers failed to realise that such results do not show that children below four years-old have representational ability, these findings indicated that children younger than four years have representational competence within their ZPD. The research by DeLoache (1989) and Perner et al (1991) was measuring the children's ZPD and they were confusing the children's potential development with the children's actual development.

Two experiments were conducted as part of this thesis, which investigated the individual ability of three to five year-old children to understand and use a map inside a maze. This research extended previous studies by requiring children to use a map when finding an object in a large-scale maze, the type of environment normally mapped by people. The experiments also used four hiding places which varied in terms of their spatial relations to nearby landmarks and the degree to which the children had to re-orientate them within the maze. The two experiments found that children developed the ability to understand and use a map around their fourth birthday. This result was in line with the findings of Blades and Spencer (in press) and contradictory of the research conducted by DeLoache (1989) and Perner et al (1992). It seems that the research conducted by DeLoache, Perner and his associates overestimated young children's representational ability by measuring their ZPD, not their actual level of development. Developmental psychologists need to acknowledge when they are measuring the ZPD so they do not confuse children's potential development with their actual development. Studies within this thesis have demonstrated that in unassisted situations children develop the ability to understand and use external representations around their fourth birthday.

In addition, the two experiments in Chapter 2 showed that four year old children's ability to understand and use a map was possibly dependent on: 1) the need to make compensatory rotations of the map, 2) the degree of concealment of the hiding places, 3) the complexity of the spatial relationship between the hiding places and nearby landmarks and 4) the availability of external landmarks. These experimental factors could be manipulated in future studies of representational ability with the aim of measuring the ZPD of four year old children. In the future, developmental psychologists must be aware of the factors within the experimental environment that influence the child's representational ability. Then these variables can be controlled and psychologists will be able to differentiate between children's actual developmental level and their potential developmental level.

The study of cognitive development has been plagued by the issue of how to determine whether a child 'has' or 'has not' got a cognitive ability or knowledge (Flavell, 1985). Psychologists have tried to develop test procedures for the presence or absence of cognitive skills in children. However, these tests have tended to either overestimate or underestimate children's ability. Overestimation can led to a diagnostic error of the false-positive variety, as in the case of DeLoache (1989). Whereas, underestimation of children's ability tends to result in a diagnostic error of the false-negative variety. There is a need for a diagnostic testing system which decreases the possibility of both kinds of errors.

The development of such a form of diagnostic testing will only occur if one examines the notion of measurement in a more abstract and theoretical manner. What does it mean to state that a child 'has' or 'does not have' a cognitive ability? A child might show an ability in all and only the relevant situations and another child might never show this ability. It is clear here which child 'has' the ability and which does not. However, it is common for some children to show an ability in only a few, very easy task situations or in all but a few, very hard task situations. This variation in the children's ability often depends on the specific nature of the testing situation. A case in point here is the research on children's ability to understand and use a spatial representation, which has found that children of the same age show different representational ability in various experimental studies. DeLoache's (1989) research on children's spatial ability involved a false-positive diagnostic error because the task situation allowed the children to obtain the right answer by consideration of only 'object attributes', an 'irrelevant solution strategy' (Smedslund, 1969) in the context of her study.

It may be necessary to ascertain several different kinds or degrees of 'having' an ability, not just whether the child 'has' or has not' got this ability. The aim would be to develop a notion of the orderly progression to the most mature level of different cognitive abilities. This process would involve a detailed examination of the component parts of an ability and the sense by which one component is different from another. The problem is how to measure the degree by which a child 'has' an ability. Flavell (1985) argues that a child might 'have' a cognitive ability in such a "rudimentary sense it may be difficult to evoke it or execute or utilize it" (p. 277). Consequently, the tester might have to evoke the ability directly through instruction. The tester could evaluate whether and how children 'have' an ability based on their reaction to training. This approach to measurement is similar to Vygotsky's view on assessing cognitive development and his emphasis on measuring the ZPD.

The diagnosis of children's cognitive ability is not essentially hopeless and it is not impossible to enhance existing procedures. Vygotsky's theory and the ZPD in my mind offers a method of improving upon traditional methods of assessment. It is necessary to know both a child's actual developmental level and their potential developmental level when determining whether and to what extent this child 'has' a certain cognitive ability. Measurement of a child's ability in a very difficult task situation would provide an indication of their actual developmental level and help avoid an overestimation of the child's cognitive development. In addition, measurement of a child's ability in an easier, assisted task situation would give an idea of their potential developmental level (their ZPD), so decreasing the possibility of an underestimation of the child's ability.

The origins of Vygotsky's sociocultural theory and the 'zone of proximal development' rested within Soviet psychology and Hegelian philosophy. This meant that Vygotsky had a dialectic view of human development which emphasised the interdependence between the mind and the external environment, in contrast to the mind-body dualism which has dominated the majority of Anglo-American psychology. Vygotsky's approach to psychology is similar to the ideas of Rubinstein who argued that cognitive development occurred through activity which leads to reflective thought and new level of consciousness.

Vygotsky operationalised the ZPD in two particular ways. Firstly, he used the ZPD as a descriptive conceptual tool to explain the relationship between education and cognitive development. Vygotsky argued that teachers could not directly install new cognitive abilities in a child, but they could enable a child to engage in cooperative activity which would create a ZPD and lead to the internalisation of psychological functions. The ZPD was also introduced by Vygotsky as a means of complementing and improving upon traditional individualised assessment of intelligence. He argued that such individual tests only evaluated the products of the child's development, while ignoring the child's potential development. Measurement of the ZPD according to Vygotsky would provide important diagnostic information beyond that given in static tests, that would be useful in predicting children's future development. Vygotsky thought that assessment of the ZPD would be particularly relevant in the case of children with learning difficulties, because they may have lacked the opportunities necessary for development and though these children may have poor innate abilities they may be able to compensate for this through the use of external cultural artifacts. Assessment of the ZPD among children with learning difficulties could indicate the ability of these children to learn from instruction and counter balance their weak innate functioning.

Contemporary interpretations of Vygotsky's ZPD have attempted to elaborate this concept in two directions. Firstly, various psychologists have introduced new concepts in order to clarify what is meant by the ZPD. 'Scaffolding' (Wood et al, 1976) seemed an inadequate description of interactive learning. Wertsch (1989a, 1989b) offered useful concepts when trying to develop a more detailed description of the interaction between the mind and the social world. These notions are situation definitions, semiotic mediation and intersubjectivity. Cole and his associates also introduced important concepts, such as functional systems and appropriation, in order to develop the ZPD as a descriptive tool. Valisiner made a valid point when he states that instruction is not always necessary for the creation of the ZPD, but it can develop through the cultural structuring of resources. Some psychologists, like Rogoff, have used new words to describe the ZPD without actually increasing the theoretical basis behind the idea.

The second advancement of Vygotsky's use of the ZPD has developed his idea of measuring the ZPD. Various researchers, such as Campione & Brown (1990), have introduced dynamic assessment techniques in order to gain a measure of the ZPD. This is achieved by assessing the number of hints required by children to reach a set level of performance, thus providing measures of children's ability to learn from instruction. It is argued that this procedure provides useful diagnostic information about a child's potential development beyond that given by individualised tests. The research conducted by Campione & Brown and others has demonstrated that measures of the ZPD do have concurrent validity with intelligence and predictive validity for improvements in performance.

Preliminary studies were completed in this thesis as pilot studies for the experiments reported in Chapter 6, which measure the ZPD with a mapping task. The first three studies enabled the researcher to choose an appropriate sample, method and apparatus for these experiments. These preliminary studies also showed that children with learning difficulties may have problems transferring their ability to use a map into a new environment. Therefore, it was decided to include tests of transfer ability in the planned experiments. The final preliminary experiment showed that future studies should examine the diagnostic value of measuring the ZPD, since static tests of mapping ability did not have concurrent validity with the children's general developmental level and the BPVS score did not show predictive validity for the children's ability to understand and use a map.

Three experiments are contained within this thesis which attempted to measure the ZPD of both 'normal' children and children with learning difficulties in a task which required them to understand and use different spatial representations. These studies found that measurement of the ZPD had concurrent validity with intelligence and predictive validity for improvements in performance within a task independent of traditional I.Q. inductive reasoning problems, namely a mapping task. It was also found, in line with Vygotsky's thinking, that measurement of the ZPD was particularly relevant in the case of children with learning difficulties, since assessments of the ZPD among this group had both concurrent validity with intelligence and predictive validity for changes in ability. Though dynamic measures of the ZPD, like static scores, did not have concurrent validity with I.Q. scores among 'normal' children evaluations of their ZPD did show predictive validity for changes in performance between a pretest and a posttest. These studies suggest that measurement of the ZPD within a spatial task could provide valuable diagnostic information additional to that obtained from individual static tests and I.Q. tests.

This thesis suggests that measurement of the ZPD has some value within psychology and education. It can, within the context of a mapping task, provide useful information about children's intelligence and their potential ability in addition to that given by individual measures and I.Q. scores. The value of measuring the ZPD is particularly pertinent among children with learning difficulties. Educational psychologists could make use of dynamic assessment techniques so presenting a more accurate picture of the potential development shown by children with learning difficulties. This method of measuring the ability of children with learning difficulties would help avoid the common underestimation of their capabilities by standardised and individualised tests. Traditional static tests do not examine the ability of children with learning difficulties to compensate for their intellectual problems through the appropriation of external artifacts in the environment. This appears to be a major fault with static tests considering the dialectical theory of human development contends that cognitive development occurs through the interaction between mind, body and the environment. Dynamic measurement of the ZPD among children with learning difficulties shows that these children often do not have a general cognitive deficit, which is stable over time, but they experience specific problems in different task domains which can be remediated through guidance and instruction.

Measurement of the ZPD among children with learning difficulties could also help educational psychologists and teachers to generate particular types of subject based instruction which can tailored to the needs of each individual child. Special needs education does require methods of assessment which can evaluate fairly accurately the developmental abilities of children with learning difficulties, as well as providing insights into how these children can be taught within schools. This is especially true in England and Wales where the national curriculum applies within special needs schools and educationalists have to assess the developmental progress of children with learning difficulties through the different stages of the national curriculum. Static tests within special needs schools would underestimate the potential ability of children with learning difficulties to reach high levels of performance in the national curriculum. Consequently, children with learning difficulties could be labelled has 'hopeless failures', plus they could generally be ignored by educationalist and excluded from mainstream schooling. Whereas, measurement of the ZPD among children with learning difficulties would give a more accurate picture of these children's potential ability. Then educationalists and governments might not ignore the pool of wasted talent that exists in special needs schools.

Teachers within the classroom should be aware of the ZPD as an educational concept, which can help them assess and understand the development of children. The observation of a child in an unassisted classroom environment would only provide a partial indication of the child's abilities. The teacher needs to investigate how the child response to instructions and the type of guidance appropriate for each individual child. This involves encouraging the children to engage in group activities with both their peers and the classroom teacher. Informal assessment of the ZPD within the classroom by teacher would assist educational evaluations of children's potential functioning and it would avoid the placement of children in unsuitable school classes, in which the children either show abilities far beyond their class mates or they have serious difficulties maintaining the class level of performance.

Future research could investigate the value of measuring the ZPD within different psychological domains, such as the areas of language development or attitudinal change. This method of assessment would give a better insight into the potential of people to develop new language abilities and attitudes. Psychologists need to note the value of the ZPD as a descriptive concept in explaining the relationship between instruction and development in all areas of psychological functioning. Specifically, psychologists need to appreciate the useful function of the zone of proximal development as a measure of potential psychological ability.

Western psychologists have in recent years been searching for new theoretical approaches which are concerned with the social origins of mental processes and the dynamic aspects of human development. This may explain the current interest in Vygotsky's theory and the 'zone of proximal development' within developmental psychology. Psychologists are beginning to appreciate that human development is a dynamic process, involving the interaction between mind, body and the environment over time. It is false to represent the child as a passive agent within development, either determined by biological or social factors. The unit of analysis in psychology should be the interaction between an active child and the cultural world within different activity settings. Vygotsky's socio-cultural theory and the 'zone of proximal development' offers an approach to psychology which is inherently dialectic and recognises the need to go beyond the individual when examining human development. The study of the individual is no longer enough, people live in a social world that is at the heart of their development.

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Appendix

The hinting sequence used in Experiment 2 (Chapter 5): in order of explicitness.

Initially all the children were given a black and white map of the maze.

1. Give the child the map with coloured boxes and coloured walls.

2. Point to the blue box on the map, take the child to that box in the maze and explain the correspondence.

3. Show the child the red (back) wall on the map, take him/her to the wall in the maze and explain the correspondence.

4. Give the child a black and white aerial photograph of the maze.

5. Give the child a coloured aerial photograph of the maze.

The hinting sequence for the dynamic training phase, plus the dynamic parts of the maintenance stage and the transfer stage (Chapter 6): in order of explicitness.

Initially all children were given a black and white map of the maze.

1. Give the child a black and white aerial photograph of the maze instead of the map. "Can you find the box with the present inside by looking at this picture?"

2. Give the child the map with coloured boxes and coloured walls. "Does this help you?"

3. Point to the blue box on the map and take the child to that box in the maze. "Can you find the box with the present hidden inside?"

4. Show the child the red (back) wall on the map and take the child to the wall in the maze. "Does this help you?"

5. Give the child a coloured aerial photograph of the maze. "Does this help you find the box with the present hidden inside?"

<u>Chapter 6</u>

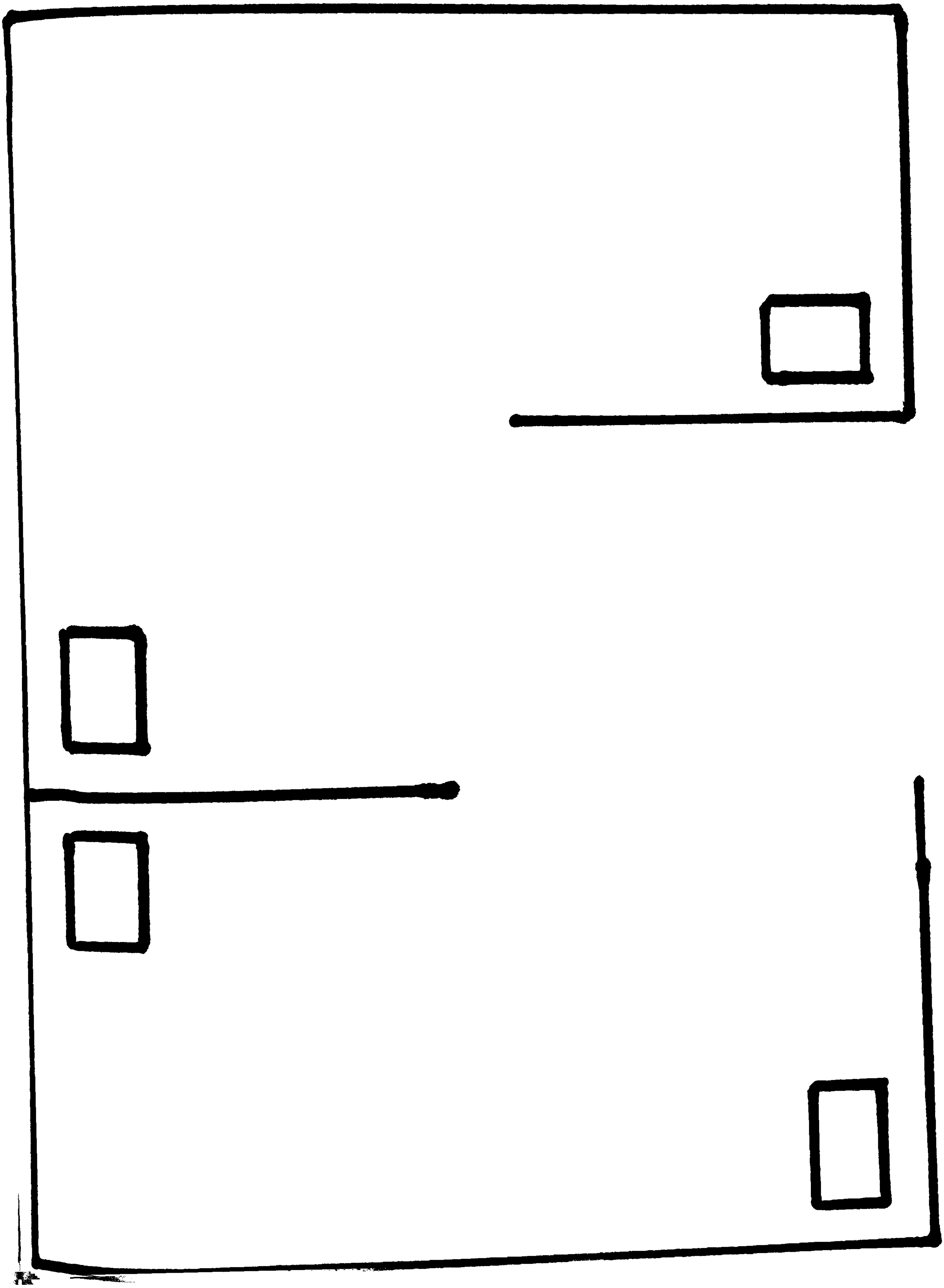
* The terms 'high I.Q.' and 'average I.Q.' are used only with reference to the particular sample who took part in Experiment 1. It is not intended that these terms should refer to the general population. These terms are the same as those used by Ferrara et al (1986) in an experiment involving a sample of 'normal' children and are only adopted in Experiment 1 for the purpose of forming two groups to make the statistical analysis possible. The sample of children with learning difficulties in Experiment 1 were not defined as mentally retarded (according to the criteria of the American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised. Washington, DC, 1987), because full I.Q. data on these children was not available from the Regional Council. Thus, for the

purpose of this experiment the sample were described as 'children with learning difficulties' because they attended a special needs school.

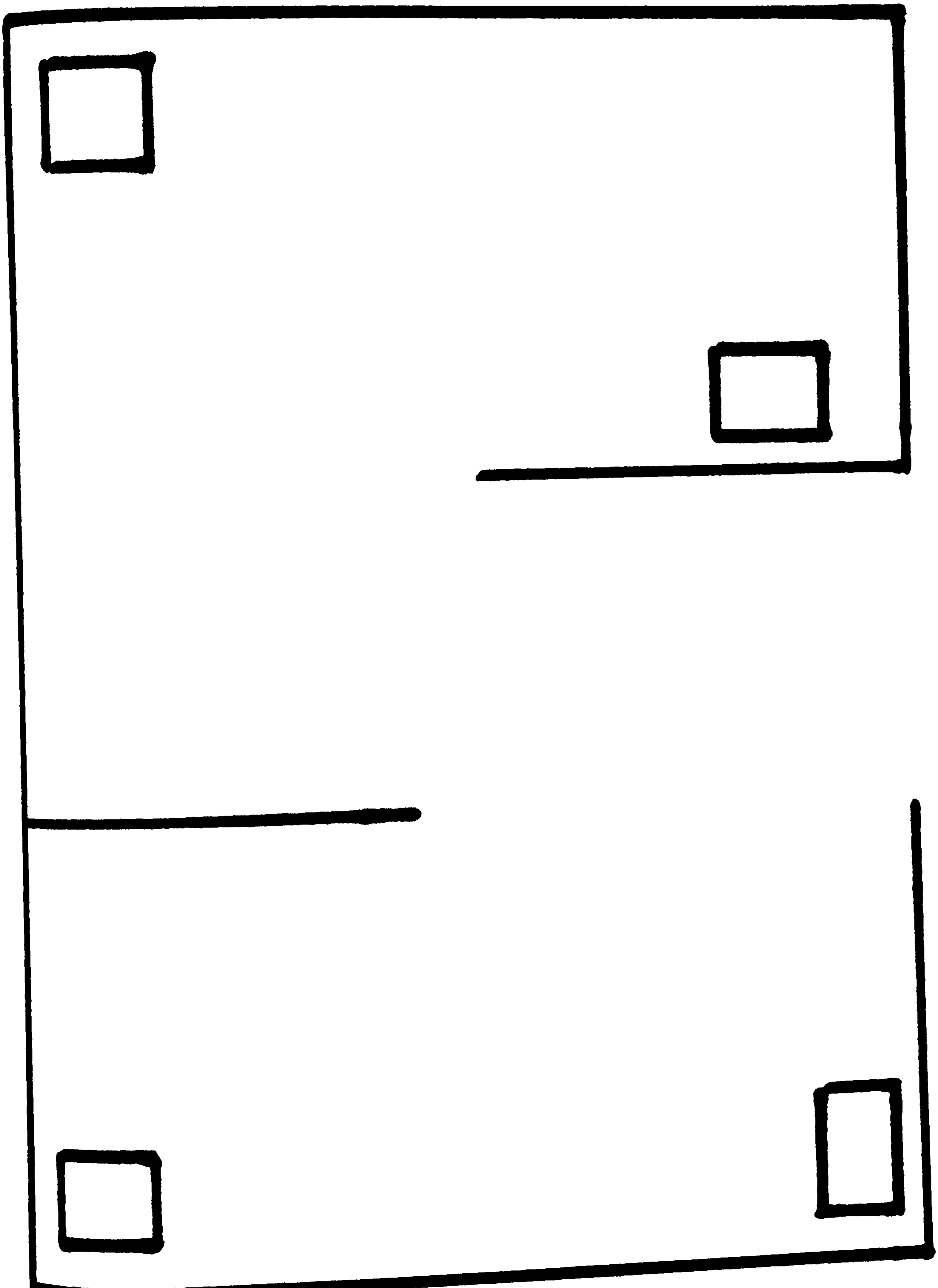
The researcher did request further background information on the children with learning difficulties used in Experiments 1 and 3. In particular, the researcher asked for medical information on any of the children's special disabilities. The Regional Council did not flatly decline this request, but referred the researcher initially to the school and the parents. However, the school would not provide the information without parental permission and was not willing to cooperate with the researcher in gaining parental approval. Therefore, considering the attitude shown by the school it was clear that any background information on the children could not be obtained.

** The terms 'high I.Q.' and 'average I.Q.' are used only with reference to the particular sample who took part in Experiment 2. It is not intended that these terms should refer to the general population. These terms are the same as those used by Ferrara et al (1986) in a similar experiment. Full I.Q. data on sample used in Experiment 2 was not available from the Regional Council. Therefore, no comment could be made about whether the children were mentally retarded or not, though the children were defined as 'mainstream' for the purpose of Experiment 2 because they attended a mainstream primary school.

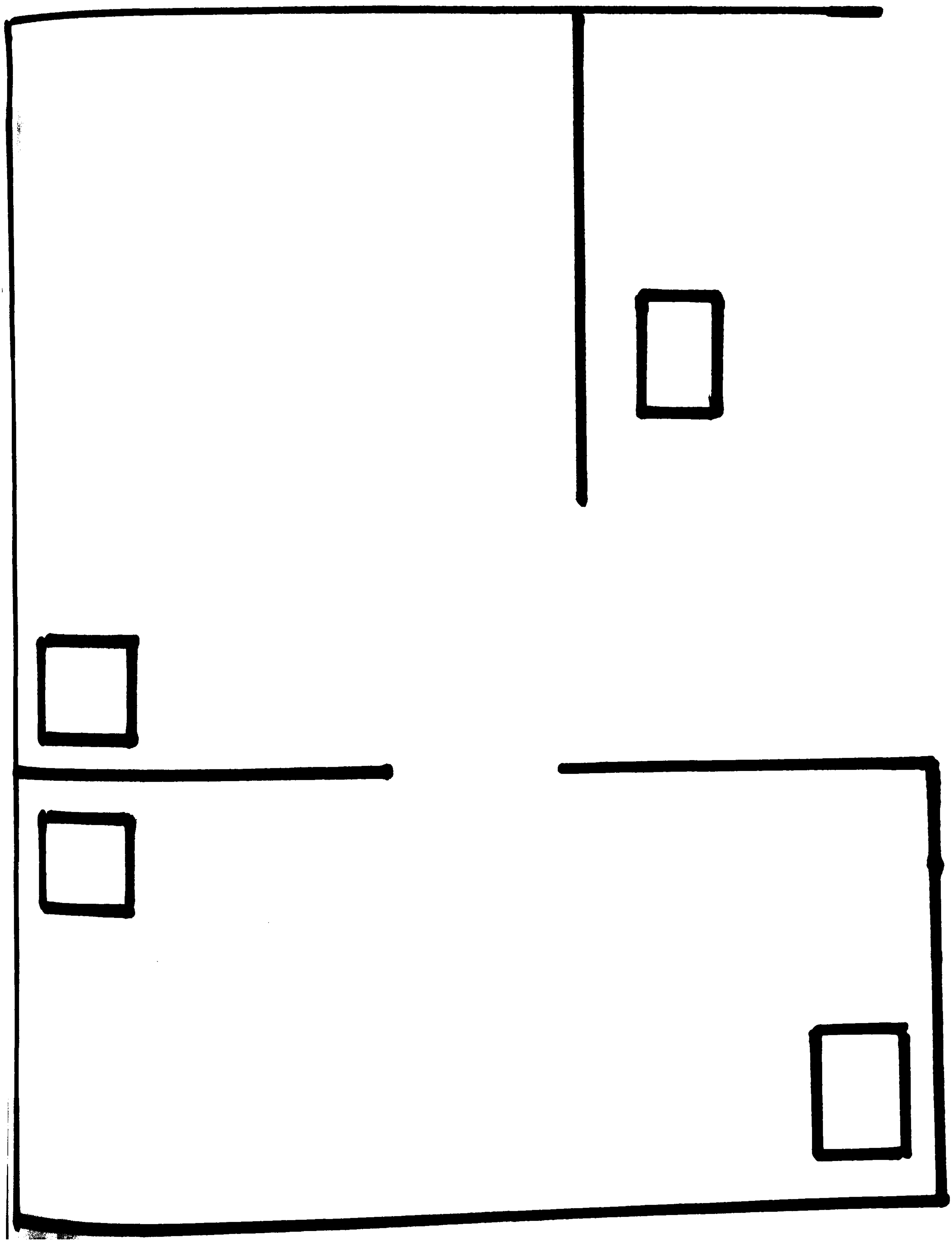
Map 1: A photocopy of a black and white map used by the children in Chapter 5 - Experiment 1, 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



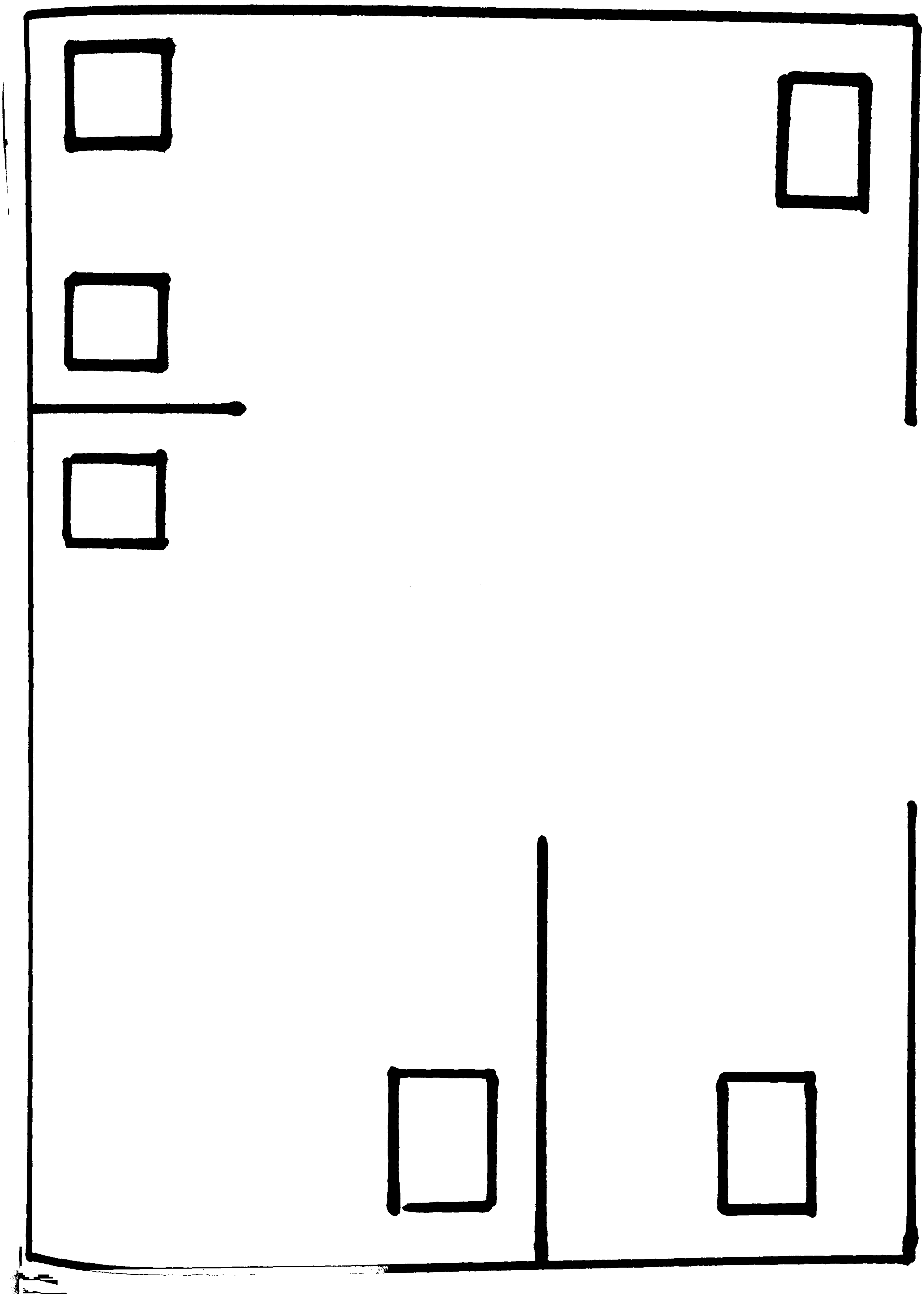
Map 2: A photocopy of a black and white map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



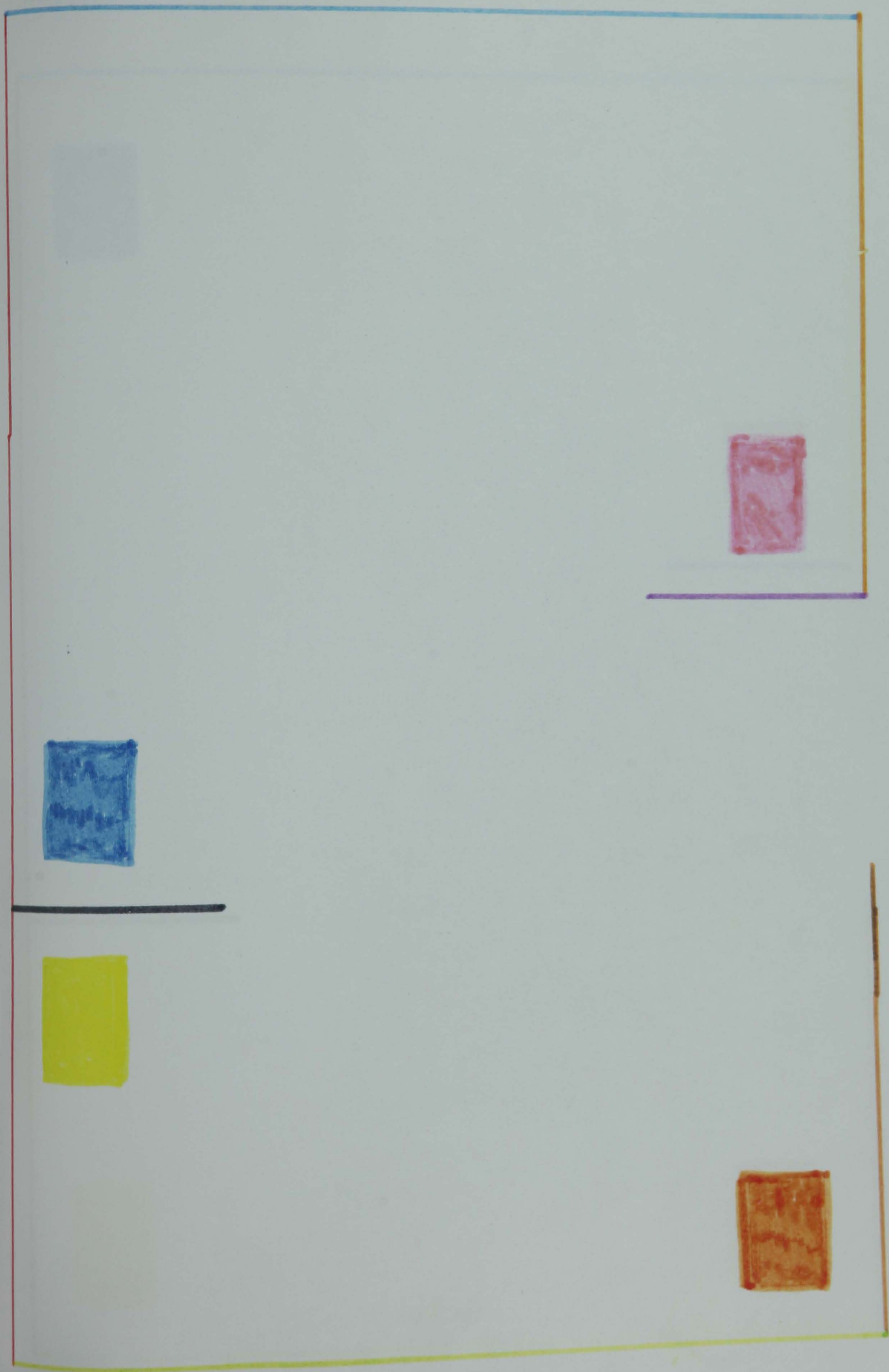
Map 3: A photocopy of a black and white map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



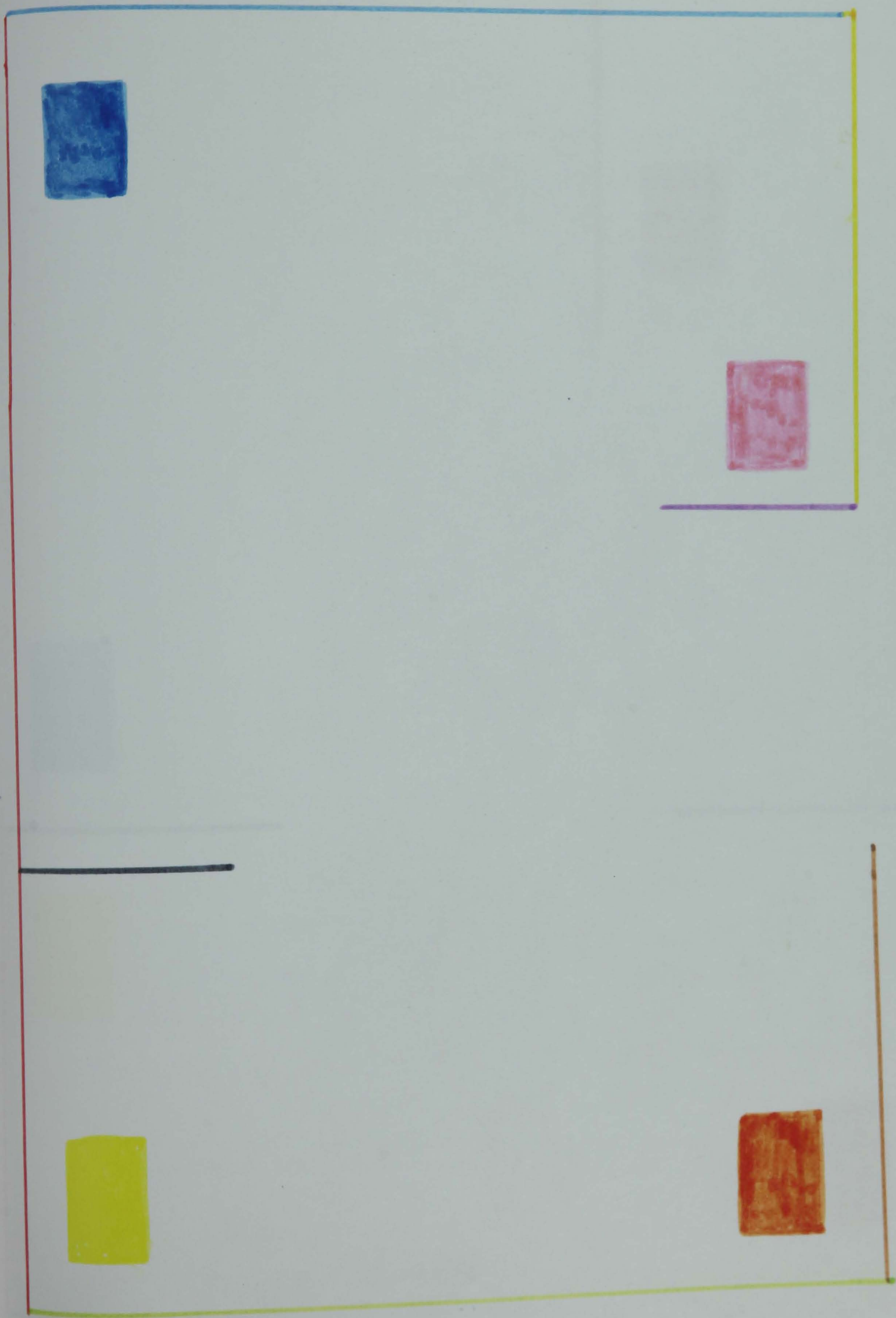
Map 4: A photocopy of a black and white map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



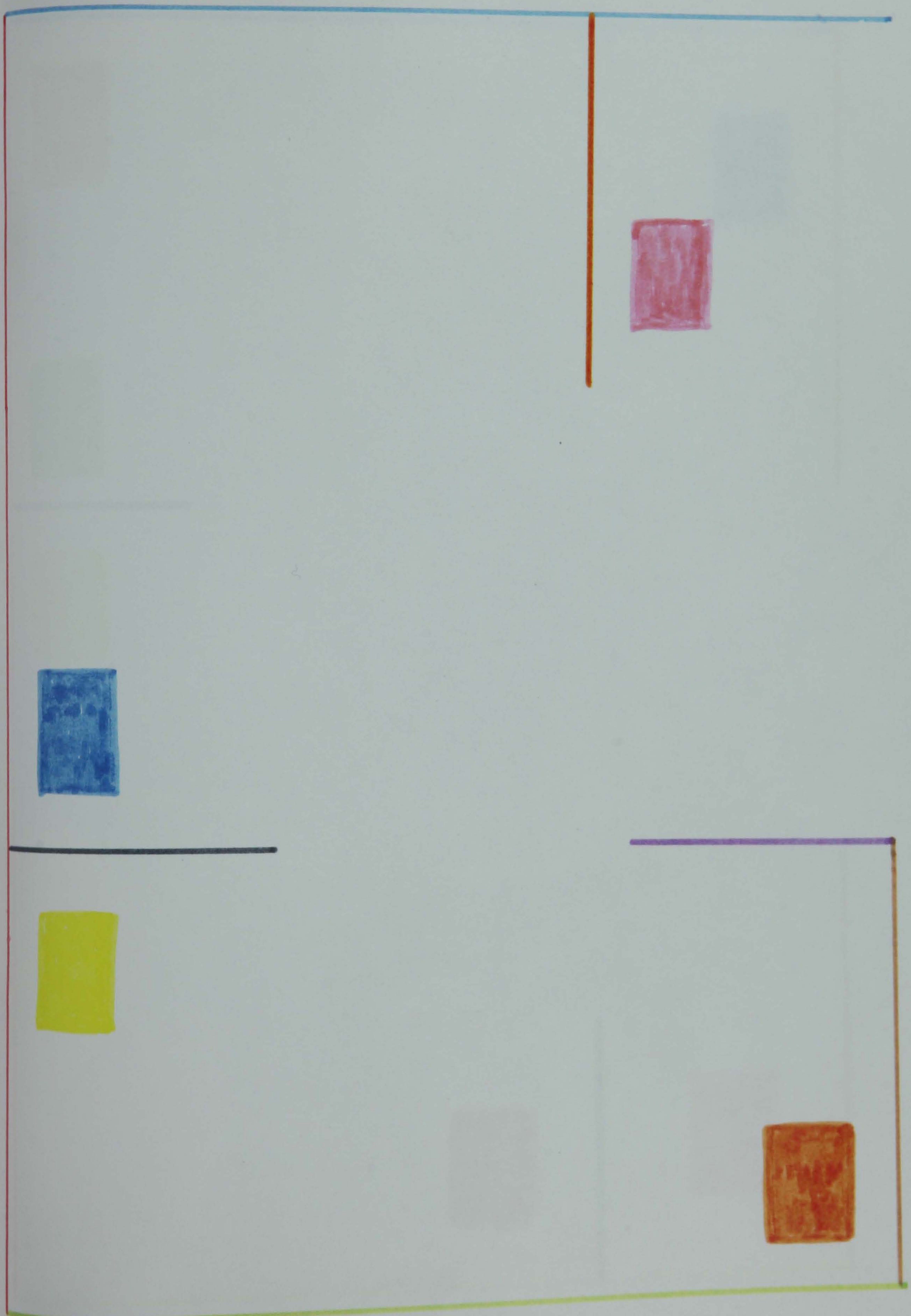
Map 5: A photocopy of a coloured map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



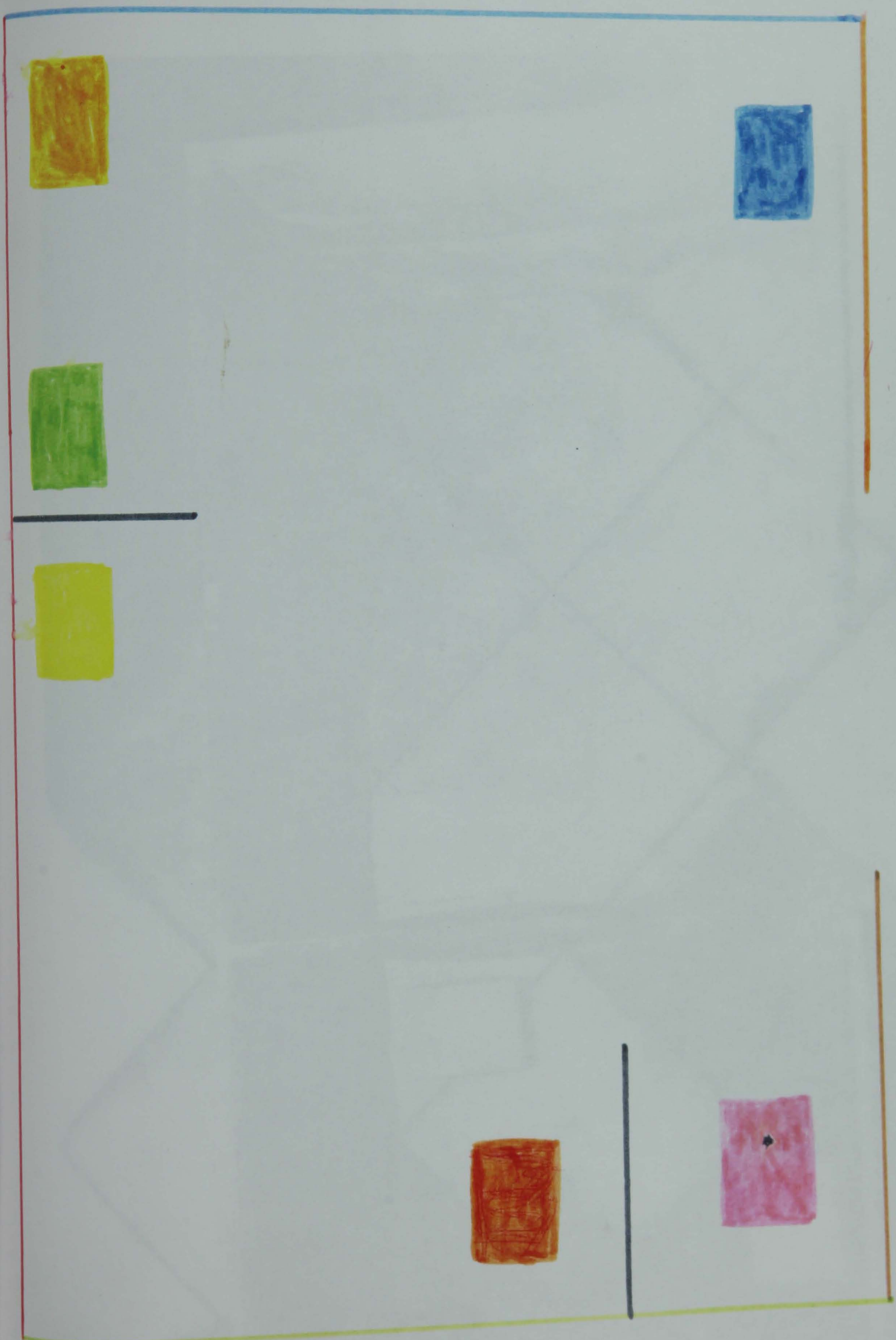
Map 6: A photocopy of a coloured map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



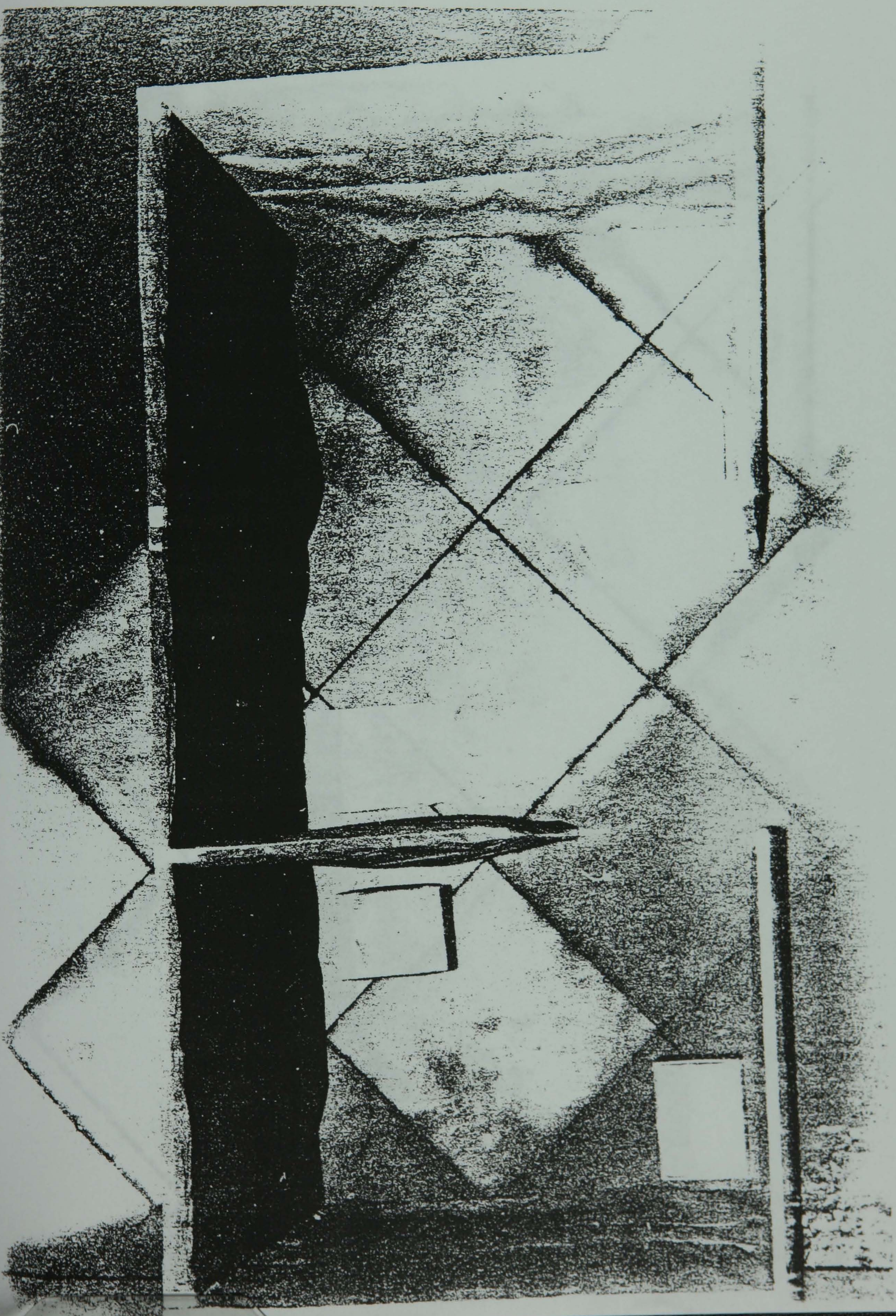
Map 9: A photocopy of a coloured map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



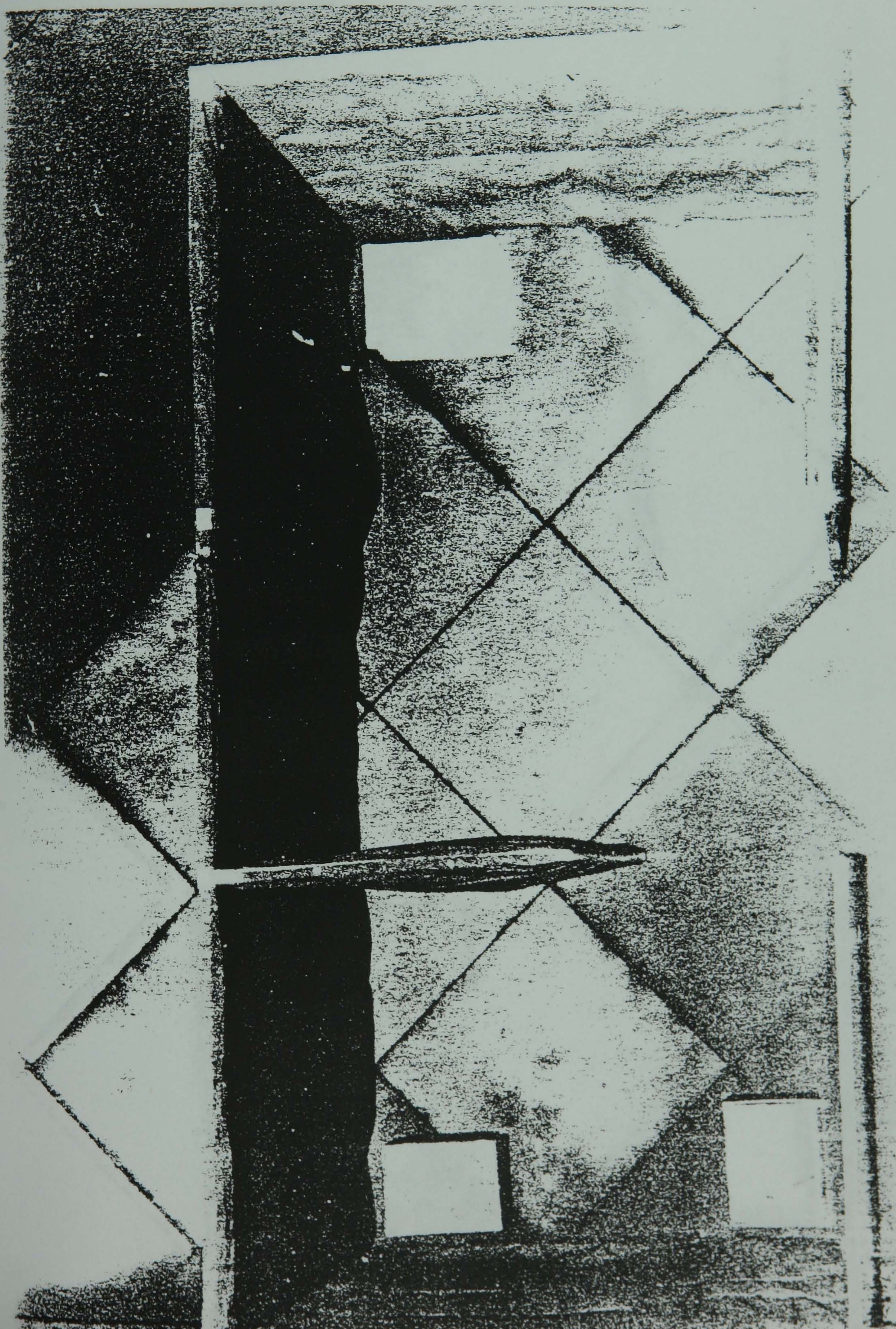
Map 2: A photocopy of a coloured map used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



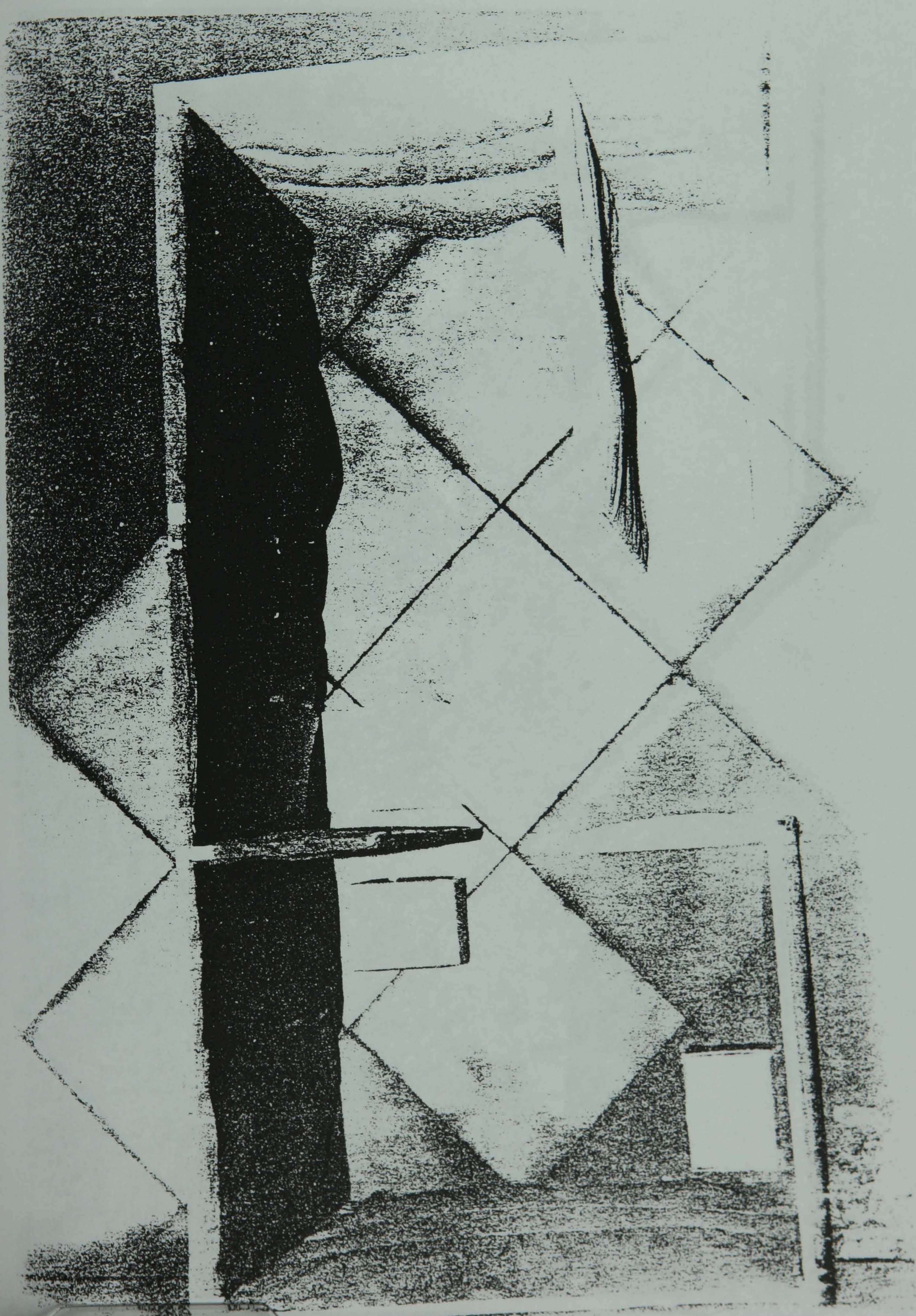
Photograph 1: A photocopy of a black and white photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



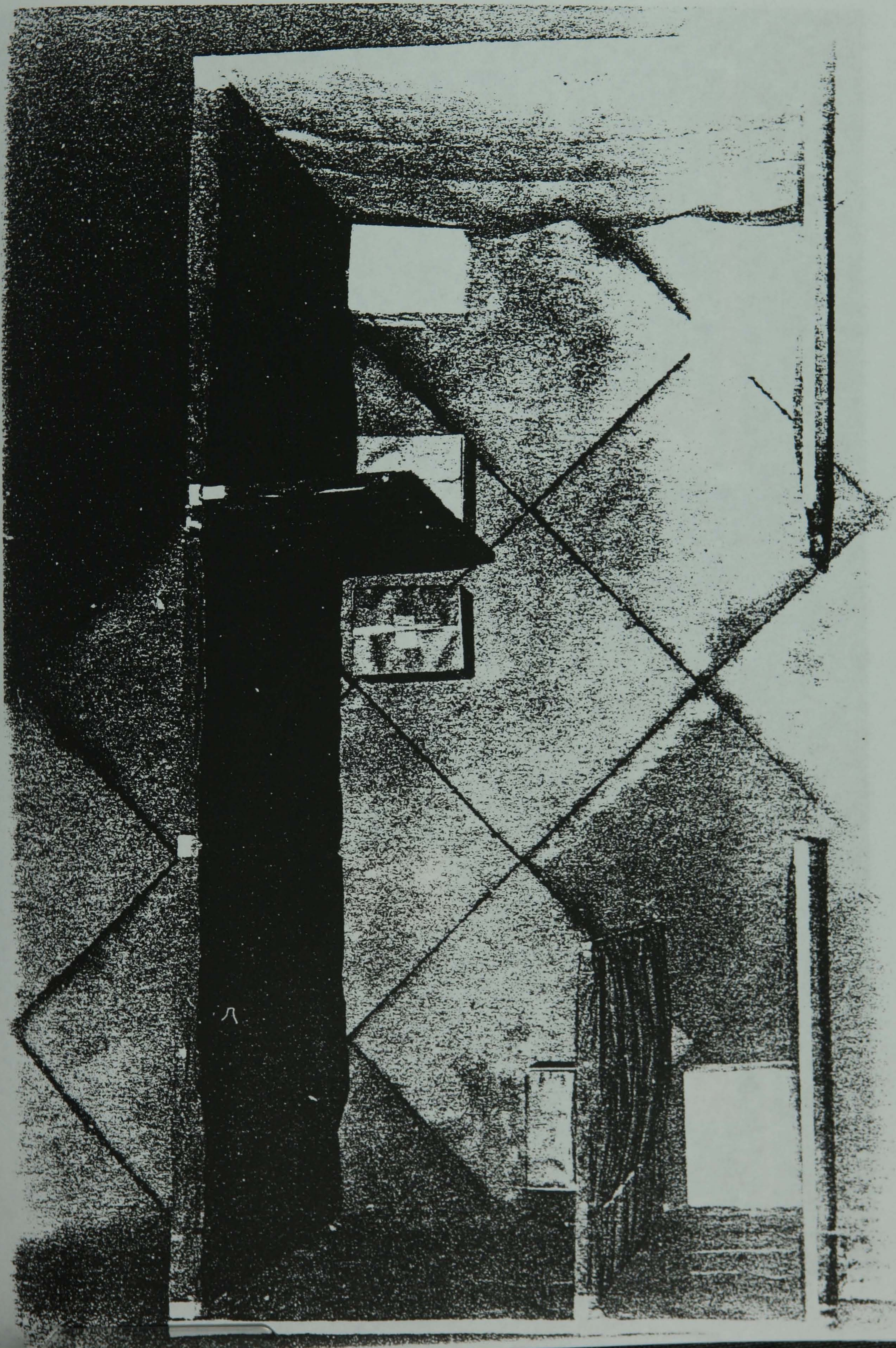
Photograph 2: A photocopy of a black and white photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



Photograph 3: A photocopy of a black and white photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



Photograph 4: A photocopy of a black and white photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.



Photograph 5: A photocopy of a coloured photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.

Photograph 6: A photocopy of a coloured photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.

Photograph 7: A photocopy of a coloured photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.

Photograph 8: A photocopy of a coloured photograph used by the children in Chapter 5 - Experiment 2 and 3, plus Chapter 6 - Experiment 1, 2 and 3.