THE REPRESENTATION OF DEPTH IN CHILDREN'S DRAWINGS

KAREN SUSAN LITTLETON

being a thesis submitted for the degree of

Doctor of Philosophy

University of York

Department of Psychology

June 1991

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ACKNOWLEDGEMENTS.

I wish to express my gratitude to Dr. M. V. Cox for her invaluable supervision: it is very much appreciated.

I would also like to thank Judith Baker, Peter Barnes, Duncan Barraclough, Margaret van Burken, Liz Freeman, Caroline Hunt, Prof. Paul Light, Graham Littleton, Nikki Pitchford, Dr. Derek Roger, Jane Simpson, Sue Stothard, Sheila Vaswani, Ian Wallhead, Patty Washienko, Angie Wilson and my experimental subjects for their help and encouragement.

Special thanks go to Emma Lakin and Kate Eames for things too numerous to mention.

Finally I would like to thank my parents for their love and support.

ABSTRACT.

The recent experimental approach to the study of children's drawings regards drawing as a form of problem solving, and aims to identify through the use of controlled studies the kinds of problems the drawer faces and the strategies s/he uses to solve them. One particular problem which has received much attention in recent years is the issue of how one represents the three-dimensional world on the two-dimensional surface of the page. The 'up-down' and left-right' dimensions of real world space are fairly readily translated into graphic terms: 'up-down' spatial relationships are represented by 'top-bottom' relationships on the page, whilst 'left-right' relationships in the scene are represented by 'left-right' relationships on the page. The problem arises with the representation of the 'near-far' or depth dimension of real world space as there is no equivalent on the flat, two-dimensional surface of the page. How does one demonstrate that an object is solid and possesses depth or that one object is positioned behind another and is therefore farther away?

Perhaps the most commonly used 'adult' solution to this problem is the system of linear perspective. This system basically involves producing a view-specific or visually realistic representation by depicting the projective image of a scene from a particular fixed point of view. More specifically, however, the projective portrayal of depth is achieved mainly by the use of two drawing devices: the partial occlusion technique and perspective 'depth' lines (Langer-Küttner, 1990). Although both these devices are used to portray depth, it is important to note that each is used to denote a particular type of depth relationship. The partial occlusion technique, for example, is used to indicate that from the observer's viewpoint part of an object is obscured by one that is nearer; it is thus a technique for depicting between-object depth relationships. In contrast to this, however, perspective 'depth lines' are employed ostensibly to depict

within-object depth relations, and are used predominantly to represent the three-dimensionality of a single object.

The experiments detailed in this thesis focus on how children, as well as adults and adolescents, solve the problem of representing depth in their drawings and on their ability to use the two main drawing devices, partial occlusion and perspective depth lines.

INTRODUCTION.

Perhaps the most commonly used 'adult' solution to the problem of representing the three-dimensional world on the two-dimensional surface of the page is the system of linear perspective. This system basically involves the production of a a view-specific or visually realistic representation by depicting the projective image of a scene from a particular fixed point of view. More specifically, however, the projective portrayal of depth is achieved mainly by the use of two drawing devices: the partial occlusion technique and perspective 'depth' lines (Langer-Küttner, 1990). Having said that both these devices are used to portray depth, it is important to note that each is used to denote a particular type of depth relationship. The partial occlusion technique, for example, is used to indicate that from the observer's viewpoint part of an object is obscured by one that is nearer; it is thus a technique for depicting between-object depth relationships. In contrast to this, however, perspective 'depth lines' are employed ostensibly to depict within-object depth relations, and are used predominantly to represent the three-dimensionality of a single object. As mentioned previously, however, these are 'adult' conventions for the portrayal of depth. So how do children deal with the problem of representing depth in their drawings? What are their solutions? Are they able to, or can they be induced to, use the adult conventions detailed above? The work detailed in this thesis constitutes an attempt to answer all these questions but focusses specifically on whether children are able to, or can be induced to, use the drawing devices described above.

A general finding with young children, below about 8 years of age, is that they do not readily use the 'adult' technique of partial occlusion in order to represent a between-object depth relationship. Instead they tend to depict two complete and separate objects positioned one above the other on the page. This tendency is especially marked when they are asked to draw a scene comprising two similar or identical objects. Only when the importance of the relationship between the two objects is made more salient do the children actually use the partial occlusion technique to produce visually realistic representations and even then only a few studies (e.g. Barrett *et al,* 1985; Light and Simmons, 1983; Ingram, 1983) have succeeded in inducing children to use the technique to represent the between-object depth relationship between two similar or identical objects. However, the fact one can actually identify tasks in which there has been some success in facilitating the production of partial occlusions calls into question one possible explanation for children's frequent non-use of this particular drawing device: the Piagetian explanation that until the development of the understanding of projective and Euclidean relations at about 8 to 9 years, young children are simply unable to represent the projective aspects of a scene. The experimenter was particularly interested in pursuing this line of inquiry, hence the first four experiments reported in this thesis attempted to facilitate children's use of the partial occlusion drawing device to represent the between-object depth relationship between two balls. The specific rationale underpinning the design of the experiments was simple: if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the use of the partial occlusion technique. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of partial concealment more salient may serve to elicit the production of projective representations of a partial occlusion scene.

The experimenter actually succeeded in identifying a task in which children do attend to the projective as opposed to the invariant aspects of a partial occlusion scene and this (in conjunction with the work cited above) enabled her to rule out one of the explanations for children's non-use of the partial occlusion technique: the Piagetian explanation (e.g. Piaget and Inhelder, 1956, 1969) that young children have not yet developed concepts of projective and Euclidean space is no longer tenable. The experimenter argues that her findings are in fact more congruent with Luquet's argument (1913, 1927) that young children are not conceptually immature and incapable of considering the projective aspects of a scene, even though they clearly prefer to emphasise its invariant aspects. Further experiments in the series considered which particular variables accounted for the task's success in facilitating the use of the partial occlusion drawing device.

Given that it was the experimenter's intention to investigate how the young child portrays depth more generally in her/his drawings she focused not only on the way in which children represent between-object depth relations, but also on how they represent <u>within-object</u> depth relations. This line of work, detailed in the latter part of the thesis, concentrates specifically on how children represent the three-dimensionality of a single solid object and focuses on their use or non-use of <u>perspective depth lines</u> in their drawings.

Studies designed to address this issue have typically required subjects to make a drawing of either a table or a cube and have revealed that young children depict both these objects as rectilinear forms: the table top being drawn as a rectangle, the cube being represented by a single square or a configuration of squares. By about the age of 12 years, however, most children have been explicitly taught 'how' to draw objects 'in perspective' and then, like adults, they typically produce oblique views of cubes and tables.

In the review of the studies considering young children's representation of between-object depth relationships, one sees many examples of studies specifically designed to induce young children to use the partial oclusion drawing device to represent such relationships. There has not, however, been any equivalent work designed to investigate whether children can be induced to represent a within-object depth relationship. Although children tend not to produce visually realistic representations of objects like cubes and tables they may actually be capable of doing so; if this is the case then one should be able to identify the particular circumstances which would elicit the production of projectively accurate drawings. In light of this, some of the studies in this thesis constituted an attempt to design a task which would lead young children to produce visually realistic representations of a simple three-dimensional object. As is the case with the studies addressing children's ability to represent a between-object depth relationship, the experimenter was seeking to address the Piagetian claim that, until the development of projective and Euclidean relations at about 8-9 years young children are unable to represent the projective aspects of a scene. Again, the specific rationale underpinning the design of the experiments was that if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the production of visually realistic representations. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of view-specificity more salient may serve to elicit the production of projective representations of the scene. Given that older subjects, as well as younger subjects, often experience problems producing visually realistic representations of simple solid objects (e.g. Cox, 1986b) the experimenter also investigated whether the tasks designed for use with children would facilitate the production of visually realistic representations by adults and adolescents.

Whilst the experimenter succeeded in designing a task which would lead adults and adolescents to produce visually realistic representations of a simple three-dimensional model, she did not succeed in her attempt to facilitate the production of visually realistic representations by young children. Possible reasons for the children's failure to use perspective 'depth lines' are discussed in relation to the work of Luquet (1913, 1927) and Piaget and Inhelder (1956, 1969). More specifically the experimenter maintains that the Piagetian notion of conceptual immaturity is too broad an explanation to explain the young children's failure to represent the projective aspects of the scene; young children demonstrably <u>can</u> represent some projective aspects of a scene (e.g. the partial occlusion of one ball by another) even though they have difficulty with representing the apparent convergence of the parallel edges of simple three-dimensional stimuli. Thus, there is no abrupt, stage-like shift from a complete inability to represent any projective relationship to an ability to represent all projective aspects of a scene. Clearly, some projective aspects are easier to depict than others.

The experimenter argues that the depiction of partial occlusion may be easier than that of convergence because young children can more readily appreciate what they have to do. In the case of partial occlusion, children simply have to omit the part of the farther object which is hidden from their view; apart from that, they are not required to alter the shape of their normal depiction of the object. In the case of convergence, in contrast, children are required to alter the actual shape of the entire object, i.e. they have to change a rectangle into a trapezium. There are various possible explanations for their difficulty with this second task. One is that the children simply do not notice the apparent convergence of the parallel edges in the scene (Piaget and Inhelder, 1956) and are forced to draw the actual shape of the objects. Another possibility is that they are aware of the apparent convergence but do not depict it because they cannot draw converging obliques, or because they do not realise that they are being asked to draw the projective as opposed to the actual shape of the object, or because they deliberately choose to draw parallel lines in order to show that these objects actually do have parallel edges; an explanation akin to the ideas of Luquet (1913, 1927; Costall, 1989).

CHAPTER ONE.

LITERATURE REVIEW.

1:1 Historical Overview and Introduction.

Historically, the study of children's drawing has followed many independent lines of inquiry. This overview details the varying theoretical approaches and the empirical work associated with some of the key areas of investigation.

The earliest developmental studies of children's drawing date from the latter part of the nineteenth century when there was widespread interest in both child development and children's art. This interest led many early investigators (e.g. Darwin, 1877; Cooke, 1885; Ricci, 1887; Brown, 1897; Hogan, 1898; Preyer, 1899; Stern, 1909) to make detailed biographical recordings of individual children's art-work, whilst other workers collected large numbers of drawings which they then described and classified, often in relation to criteria such as the cultural background (e.g. Lamprecht, 1906) or the intelligence (e.g. Lobsien, 1905) of the drawer. In several studies the popularity of particular drawing topics was discussed (Maitland, 1895; Katzaroff, 1910) and in some cases (e.g. Schuyten, 1904) attempts were made to devise purely objective scoring systems for describing the drawings.

These studies, and others like them (e.g. Perez, 1888; Barnes, 1893; Clark, 1897; Sully, 1896; Claparède, 1907) not only provided impressive detailed chronological and descriptive accounts of children's art-work, but also established a basis for the classification of drawings into developmental sequences. Many workers (e.g. Kerschensteiner 1905; Rouma, 1913; Burt, 1921; Eng, 1931; Lark-Horowitz, Lewis and Luca, 1967; Kellogg, 1970) have made notable contributions towards the identification of such sequences in children's drawing, but perhaps the most comprehensive and influential of these was that ventured by Luquet (1913, 1927). Luquet's classification, which was to provide the basis for Piaget and Inhelder's (1956, 1969) account of drawing, is detailed below.

According to Luquet's (1927) taxonomy, drawings develop through a sequence of ontogenetic stages, the first of these being the scribbling stage. During this stage children's initial attempts at drawing involve 'trace making activities solely for their own sake' (Luquet, 1927, p.112); their early scribbles are not the result of an intention to represent a particular object, rather they are the result of both imitative and spontaneous perceptual-motor activity (Luquet, 1927; Eng, 1931; Meili-Dworetzki, 1957; Lowenfeld, 1947; Kellogg, 1970; Haas, 1983). Gradually, as control over the drawing implement develops, children begin to experiment further with making marks on the page and at around 2:6 years of age, they suddenly begin to interpret their scribbles as representations of objects. Such interpretation is said to be fortuitous, as it occurs as a *post hoc* attribution of likeness, the child discovering in a scribble, 'a resemblance which he or she did not seek to place there' (Luquet, 1927, pp. 112). It is through such interpretation of accidental forms that the child comes to understand that her/his graphic productions can represent real objects. As the stage progresses the child will begin to announce representational intentions earlier in the production process; s/he may not, however, be able to sustain these intentions and may re-interpret the identity of an object as the drawing progresses. Interpretation thus goes beyond simply deciding what a drawing represents; according to Luquet interpretation influences successive phases of the drawing process and hence the final product.

During the initial phase of the pre-schematic stage, children's drawings are said to be characterised by failed realism. Whilst having prior intentions regarding what they want to draw, children inevitably experience difficulty in sustaining attention and in organising the different elements of a drawing into the correct spatial relationship. Later, however, in the sub-stage of intellectual realism, as the result of general development and the development of attention in particular, children are able to organise the composite elements of a drawing and bring them into the correct spatial arrangement. Nevertheless, their drawings are not yet visually realistic since there is a tendency towards drawing the object so as to display its criterial features or typical attributes and, in doing so, both visible and non-visible parts of an object may appear in the same drawing. It appears that the children do not concern themselves with the representation of a scene from a particular viewpoint but place great importance upon the production of a picture which shows the clearest exemplar or generic form of an object. As Luquet (1927, p. 184) argues it seems that 'what matters to the child is not the appearance an object takes from a contingent, variable viewpoint' but the persisting properties of that object. Moreover, it would appear that the child tends to draw what s/he knows rather than what s/he sees (Luquet 1927, p. 224). This tendency appears to be particularly well documented in the early literature. Sully (1896), for example, maintained that the child's 'sense perceptions have for artistic purposes become corrupted by too large an admixture of intelligence', whilst Clark (1897, p. 287) notes that children '....draw things as they are best known to be, not as they appear.'

In formalising the notion of intellectual realism, Luquet maintained that children's apparent lack of concern for perspective arises because their drawings are usually based on a modèle interne (internal model); a notion analogous to Piaget's concept of the 'mental image' (Piaget and Inhelder, 1969) and defined as the mental representation of an object based on the child's prior knowledge and experience of that object. According to Luquet, then, during the stage of intellectual realism, the internal model normally takes precedence over direct and immediate perceptual experience in both spontaneous drawings and those derived from an actual scene. Consider as an illustration of this point, children's profile drawings of a person: when drawing a person in profile children have a tendency to include two eyes and two legs in their representations. Explained in Luquet's terms, the child's intention to draw a person summons up the appropriate internal model and since children know that people have two eyes and two legs, these criterial features constitute an integral part of this schema. Subsequent representational activity, mediated by the internal model, results in a drawing which contains some features, such as two eyes, which would not actually be visible if the drawing was made from a single vantage point.

After a transitional period the child moves on to the schematic stage. This final stage, achieved by the age of about 8-9 years of age, marks the endpoint of development and is characterised by visual realism. During this stage, the child tries to draw the scene from one particular point of view. S/he will eliminate from her/his drawing those objects or parts of objects which are not visible from this viewpoint, and s/he will also begin to draw foreground objects larger than background ones, and begin to converge parallel edges into the 'distance' of the picture. By means of the conventions of perspective s/he will be able to unify the objects in the scene in order to produce a more photographically realistic representation.

It is this classification, then, which is said by many (e.g. Thomas and Silk, 1990) to represent perhaps the most significant account of the ontogeny of drawing. One can attribute the importance of Luquet's description, in part, to its influence on the subsequent work of Piaget (Piaget and Inhelder, 1956, 1969) who regarded the development of drawing as relating directly to the child's developing conception of space.

According to Piaget, very young children (in the sensori-motor period between 0-2 years of age of age) have only a practical understanding of space; although this ability enables them to negotiate their way about their immediate environment, it nonetheless limits them to the 'here and now'. With the development of the symbolic function, however, which heralds the arrival of the preoperational period (2-7 years) children are able to imagine or mentally represent the spatial relationships among objects. At first it is the topological aspects which are conceptualised. So, for example, children can represent the proximity or separateness of two objects and can also consider relationships of order and enclosure (e.g. one object inside another). Nevertheless, their concept of space is still very limited in that relationships among objects are not yet considered from a particular point of view or within a system of axes or co-ordinates (Piaget and Inhelder, 1956). In fact, representational space at this stage is regarded as static, irreversible and egocentric.

In the concrete operational sub-period (7 to 11 years of age), however, symbolic imagery develops further and this enables children to begin to perform internal geometric operations on spatial figures and spatial relations (Inhelder, 1955). Representational space is said to be mobile and reversible, even though it is still dependent upon the presence of manipulable objects. By means of their developing concepts of projective and Euclidean space children mentally construct an abstract system of axial co-ordinates with precise distances and relative positions within it. This enables them to imagine particular views of objects and the relationships between objects from different points of view, an ability which finally comes to fruition in the formal operational period (11-15 years of age).

Piaget claimed that the drawings of young children typical of the stages outlined by Luquet, support his claim that the child understands topological spatial relations, before understanding projective and Euclidean relationships. Thus, during the stage of failed realism the child may successfully place associated elements together (facial features for example) but fail to maintain a consistent viewpoint and to draw the different elements correctly in proportion. Whilst the drawings of the intellectual realist reveal the beginnings of Euclidean geometry, only in the stage of visual realism is the child able to co-ordinate projective and Euclidean relationships enabling her/him to represent the correct proportions between objects and parts of objects as seen from any given viewpoint.

In incorporating Luquet's account of the development of drawing into the more general framework of his own cognitive-developmental theory, Piaget notes that Luquet's classification implies that a child's drawing is always realistic in intent, and consists of an attempt by the child to imitate within the graphic medium, properties of the actual object. Piaget thus regards drawing as an activity characterised by imitative accommodation, where the child always accommodates and adjusts her/his graphic schema in an attempt to make them represent and imitate reality (Piaget and Inhelder, 1969). In Piagetian terms, then, drawing is more closely related to the construction of mental images (which also imitate reality) than to symbolic play (where the child may assimilate objects with no regard for their objective characteristics).

Paralleling this view that the drawings of young children reflect their knowledge of objects was the notion that drawings could be used to measure intellectual maturity. Indeed, it was against the background of developmental stages proposed by Luquet and others that Goodenough (1926) published her book on the measurement of intelligence by drawings. This work and that of

Harris (1963), established the tradition of using drawings as a diagnostic tool for the assessment of intellectual development: the underlying assumption being that a child's drawing is directly related to and expressive of her/his concept of a particular topic. Whilst drawing is no longer widely used to assess intelligence this tradition of research still remains in evidence, with tests such as the 'Draw-a-Man Test' (Goodenough-Harris, 1926, 1963) being used to screen for those of below average intelligence (Scott, 1981).

Historically speaking, however, once drawing was no longer widely used to assess intelligence it became a relatively neglected area of study within developmental psychology. Part of the reason for this neglect lies in the Piagetian theory which came to dominate this field. Whilst, as detailed previously, Piaget used drawings to illustrate his theory (notably, those aspects concerned with the representation of space), studies of drawing were not central to the development of his theory, nor did they afford crucial tests of his claims. Thus, neither Piaget nor subsequent investigators influenced by his theories devoted much attention to children's drawings. That is not to say, however, that the study of drawing was completely neglected. For, just as Goodenough (1926) and Harris (1963) assumed that drawings are directly expressive of concepts, so others assumed that drawings are directly expressive of emotional states. From the 1940's onwards, then, a quite different interest in drawing began to flourish. Based on the assumption that children project their emotions and motives into their depictions, drawings were used to assess psychological adjustment and personality (e.g. Machover, 1949; Hammer, 1958; Koppitz, 1968, 1984). Closely related to this clinical-projective approach is the 'artistic-expressive' tradition; a tradition which is often regarded as the educational application of the clinical notion that children will project their perceptual, intellectual and emotional experiences into their drawings. The crucial additional principle being advocated by proponents of this approach, however, is that by encouraging spontaneous self expression in art, one can promote cognitive development and personal growth (Strauss, 1978; Lowenfeld, 1939, 1947). Whilst the underlying psychological theorising is often criticised for its vagueness, this particular notion has exerted considerable influence, over the past 50 years, on art education and art therapy in North America and Western Europe (Thomas and Silk, 1990).

In striking contrast to both these traditions, is the more recent experimental approach (cf. Freeman, 1980) to the study of children's drawings. This approach, which has rekindled interest in children's drawings as a topic for study within the field of developmental psychology, regards drawing as a problem solving exercise, and aims to identify through the use of controlled studies the kinds of problems the drawer faces and the strategies s/he uses to solve them. One particular problem which has received much attention in recent years is the issue of how one represents the three-dimensional world on the two-dimensional surface of the page. The 'up-down' and the 'left-right' dimensions of real world space are fairly readily translated into graphic terms: 'up-down' spatial relationships are represented by 'top-to-bottom' relationships on the page, whilst 'left-right' relationships in the scene are represented by 'left-right' relationships on the page. The problem arises with the representation of the 'near-far' or depth dimension of real world space as there is no equivalent on the flat, two-dimensional surface of the page. How does one demonstrate that an object is solid and possesses depth or that one object is positioned behind another and is therefore farther away?

Perhaps the most commonly used 'adult' solution to this problem is the system of linear perspective. This system basically involves producing a <u>view-specific</u> or <u>visually realistic</u> representation by depicting the <u>projective image</u> of a scene from a particular fixed point of view. More specifically, however, the projective portrayal of depth is achieved mainly by the use of two drawing devices: the partial occlusion technique and perspective 'depth' lines (Langer-Küttner, 1990). Having said that both these devices are used to portray depth, it is important to note that each is used to denote a particular type of depth relationship. The partial occlusion technique, for example, is used to indicate that from the observer's viewpoint part of an object is obscured by one that is nearer; it is thus a technique for depicting between-object depth relationships. In contrast to this, however, perspective 'depth lines' are employed ostensibly to depict within-object depth relations, and are used predominantly to represent the three-dimensionality of a single object. As mentioned previously, however, these are 'adult' conventions for the portrayal of depth. So how do children deal with the problem of representing depth in their drawings? What are their solutions? Are they able to, or can they be induced to, use the adult conventions detailed above?

The work in this thesis constitutes an attempt to answer all these questions, but focusses specifically on whether children are able to, or can be induced to, use the two drawing devices described above. Before detailing the rationale underpinning the conception of the experimental studies, however, it is important to consider the existing literature relating to the representation of depth in children's drawings.

There is a wealth of research relating to the representation of depth in children's drawings. One notable characteristic of this work is that the studies tend, on the whole, to address themselves either to how children represent between-object depth relationships or to how they represent within-object depth relationships. Very seldom is the use of the partial occlusion device considered alongside the use of perspective 'depth' lines (one notable exception to this being Willats, 1977). This characteristic undoubtedly reflects the general concern that if one were to study the use of the two types of drawing device together in the same task, one would be unable to guarantee that the use of one device had not exerted an undue influence over how the other was subsequently employed. For research purposes then it is preferable that each drawing device is studied in isolation, hence the reason why each line of work is reviewed, and subsequently studied, independently here.

1:2 Young children's representation of between-object depth relations.

When adults draw a picture of a scene they usually attempt to depict it exactly as they see it from a single fixed point of view. Any part of the scene which is not actually visible from that particular perspective is omitted from the drawing. In addition, if a nearer object partially masks one which is behind and therefore farther away, the depth relationship between the two objects and the partial concealment of one object by the other is depicted by the use of the hidden-line elimination device (Freeman, 1980, pp 214-217) a device which is also known as the technique of partial occlusion (Cox, 1981 and 1985). How, then, do children represent the partial concealment of the farther object and the spatial-depth relationship between objects in such an array?

One of the earliest observations relating purely to the issue of how children represent the partial concealment of one object by another was made by Clark (1897) who asked children (aged between 6 and 16 years) to draw an apple which had a hat pin penetrating its centre. Clark noted that the way in which the children depicted this model was directly related to age. Virtually all the 6-year-olds drew the scene as a 'transparency' with the hat pin passing across the apple in a continuous straight line. In contrast to this, almost all the older children (9 years upwards) represented the model as it appeared from their particular point of view, including only the visible parts of the pin (projecting from either side of the apple) in their drawings. Clark accounted for the discrepancy between the responses of the younger and the older children by suggesting that, for the younger children, the objects were important with respect to their function as opposed to their appearance. Consequently, the younger children tended to represent what they knew about the pin (that it was complete) rather than how it looked (two separate pieces projecting from either side of the apple): '...they draw things as they are known to be, not as they appear' (Clark, 1897, p.287).

The transparency drawings in Clark's study may have resulted from the particular kind of partial occlusion in the scene. Although the children could not see the central portion of the hatpin they knew that it was complete; furthermore they also knew (and could see) that the pin pierced the apple and was thus structurally united with it: both pieces of knowledge were in fact reflected in their drawings. In a later replication and extension of Clark's work, Freeman (1980) showed that children no longer produce transparencies if the pin (or in his case the pencil) does not actually penetrate the apple but is placed behind it. When the two objects are no longer structurally united but are nonetheless still visually united, children will draw the two objects whole but will separate them on the page to preserve their spatial integrity. Let us consider in greater detail children's drawings of partial occlusion scenes in which the two objects are structurally separate.

Freeman, Eiser and Sayers (1977) attempted to construct a model to account for the major developmental changes in children's drawings of two structurally separate objects placed one behind the other. From a review of the existing literature they predicted that there would be a series of approximations to the adult strategy of partial occlusion based on the acquisition of discrete rules. More specifically they maintained that a simple model working on the accretion of rules would involve the following four sequential rules:

Rule 1: Very young children would depict the objects side by side on the page, a relationship which would be least informative of a 'depth' relationship.

Rule 2: The addition of the rule 'up on the page means behind' would lead to a more informative vertical separate arrangement.

Rule 3: Later the acquisition of a 'superimposition' rule would result in two complete but overlapping forms.

Rule 4: Finally, these overlapping forms would be turned into a partial occlusion. This transformation would be achieved by inserting a 'restricted delete' instruction into the 'program', thereby specifying that the further object should start at the contours of the nearer object without crossing them.

So, it was predicted that with age there should be a shift from a horizontal arrangement to a vertical arrangement, and a shift from a tendency to separate the two objects on the page to a tendency to unite them. In order to test this model, Freeman *et al* asked children (within the age range 5 to 10 years inclusive) and adults to (i) make a drawing of an apple from memory and then (ii) draw a second apple positioned behind the first. An analysis of the resulting drawings revealed that in general their predictions were supported: 5 to 6-year-olds drew the apples separately, side by side; 7-year-olds drew them separately with the farther apple positioned vertically above the nearer, whilst 9 and 10-year-olds and adults drew partial occlusions. As predicted, then, there was an age related shift from a tendency to separate the objects in a drawing, to a tendency to put them together, with the cross over occurring at about 8 years. There was also a shift from a horizontal-separate to a vertical separate arrangement at about age 7 years. It is interesting to note, however, that there were very few instances of the superimposition rule; clearly, when the two objects in the scene are structurally separate, those children who depict two complete objects tend to separate these objects on the picture plane. What these findings appear to demonstrate, then, is that (i) children as young as 7 years are sensitive to the depth relationship between the two apples and use the convention of 'up on the page = farther away' to represent it and that (ii) the partial occlusion technique is not used until approximately 9 years of age. Why, then, if children are sensitive to the depth relationship between the two apples (as indicated by the large number of vertical-separate drawings), do partial occlusions not appear until relatively late in development?

One possible explanation is that the results of the Freeman *et al* study are peculiar to the fact that the children were asked to draw the 'behind' relationship from memory: Cox (1978, 1981) details the implications of this procedure. First, the younger children (aged 5 years) in particular may not have known what the spatial term 'behind' meant: given this they may not have been attempting to depict a spatial relationship at all. Second, even if the children were attempting to depict a spatial relationship, it is possible that their notion of behind may have been markedly different from an adult's. Adults may think of objects being one behind another along their line of sight. Two items can, however, be positioned one behind another across one's line of sight. Third, whatever the particular spatial relationship the children were attempting to draw, it is possible that they were so engrossed in getting the marks down on the page that, in the absence of a model, they forgot the relationship they had originally set out to depict. Fourth, even if the children were attempting to draw one apple behind another along their line of sight, the instructions do not indicate how far apart these apples should be. If they were close together the nearer apple may well partially occlude the other; the farther apple could, however, be positioned far enough away so that no partial occlusion would be involved. Given this, it may well be the case that the adults and the older children simply imagined a closer arrangement than did the 7- to 8-year-olds. In investigating this issue further, then, a model should necessarily be presented.

Just as Freeman *et al's* study was published Cox (1981, Study 1) was completing a similar experiment. Her study differed, however, in that she had presented a model for the children to draw. Children (age range 4:11-5:10 years) were asked to draw two differently coloured plastic funnels. The funnels were inverted and placed on a table, either side by side or one behind the other, close together but not touching. The subjects were asked to draw what they could see. Half the subjects saw the two funnels arranged side by side whilst the other half saw them arranged one behind the other. The order in which each funnel was drawn was recorded.

The results revealed that all the children drew the funnels separate and side by side and that there was no observable difference in the finished drawing of the two spatial relationships. Whilst the children in the 'side by side' group drew the left hand funnel on the left hand side of the page and the right hand funnel on the right hand side, there was no preferred order in which this was undertaken: half the subjects drew the left-hand funnel first and half drew the right. Children in the 'behind' or 'near-far' group produced the same side by side separate arrangement of the funnels. However, not only did these children have a preferred position on the page for each funnel, there was also a definite order in which they were drawn: the nearer funnel was usually drawn first and placed on the left-hand side of the page; conversely, the farther funnel was usually drawn second and placed on the right.

Thus, when a model is present, young children represent the between-object depth relationship by separating the two elements and arranging them side by side on the page on the page. This result would appear to confirm the findings of Freeman *et al*, in particular that young children do not mark the spatial relationship 'behind' by the use of the partial occlusion technique. Whilst an examination of the finished product reveals no clear difference between the representation of a side by side or behind (near-far) relationship, the order in which the objects were drawn was in fact very different. Although, for the side by side arrangement there was no preferred order in which the objects were drawn, with the behind (near-far) arrangement, the nearer object was usually drawn first and was placed on the left hand side of the page. Maybe in some sense, then, the children in the 'behind' (near-far) group felt that they had dealt with the near-far spatial dimension of the scene: for whilst their drawings looked like those of the side-by-side group, in that they had produced a horizontal separate arrangement, both the position and the temporal order used in the process of drawing were consistent across subjects. This contrasts sharply with the results of the other group where the temporal order was, as noted previously, inconsistent.

Given that the children in Cox's experiment were not explicitly asked to portray the relationship between the two funnels, it is possible that they did not consider it to be the most important or relevant feature to be represented in their drawings. How would children respond if it was indicated that the main purpose of the task was the representation of a particular spatial relationship between two objects? Cox (1981, Study 2) undertook a study in which she aimed to make it clear to the children that the main purpose of the task was the representation of a particular spatial relationship between two objects. Children (aged between 4 and 10 years) were asked to draw a picture of two balls (balls were chosen in order to simplify the drawing task), one red and one blue, placed one behind another on a table.

The results revealed that when a model is present and when young children's attention is drawn to the spatial relationship between the objects, they do attempt to portray that relationship. In contrast to the children in the previous study and those in the study by Freeman *et al* (1977), children as young as 5 years used a vertical-separate arrangement as opposed to a horizontal arrangement in order to represent depth. The cross over from a horizontal to a vertical arrangement was found to be between 4 and 5 years whereas Freeman *et al* found it to be between the ages of 6 and 7 years. As in the Freeman *et al* study, however, the cross over to the use of the partial occlusion technique did not occur until about the age of 8 years. Given that most of the 5-year-olds drew a vertical-separate arrangement and that only the 4-year-olds used a horizontal-separate to any great extent, it would appear that the presence of the model and the instruction to draw one ball <u>behind</u> another demonstrates to the children the type of arrangement they are supposed to be depicting.

This predominantly vertical-separate arrangement of objects on the picture plane has not, however, been found in all studies. Light and Humphreys (1981), for example, found that only one third of their 'separate' depictions possessed a vertical arrangement. One can, however, account for this apparent discrepancy in terms of the angle from which the subjects view the scene (Cox, 1986a): in Cox's research studies, the subjects look down at the model which is placed on a table in front of them and can see the farther object visible over the nearer; in Light and Humphreys' study, in contrast, the model is raised up on a platform to the subject's eye-level, so that the farther object is not visible over the nearer one, although it can be seen round the side if the subject moves her/his head to the left or right.

Despite the differences invoked by the presence or absence of a model, the type of instruction issued to the child and the angle at which the child views the scene, Freeman *et al's* developmental pattern concerning the development of hidden-line elimination is, in general supported. Horizontal-separate arrangements give way to vertical-separate arrangements, and these in turn give way to partial occlusions at the age of 8 years. How, then, can we account for the young child's response? Why do children below the age of 8 years not use the technique of partial occlusion to represent a between-object depth relationship?

One possible explanation for the young child's behaviour is that s/he is simply unaware of the partial occlusion technique: s/he may not notice it in other people's drawings or, even if s/he does, s/he may not understand its use. This does not, however, appear to be the case, for when Hagen (1976) asked children, aged between 3 and 7 years, to select a three-dimensional scene to match each of a number of pictures, she found that given a set of four scenes almost all the children were able to match a partial occlusion picture with a scene consisting of one complete object behind another. Furthermore, there is anecdotal evidence to suggest that children do in fact understand the technique of partial occlusion; Cox (1985) has observed that children as young as 2 years interpret 'disembodied' heads in their story books in terms of s/he is 'peeping out' or 'hiding': they appear to accept that a whole person is there, but is being masked by another object. From this evidence it would appear that young children do actually understand the partial occlusion device. This leads one to ask whether their failure to use this device derives from a lack of graphic skill. The production of a partial occlusion would certainly pose a particular problem if the children were utilising 'some kind of internal visual description of the complete objects so that specific deletions would be necessary to represent occlusion' (Light and MacIntosh, 1980). It also leads one to question whether the children's failure to use the device could possibly be attributed to their concern to represent both objects as they know them to be (complete and separate).

A study by Light and MacIntosh (1980) aimed to investigate children's sensitivity to a between-object depth relationship whilst removing both the problem of graphic skill (by eliminating the need for hidden-line-elimination) and the need to depict an incomplete object. These three aims were achieved by making the nearer of the two objects in the scene transparent. With this design, then, the opaque farther object remained completely visible behind the transparent nearer one: the result being that no 'incompleteness' or hidden-line-elimination was necessarily involved in the depiction of the scene.

The experiment was divided into two parts, with the first part being similar to the study performed by Cox (1981). Children (aged 6 years) were asked to draw two differently coloured inverted plastic funnels positioned one behind the other: the results obtained from this part of the study replicated Cox's findings. The second part of the experiment, however, involved two transparent glass beakers and two small toy houses; materials which were subsequently arranged in two ways. In one arrangement the house was placed inside the beaker whilst in the other the house was positioned behind it. Subjects were allocated either to the 'inside' condition or the 'behind' condition. The results of the house inside the beaker condition revealed that all the children produced enclosure drawings with the house being drawn inside the confines of the beaker. When the house was placed behind the beaker, however, approximately half the subjects depicted the objects separately, that is to say half the children depicted the house and the beaker positioned side by side or one above the other.

The authors assert that the separate drawings of the behind-glass arrangement cannot be explained in terms of any difficulties of graphic production, since all the children produced 'unified' drawings of what they saw in the inside-glass arrangement and what they saw was virtually identical in both cases. Neither, they argue, can one account for the separate drawings of the behind-glass arrangement in terms of any loss of information about the farther object, as all the features of the house can be equally well represented within the confines of the glass as outside it. So why is it, when neither array necessitates the use of hidden-line-elimination and neither array requires the omission of part of an object, that the children are prepared to represent their own view when the house is inside the beaker but not when it is behind it? Light and MacIntosh (1980) borrow a distinction from Gibson (1950) and suggest that one can account for these results if one accepts that young children are more concerned to represent visual world or array-specific information than visual field or view-specific information. This hypothesis was subsequently tested in a study by Light and Humphreys (1981) who asked children aged between 5 and 8 years of age to draw either two differently coloured toy pigs or two blocks. The array configurations were presented to the children in four different 90 degree rotations. For the pigs two of these rotations were side views of a red pig following a green pig whilst the other two rotations were end views 'in depth' (note, however, that the red pig always followed the green pig). Similar orientations were used with the two blocks. The lateral arrangements elicited accurate performances from virtually all the children. The pigs, for example, were drawn in side view with the left-right relationship between them being maintained. The 'in depth' arrangements, however, produced more varied results. The older children produced more occlusions than the younger children, who depicted two complete and separate objects either side by side or vertically one above the other. Perhaps the most striking finding, however, is that 80% of the children preserved the spatial relationship between the two objects, for example, by depicting the red pig following the green pig. Light and Humphreys argue that these drawings actually fulfill the prediction that the younger children's drawings would reflect array as opposed to view-specific relationships. Furthermore, they assert that the overall increase in occlusions with age is not associated with the development of graphic skill since it is the younger children who produce the most graphically complex drawings.

Cox (1986a) would also support the notion that one cannot attribute young children's failure to use the partial occlusion technique to a lack of graphic skill. For when she asked young children aged between 5 and 7 years of age to copy a pre-drawn partial occlusion configuration of one ball behind another, a high rate of accurate copying was obtained thereby demonstrating that young children do in fact possess the motor skill necessary to produce a partial occlusion. Having said this, however, a copying task such as this where the child copies a two-dimensional line drawing on a two-dimensional piece of paper is not the same as drawing from a three-dimensional model. When drawing from a model the child must represent a three-dimensional scene on a two-dimensional surface. The arc in a two-dimensional copying task does not necessarily represent part of a complete circle. This contrasts with the arc produced when drawing from a model: such an arc does represent the visible part of a round object. Perhaps then, it is the case that the young children' s difficulty is in inhibiting a tendency to depict a full contour. Freeman *et al* (1977) postulated that this could well be the case.

If young children were simply failing to eliminate the hidden part of the farther object, however, one would expect to see many overlaps in their drawings. But, from the studies reviewed so far we know that when children are asked to draw two objects one behind the other, they produce very few overlapping forms, a finding which has been confirmed in a recent study by Ingram and Butterworth (1989). Young children seem to progress directly from depicting two discrete and whole objects to producing the partial occlusion configuration. So, if it is the case that the children below the age of 8 years are unable to inhibit the tendency to depict a complete object, then it is also the case that they are concerned to place the second object separate from the first one.

This seemingly deliberate strategy to depict two complete and separate objects does not appear to be confined to a drawing task. For when Cox (1981, Study 3) asked children (aged 4, 6, 8, and 10 years) and adults to draw a picture of one ball behind another and also to select an appropriate representation from two pre-drawn alternatives, children below the age of 8 years both drew and selected a picture which showed the objects as separate. In reading the literature one notices an apparent discrepancy between the findings of this study and those of other studies by Freeman (1980, pp. 246) and Cox (cited in Cox, 1985). The results of both these studies indicate that young children select partial occlusions more often than they draw them. This in turn seems to imply that the young child's problem is a graphic one rather than a more general representational one. Freeman, however, points out that there is a weakness in the experimental design of these studies: in both cases the drawing and the selection data are obtained from different children. If one gives the two tasks to the same children one finds, as detailed earlier (Cox, 1981, Study 3), that the young children's failure to produce partial occlusions is not confined to the drawing mode of representation, it occurs also in a selection task.

It would thus appear that young children both understand the use of partial occlusion and posses the graphic and motor skill necessary to produce the configuration in a copying task. A problem seems to arise, however, when the child is presented with a three-dimensional scene which must be depicted on the two-dimensional surface of the page. Now, is it the case that young children cannot draw scenes comprising one object behind another 'as they look' or is it the case that they simply do not realise that that is what they are being asked to do?

Piaget's theory (Piaget and Inhelder, 1956, 1969) would appear to favour the former explanation: that is to say according to Piaget, until the development of the understanding of projective and Euclidean relations at about 8 to 9 years, young children cannot represent the projective aspects of a scene. In contrast, however, Luquet's (1913, 1927) writing, according to Costall (1989), would appear to favour the latter explanation. Which, account, then, is correct? Is it the case, as Piaget would argue, that young children cannot use the partial occlusion technique in order to represent the projective aspects of a partial occlusion scene comprising two similar objects, or is it as Luquet would maintain, simply that they do not? If the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the use of the partial occlusion technique. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than a lack of cognitive ability, then restructuring the drawing task in order to make the notion of partial concealment more salient may serve to elicit the production of projective representations of a partial occlusion scene. In his study of perspective taking, Flavell (1968) notes that even if children are capable of adopting a particular point of view they may not see the necessity to do so. Such a problem may arise in the study of children's drawings: a child may assume that s/he should draw *what* can be seen, s/he may not realise that the experimenter wants the objects drawn exactly *how* they appear. How, then, would children respond if the notion of view-specificity was made more salient?

Barrett, Beaumont and Jennett (1985) sought to address this issue, and attempted to make the notion of partial concealment more salient by emphasising the importance of visual realism in the verbal instructions. Children aged 7 years were shown a model of two balls positioned one behind the other such that the nearer ball partially occluded the farther. They were then asked to draw this model, using either one of the following two sets of instructions:

Instructions 1: 'Please can you draw this for me. Please do not touch it or move from your chair.'

Instructions 2: 'Please can you draw this for me exactly as you see it from where you are sitting. Look very carefully at it so that you can draw it just as you see it. Please do not touch it or move from your chair.'

Successful implementation of the partial occlusion technique occurred in only 6% of the drawings elicited by Instructions 1. In contrast to this, however, when the importance of visual realism was actually emphasised in the verbal instructions (Instructions 2), 35% of the elicited drawings showed the farther ball partially occluded by the nearer. Clearly, then, simply by altering the nature of the verbal instructions, one can cue the children into what they are 'supposed' to be doing, namely, using the partial occlusion device to depict the projective image of the partial occlusion scene. This would suggest that the previous failure to use this drawing device to represent the depth relationship between two objects reflects, as Luquet would maintain, a lack of concern rather than a lack of cognitive ability. So, are there any other circumstances under which children can be induced to use the partial occlusion drawing device? Light and Simmons (1983) investigated this issue.

These researchers adopted a 'communication game' strategy to investigate whether young children could be induced to replace their typically object centred drawings of one object behind another with view-specific representations. Children at three different age levels (5-6 years, 7-8 years, 9-10 years) were tested under two conditions. In the communication game condition the children were tested in pairs. Each child was shown a red and a blue ball positioned on a table and surrounded by four chairs. From each chair the position of the two balls was seen differently by the viewer. The children were asked to draw the balls and were told that their drawing was to be used by their partner (who was waiting outside the room) to determine which chair they had been sitting on when they made the drawing. View-specificity was thus emphasised in an information conveying context. In the control condition the children were simply asked to make the best drawing they could. In both conditions the red ball was positioned behind the blue ball such that the blue ball partially occluded it. The results revealed that the intermediate age level was affected by the communication strategy and produced significantly more partial occlusions of one ball by another in the communication condition. The youngest age group (5-6 year-olds) drew the balls in a horizontal orientation thereby disregarding their viewing position in both the experimental and control condition, whilst the older subjects produced partial occlusions in both the experimental and the control conditions.

In a different approach to the problem of getting young children to represent a between-object depth relationship by use of the partial occlusion device, Cox (1981, Study 5) takes as her starting point the fact that in many of the previous studies (e.g. Cox, 1981) the child may have seen no reason deliberately to obscure part of the farther object in the scene. Given this, she sought to investigate how children would respond when a task actually includes a reason for omitting part of the scene from the picture. Cox thus devised a task in which the idea that part of the scene should be omitted from the drawing would easily suggest itself to the child: the 'message' to omit part of the scene was incorporated into both the verbal and the non-verbal aspects of the task. Cox felt that it was important to incorporate the notion of masking or hiding into the task for this represents what is essentially involved in partial occlusion. She argues that if the notion of hiding was given prominence, then young children may see the need to incorporate it in their drawings. Cox's task involved a robber who was being chased by a policeman. The robber hid behind a wall where he believed he was safe. The policeman, however, knew where the robber was hiding as the top of the robber's head was clearly visible over the wall. This 'cops and robbers' game was enacted on a table in front of the child using models. Half the subjects had to pretend that they were the policeman, and for the other half a toy policeman was placed before them in front of the wall. In both these conditions the view was essentially the same. The subjects were 4-, 6-, 8-, 10-year-olds and adults. Each subject completed two tasks: a drawing and a selection task; half received the drawing task first and half received the selection task first.

There were no significant differences between the two policeman conditions, and there were no significant differences between the drawing and the selection tasks. The dominant response of the children age 6 years and above was clearly that of partial occlusion. Although the responses of the 4-year-olds were somewhat varied, 44% were able to draw a partial occlusion. So here is a task which demonstrates that very young children are able to use the technique of partial occlusion in order to produce a view-specific representation of a scene. Any tendency to draw the complete contour of the farther object and any tendency to separate the two objects on the page is curbed. Thus the 'cops and robbers' hiding game facilitated the use of this particular drawing device. How did it do so? Obviously there are numerous differences between this task and those, such as the ball behind a ball task, used in previous research. Not only do the actual objects used differ but the procedures followed and the instructions issued vary quite considerably. Cox's next task was to determine which of these variables, or indeed combination of variables, is important in facilitating the production of the partial occlusion response.

First a comparison was made between the two sets of task materials. Children (aged between 4 and 10 years) and adults were divided equally between a man-wall and a ball-ball condition. Within each of these two groups, half the subjects were told that one object was hiding behind the other whilst the other half were told that one object was behind the other. The notion of hiding was thus manipulated in the verbal instructions with both sets of materials. The results revealed that whilst there was a tendency, especially among the younger children, to produce more partial occlusions in the 'hiding' conditions, the difference between the two sets of instructions was actually not significant. The difference between the two sets of task materials, however, was significant: more partial occlusions were produced using the man-wall materials than the two balls. Thus the important finding is that the variable that elicits the production of partial occlusions in this experiment is the task materials. It is not necessary to present the task as a game or mention the word 'hiding'. Simply placing a man behind a wall was sufficient to elicit partial occlusion, at least for the majority of 6-year-olds: placing one ball behind another is not (see also Light and Simmons, 1983). In light of these findings, Cox (1985) set about investigating the task materials in order to determine why they produced such different rates of partial occlusion; what is it about the man-wall materials that makes them so successful at facilitating the production of partial occlusions?

To begin with, Cox (1985) asked if any object could be placed behind a wall and achieve high rates of partial occlusion, or is there something special about a man being placed behind a wall? In order to determine this, she presented a series of different objects (a man, a bottle, a block, a disc, a cube and a rectangle) behind a red wall-like rectangular block to different groups of 4-, 6- and 8-year-olds. She also wanted to find out if there was anything special about the occluder being rectangular in shape. Thus, the objects used as occluders were varied: a block, a cube, a ball and a disc. The pairs of objects, one partially occluding another, were presented to subjects in random order and subjects were asked to draw what they could see. The results revealed that particularly for 6- to 8-year-olds not all object pairs elicited the same amount of partial occlusion: when the two objects in a scene were similar the children tended to separate them, when they were dissimilar the children tended to use partial occlusion to depict them. Consequently, Cox argued that it is asymmetry between objects in a scene which leads children to produce partial occlusions; in contrast to this it is similarity which results in the objects being depicted separately on the page.

Why is it that scenes in which the objects differ prompt children to depict the depth relationship between the two objects by the use of the partial occlusion device? One possible explanation is the more similar the objects the more ambiguous the finished drawing. This explanation, however, rests mainly on the similarity of shape between the two objects, and given that if the shape remains the same but the depth is changed (e.g. a ball positioned behind a disc) one observes an increase in the number of partial occlusions produced, this explanation is unsatisfactory. Perhaps, then, the explanation lies in the way the children tackle the drawing tasks. When a drawing task commences the children first look at the scene they have been asked to draw. If the two objects are similar, the children might make a drawing of the scene without having to refer back to it, by accessing two separate and identical mental images (or possibly even a repetition of the first one) and drawing these on the page. Thus the drawing would not represent the objects as they actually appear in the scene: in order to modify the second image the child would need to look back at the scene. When the two objects comprising the scene are markedly dissimilar, it is perhaps more difficult for the child to retain a mental image of the second object, whilst drawing the first. After completing the first object the child may need to take a second look at the scene in order to ascertain what must be depicted next. Not only does the child actually see the object that she is supposed to be drawing, s/he is also likely to notice how much of it is visible; thus the chances of a view-specific representation being produced are enhanced (Cox, 1986a). It would be decidedly difficult to draw the scene 'as it looks' without referring back to it at some stage in the drawing process. In order to do so one would necessarily have to note the two objects to be drawn, access the two mental images, retain one of these whilst the other was being drawn, and then make appropriate modifications to the second image in accordance with some visual memory of the scene acquired during the initial viewing.

One could investigate the possibility detailed above in at least two ways. First of all, one could simply observe the child's looking patterns: one should expect to see children make fewer visual checks when drawing identical objects. Another method of investigation, however, would be to attempt to manipulate the child's looking pattern experimentally. Thus, for example, one could take an identical-objects scene and then ask the children to look at the occluded object after the first one had been depicted. Ingram (1983, Experiment 3) has done precisely this. In his third experiment, Ingram positioned one cube behind another and then asked children to make a drawing of the scene. Having allowed them to draw one cube, he then asked them to point to the corresponding cube in the scene before continuing with their drawing. He found that there were more partial occlusions with this interruption procedure than without: a finding which has been replicated by Stapeley and Cox (cited in Cox, 1986a).

In summary then, a general finding with young children, below about 8 years of age, is that they do not readily use the 'adult' technique of partial occlusion in order to represent a between-object depth relationship. Instead they tend to depict two complete and separate objects positioned one above the other on the page. This tendency is especially marked when they are asked to draw a scene comprising two similar or identical objects. Only when the importance of the relationship between the two objects is made more salient do the children actually use the partial oclusion technique to produce visually realistic representations and even then only a few studies (e.g. Barrett *et al,* 1985; Light and Simmons, 1983; Ingram, 1983) have succeeded in inducing children to use the technique to represent the between-object depth relationship between two similar or identical objects. However, the fact one can actually identify tasks in which there has been some success in facilitating the production of partial occlusions calls into question one possible explanation for children's frequent non-use of this particular drawing device: the Piagetian explanation that until the development of the understanding of projective and Euclidean relations at about 8 to 9 years, young children are simply unable to represent the projective aspects of a scene. The experimenter was particularly interested in pursuing this line of inquiry, hence the reason why the first four experiments reported in this thesis attempted to facilitate children's use of the partial occlusion drawing device to represent the between-object depth relationship between two balls. The specific rationale underpinning the design of the experiments was simple: if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the use of the partial occlusion technique. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of partial concealment more salient may serve to elicit the production of projective representations of a partial occlusion scene.

Given, however, that the intention was to investigate how the young child portrays depth more generally in her/his drawings the experimenter decided to focus not only on the way they represent between-object depth relations, she also decided to investigate how they represent within-object depth relations. Hence there follows a review of the literature which relates directly to the young child's ability to represent a within-object depth relationship. More specifically the review concentrates on how children represent the three-dimensionality of a single solid object.

1:3 Young children's representation of within-object depth relations.

Many studies have sought to investigate how children represent depth relationships in their drawings. Some of these studies, already discussed, have examined how children represent the depth relationship between two separate objects placed one behind another. Others, however, have focussed on how children depict the three-dimensionality of a single solid object. Studies concerned with the three-dimensionality of single solid objects, have typically required subjects to make a drawing of either a cube or a table. This choice of stimuli undoubtedly reflects the fact that depth is an important, if not defining, property of both these objects. The fact that all 6 sides of a cube are square is defining, but so is the fact that a cube possesses faces in all three spatial dimensions (up-down, near-far, left-right). The most typical example of a table consists of a rectangular 'top' surface supported by four legs, the important point being that the top surface lies in a horizontal plane both across and along the viewer's line of sight. Bearing in mind the importance of depth as a feature of both cubes and tables, let us consider how adults respond when asked to depict these two objects.

Cox (1986a) asked 26 undergraduate students to produce two drawings from memory: one of a table and one of a cube. The results (shown in Figure 1.1) revealed that 25/26 of Cox's subjects attempted to depict the depth of the table by drawing it in an oblique projection. In 15 of the 25 oblique depictions, the front edge of the table was positioned parallel to the horizontal axis of the paper. Only one subject in the sample produced a frontal view. In the cube drawing task all 26 subjects produced oblique representations: the 'depth' lines were drawn obliquely across the picture plane and the opposite edges were parallel and of approximately the same length. All the depictions showed the top face, a side face and a square front face. In some instances 'hidden' edges were depicted and these were drawn in either solid or dotted lines (see Figure 1.1).

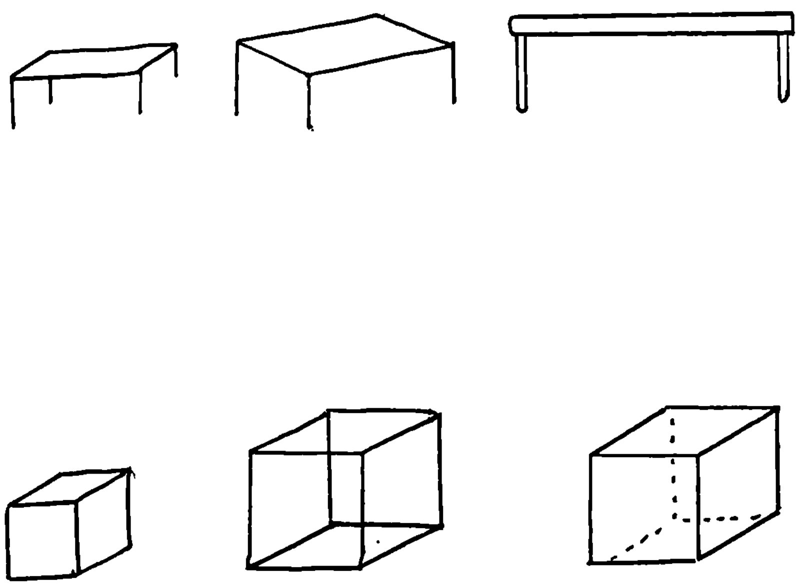


Figure 1.1: The responses of 26 adults who were asked to draw a table and a cube (Adapted from Cox, 1986a, Figures 8.2 and 8.3).

Whilst drawing the cube, many of Cox's subjects commented that they had learned 'this trick' at school: subsequent inquiries among primary and secondary school teachers, confirmed that by the age of 12 years most children have been explicitly taught that this is the way to draw a cube 'in perspective'. Drawing 'in perspective', however, involves more than simply depicting an object 'in depth', it involves the ability to depict an object exactly as it appears from any given viewpoint. Given that the oblique projections described above do not represent possible views, they cannot be described as perspective representations. Consider as an illustration of this point the drawings of a cube as shown in Figure 1.1. All 26 subjects depicted the front face of the cube as a square. The front face of a cube, however, only ever appears square when viewed at eye-level, such that no other sides are visible. Even when a cube is positioned so that it is viewed from a corner angle, no angles appear as right angles and no face 'squarely' confronts the viewer. Figure 1.2 shows a more accurate perspective projection of an oblique view of a cube. Note just how sharply this representation contrasts with those of the adult subjects in Cox's study.

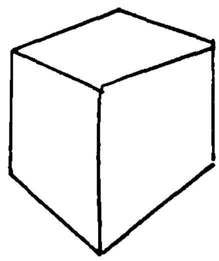


Figure 1.2: A perspective projection of an oblique view of a cube (Taken from Cox, 1986a, Figure 8.4).

Rather than making an accurate depiction of the projection of a cube at the eye, there appears to be a tendency for adults to produce oblique projections with only a small degree of convergence of lines. A study by Hagen and Elliott (1976) reveals that the tendency to favour this type of representation is not restricted to drawing tasks. These researchers presented adults with 6 pictures of a cube. The pictures varied in the degree of perspective convergence from a conical (traditional linear perspective) to an axonometric (parallel) projection. When asked to order the depictions, from the 'most natural' to the 'least natural' representation, an oblique projection with only a slight degree of convergence of lines, was consistently rated as being the most natural and realistic looking depiction. The subjects thus tended to use an almost parallel projection as the most preferred picture rather than a linear perspective projection.

parallel lines are important key features. In addition to this they solve some of the graphic production problems involved in the representation of a cube. The production of an oblique form typically begins with the depiction of a square: this represents the front face of the cube. Next, the left-hand edge of the top face is added. This is then followed by the right-hand edge, which in turn is followed by the lower edge of the right-hand face: all three 'depth' lines are drawn at the same angle and are exactly the same length. The drawing is finally completed by joining up the 'free' ends of the 'depth' lines with a horizontal and a vertical line (Cox, 1986a). Essentially, once one has constructed a square front face the only major decision which remains is the actual angle at which the first of the 'depth' lines should be attached: thus there are cues contained within the drawing itself, to guide the artist from one step to the next. Contrast this method of representation with that needed to depict a cube exactly as it is projected to the eye. Whilst the vertical lines are actually parallel they may, as shown in Figure 1.2, vary in length. In addition to this, with the exception of the vertical lines, none of the remaining pairs of opposite lines is parallel. Clearly then, this is a difficult configuration to produce but if, as Luquet (1913, 1927) maintained, adults are in a stage of visual realism, they should be capable of drawing a cube as it is projected to the eye. Moreover, they should be capable of depicting it as it is projected from any given orientation. How then do adults respond when presented with an actual cube to draw?

Cox (1986b) investigated this, presenting adults with a cube placed directly in front of them on a table such that only the front and top faces could be seen. Subjects in Condition 1 were simply asked to draw what they could see. Subjects in Condition 2, however, were asked to report which parts of the cube were visible from their particular viewpoint before they were asked to draw what they could see. It was predicted that, instead of drawing an oblique view with were visible from their particular viewpoint before they were asked to draw what they could see. It was predicted that, instead of drawing an oblique view with three faces, the adults in both these conditions should be able to draw what they could see - namely a non-oblique view with two faces (see Figure 1.3).

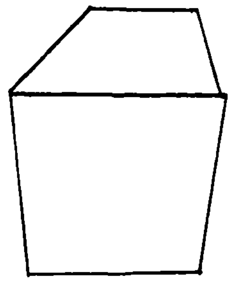


Figure 1.3: A view-specific representation of the cube.

When the criterion of a 'view-specific' response was simply a match between the number of faces depicted and the number of faces visible on the model, adults were very good at drawing what they could see. The results revealed that 88% of the subjects in Condition 1 drew just the two visible faces of the cube and only 12% drew the three faces of an oblique view. In Condition 2, 96% drew the two visible faces and only 4% drew an oblique view.

Cox then went on to consider precisely how the faces of the cube were depicted. Of the 93 adults who drew just the two visible faces of the cube, only 42% converged the side edges of the top face and depicted the 'distant' horizontal line as being shorter than the 'near' edge. Whilst some adults attempted to produce what Cox termed 'other angled' solutions, the majority actually produced rectilinear representations: this pattern of response was similar for both Condition 1 and 2. All the subjects depicted the front face of the cube as a square, and there was no attempt to represent the slight 'downward' convergence of the front face.

'natural' tendency to see a cube as a three-dimensional square form made up of parallel lines and right angles. Consequently, whilst adults should be capable of drawing a cube how it looks, it actually transpires that many cannot.

Having discussed (with particular reference to their drawings of a cube) the way in which adults represent the three-dimensionality of a single solid object, let us now consider how children tackle the problem of representing a three-dimensional object on the two-dimensional surface of the page. The first set of studies to be described is concerned with children's drawings of a table.

In order to test the ability of children to represent three-dimensional space in a drawing, Willats (1977) gave children (aged between 5 and 17 years) a scene to draw from a fixed viewpoint. This scene consisted of a radio, a box and a saucepan standing on a table. The table was arranged so that the subject faced one of the long edges and the radio was arranged so as to partially occlude the box. All three objects occluded sections of the far edge of the table. Care was taken to ensure that each subject viewed the scene from the same vantage point.

Children's attempts at depicting the table top and the three objects on it were graded from a simple drawing in which no coherent projective system was utilised (Class 1), through to a drawing which approximated an accurate perspective drawing of the scene (Class 6). These classes, which were based on the family of systems described by Dubery and Willats (1972), comprise of a set of progressively more complex drawing systems and are described briefly below.

Class 1: No projection system.

Class 2: Orthographic Projection: This is the most basic system, relying on the use of parallel lines positioned perpendicular to the drawing surface. Vertical lines in the picture represent vertical edges in the real world.
Class 3: Vertical Oblique Projection: Here aerial and front views are summed.
Class 4: Oblique Projection: A system which amalgamates aerial, side and front views. Edges are represented by oblique lines.
Class 5: Naive Perspective: A precurser to perspective. No particular viewpoint is fixed.
Class 6: Perspective: The viewer's position is fixed by a single point from which parallel lines converge to a vanishing point.

The results revealed that the use of these six systems is related to chronological age: with increasing age children are able to use increasingly more complex types of drawing system. It is surprising that by the age of 16 or 17 years only a minority of children were using anything approaching true perspective. Perhaps even more surprising is the fact that overall the most commonly used system was the vertical oblique projection: this is not a taught solution to the problem of representing depth and neither is it a system normally encountered in the child's pictorial environment. Given this, it is readily apparent that children do not simply imitate what they see from nature; nor do they imitate perspective representations in the pictures they see around them. Willats argues that in the early classes the drawings show the children's own invented solutions to the problem of representing depth in their drawings. As Cox (1986a) notes, the latter classes, however, probably reflect an interaction between the level of the child's own graphic skill, formal taught solutions and the child's cognizance of the linear perspective solution common in Western art.

One criticism of Willats' task is that it is actually rather complex. Not only did the children have to solve the problem of how to depict the projective image of the table, they also had to decide how to depict the objects which were arranged on top of the table: this in turn involves partial occlusion. How, then, do children respond if they are simply asked to draw a picture of a table? Hayton and Freeman (cited in Freeman, 1980, pp. 256-258) investigated this and asked 20 children aged between 10 and 11 years to draw a picture of a table: a small doll's table was used as the model. The distribution of drawing systems obtained was 11 vertical oblique, 6 oblique and 3 naive perspective: results which are clearly similar to those obtained by Willats. More recently, however, Lee and Bremner (1987) have attempted to replicate Willats' findings regarding children's depictions of a table using a larger sample of subjects, aged between 4 and 14 years. The results revealed that in general, the relationship between age and the use of projection system found by Willats was supported, although there was no evidence to support a clear cut distinction between naive and true perspective: their being no relationship between the amount of convergence depicted and the age of the child. Moreover, none of the subjects used linear perspective that was correct for their viewing position and the majority of subjects who drew the table top 'in perspective', drew the legs with more, rather than less, convergence than they had used for the table tops; this is the exact opposite of the response that would be expected from a true understanding of the projective system.

According to the data from these studies, then, children below the age of approximately 9 years of age represent the top of a table with either a single horizontal line or with a rectangle; only later do the angles deviate from right angles. The first departure is typically an oblique projection in which the side edges of the table top are parallel. Later, in the perspective system the side edges are depicted as converging into the distance. Having now addressed the issue of how children attempt to represent the three-dimensionality of a table, let us focus our attention on their drawings of a cube. The first issue to be considered is how children draw a cube when there is no model present.

Cox (cited in Cox, 1986a) asked children (aged between 7 and 15 years) to draw a picture of a cube from memory. The results revealed that below the age of approximately 9 years, the children were drawing an assortment of rectilinear configurations. By the age of 11 to 12 years, however, 79% of the children tested were producing an oblique view and by the age of 14 to 15 years 91% of the children were producing oblique representations. How do these responses compare with those of children drawing from an actual model?

Mitchelmore (1978) considered this and asked 80 children (aged between 7 and 15 years) to draw an actual cube which had been placed in front of them in an oblique orientation. The resulting drawings were then classified, with each drawing being assigned to one of four stages. Stage 1 (plane schematic) consisted of drawings showing a single square and according to Mitchelmore this square could represent either a single face viewed orthogonally or the general outline of the cube. Drawings showing a number of squares juxtaposed together were judged to be schematic and these were assigned to Stage 2 (solid schematic). Essentially, in this stage, the cube was represented by several of its faces. Such representations often included both hidden and visible faces and these faces were often drawn incorrectly in relation to one another. Unfaithful representations depicted from a single vantage point constituted a third stage (pre-realistic). In this stage attempts were made to depict the cube 'in depth' as seen from a single viewpoint. Only the visible faces were represented and these were positioned correctly in relation to one another. This stage was separated into Stage 3A (the first break-away from the exclusive use of squares) and Stage 3B (almost faithful drawings). In Stage 4 parallels in the solid were consistently represented by parallels or near parallels in the drawing.

Most of the 7-year-olds in Mitchelmore's study drew a single square (Stage 1). Now, as noted previously, according to Mitchelmore, a single square could represent either a single face viewed orthogonally or the general outline of the whole cube. The results of a study by Moore (1986), who used a colouring task to elucidate children's drawings of a solid cube, suggest that for younger children the latter is more likely to be the case, and for older children the former is more likely. Moore asked 60 children (30 infants, mean age 7 years 5 months and 30 juniors, mean age 9 years 5 months) to explore and then draw a mutli-coloured cube. The children were provided with white drawing paper and ten felt-tip pens. The colours of these pens represented the six colours used for painting the cube (each face was painted a different colour) plus an additional four different colours.

The results revealed that the juniors who produced a single square used a single colour which corresponded to the front face of the cube. In contrast to this, the infants who produced a single square used six colours, which corresponded to the six faces of the cube and were placed in either vertical or horizontal stripes. Moore notes that the infants tended to rotate the cube as they added successive colours thereby indicating adjacent faces which shared a common boundary. So, although their responses were classified as incorrect, in terms of visual realism they appeared to be systematic, with adjacent colours being indicative of adjacent faces. These results are in accordance with Piaget and Inhelder's (1956) suggestion that younger children's drawings are often based on topological rather than projective relationships: a closed figure represents a volume occupied by the object rather than a particular view of its outer surface. A single square, then, represents the volume occupied by the cube, as well as giving some indication of its shape. Mitchelmore found that the single square was still common at the age of 9 and at 11 years. Those 9-year-olds who did not produce single squares tended to produce Stage 2 rectilinear depictions. From 9 years onwards, however, the children made some attempt to depict the oblique orientation of the model as seen from a particular viewpoint (Stages 3A and 3B), but very few realistic (Stage 4) depictions were produced even at 14 years of age.

Cox (1986b) asked whether in producing an oblique view, the children were actually responding to the particular view of the cube in front of them or whether they were simply drawing their stereotype of a cube. In order to investigate this she asked 7- and 12-year-olds to draw a cube which had been placed directly in front of them on the table so that only the front and top faces could be seen. As with the adult sample detailed earlier, the subjects were divided into two conditions. In Condition 1 the children were simply asked to draw what they could see; in Condition 2 their attention was also drawn to the fact that only two faces of the cube were visible. Cox argued that if children of approximately 7 years of age are in a stage of intellectual realism they will not be concerned to represent the cube as it appears from a single fixed view-point, rather they will attempt to capture the essence of the cube *per se*: and one would not expect the more detailed verbal instructions in Condition 2 to alter their responses. One might, however, expect 12-year-olds to be in an intermediate stage whereby they produce their stereotyped representation in Condition 1, but draw what they can actually see in Condition 2.

The results revealed that in Condition 1, 29% of the 7-year-olds produced a single square, 43% produced drawings comprising two sections, and 27% produced configurations consisting of three or more sections. At 12 years of age, 46% produced two-section drawings and 50% produced three-section configurations. Clearly, less than half the children were producing two-section representations and there was a shift with age from drawing a single square to drawing the stereotyped three-section oblique view. In Condition 2, only 16% of the 7-year-olds drew a single square. The percentage of two-section drawings, however, was 70%; the remaining responses were distributed across both the three- and four-section categories. The dominant response amongst 12-year-olds was a two-section configuration, with 87% of the children producing it. The remaining responses were all three-section representations.

Cox argues that what appears to be happening is that children as young as 7 years are capable of producing a drawing of a cube which matches the number of faces they can actually see, if this requirement is brought to their attention. By the age of 12 years, however, most children have been taught 'how to draw a cube' and their tendency is to produce this stereotyped representation. This can, however, be curbed if it is stressed that only two faces on the model cube are visible. Contrary to the prediction, then, detailed verbal instructions from the experimenter are successful in eliciting view-specific responses from children as young as 7 years. Remember that adults are already capable of producing view-specific representations and are thus not dependent on the more detailed instructions afforded by Condition 2. Very few children, even at the age of 12 years, produced converging lines in order to depict the appearance of the top face of the cube: most depicted the edges as parallel. Whilst Cox took a very liberal criterion of view-specificity, viz. a two-section drawing irrespective of the way the sections were drawn, one can still trace a developmental trend concerning the way in which the top face is drawn: perpendicular parallel lines at 7 years, oblique parallel lines at 12 years and converging lines among adults.

Perhaps, then, the most striking difference between younger children's drawings of objects in depth and those of older subjects is that younger children depict these objects as rectilinear forms which emphasise vertical and horizontal lines and right angles. In contrast older children's representations are characterised by oblique lines and acute angles.

The traditional theory that young children draw what they know rather than what they see (Luquet 1913, 1927) has been invoked to account for the prevalence of rectilinear forms in children's drawings. According to this theory, the young child produces a rectilinear configuration simply because s/he knows that the object is constructed in this way. There are, however, several other possible explanations which are not necessarily mutually exclusive and these are are detailed below.

One possible explanation for the pre-dominance of rectilinear forms in young children's drawings is that young children simply have difficulty in drawing obliques. Piaget and Inhelder (1956) observed that children are able to draw a circle by approximately 3 years of age, a square at 4 years of age, a triangle at 5 years of age and a diamond at 7 years of age. Clearly then, figures involving obliques appear at a later age than figures involving horizontals and verticals. As a result of this observation, much attention has been focussed upon young children's apparent inability to draw oblique lines.

Several studies have looked at the background shape of the paper on which the figure has been drawn. Drawing-paper is typically rectangular and thereby provides both vertical and horizontal cues. It should be fairly easy, then, to produce either a vertical or a horizontal line: both can be drawn parallel to the existing edge of the page. Given that there are no oblique edges, however, an oblique line may well prove difficult to draw. Berman (1976) presented 3- to 4-year-olds with square cards. Drawn on these cards were a horizontal, a vertical and an oblique line. Once the child had seen a card it was removed and s/he was asked to reproduce the line on another square card. The results revealed that the children's reproductions of the oblique line were significantly less accurate than those of other orientations; the horizontals and verticals did not differ significantly from each other in accuracy. Interestingly, there was a systematic pattern of errors in reproducing the oblique: younger children erred by substituting horizontals and verticals and older children substituted opposite obliques, but only when the model line extended from one corner of the paper to the other. Berman, Cunningham and Harkulich (1974) performed a similar study in which the model stimuli, a horizontal, a vertical and an oblique line, were presented to the children centred on circular white cards which were placed on a circular table. Children aged between 3 and 5 years were asked to reproduce these figures from immediate memory on circular, as opposed to square, backgrounds. Reproductions of the vertical line were significantly more accurate than reproductions of the horizontal and the oblique lines; the difference between the horizontal and the oblique was statistically insignificant. However, both these studies rely heavily on memory, as the stimulus cards were removed before the child had begun to draw. How, then, do children respond when they are able to view the stimulus design for the entirety of the drawing procedure?

Brittain (1976) performed a study in which the child was allowed to observe the stimulus design throughout the drawing procedure. His results revealed that for children aged between 3 and 5 years, circles, squares and triangles were all easy to draw if the shape of the drawing paper coincided with the shape of the figure to be drawn: the child can clearly draw lines parallel to the edges of the surrounding page. Naeli and Harris (1976) also found that a compatible frame facilitated task performance, whilst an incompatible frame hindered it. This pattern of results was obtained irrespective of whether the child had to draw a figure or position a cut-out shape on the frame.

What these results suggest, then, is that oblique lines are not that difficult to draw when there is a cue available in the shape of the surrounding frame. In the cube and table drawing tasks cited previously, there is clearly no oblique cue in the surrounding frame. Perhaps this could explain why the children do not represent the 'depth' lines of these objects with converging obliques. Whilst this may seem to be a plausible explanation, such a notion could not in fact account for the 'errors' in children's spontaneous drawings in which obliques are routinely produced even though the frame is rectangular see Figure 1.4.

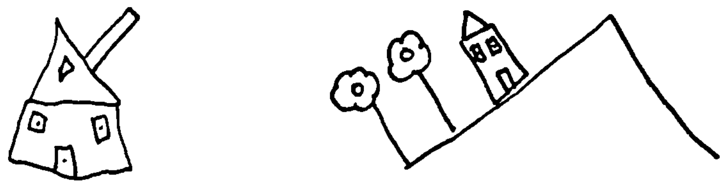


Figure 1.4: Examples of 'errors' in children's spontaneous drawings.

The sides of the chimney should actually be vertical and parallel with the sides of both the house and the paper. Similarly, the trees on the mountain side should be vertical. In both, cases, however, the lines are oblique to and not parallel with nearby cues. Piaget and Inhelder (1956) accounted for these errors in terms of a lack of understanding of the Euclidean concepts of the vertical and horizontal. If this were so one would predict that these errors would occur randomly. What is most striking about these pictures, however, is that both the chimney and the trees are drawn perpendicular to their baselines. The errors are quite systematic. Moreover, whilst the errors occur in production tasks they are much less marked in selection tasks (Perner, Kohlmann and Wimmer, 1984) . Children clearly recognise that vertically drawn chimneys are correct whilst perpendicularly drawn chimneys are incorrect. Could it be the case, then, that children do not have difficulty drawing an oblique *per se*, nor do they have difficulty drawing an oblique in a rectangular frame, nor do they demonstrate a lack of conceptual knowledge regarding verticals are horizontals? Rather, it is the tendency towards drawing perpendiculars onto a local baseline which accounts for the production of rectangular representations by young children.

Ibbotson and Bryant (1976) sought to investigate whether this bias was present in decontextualised tasks. Children, aged between 5 and 6:6 years were asked to copy a series of figures. Each figure was composed of a short line drawn onto a larger baseline: the angle between these two lines was either 90 or 45 degrees. The figures were presented in a number of different orientations, such that the baseline was either horizontal, vertical or oblique. A pre-drawn baseline was present on the response card and the child was asked to draw in the second, shorter line.

The results revealed that the 90 degree figures were copied more accurately than the 45 degree figures. It was also found that there was a strong perpendicular bias in the errors of the 45 degree figures, the shorter line being drawn more perpendicular to its base than it should have been. This error was found to be quite strong with both horizontal and oblique baselines, but not with vertical baselines. Ibbotson and Bryant refer to this as the vertical effect. This pattern of results was replicated in two subsequent experiments when (a) the motor response was changed so that the children had to place a straight wire onto a baseline and when (b) different figures were used such that the line to be copied was inside a rectangle.

Bayraktar (1985) notes that the perpendicular bias is exceedingly stubborn. Even when strong cues were provided by making the edge of the paper parallel to the target line or by placing a red line parallel to the target line the perpendicular bias still persisted. Whilst the bias begins to fade at about age 7 years it was found to be still there to some extent even among adults.

Clearly then, children find it difficult to draw a line at an acute angle to a baseline, especially if the baseline lies in a horizontal or an oblique orientation; the tendency is to draw the line perpendicular to the base. Bremner and Taylor (1982) have argued that the perpendicular bias found by Ibbotson and Bryant may reflect the tendency to bisect the baseline and so create two equal angles opposed to the tendency to draw a line perpendicular to the baseline. In order to test this notion they presented 'dog-leg' baselines which subtended an obtuse angle. In some instances a central, intersecting line bisected the angle, in others, this intersecting line created a right angle and an acute angle. Bremner and Taylor also presented figures with straight baselines, and with intersecting lines being drawn either oblique to or perpendicular to this baseline. These figures were presented to the subjects in a variety of different orientations.

Each baseline was drawn on card in black ink whilst the intersecting line was drawn in red. The children were provided with a response card with an identical baseline drawn on it and they were asked to draw in the red intersecting line. If the error is a perpendicular error then one would predict that the intersecting line should be drawn to form a right angle. If, however, the tendency is towards bisection, then the children should draw the intersecting line so as to bisect the angle of the baseline. The results clearly supported the notion of bisection: children copied bisected figures more accurately than non-bisected ones, even though these figures contained a right angle. Now then, do the findings of Bremner and Taylor and of Ibbotson and Bryant actually relate to the way in which children attach 'depth' lines to the front face of a cube or to the horizontal front edge of a table?

When 'depth' lines are drawn onto a cube or a table they are not attached to the middle of the baseline; they are attached to 'corners'. Bremner (1984) noted that the bisection tendency cannot occur if the line to be copied joins a baseline at its end: in this particular instance children are constructing one angle as opposed to two. Bremner proceeded to test twenty 4-year old children on two types of angular figure: (i) a baseline with another line joining at end at 45, 90 or 135 degrees and (ii) a baseline with another line joining at the middle at 45 or 90 degrees. Subjects had to copy figures drawn on cards by completing partial figures drawn on cards of the same size. When Bremner compared 'middle' and 'end' figures he found that children tended to make errors towards the perpendicular in both. A bisection bias cannot be the sole explanation of the perpendicular error; there does appear to be a genuine perpendicular bias.

Nevertheless, the 'end' task still doesn't seem to be the same kind of problem as adding a 'depth' line to a table or a cube: the 'depth' line is not attached to the middle of a baseline, nor is it strictly speaking attached to the end of a line, it is attached to the origin of an angle. To date there has not been a study devised to investigate how children copy an 'outside' line as opposed to the intersecting line such a configuration. It is possible that the child would treat such a task in the same way as an 'end' task ignoring the vertical left hand line and simply attaching the 'depth' line to the end of the horizontal line. If this were the case one would expect the perpendicular bias to operate. The child may, however, treat the depth line as a continuation of the left hand 'baseline' and regard the horizontal line as the intersecting one. In this instance the bisection bias would be expected to operate to produce two equal angles. Either way, the result would be the production of a line lying perpendicular to the horizontal front edge of the cube or the table. Of course, one must not discount the fact that there may well be another cue influencing the production of the drawing, namely the edge of the paper. Thus the biases operating and the cues available in the task, either separately or together, appear to militate against the child producing an oblique 'depth' line. So far, there is no satisfactory explanation of the perpendicular bias. Ibbotson and Bryant (1976) suggested that it is the product of the 'carpentered' world in which we live. Bayraktar (1985), however, argues that this is not an adequate explanation given that the bias is equally as strong among rural Turkish children who do not live in such a carpentered environment. (Cox, 1986a).

The studies detailed above suggest that powerful production biases may be at work, at least in two-dimensional and essentially decontextualised tasks. Whilst it is undoubtedly useful to decontextualise a task and employ abstract figures in order to demonstrate the existence of a production bias, it does not necessarily follow one can account for the drawing of a 'real' object solely in these terms. All one can actually say is that there is a tendency towards a production bias irrespective of the child's knowledge regarding the characteristics of the object to be depicted. In addition to a production bias it may well be the case that the child's knowledge of the object she is depicting, in itself, influences her choice of line. If, for example, the child knows that the top surface of a table is rectangular and that the six sides of a cube are square, then these features may be preserved in her drawing. This certainly seems to be the implication of the results of four studies conducted by Phillips, Hobbs and Pratt (1978), Moore (1987), Cox (1989) and Lee (1989).

Phillips, Hobbs and Pratt (1978) asked the children to copy simple line drawings of perspective views of cubes and similar designs which were unlikely to be regarded as representing objects. The views of the cubes were copied less accurately than the non-object patterns, and the errors made in copying the cubes involved the replacement of properties specific to the single perspective view by properties more appropriate to the object itself. Some copies were drawn with the child continually observing the model, unable to view her own copy; other depictions were made in the normal way. Copies made in the former way were more accurate, but even under these conditions cubes were copied less accurately than the non-object patterns. The disadvantage of object pictures regarding literal copying accuracy was still present at 9:6 years of age; it was, however, less than at 7:6 years of age. When copying the line drawings of the cube the children did not produce single squares as they probably would have done had an actual cube been presented: the line drawing showed multiple facets and the children had attempted to represent these. Presumably the knowledge that the child has regarding real cubes, namely that they are composed of a number of square faces, is triggered by the drawing. No such knowledge is available regarding the other figure and thus it is unable to interfere with the drawing process; the child is much freer to draw the design as it appears.

The suggestion that children copy pictures of objects less accurately than non-object patterns of equal complexity was investigated further by Moore (1987). She examined the accuracy of children's copies of outline drawings of a familiar object (a cube) and an unfamiliar nonsense object, both before and after controlled exposure to a three-dimensional model of each object. Thirty 7-year-olds and thirty 9-year-olds were assigned to one of the two exposure conditions. In the 'visual' condition the models were viewed in a standard orientation. In the 'manipulative' condition the models were explored manually. In a control condition no model was presented. The results revealed that initial copies of the cube drawings were less accurate than the initial copies of the nonsense object, and that children in both age groups copied less accurately following exposure to both models; there was no significant difference between the two exposure conditions. Moore suggests that minimal exposure to the properties of an object is sufficient to induce children to represent this information in a drawing, even if the result is a less accurate representation.

More recently, Cox (1989) asked 7- and 9-year-olds to draw two three-dimensional objects: a cube and a wedge. When the appearance of the object coincided with the children's knowledge of it (wedge) they produced a perspective representation, including converging obliques. When the children's knowledge of the object and its apparent shape failed to coincide, the invariant, as opposed to the variant, features were depicted: the result being the production of rectilinear solutions. The majority of children were able to make an accurate copy of a two-dimensional perspective projection of the objects including converging obliques. Having said this, however, the children's knowledge of what the line drawing was intended to represent affected the type of drawing they produced: the children drew fewer converging obliques when the same line drawing was called a 'building block' (a rectangular object) than when it was called a 'shape' or a 'house' (an object known to contain obliques). This pattern of results was also observed in a second experiment in which a selection task was used.

Lee (1989) obtained similar results in her study of children's drawings of a table: the errors in copying line drawings of a table were directly related to the knowledge that the lines represented a table; the children experienced little difficulty in drawing the lines themselves. When the children were asked to copy the component parts of these line drawings, fewer errors were made when the children had not previously been told what the lines represented.

From the results of these four experiments, it would appear that young children are concerned to represent their knowledge of the objects they have been asked to depict. Moreover, Crook (1985) argues that the perpendicular bias found in the Ibbotson and Bryant-type task is not in itself substantial enough for one to conclude that this production bias alone accounts for the perpendicular errors so characteristic of children's spontaneous drawing. Trees toppling off the sides of mountains and chimney pots jutting off roofs surely reflect the child's knowledge of the real world: trees normally grow perpendicular to a horizontal ground and chimney pots normally rest on, and are positioned perpendicular to, the horizontal ridges of roofs. Thus we have apparently returned to the traditional notion that the child's knowledge of an object influences the way in which it is drawn. Now, is it the case that young children tend to draw simple solid objects 'as they are known to be' because they are unable to draw them 'as they look', or is it the case that the children simply do not realise that is what they are being asked to do?

As detailed earlier, Piaget's theory would appear to favour the former explanation; for according to Piaget (Piaget and Inhelder, 1956, 1969) until the development of projective and Euclidean relations, young children are unable to represent the projective aspects of a scene. In contrast, however, Luquet's writing, according to Costall (1989), would appear to favour the latter explanation; that is to say, children's failure to represent the within-object depth relationship in a simple solid object reflects a lack of concern rather than a lack of cognitive ability. Which account, then, is correct?

From the work relating to young children's use of the partial occlusion drawing device we have some evidence which suggests that young children are actually capable of representing the projective aspects of a scene. There is, however, no such evidence from studies examining children's ability to represent a simple solid three-dimensional object. Given that this is so the experimenter embarked upon a series of studies which attempted to facilitate children's use of perspective 'depth lines' in order to represent a within-object depth relationship. The rationale underpinning the studies was quite simply (as in the studies relating to the representation of a between-object depth relationship) that if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956, 1969) then no amount of task manipulation should facilitate the use of converging oblique perspective depth lines.

In summary, then, the study of how children represent within-object depth relations has tended to focus specifically on the way in which young children represent the three-dimensionality of a single solid object. Studies designed to address this issue have typically required subjects to make a drawing of either a table or a cube. Young children depict both these objects as rectilinear forms: the table top being drawn as a rectangle, the cube being represented by a single square or a configuration of squares. By about the age of 12 years, however, children have been explicitly taught 'how' to draw objects 'in perspective' and they typically produce oblique views of cubes and tables. Adults also produce oblique representations of these objects, representations which are in fact impossible views. If one presents adults with an actual cube, placed in front of them so that only the top and front faces can be seen, they will modify their stereotyped oblique drawings and draw only the number of faces they can see. Young children, however, will only do this when the instructions are made explicit. It is perhaps not surprising that young children produce rectilinear forms instead of using converging obliques to depict the top face of the cube; but it's very surprising that many adults use these forms too.

It may well be the case that powerful production biases militate against the young child producing visually realistic representations of these objects. In addition to these biases, the child may also experience difficulty in suppressing what s/he knows about the scene s/he is drawing: tables and cubes are rectangular forms so perhaps it is 'unnatural' or 'difficult' to have to inhibit drawing them as such. The same problems may well confront adults, although to a lesser extent and this may well explain why many adults find drawing a difficult and frustrating task.

In the earlier section which related to between-object depth relationships, there were many examples of studies specifically designed to induce young children to use the partial oclusion drawing device to represent such relationships. There has not, however, been any equivalent work designed to investigate whether children can be induced to represent a within-object depth relationship. Although children tend not to produce visually realistic representations of objects like cubes and tables they may actually be capable of doing so; if this is the case then one should be able to identify the particular circumstances which would elicit the production of projectively accurate drawings. In light of this, some of the studies in this thesis constitute an attempt to design a task which will lead young children to produce visually realistic representations of a simple three-dimensional object. As is the case with the studies addressing children's ability to represent a between-object depth relationship, the experimenter was seeking to address the Piagetian claim that, until the development of projective and Euclidean relations at about 8-9 years young children are are unable to represent the projective aspects of a scene. Again, the specific rationale underpinning the design of the experiments was that if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the production of visually realistic representations. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of view-specificity more salient may serve to elicit the production of projective representations of the scene. Given that older subjects, as well as younger subjects, often experience problems producing visually realistic representations of simple solid objects (e.g. Cox, 1986b) the experimenter also investigated whether the tasks designed for use with children would facilitate the production of visually realistic representations by adults and adolescents.

CHAPTER TWO.

In the representation of the three-dimensional world on the two dimensional surface of the page, the 'up-down' and the 'left-right' dimensions of real world space are fairly readily translated into graphic terms: 'up-down' spatial relationships are represented by 'top-to-bottom' relationships on the page, whilst 'left-right' relationships in the scene are represented by 'left-right' relationships on the page. A problem arises with the representation of the 'near-far' or depth dimension of real world space, there being no equivalent on the flat, two-dimensional surface of the page. How does one indicate that one object is positioned behind another and is therefore farther away?

Perhaps the most common, and to some the most 'natural', solution to this problem is the 'linear perspective' system. The essence of this system is that the artist represents the projective aspects of a scene, by drawing exactly what s/he can see from a particular fixed viewpoint. Everything which cannot be seen is omitted from the picture. Objects which in the real world are more distant are drawn higher up the page and smaller in size and, in addition to this, objects which are nearer may be depicted as masking or 'partially occluding' those which are behind and farther away.

A general finding with children below approximately 8 years of age, however, is that they strive to represent in their drawings, the known, invariant qualities of a scene rather than the projected image. Thus, for example, rather than use the partial occlusion technique (Cox, 1981, 1985) to represent the partial concealment of one object by another and the depth relationship between the two objects, young children tend to depict the complete contour of the partially hidden farther object. This tendency is particularly striking when they are asked to draw two similar objects positioned such that the nearer object partially masks the farther one (e.g. Freeman, Eiser and Sayers, 1977; Cox, 1981).

Now, is it the case that young children necessarily depict the invariant aspects of a partial occlusion scene comprising two similar objects because the projected image is simply too difficult for them to produce? Apparently not. When Cox (1986a) asked 5- to 7-year-olds to copy a line drawing of a two-ball partial occlusion configuration, the high rate of accurate copying from children of all ages revealed that they clearly possessed the motor skill needed to produce a partial occlusion. Perhaps, then, the children's difficulty is in inhibiting a tendency to draw a full contour (Freeman *et al,* 1977). If this was the problem, however, one would expect to see many overlaps in their drawings of partially occluded similar objects and this is clearly not the case (see Freeman *et al*, 1977; Ingram and Butterworth, 1989).

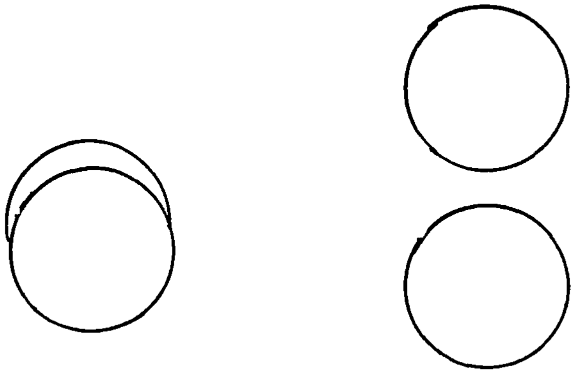
Having discounted the previous two explanations, one might consider two further possibilities. The first of these is that the child fails to represent the projective aspects of a partial occlusion scene comprising two similar objects because s/he simply does not 'see' them: that is to say s/he only attends to the identity of the objects and their invariant features. The other possibility is that the child is actually capable of considering the projective aspects of the scene (how things look) but nonetheless prefers to represent the invariant rather than the variant features of the array.

Piaget's theory (Piaget and Inhelder, 1956, 1969) would appear to favour the former explanation: that is to say that until the development of the understanding of projective and Euclidean relations at about 8 to 9 years, young children cannot represent the projective aspects of a scene. In contrast, Luquet's (1913, 1927) writing, according to Costall (1989), would appear to favour the latter explanation. Which, account, then, is correct? Is it the case, as Piaget would argue, that young children cannot use the partial occlusion technique in order to represent the projective aspects of a partial occlusion scene comprising two similar objects, or is it as Luquet would maintain simply that they do not? The experiments detailed in the following two chapters were designed to address this issue. The specific aim, then, was to ascertain whether young children are unalterably object-centred in their drawing or whether one can induce them to represent view-specific (projective) information by use of the partial occlusion drawing device. The rationale underlying these experiments was simple: if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the use of the partial occlusion technique. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than a lack of cognitive ability, then restructuring the drawing task in order to make the notion of partial concealment more salient may serve to elicit the production of projective representations of a partial occlusion scene.

Experiment One.
Drawing One Ball Behind Another.
Partial Occlusion versus Non-Occlusion.

Introduction.

Cox (1981, Study 2) asked young children to draw two balls, of identical size and shape, positioned one behind another such that the nearer ball partially occluded the farther ball. Despite emphasising in the instructions, that the main purpose of the task was the representation of the projective image of the scene, Cox found that children aged between 5 and 8 years tended to represent the invariant characteristics of the individual objects. Thus, rather than use the partial occlusion technique (see Figure 2:1a) to produce a visually realistic representation of the nearer ball masking the farther ball, the majority of children drew two complete and separate circles positioned vertically one above the other (see Figure 2:1b).



(a) (b)

Figure 2:1: (a) The technique of partial occlusion used by adults and children from around 8 years of age and (b) One ball behind another as depicted by children aged between 5 and 8 years.

Why did the children fail to use the partial occlusion technique to represent the depth relationship between the two balls? One possible explanation is that they simply did not realise that it was important to depict the partial concealment of the farther ball by the nearer; they had after all attempted to represent the spatial depth relationship between the two objects by drawing one above the other. Could it be the case, then, that children would produce visually realistic representations of this array if the importance of partial concealment was made more salient?

This possibility was addressed by Barrett, Beaumont and Jennett (1985), who attempted to make the notion of partial concealment more salient by emphasising the importance of visual realism in the verbal instructions. Children aged 7 years, were shown a model of two balls positioned one behind the other such that the nearer ball partially occluded the farther. They were then asked to draw this model, using either one of the following two sets of instructions:

Instructions 1: 'Please can you draw this for me. Please do not touch it or move from your chair.'

Instructions 2: 'Please can you draw this for me exactly as you see it from where you are sitting. Look very carefully at it so that you can draw it just as you see it. Please do not touch it or move from your chair.'

Successful implementation of the partial occlusion technique occurred in only 6% of the drawings elicited by Instructions 1. In contrast to this, however, when the importance of visual realism was actually emphasised in the verbal instructions (Instructions 2), 35% of the elicited drawings showed the farther ball partially occluded by the nearer. Clearly simply by altering the nature of the verbal instructions, one can cue the children into what they are 'supposed' to be doing, namely, using the partial occlusion device to depict the projective image of the scene. This quite striking result suggests that young children are not unalterably object-centred in their drawing of a partial occlusion scene comprising two similar objects and that one can in fact induce them to represent view-specific (projective) information. The results of this study (along with others by e.g. Light and Simmons, 1983; Ingram; 1983) have far reaching implications as they call into question one of the explanations for children's non-use of the partial occlusion: the Piagetian explanation (Piaget and Inhelder, 1956, 1969) that young children have not yet developed concepts of projective and Euclidean space. In the experiments to be reported here the experimenter pursued this general line of inquiry and, in particular, attempted to facilitate children's use of the partial occlusion drawing device to represent the between-object depth relationship between two balls by manipulating the <u>non-verbal</u> <u>aspects</u> of the task.

The design of the following experiment, which sought to address this issue, was influenced by work (e.g. Davis, 1983; Davis and Bentley, 1984) which has shown that a contrast in object orientation, either within a scene or between two consecutive arrays, will prompt young children to produce visually realistic representations of the experimental display. The specific aim of the experiment detailed here was to investigate whether the presence of a contrast in object orientation across two arrays, would serve to make the importance of partial concealment more salient and thereby facilitate the use of the partial occlusion technique to represent the projective aspects of a partial occlusion scene.

The contrast in object orientation across the two arrays was established by asking the children (aged between 6:6 years and 7:6 years) to draw (1) two balls, one in front of but not occluding the other, and then (2) to draw two balls positioned one behind the other such that the nearer ball partially occluded the farther. It was predicted that this juxtaposition of object orientation across the two arrays would serve to indicate to the children that they should be attending specifically to the nature of the spatial relationship between the two balls and that this in turn would serve to highlight the importance of representing, via the use of the partial occlusion technique, the partial concealment of the farther ball in (2). The responses of these children were compared with those of another group who were asked to draw (2) first and then (1). If, as hypothesised, the contrast in object orientation is successful in eliciting the use of the partial occlusion technique, one would predict that the children who performed the occlusion task second would produce more partial occlusions than those who performed it first. This is because many of the children who start with the Occluding task will make the mistake of drawing two complete and separate circles to represent the two balls in the array, an error which is irrevocable even if they then correctly re-interpret the demands of the task on the second Non-Occluding task.

Method.

Subjects.

Subjects were 32 children aged between 6:6 years and 7:6 years (Mean Age = 7:2). There were approximately equal numbers of boys and girls.

Materials.

A red ball and a blue ball (6.5 cm in diameter), red and blue coloured pencils and white A4 drawing paper.

Procedure.

Each subject was tested individually in a school room made available for this purpose. Half the subjects completed task one and then task two; conversely the other half completed task two first and then task one. Each task was conducted on a different day. Those subjects who saw the blue ball behind the red ball in task one also saw the blue ball behind the red ball in task two; those subjects who saw the red ball behind the blue ball in task one also saw the red ball behind the blue ball in task two. Half the subjects in each task saw a blue ball behind a red ball, the other half saw a red ball behind a blue ball. Throughout both the drawing tasks the experimenter recorded precise details of the actual drawing procedure along with any comments made by the children.

Task 1: The Ball Behind A Ball Task (Non-Occluding).

The experimenter sat beside the subject at a table. After some preliminary discussion to make the child feel at ease, the experimenter showed the child the blue and the red balls (one held in each hand). As the experimenter did this she said:- "I've got a blue ball and a red ball". Then, moving each ball in turn towards the child she said:- "Here is the blue ball" and "Here is the red ball". The blue and red balls were then placed simultaneously on the table (the first ball was positioned about 45 cm from the edge of the table) in front of the child, one behind the other, 45 cm apart so that the nearer ball did not occlude the farther. As the experimenter did this she said:- "Oh look, I am putting the blue ball behind the red one", and then, pointing to the array:- "Now, I want you to draw a picture of the blue ball behind the red one. The child was then given a red and a blue coloured pencil, and a sheet of white A4 drawing paper, which was presented in a 'landscape' orientation (see Figure 2:2). This particular choice of paper orientation reflects the fact that in a pilot study where children were allowed to orientate their drawing paper as they wished, the majority chose the orientation shown below.

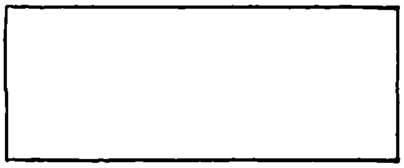


Figure 2:2 The Orientation of the Paper.

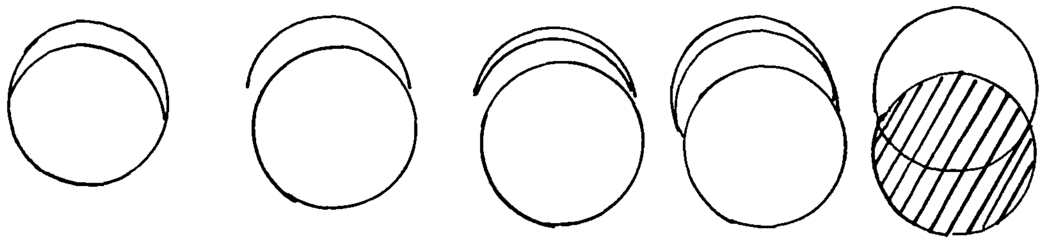
Each ball had a piece of Sellotape fixed on the base to prevent it from rolling away. Half the subjects were told that the experimenter had a blue ball and a red ball; half were told the experimenter had a red ball and a blue ball. Half the subjects were shown the blue ball first and half the subjects were shown the red ball first. Half the subjects saw the blue ball behind the red one, and half saw the red ball behind the blue one and the instructions were altered accordingly.

Task 2: The Ball Behind A Ball Task (Occluding).

This task was similar to the Ball Behind A Ball Task (Non-Occluding) detailed above, the only difference being that in this task the balls were placed one behind another (close together but not touching) such that the nearer ball partially occluded the farther.

Scoring.

When researchers describe a drawing of one ball behind another as being 'visually realistic', what they essentially mean is that the technique of 'partial occlusion' (Cox, 1981, 1985) has been used to depict the partial concealment of the farther ball by the nearer. The term 'partial occlusion' refers to the fact that only the visible part of the partially occluded ball is detailed in the drawing and that this visible section is represented in a united configuration with the outline of the nearer ball For a partial occlusion to be considered truly visually realistic, it is also important that the arrangement of the balls in the drawings corresponds to the arrangement of the balls in the scene. If, for example, the partially occluded ball is visible over, as opposed to round the side of, the nearer ball (as is the case in this study), it is important that this arrangement is reproduced on the page. Some researchers (e.g. Willats, 1977; Ingram, 1983) specify that the contours of the occluded object should meet the occluding object at 'junctions'. Such a representation is perhaps the 'best' example of a visually realistic response and some would regard it as the only 'correct' response. An example of this type of response can be seen in Figure 2:1(b). Typically, the circle representing the front ball is depicted first, with the arc representing the back ball being added afterwards. In addition to this kind of representation, however, five other types of response were included in the partial occlusion classification used in this study. These are shown below:

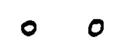
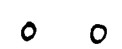
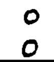


(b) (c) (d) (e) (f)

Response (b) was included in the classification as the only difference between it and the representation shown in (a) is that the child drew a circle first and then segmented it to produce a partial occlusion. Responses (c) and (d) were included as only the visible part of the farther ball is shown and this is combined in a uniform configuration with the nearer ball. The experimenter believes that these two facts offset the fact that the contours of the two objects do not meet at junctions. Response (e) was included as only the visible part of the farther ball is shown and is combined in a united configuration with the nearer ball; also, the contours of the two balls meet at 'junctions'. Response (f) is indicative of a planning error by the child; thus, when the back ball was drawn first and the nearer ball was added and then coloured over in an attempt to hide the non-visible part of the back ball, the response was classified as a partial occlusion. Drawings were not classified as partial occlusions if, when the back ball was presented first, the balls were not coloured or the balls were inappropriately coloured.

Results.

The results are shown in Tables 2:1 (a) and (b).

Subject Number	Non-Occluding (1)	Occluding (2)
1		
2		
3		
4		
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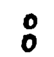
6		
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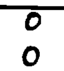
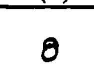
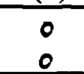
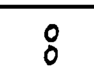
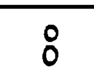
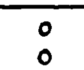
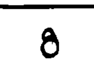
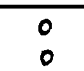
16		

Table 2:1 (a):- The Results of Experiment One.

Subject Number	Occluding (1)	Non-Occluding (2)
1		
2		
3		
4		
5		
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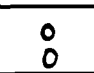
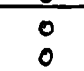
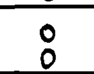
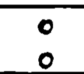
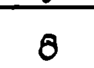
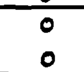
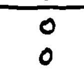
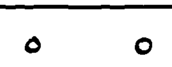
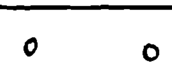
7		
8		
9		
10		
11		
12		
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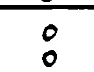
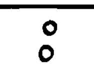
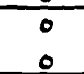
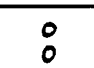
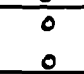
14		
15		
16		

Table 2:1 (b):- The Results of Experiment One.

When the Occluding task was presented first, 4/16 children partially occluded the balls, whilst the remaining 12 did not. In the Non-Occluding task which followed, all 16 children depicted the two balls as being complete and separate. When the Occluding task was presented second, 7/16 children partially occluded the balls whilst the remaining 9 did not. In the preceding Non-Occluding task all 16 children had depicted the two balls as being complete. There was no significant difference between the Occluding task presented first versus Occluding task presented second (Chi-Square = 0.56, 1df, N.S.). The data on which this analysis was performed are shown in Table 2:2.

	Type of Response Occlude	Not	Total
Occluding Task 1st	4	12	16
Occluding Task 2nd	7	9	16
Total	11	21	32

Table 2:2 : Summary of Results.

Upon measuring the distance (in millimetres) between the two balls in each drawing, it was found that all 21 of the children who did not draw partial occlusions in the Occluding task drew the balls closer together in the Occluding task than in the Non-Occluding task. This difference was statistically significant (Student t-test: $t = 5.76$, 20df, $p < 0.001$).

Discussion.

It was hypothesised that if the contrast in object orientation across two tasks was successful in eliciting the use of the partial occlusion technique, the children who performed the Occluding task first would produce fewer partial occlusions than those who performed it second. This hypothesis was not supported: there was no significant difference between the Occluding task first versus Occluding task second responses.

However, one should be wary of assuming, in light of these findings, that many of the children had made no attempt to represent the different spatial relationships between the balls across the two tasks. Regardless of whether the Occluding task was undertaken prior to or after the Non-Occluding task, all the children who did not produce partial occlusions drew the balls closer together in the Occluding task than in the Non-Occluding task. These results are similar to those obtained by Chen and Holman (1989) who asked children (aged between 5 and 7 years) to draw a scene which consisted of two pairs of balls. One of the pairs (Pair 1) was arranged such that the front ball partially occluded the back ball, whilst the other (Pair 2) was arranged so that, from the child's point of view, the front ball did not occlude the back ball. The contrast in the array did not, however, facilitate the use of the partial occlusion technique to represent the arrangement of the balls in the Pair 1. But, as in the present experiment, the children had clearly noted the difference in the proximity of the balls in the two pairs and had attempted to portray this difference by varying the proximity of the balls in their drawings accordingly. In both these experiments then, the children appear to have responded to the difference in the distance between the balls in each pair by varying the distance of the circles on the page accordingly - a result which supports Davis' (1983) idea that children are able to note a contrast between two scenes and mark it.

There is, however, a problem associated with the design of Experiment 1. Namely, it may be that the children did not use the partial occlusion technique simply because they had an alternative cue, i.e. that of distance. This leads one to speculate how the children would respond if there was only one cue available for use, namely that of partial occlusion. Whilst this particular question is not addressed in this thesis, further work is required to clarify this issue.

CHAPTER THREE.

Experiment Two.

Drawing One Ball Behind Another: Turning Balls into Characters.

Introduction.

The results of the previous study demonstrate that contrast in object orientation between tasks fails to facilitate the use of the partial occlusion technique by young children. Although the children marked the contrast between the two arrays, they did so by varying the distance between the two complete and separate circles. Why was the partial occlusion technique not used?

One possible explanation is that from the child's point of view there may appear to be no real reason for deliberately obscuring part of the farther ball; s/he has after all attempted to represent the spatial depth relationship by drawing one object above the other and s/he has also varied the distance between the circles to correspond with the distance between the balls in the two tasks. How would children respond if the task actually included a reason for omitting part of the farther ball from their drawing - would such a procedure result in their being able to use the partial occlusion technique in order to represent the projective aspects of a partial occlusion scene comprising two similar objects? The experiment detailed here addresses this issue.

In this study, children aged between 6:6 and 7:6 years performed a task in which the balls had been turned into characters by the addition of simple caricature faces. One of the characters was 'shy' and the children were asked to make a drawing of this shy character hiding behind the other one. Given that previous work has shown that this type of 'hiding' task is successful in eliciting view-specific pictures from young children (Cox, 1981, Study 5), it was predicted that this 'game' would facilitate the use of the partial occlusion technique by conveying to the children, both in the instructions and in the non-verbal aspects of the task, the notion that part of the scene should be omitted from their drawings.

In addition to performing the faces task detailed above, the same children were also asked to make a drawing of one ball positioned behind another. Half the children performed this task before the faces task, whilst the other half performed it afterwards. Each task was conducted on a different day. This ball behind a ball task was included for two reasons. First, by examining the responses of those children who performed this task first and the faces task second, one can determine (a) how the children would normally draw one ball behind another and then (b) by comparing their performance across the two tasks one can determine whether the faces task elicits a significant change in the nature of their responses. Secondly, by examining the responses of those children who performed the faces task first and the ball behind a ball task second, one can determine whether prior experience of the faces task influences how the children subsequently approach drawing one ball behind another.

Method.

Subjects.

Subjects were 40 children aged between 6:6 and 7:6 years (Mean Age = 6:11). There were approximately equal numbers of boys and girls.

Materials.

A red ball and a blue ball (6.5 cm in diameter), a red ball and a blue ball with simple caricature faces drawn on (6.5 cm in diameter), a red, a blue and a black coloured pencil and white A4 drawing paper.

Procedure.

Each subject was tested individually in a small room. Half the subjects completed task one first and then task two, conversely the other half completed task two first and then task one. Each task was conducted on a different day. Those subjects who saw the blue ball behind the red ball in task one also saw the blue character ball called Happy hiding behind the red character ball called Smiley in task two. Those subjects who saw the red ball behind the blue ball in task one also saw the red character ball called Smiley hiding behind the blue character ball called Happy in task two. Half the subjects in each condition saw a blue object behind a red object, the other half saw a red object behind a blue object. Throughout both the drawing tasks the experimenter recorded precise details of the actual drawing procedure along with any comments made by the children.

Task 1: The Ball Behind A Ball Task.

This task was identical to the Ball Behind a Ball Task (Occluding) detailed in Experiment One.

Task 2: The Faces Task.

The experimenter sat beside the subject at a table. After some preliminary discussion to make the child feel at ease, the experimenter showed the child the red and blue character balls (one held in each hand). As the experimenter did this she said:- "I've got Happy (the blue ball) and Smiley (the red ball)". Then moving each ball in turn towards the child:- "Here is Happy" (the blue ball) and "Here is Smiley" (the red ball). Happy (the blue ball) and

Smiley (the red ball) were then placed simultaneously on the table (about 45 cm from the edge of the table) in front of the child, one behind the other, close together but not touching. As the experimenter did this she said:- "Oh look, Happy is <u>shy</u> and is <u>hiding behind</u> Smiley", and then, pointing to the array:- "Now, I want you to draw a picture of Happy <u>hiding behind</u> Smiley". The child was then given a red, a blue and a black coloured pencil and a sheet of white A4 drawing paper which was placed on the table in a 'landscape orientation'.

Each ball had a piece of Sellotape fixed on the base to prevent it from rolling away. Half the subjects were told the experimenter had Happy and Smiley; half the subjects were told the experimenter had Smiley and Happy. Half the subjects were shown the blue character ball (Happy) first and half the subjects were shown the red character ball (Smiley) first. Half the subjects saw the blue character ball (Happy) <u>hiding behind</u> the red one (Smiley), and half saw the red character ball (Smiley) <u>hiding behind</u> the blue one (Happy) and the instructions were altered accordingly. Only the eyes and eyebrows on the face of the farther 'shy' ball were visible to the child when the balls were positioned one behind another. All the features of the nearer ball's face were clearly visible.

<u>Scoring.</u>

The scoring procedure was identical to that detailed in Experiment 1.

Results.

The results are shown in Tables 3:1(a) and (b).

Subject Number	Faces (1)	Balls (2)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Table 3:1(a) :- The Results of Experiment Two.

Subject Number	Balls (1)	Faces (2)
1	o o	8
2	o o	8
3	8	8
4	o o	8
5	o o	o o
6	o o	8
7	8	8
8	o o	8
9	8	8
10	8	8
11	◎	8
12	8	8
13	8	8
14	8	8
15	8	8
16	o o	8
17	o o	8
18	o o	o o
19	o o	8
20	o o	8

Table 3:1(b) :- The Results of Experiment Two.

A summary of the results are shown in the Tables below:-

Response	Task Type Faces (1)	Balls (2)	Total
Partial Occlusion	18	18	36
Other Response	2	2	4
Total	20	20	40

Table 3:2: The responses of the children who performed the Faces task first and the Balls task second.

Response	Task Type Balls (1)	Faces (2)	Total
Partial Occlusion	4	17	21
Other Response	16	3	19
Total	20	20	40

Table 3:3: The responses of the children who performed the Balls task first and the Faces task second.

When the faces were presented first, 18/20 children partially occluded them and then went on to partially occlude the balls (Binomial Test: $p < 0.001$). One child separated the objects vertically in both tasks (Child Number 11) and another separated them horizontally in both tasks (Child Number 12). These two children did, however, mark the differences between the two tasks by depicting the faces in the faces task only. In addition to this, Child Number 12 omitted the mouth on the farther 'shy' ball and depicted it as being smaller than the other ball because it was "farther away". Each child responded to both tasks in the same way.

When the balls were presented first, only 4/20 children partially occluded them. These same four children and another thirteen then went on to occlude the faces. This shift across tasks was significant (McNemar Test: Chi-Square = 15.08, 1 df, $p < 0.001$). The three children who failed to produce partial occlusions in the faces task did, however, mark the difference between the two tasks by depicting the faces in the faces task only.

Significantly more children drew partial occlusions when the faces were presented first than when the balls were presented first (Chi-Square = 17.06, 1df, $p < 0.001$) and significantly more children drew partial occlusions when the balls were presented after the faces than when they were seen first (Chi-Square = 17.06, 1df, $p < 0.001$). There was no significant difference between the faces first versus balls second responses (Fisher's Exact: $p = 0.5$). Similarly there is no significant difference between the faces first versus faces second responses (Fisher's Exact: $p = 0.5$).

Discussion.

The experiment detailed in this chapter investigated how children represent one ball partially occluding another, when the notion of hiding and partial concealment of one ball forms an integral part of the task they are asked to perform.

Previous research has demonstrated that children aged between 5 and 8 strive to represent in their drawings, the known, invariant qualities of a scene rather than the projected image. Thus, for example, rather than use the partial occlusion technique (Cox, 1981, 1985) to represent the partial concealment of one ball by another and the depth relationship between the two balls, young children tend to depict the complete contour of the partially hidden farther ball. This finding was replicated in the present study when the balls task was presented first. During the faces task which followed, however, most children altered their response and produced partial occlusions. Moreover, when the faces task was presented prior to the balls task, the dominant response for both tasks was that of partial occlusion; the children's prior experience of the characters had subsequently influenced how they then approached the balls task. Clearly, then, if 7-year-olds can be induced to represent the projective aspects of a partial occlusion scene, their normal failure to do so cannot be attributed to conceptual immaturity. In that case, what particular aspect of the faces task facilitated the production of visually realistic drawings?

One possible explanation is that the presence of the faces elicits a change in terms of the temporal order in which the balls are drawn. That is to say, the reason why very few children produce partial occlusions in the balls task, could be because many initiate their drawings by depicting the complete contour of the back ball, an 'error' which makes it very difficult for the child to then rectify and produce a 'correct' partial occlusion response. In terms of this explanation, then, what the faces might serve to do is to prompt children to depict the front ball first; this in turn results in more children going on to produce a correct partial occlusion configuration. In essence one could argue that the faces task serves to facilitate a strategic change from a back ball first/front ball second to a front ball first/back ball second drawing order. This does not, however, appear to be the case as only one child (Child Number 9: Faces (1), Balls (2)) initiated his drawings by depicting the back ball. The remaining 39 children all initiated both their drawings by depicting the front ball.

This leads one to question whether it might be the saliency of the objects (balls versus faces) or the suggestion of occlusion in the instructions (hiding versus behind), or indeed a combination of the two, which leads children to use the partial occlusion technique in the faces task. The following experiment (Experiment 3) was designed to address this issue.

Experiment Three.
Drawing One Ball Behind Another:
How Important is the Story Line?

Introduction.

In the previous study the 'faces task', which involved turning balls into characters by the addition of simple caricature faces, elicited the use of the partial occlusion technique by young children. What is it about this task that causes children to produce view-specific representations?

There are several differences between the traditional 'ball behind a ball task' (Cox, 1981, Study 2) and the 'faces task' not only in the materials used (balls versus faces), but also in the way the materials are presented (hiding versus behind). This experiment was designed to ascertain which of these differences is important.

The two sets of task materials were compared directly. Children aged between 6:6 and 7:6 years were divided equally between a ball-ball and faces-faces condition. Within each of these, half the subjects were told that one object was 'behind' the other, wheres the other half were told that one object was 'shy' and was 'hiding behind' the other. Given the results of the study by Cox (1986a) (see literature review for details) one would predict that it is more likely to be the difference in the task materials, rather than the difference in verbal instructions, which accounts for the difference in performance across the two tasks.

Method.

Subjects.

Subjects were 160 children aged between 6:6 and 7:6 years (Mean Age = 7:0). There were approximately equal numbers of boys and girls.

Materials.

The materials used in this experiment were the same as those used in Experiment Two.

Procedure.

Each subject was tested individually in a small room. Each subject completed one task. The subjects were divided equally between a ball-ball and faces-faces condition. Within each of these, half the subjects were told that one object was 'behind' the other, whereas the other half were told that one object was 'shy' and was 'hiding behind' the other. Half the subjects in each condition saw a blue object behind a red object, the other half saw a red object behind a blue object. Throughout each of the drawing tasks the experimenter recorded precise details of the actual drawing procedure along with any comments made by the children.

The Ball Behind A Ball Task: Behind.

This task was identical to the Ball Behind a Ball Task (Occluding) detailed in Experiment One.

The Ball Behind A Ball Task: Hiding Behind.

This task was similar to the Ball Behind a Ball Task (Occluding) detailed in Experiment One, the only difference being that in this task the term 'behind' was replaced by the term 'hiding behind'.

The Faces Task: Behind.

This task was similar to the Faces Task detailed in Experiment Two, the only difference between the two tasks being that in this task the term 'hiding behind' was replaced by the term 'behind'.

The Faces Task: Hiding Behind.

This task was identical to the Faces Task detailed in Experiment Two.

Scoring.

The scoring procedure was identical to that detailed in Experiment One.

Results.

The results are shown in Table 3:4.

Response	Faces		Balls		Total
	Hiding	Behind	Hiding	Behind	
P.O.	29	22	10	5	66
Other	11	18	30	35	94
Total	40	40	40	40	160

P.O = Partial Occlusion Other = Other Response

Table 3:4: The Results of Experiment Three.

A partitioned Chi-Square revealed that there was an overall significant effect of task type on response (Chi-Square = 37.25, 3df, $p < 0.001$), that although there was a tendency for the hiding condition to elicit more partial occlusions, there was no significant difference between the two sets of instructions (Chi-Square = 3.14, 1df, N.S.), that there was a significant difference between the two sets of task materials (i.e. the faces elicited far more partial occlusions than did the balls, Chi-Square = 31.58, 1df, $p < 0.001$) and that there was no significant interaction between the task materials and instruction type (Chi-Square = 2.53, 1df, N.S.).

Discussion.

The results of this experiment reveal that it is not necessary to talk about 'shyness' or 'hiding'; simply asking children to draw two balls with faces on, one behind another, is enough to elicit a partial occlusion response from them.

It is apparent, however, that there is still a fundamental difference between the tasks involving the balls and the tasks involving the faces. In the tasks which involve the faces the characters are actually named - they are referred to as Happy and Smiley. In the balls tasks, however, there is no naming process; the balls are simply referred to as balls. It is possible that the act of naming in itself is an important factor in eliciting the partial occlusion response. The following experiment was thus designed to ascertain whether this was so.

Experiment Four.

Drawing One Ball Behind Another.

Do we Need to Name the Faces?

Introduction.

The results of the previous study revealed that simply asking children to draw two character balls with faces on, one behind the other was enough to elicit partial occlusion responses from them. It was not necessary to talk about one of the characters being 'shy' and 'hiding' behind the other.

It was, however, noted that there is still a fundamental difference between the tasks involving balls and the tasks involving faces. In the tasks involving the faces the characters are actually named as Happy and Smiley. In the tasks involving the balls there is no naming process; the balls are simply referred to as balls. Thus we do not know whether it is the fact that the balls have faces or that they have character names which is eliciting partial occlusion responses. This experiment was designed to disentangle these two variables.

There is some evidence from previous research which suggests that the actual naming of the objects is not the important variable, at least not for the 6:6-7:6 age group. Cox and Simm (cited in Cox, 1986a) asked children to draw from a model of a man behind a wall. For half the children they described the objects as 'a man behind a wall', and for the other half as 'a man behind a block'. The results revealed that 4- and 5-year-olds produced far more partial occlusions when the man was behind a wall rather than behind a block. With 7- and 8-year-olds, however, there was no significant difference in the responses elicited by these two conditions; children in both groups were already drawing partial occlusions The results of this experiment suggest that the naming of an object only actually alters how very young children interpret the object in a scene. Given this, one would not expect the children, aged 6:6 to 7:6 years, in this experiment to draw more partial occlusions when the character balls were called 'Happy' and 'Smiley' as opposed to when they were simply referred to as 'balls'. Neither would one predict any significant effect of naming on the children's responses when drawing two balls without faces.

Children aged between 6:6 years and 7:6 years were divided equally between a ball-ball and faces-faces condition. Within each of these conditions half the subjects saw balls/faces which were called 'Happy and Smiley' and half the subjects saw balls/faces which were called balls. Given that the results of the previous study revealed that it is not necessary to talk about 'shyness and hiding' in order to elicit the use of partial occlusion technique, the children were simply asked to draw one object <u>behind</u> another.

<u>Method.</u>

<u>Subjects.</u>

Subjects were 60 children aged between 6:6 and 7:6 years (Mean Age = 7:1). There were approximately equal numbers of boys and girls.

<u>Materials.</u>

The materials used in this experiment were the same as those used in Experiment Two.

<u>Procedure.</u>

Each subject was tested individually in a small room. Each subject completed <u>one</u> task. The subjects were divided equally between a ball-ball and faces-faces condition. Within each of these conditions half the subjects saw balls/faces which were called 'Happy and Smiley', and half the subjects saw balls/faces which were called 'balls'. Half the subjects in each condition saw a red ball/face behind a blue ball/face, the other half saw a blue ball/face behind a red ball/face. Throughout each of the drawing tasks the experimenter recorded precise details of the actual drawing procedure along with any comments made by the children.

The Ball Behind A Ball Task: Balls.

This task was identical to the Ball Behind a Ball Task (Occluding) detailed in Experiment One.

The Ball Behind A Ball Task: Happy and Smiley.

This task was similar to that used in the Ball Behind a Ball Task (Occluding) detailed in Experiment One, the only difference between the two tasks being that in this task, the red ball was referred to as Smiley whilst the blue ball was referred to as Happy.

The Faces Task: Balls.

This task was similar to that used in the Faces Task detailed in Experiment Two, the only difference between the two tasks being that in this task the character ball Smiley was referred to as the red ball whilst the character ball Happy was referred to as the blue ball.

The Faces Task: Happy and Smiley.

This task was identical to the Faces Task detailed in Experiment Two.

Scoring.

The scoring procedure was identical to that detailed in Experiment One.

Results.

The results are shown in Table 3:5:

Response	Faces		Balls		Total
	Names	Balls	Names	Balls	
P.O.	13	10	4	3	30
Other	2	5	11	12	30
Total	15	15	15	15	60

P.O = Partial Occlusion   Other= Other Response

Table 3:5: The Results of Experiment Four.

A partitioned Chi-Square revealed that there was an overall significant effect of task type response (Chi-Square = 18.38, 3df, $p < 0.001$), that there was no significant difference between the two sets of instructions (Chi-Square = 0.6, 1df, N.S.), that there was a significant difference between the two sets of task materials (the faces elicited far more partial occlusions than did the balls; Chi-Square = 15.0, 1df, $p < 0.001$) and that there was no significant interaction between the task materials and instruction type (Chi-Square = 2.78, 1df, N.S.).

Discussion.

The results of this experiment reveal that naming two plain balls Happy and Smiley does not lead to the production of partial occlusions. They also show that it is not necessary to call the character-balls Happy and Smiley: simply asking children to draw two balls with faces on, one behind the other, is enough to elicit partial occlusion responses from them.

This second finding supports the prediction that the children would not produce more partial occlusions when the character-balls were called Happy and Smiley: this is in accordance with the findings of Cox and Simm (1986a) detailed in the Introduction.

CHAPTER FOUR.

Summary and Conclusions.

Previous work has shown that young children, below approximately 8 years of age, tend to represent in their drawings, the known, invariant aspects of a scene rather than the projected image. Thus, for example, rather than use the partial occlusion technique (Cox, 1981, 1985) to represent the partial concealment of one object by another and the depth relationship between the two objects, they tend to depict the complete contour of the partially hidden farther object. This tendency is particularly striking when they are asked to draw two similar objects positioned such that the nearer object partially masks the farther one (e.g. Freeman, Eiser and Sayers, 1977; Cox, 1981). Now is it the case that young children cannot use the partial occlusion technique in order to represent the projective aspects of a partial occlusion scene comprising two similar objects as Piaget would maintain (Piaget and Inhelder, 1956, 1969), or is it simply, as Luquet (1913,1927) would argue, that they do not ?

The experiments detailed in the previous two chapters were designed to ascertain this, the rationale being that if Luquet is correct and young children are capable of representing the projective, as opposed to the invariant aspects of a scene, then one should be able to create situations in which children will use the partial occlusion technique to represent the projective aspects of a partial occlusion scene comprising two similar objects.

Experiment 1 investigated whether contrast in object orientation across two tasks would serve to make the importance of partial concealment more salient and hence facilitate the use of the partial occlusion technique. The contrast in object orientation across the two arrays was established by asking the children (aged between 6:6 years and 7:6 years) to draw (1) two balls, one in front of but not occluding the other, and then (2) to draw two balls positioned one behind the other such that the nearer ball partially occluded the farther. It was predicted that this juxtaposition of object orientation across the two arrays would serve to indicate to the children that they should be attending specifically to the nature of the spatial relationship between the two balls and that this in turn would serve to highlight the importance of representing, via the use of the partial occlusion technique, the partial concealment of the farther ball in (2). The responses of these children were compared with those of another group who were asked to draw (2) first and then (1). If, as hypothesised, the contrast in object orientation is successful in eliciting the use of the partial occlusion technique, one would predict that the children who performed the occlusion task second would produce more partial occlusions than those who performed it first. This is because many of the children who start with Occluding task will make the mistake of drawing two complete and separate circles to represent the two balls in the array, an error which is irrevocable even if the children then correctly re-interpret the demands of the task on the second Non-Occluding task.

This prediction was not supported: there was no significant difference in the occlusion task first versus occlusion task second responses. The children had, however, noted the different spatial relationships in the two arrays and had attempted to portray this by varying the proximity of the balls in their drawings accordingly. They seemed to be responding to an actual difference in distance between the balls by varying the distance of the circles on the page. Thus, whilst they did not produce partial occlusions they did vary the distance between the two circles on the page across the two drawings. This supports Davis' (1983) idea that children are able to note a contrast between two scenes and mark it.

So why was the technique of partial occlusion not used? One possible explanation is that from the child's point of view there may appear to have been no real reason for deliberately obscuring part of the furthest ball; s/he has after all attempted to represent the spatial depth relationship by drawing one ball above the other. S/he has also varied the distance between the two circles to correspond with the distance between the balls in the two tasks. How, then, would children respond if the task actually included a reason for omitting part of the farther ball from their drawing? Experiment 2 was designed to address this issue.

In Experiment 2, children aged between 6:6 and 7:6 years performed a task in which the balls had been turned into characters by the addition of simple caricature faces. One of the characters was 'shy' and consequently was hiding behind the other and the children were asked to make a drawing of this scene. It was predicted that this 'game' would facilitate the production of partial occlusions by conveying to the children, both in the instructions and in the non-verbal aspects of the task, the notion that part of the scene should be omitted from their drawings.

In addition to the faces task the same children were also asked to make a drawing of one ball positioned behind another. Half the children performed this task before the faces task, whilst the other half performed it afterwards. Each task was conducted on a different day. This ball behind a ball task was included for two reasons: first, by examining the responses of those children who performed this task first and the faces task second, one can determine (a) how the children would normally draw one ball behind another and then (b) by comparing their performances across the two tasks one can determine whether the faces task elicits a significant change in the nature of their responses; second, by examining the responses of those children who performed the faces task first and the ball behind a ball task second one can determine whether prior experience of the faces task influences how the children then approach drawing one ball behind another.

As noted earlier, previous research has demonstrated that 5- to 8-year-olds tend to separate the balls on the page rather than use the technique of partial occlusion, and this finding has been replicated in the research reported here when the balls task was presented first; during the faces task which followed, however, most children altered their responses and produced partial occlusions. When the faces task was presented first the children drew partial occlusions, a response which they repeated when they were subsequently presented with the balls task. The children's prior experience of the faces appears to have influenced how they then approached the balls task. The fact that, like Barrett *et al* (1985) (and also Light and Simmons, 1983; Ingram, 1983), we have identified a task in which children do attend to its projective as opposed to its invariant aspects enables us to rule out one of the explanations for children's non-use of partial occlusions: the Piagetian explanation (e.g. Piaget and Inhelder, 1956, 1969) that young children have not yet developed concepts of projective and Euclidean space is no longer tenable. The findings are in fact more congruent with Luquet's argument (1913, 1927) that young children are not conceptually immature and incapable of considering the projective aspects of a scene, even though they prefer to emphasise its invariant aspects. The next step in the research programme was to try to specify what it is about the faces task which leads children to focus on its projective aspects and to depict it in a visually realistic way.

One possible explanation might be that the presence of the faces elicits a change in terms of the temporal order in which the balls are drawn. That is to say, normally the children might initiate their drawings by depicting the complete contour of the back ball first, an 'error' which would make it very difficult for the child to modify her/his drawing and produce a 'correct' partial occlusion response. In terms of this explanation what the faces serve to do is to prompt children to depict the front ball first; this in turn results in a more children being able to go on to produce a correct partial occlusion configuration. In essence, one could argue that the faces task serves to facilitate a strategic change from a back ball first/front ball second to a front ball first/back ball second drawing order. This does not, however, appear to be the case as only one child (Child Number 9: Faces (1), Balls (2)) initiated his drawings by depicting the back ball; the remaining 39 children all initiated their drawings by depicting the front ball.

Another explanation might be that it is the saliency of the objects (balls versus faces) or the suggestion of occlusion in the instructions (hiding versus behind), or indeed a combination of the two, which leads children to use the partial occlusion technique in the faces task. Experiment 3 was designed to address this issue.

Children were divided equally between a ball-ball and a faces-faces condition. Within each of these, half the subjects were told that one object was shy and was hiding behind the other, whereas the other half were told that one object was behind the other. The results revealed that although there was a tendency for the hiding condition to elicit more partial occlusions, there was no significant difference between two sets of instructions. There was, however, a significant difference between the two sets of task materials: the faces elicited more partial occlusions than did the balls. There was no significant interaction between the task materials and the instruction type. Thus, it was not necessary to talk about 'shyness' or 'hiding'; simply asking children to draw two balls with faces on one behind the other was enough to elicit partial occlusion responses from them.

It was apparent, however, that at this stage there was still a fundamental difference between the tasks involving the balls and the tasks involving the faces. In the tasks involving the faces the characters were actually named - they were referred to as Happy and Smiley. In the balls tasks, in contrast, there was no naming process; the balls were simply referred to as balls. Experiment 4 was designed to investigate whether the act of naming in itself is an important factor in eliciting the production of partial occlusions.

Children were divided equally between a ball-ball and faces-faces condition. Within each of these conditions half the subjects saw balls/faces which were called Happy and Smiley and half the subjects saw the balls/faces which were called balls. The results revealed that there was no significant difference between the two sets of names. There was, however, a significant difference between the two sets of task materials: the faces elicited far more partial occlusions than did the balls. There was no significant interaction between the task materials and instruction type. Thus the results revealed that it was not necessary to call the balls Happy and Smiley; simply asking children to draw two balls with faces on, positioned one behind the other is enough to elicit partial occlusions from them.

Why is it then that the faces alone are so successful in facilitating the production of partial occlusions? One possible explanation is that the materials themselves are very effective at conveying the notion that part of the scene should be omitted from the drawing. What may be happening here is the mere fact that only the eyes and eyebrows of the farther ball are visible <u>implies</u> that the ball is hiding behind the other one. The child does not have to be told that one of the characters is shy and is consequently hiding behind the other. The child is able to grasp the sense of the task for him/herself. The child can see that the farther ball is peeping out from behind the nearer as only the eyes and eyebrows of the back ball are visible and this leads her to omit part of the scene and depict partial occlusion. The explanation may not, however, be as simple as this. Recall Cox's (1986a) explanation of why two similar objects in a scene prompt children to separate them on the page, whilst scenes in which the two objects differ are the ones which elicit partial occlusion.

Cox suggested that upon being asked to draw a scene, children first scan the scene and note the objects they are required to depict. If the two objects are very similar it is possible that they are drawn without the child having to refer back to the scene. Thus, Cox argues, two separate and complete mental images (or a repeat of the first one if the two objects are the same shape) are drawn and accessed without consideration of how they should be united on the page. In order to know how the second image should be modified the child would need to refer back to the scene.

When two objects are dissimilar, however, Cox argues that it may be more difficult for the child to retain the mental image of the second object whilst the first is being drawn. Consequently, s/he may need to look back at the scene in order to ascertain what s/he should do next. Not only does the child see the object that s/he is required to draw, but s/he is also likely to notice how much of it s/he should draw: the chances of him/her producing a view-specific representation are thus enhanced. Cox suggests that it would be very difficult to draw the scene exactly as it looks without referring back to it in some stage of the drawing process. One would have to note the two objects to be drawn, access two mental images, hold on to one whilst the first was being depicted, and then modify the second image according to some visual memory of the scene formed during the initial viewing.

In terms of this explanation, then, it is possible that the appearance of the character-balls placed one behind the other so that one can only see the eyes and eyebrows of the farther ball, as compared to the full facial features of the nearer ball results in their being treated as dissimilar objects. It may be more difficult for the child to retain the mental image of the partially concealed farther character-ball whilst the first is being drawn. Consequently, s/he may need to look back at the scene in order to ascertain what s/he should do next. Not only does the child see the character-ball that s/he is required to draw, but s/he is also likely to notice how much of it s/he should draw: the chances of him/her producing a view-specific representation are thus enhanced.

Clearly further research is required to clarify this issue. Is it the notion of hiding or the notion of dissimilarity, or indeed a combination of the two, which accounts for the success of the faces in facilitating the production of partial occlusions? In addition to clarifying this issue, the study should be extended to incorporate younger children: could the faces task facilitate the production of view-specific representations in children younger than 6:6 years? Further studies should investigate whether children, who succeed in producing partial occlusions as a result of experiencing the faces, are subsequently able to use this technique to depict other round objects, such as apples or oranges, positioned one behind the other. Similarly, further work should seek to ascertain whether those children who were able to depict partial occlusion in the faces task, actually retain this drawing device in their repertoire. Another issue requiring clarification is whether both faces are needed to produce the effect detailed here. Would, for example, a ball with a face peeping out from behind a plain ball produce the same effect?

How would the responses of children who undertook such a task compare with those who saw a plain ball behind a ball with a face?

Having ascertained that under certain circumstances children are able to represent the projective aspects of a partial occlusion scene, the experimenter began to contemplate whether one could induce children to represent the projective image of a simple three-dimensional solid object such as a cube or a table. Such objects, which are normally depicted as rectilinear forms, are difficult to draw 'in perspective' as the production of a successful visually realistic representation depends not, as in the occlusion task, on omitting part of the scene but on representing the perceived shape of the object's side edges. Again, although children tend not to produce visually realistic representations of objects like cubes and tables, they may nonetheless actually be capable of doing so and one should be able to identify the particular circumstances which would elicit those projectively accurate drawings. The experiments detailed in the following chapters attempted to create circumstances under which children can be induced to represent the projective image of a rectangular object.

CHAPTER FIVE.

The work detailed thus far has revealed that whilst young children tend not to use the technique of partial occlusion to produce a visually realistic representation of the depth relationship between two similar objects, they can in fact be induced to do so. Such a finding appears to refute the Piagetian notion that children are conceptually immature and incapable of representing the projective aspects of a scene. There is, however, no equivalent evidence from studies examining children's ability to represent a simple solid three-dimensional object. Given this, the experimenter embarked upon a series of studies which attempted to facilitate children's use of perspective 'depth lines' in order to represent a within-object depth relationship. The rationale underpinning the studies was the same as that detailed previously: if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956, 1969) then no amount of task manipulation should facilitate the use of converging oblique perspective depth lines.

Experiment Five.
Drawing a Table, a Cube and a Road.

Introduction

When investigating how children represent the three-dimensionality of a simple solid object, researchers (see literature review for details) have typically required their subjects to make a drawing of either a cube or a table, depth being an important if not defining feature of both these objects. The results of this work have revealed that children tend to depict cubes and tables as rectangular forms, forms which emphasise vertical and horizontal lines and right angles. In contrast to this, older children's and adults' representations are characterised by oblique lines and acute angles: lines and angles which are clearly used in an attempt to capture the way in which the side edges of these objects appear to converge into the distance. Having said this, however, if one presents adults and older children with an actual cube or table to draw, many experience difficulty in producing a visually realistic representation of the object. Cox (1986b) presented adults, adolescents (aged 12 years) and children (aged 7 years) with a cube placed in front of them on a table such that only the front and top faces of the cube could be seen. The results revealed that of the adults who drew the two visible faces of the cube (88% of the original sample) only 42% actually converged the lines of the top face and made the more 'distant' line shorter than the near edge. Whilst a few adults attempted other 'angled' solutions (e.g. parallel obliques) most drew rectilinear representations. Very few children produced converging lines on the top of the cube: even at the age of 12 years most drew the side edges parallel to one another.

The present experimenter obtained similar results to these when she ran a pilot study asking adults, adolescents and children to draw a doll's table: prodominantly rectangular solutions were produced by subjects of all ages. How, then, can one account for these visually unrealistic representations of cubes and model tables?

One could invoke the Piagetian notion of conceptual immaturity to account for the responses of the young children. That is to say one could argue that the young children fail to produce visually realistic representations, as they have not yet developed concepts of projective and Euclidean space. It is, however, clearly evident that adults and adolescents, who should, according to Piaget have an understanding of projective and Euclidean space, also fail to produce visually realistic representations of objects such as cubes and tables. One must therefore consider the possibility that the young child's rectilinear representations of simple solid objects do not reflect an <u>inability</u> to represent a within-object depth relationship, rather they represent an artifact of the rather complex objects the children have been asked to draw. Furthermore, one could also argue that it is the stimulus complexity which results in adults and adolescents failing to depict the projective aspects of a scene. For, whilst a cube and a table are supposed to represent simple three-dimensional solid objects, they are in fact quite difficult objects to draw. In order to draw Cox's cube 'in depth', the subject must represent two visible surfaces (the front and the top); in addition to this s/he must also depict these surfaces in a united configuration. Likewise, when drawing a table, the subject must represent the table top correctly, as well as depicting and positioning the legs correctly. How, then, would subjects respond if they were asked to depict a less complex three-dimensional object? Would they be able to produce visually realistic projecttions of a within-object depth relationship?

In this experiment, in addition to drawing a cube and a table, adults, adolescents and children were asked to make a drawing of a cardboard model road. As is the case with a cube and a table, depth is an important feature of a road. A road, however, is theoretically not such a complicated object to draw: there is only a single surface to depict (a surface somewhat akin to the top face of a cube and top surface of a table) and the actual appearance of this surface is fairly readily represented by the production of two converging 'depth' lines. It was predicted that in the road condition, the simplified nature of the model and its depiction would induce subjects of all ages to produce visually realistic 'converging' perspective representations of the model. In contrast, on the basis of past research (cited above), one would predict that the subjects would not produce visually realistic representations of either the cube or the model table.

Method.

Subjects.

Subjects were 40 adults (20 males and 20 females) aged between 18:9 and 24:6 years (Mean Age = 22:7), 40 adolescents (20 boys and 20 girls) aged between 11:10 and 12:10 years (Mean Age = 12:6) and 40 children (20 boys and 20 girls) aged between 6:6 and 7:11 years (Mean Age = 7:3).

Materials.

White A4 size paper paper and pencils were provided for the drawing tasks. Three models were used as stimuli. Model 1 = a cardboard model road (a strip of black card, 10cm wide and 30cm long, surrounded on either side by strips of grey card representing the pavement, 5cm wide and 30cm long. Each section of grey card had been scored and folded in order to form a curb. No white lines were painted on the model. Model 2 = a doll's table (6cm x 10cm, height = 7.5cm). Model 3 = a cube, 6cm x 6cm x 6cm. Cox (1986b) notes that the term 'cube' is not commonly used by children and so the cube was referred to as a 'block' in the instructions.

Procedure.

Each subject was tested individually in a small room. The subject and the experimenter sat side by side at a table. Each subject was asked to make three drawings: one of the cardboard model road, one of the doll's table and one of the block (cube). The order in which the models were presented to the subjects was randomised. Each drawing was made on a separate day. Throughout the drawing tasks the experimenter recorded the precise details of the actual drawing procedure along with any comments made by the subjects. The instructions were as follows:-

Model 1: The Road.

The experimenter seated the subject at the table. The subject was then given a piece of paper (which was placed on the table in a 'portrait' orientation: see Figure 5.1) and a pencil. After some preliminary discussion to make the subject feel at ease, the experimenter placed the model on the table (approximately 45cm away from the front edge of the table) directly in front of the subject and said:-"Here is the road (experimenter pointed at the road only) and here is the pavement (experimenter pointed at the pavement). Now I want you to draw a picture of the road. Not the pavement, just the road...this bit here (experimenter pointed at the road only). Draw exactly what you can see. Draw the road exactly as it looks from where you are sitting."

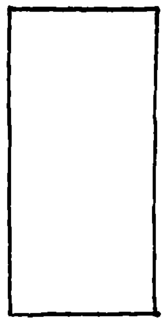


Figure 5.1 The orientation of the paper.

Model 2: The Table.

The experimenter seated the subject at the table. The subject was then given a piece of paper (which was placed on the table in a 'portrait' orientation) and a pencil. After some preliminary discussion to make the subject feel at ease, the experimenter placed the doll's table on the table (approximately 45cm away from the front edge of the table) directly in front of the subject (such that the subject sat facing one of the long edges of the doll's table) and said:- "Here is a table (experimenter pointed at the model). Now I want you to draw a picture of the table. Draw exactly what you can see. Draw the table exactly as it looks from where you are sitting."

Model 3: The Block (Cube).

The experimenter seated the subject at the table. The subject was then given a piece of paper (which was placed on the table in a 'portrait' orientation') and a pencil. After some preliminary discussion to make the subject feel at ease, the experimenter placed the block on the table (approximately 45cm away from the front edge of the table) directly in front of the subject, such that only the top and front faces of the cube could be seen, and said:- "Here is a block (experimenter pointed at the model). Now I want you to draw a picture of the block. Draw exactly what you can see. Draw the block exactly as it looks from where you are sitting."

Scoring.

(i) The Actual Measurement Scoring System.

The representations of the roads were measured accurately with a ruler and were then classified according to whether the representations were correct (visually realistic) or not. A correct representation is one in which both side edges of the depiction converge. An example of such a response is shown in Figure 5.2. Even if both side edges of the road converged by only 1-2mm the drawing was still classified as being a correct response.

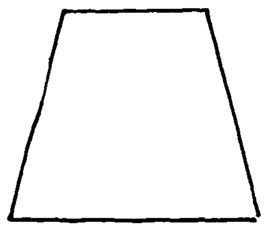
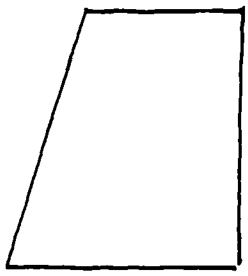


Figure 5.2 An example of a correct visually realistic representation.

Note that the subjects' drawings of a cube and a table were scored according to the same scoring criteria: the analysis of these drawings was restricted to a consideration of how the top face of the cube and the top surface of the table were represented. Whilst the experimenter acknowledges that other systems exist for scoring drawings of cubes and tables (see literature review for details) these were not used: the experimenter wanted to score the drawings of the three objects according to one system.

(ii) The Judges' Ratings.

In a drawing task, it is not always clear what the subject intended to draw. Consider the example drawn overleaf:-



What was intended here? Is this an intended 'correct' solution or is it a failed rectangular form? In an attempt to ascertain such information the experimenter employed a second scoring system. Three independent judges were asked to rate whether the responses of each subject were correct 'intended' depictions or whether they were incorrect depictions. Each judge was shown all the drawings (one at a time) and s/he was asked to indicate whether s/he thought each one a correct 'intended' representation or an incorrect representation.

This Rating of Intent procedure arose from an unsuccessful questioning procedure employed in a pilot study, when, immediately after the completion of a drawing task, the experimenter had attempted to question each child concerning what s/he had intended to draw. Irrespective of whether they were explicitly questioned about their drawings, or simply asked to talk about them, most children interpreted the discussion as meaning that their drawings were somehow not of a high enough standard or, alternatively, that they had done something 'wrong'. The children were clearly more concerned to establish whether or not their drawing was 'good' than to discuss what they had actually intended to draw.

Note that the subjects' drawings of a cube and a table were rated according to the same criteria. The analysis of these drawings was restricted to a consideration of how the top face of the cube and the top surface of the table were represented.

Results.

The Actual Measurement Scoring System.

Model 1: The Road.

The results, based on the Actual Measurement scoring system, are shown in Table 5.1.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	22	18	40
Adolescent	20	20	40
Child	14	26	40
Total	56	64	120

Table 5.1: The Correct/Incorrect results based on the Actual Measurement scoring system.

22 adults produced correct representations of the road, whilst 18 produced incorrect representations (Binomial Test: N.S.). 20 adolescent subjects produced correct representations of the road whilst 20 produced incorrect representations (Binomial Test: N.S.). 14 children produced correct representations of the road, whilst 26 produced incorrect representations (Binomial Test: $p = 0.0066$). There was no evidence of an association between response type and age (Chi-Square = 3.47, 2df, N.S.). One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were all non-significant.

Model 2: The Table.

The results, based on the Actual Measurement scoring system, are shown in Table 5.2.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	11	29	40
Adolescent	13	27	40
Child	7	33	40
Total	31	89	120

Table 5.2: The Correct/Incorrect results based on the Actual Measurement scoring system.

11 adults produced correct representations of the table top, whilst 29 produced incorrect representations (Binomial Test: $p = 0.0036$). 13 adolescent subjects produced correct representations of the table top whilst 27 produced incorrect representations (Binomial Test: $p = 0.0197$). 7 children produced correct representations of the table top, whilst 33 produced incorrect representations (Binomial Test: $p = 0.00005$). There was no evidence of an association between response type and age (Chi-Square = 2.43, 2df, N.S.). One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were all non-significant.

Model 3: The Cube.

The results, based on the Actual Measurement scoring system, are shown in Table 5.3.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	17	23	40
Adolescent	6	34	40
Child	6	34	40
Total	29	91	120

Table 5.3: The Correct/Incorrect results based on the Actual Measurement scoring system.

17 adults produced correct representations of the top surface of the cube, whilst 23 produced incorrect representations (Binomial Test: N.S.). 6 adolescent subjects produced correct representations of the top surface of the cube whilst 34 produced incorrect representations (Binomial Test: $p = 0.00003$). 6 children produced correct representations of the top surface of the cube, whilst 34 produced incorrect representations (Binomial Test: $p = 0.00003$). There was an association between response type and age (Chi-Square = 10.99, 2df, $p < 0.05$). A series of 2x2 Chi-Square tests of association performed on the component parts of this table revealed that whilst there was no significant difference between the responses of the adolescents versus children, there was a significant difference between the responses of the adults versus adolescents (Chi-Square = 6.1, 1df, $p < 0.05$) and adults versus children (Chi-Square = 6.1, 1df, $p < 0.05$): the children and the adolescents produced significantly more incorrect responses than the adults.

Judges' Rating of Intent.

Model 1: The Road.

The results, based on the Judges' Rating of Intent scoring system, are shown in Table 5.4.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	10	30	40
Adolescent	6	34	40
Child	3	37	40
Total	19	101	120

Table 5.4: The Correct/Incorrect results based on the Rating of Intent scoring system.

10 adults produced drawings which were rated by the judges as correct representations of the road, whilst 30 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.0013$). 6 of the adolescent subjects produced drawings which were rated by the judges as correct representations of the road, whilst 34 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.00003$). 3 of the children produced drawings which were rated by the judges as correct representations of the road whilst, 37 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.00003$). There was no evidence of an association between rated response type and age (Chi-Square = 4.63, 2df, N.S.). One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were all non-significant.

Model 2: The Table.

The results, based on the Rating of Intent scoring system, are shown in Table 5.5.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	10	30	40
Adolescent	1	39	40
Child	1	39	40
Total	12	108	120

Table 5.5: The Correct/Incorrect results based on the Rating of Intent scoring system.

10 adults produced drawings which were rated by the judges as correct representations of the table top, whilst 30 produced drawings which were rated as incorrect representations (Binomial Test: p = 0.0013). 1 of the adolescent subjects produced a drawing which was rated by the judges as a correct representation of the table top, whilst 39 produced drawings which were rated as incorrect representations (Binomial Test: p = 0.00003). 1 of the children produced a drawing which was rated by the judges as a correct representation of the table top whilst, 39 produced drawings which were rated as incorrect representations (Binomial Test: p = 0.00003). One is unable to run a Chi-Square test of association on the data in this form because the expected frequencies associated with some of the individual cells fell below 5. One should note that a 2x2 Chi-Square test performed on the adult versus adolescent data revealed that there was a significant association between age and rated response type: the

adolescents produced significantly more incorrect responses than the adults (Chi-Square = 6.7457, 1df, $p < 0.01$). Similarly, a 2x2 Chi-Square test performed on the adult versus child data revealed that there was a significant association between age and rated response type: the children produced significantly more incorrect responses than the adults (Chi-Square = 6.7457, 1df, $p < 0.01$). Clearly there is no significant difference between the rated responses of the adolescents versus the children.

<u>Model 3: The Cube.</u>

The results, based on the Rating of Intent scoring system, are shown in Table 5.6.

	Type of Representation Produced		
	Correct	Incorrect	Total
Adult	13	27	40
Adolescent	4	36	40
Child	4	36	40
Total	21	99	120

Table 5.6: The Correct/Incorrect results based on the Rating of Intent scoring system.

13 adults produced drawings which were rated by the judges as correct representations of the top surface of the cube, whilst 27 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.0197$). 4 of the adolescent subjects produced a drawing which was rated by the judges as a correct representation of the top surface of the cube, whilst 36 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.00003$). 4 of

the children produced a drawing which was rated by the judges as a correct representation of the top surface of the cube whilst, 36 produced drawings which were rated as incorrect representations (Binomial Test: $p = 0.00003$). There was an association between the rated response type and age (Chi-Square 9.35, 2df, $p < 0.05$). A series of 2x2 Chi-Square tests performed on the component parts of this table revealed that there was a significant difference between the rated responses of the adults versus the adolescents (Chi-Square = 4.7806, 1df, $p < 0.05$): the adolescents produced significantly more incorrect responses than the adults. Similarly, there was a significant difference between the rated responses of the adults versus the children (Chi-Square = 4.7806, 1df, $p < 0.05$): the children produced significantly more incorrect responses than the adults. Clearly there was no significant difference between the rated responses of the adolescents versus the children.

Discussion.

It had been predicted that in the road task, the simplified nature of the model and its depiction would lead subjects of all ages to produce visually realistic representations of the model road. This prediction was not supported. The results from the Actual Measurement scoring system revealed (a) that the children produced significantly more incorrect than correct responses and (b) that there was no significant difference between the number of correct and the number of incorrect representations produced by either the adult or the adolescent subjects. In addition to this the Rating of Intent scoring system revealed that the subjects of all ages overwhelmingly produced drawings which were rated as incorrect.

The prediction that the subjects would not produce visually realistic representations of the table was supported. The results from the Actual

Measurement scoring system revealed that subjects of all ages overwhelmingly produced significantly more incorrect than correct representations of the table top. Moreover, the results from the Rating of Intent scoring system revealed that, as in the roads task, subjects of all ages produced drawings which were rated as incorrect.

Similarly, the prediction that the subjects would not produce visually realistic representations of the cube was supported. The results from the Actual Measurement scoring system revealed that with the adult subjects there was no significant difference between the number of correct and the number of incorrect representations of the top surface of the cube. The adolescent subjects and the children, however, both produced significantly more incorrect than correct representations of the top surface of the cube. Moreover, the results from the Rating of Intent procedure revealed that once again subjects of all ages overwhelmingly produced drawings which were rated as incorrect.

Clearly, then, in the road task the simplified nature of the model and its depiction does not result in the subjects' producing visually realistic representations. How, then, could one attempt to facilitate the production of 'converging perspective' representations of the model road? The following experiment was designed to address this issue.

CHAPTER SIX.

Experiment Six.

Drawing a Model Road: Altering the Length of the Model.

Introduction.

The results of the previous experiment revealed that adults, adolescents and children produced incorrect depictions of the model road. Very few subjects used the technique of converging the 'depth' lines in order to depict the way in which the side edges of the road appeared to converge into the distance. How, then, could one attempt to facilitate the production of 'converging perspective' representations?

One possible method would be to alter the length of the road. Since the model used in the previous study was only 30cm long, the effect of apparent convergence may have been too slight to have been noticed, let alone represented by the subjects. In this experiment, groups of adults, adolescents and children were asked to draw a longer model road (60cm in length). The responses of the subjects in these three age groups were compared with the responses of adults, adolescents and children who had been asked to draw the short (30cm) model used in the previous experiment. It was predicted that the effect of apparent convergence of the longer (60cm) model would be more noticeable than in the shorter and that this in turn would lead the subjects of all ages in the 'long road' condition to produce more converging perspective responses than those in the 'short road' condition.

Method.

Subjects.

Subjects were 30 adults (15 males and 15 females) aged between 22:0 and 24:0 years (Mean Age = 22.6), 30 adolescents (15 boys and 15 girls) aged between 11:10 and 12:10 years (Mean Age = 12.1) and 30 children (15 girls and 15 boys) aged between 6:6 and 7:11 years (Mean Age = 7:0).

Materials.

White A4 size paper and pencils were provided for the drawing tasks. Two models were used as stimuli. Model 1 = the cardboard model road used in Experiment 5. Model 2 = a cardboard model road which had been constructed in the same manner as Model 1. It consisted of a strip of black card (the road) 10cm wide and 60cm long, surrounded on either side by strips of grey card (the pavement) 5cm wide and 60cm long. Each section of grey card had been scored and folded in order to form a curb. No white lines were painted on the model.

Procedure.

Each subject was tested individually in a small room. The subject and the experimenter sat side by side at a table. Each subject was asked to complete one drawing task. Half the subjects in each age group drew Model 1 and half the subjects in each age group drew Model 2. The procedure and instructions given to the child were identical to those detailed in the road drawing task in the previous experiment.

Results.

The results, based on the scoring systems described in the previous experiment, were as follows.

Adult Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.1.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	9	6	15
Long Road	8	7	15
Total	17	13	30

Table 6.1: The Adult Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

With the short road, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). With the long road, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Chi-Square = 0, 1df, N.S.).

Adult Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.2.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	0	15	15
Long Road	1	14	15
Total	1	29	30

Table 6.2: The Adult Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

With the short road, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). With the long road, 1 subject produced a representation which was rated as being correct and 14 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.5$, N.S.).

Adolescent Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.3.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	6	9	15
Long Road	9	6	15
Total	15	15	30

Table 6.3: The Adolescent Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

With the short road, 6 subjects produced correct representations and 9 subjects produced incorrect representations (Binomial Test: N.S.). With the long road, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Chi-Square = 0.5332, 1df, N.S.).

Adolescent Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.4.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	0	15	15
Long Road	2	13	15
Total	2	28	30

Table 6.4: The Adolescent Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

With the short road, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). With the long road, 2 subjects produced representations which were rated as being correct and 13 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.004$). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.2414$, N.S.).

Children: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.5.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	6	9	15
Long Road	8	7	15
Total	14	16	30

Table 6.5: The Children's Correct/Incorrect results based on the Actual Measurement scoring system.

With the short road, 6 subjects produced correct representations and 9 subjects produced incorrect representations (Binomial Test: N.S.). With the long road, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Chi-Square = 0.1339, 1df, N.S.).

Children: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.6.

	Type of Representation Produced		
	Correct	Incorrect	Total
Short Road	0	15	15
Long Road	0	15	15
Total	0	30	30

Table 6.6: The Children's Correct/Incorrect results based on the Rating of Intent scoring system.

With the short road, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). With the long road, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.001$). There was no evidence of an association between the road type (short versus long) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 1$, N.S.).

In addition to the analyses detailed above the experimenter also performed the following comparisons.

Using the Actual Measurement Data, the experimenter assessed whether the number of correct representations produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.61, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.7.

	Type of Road		
	Short	Long	Total
Adult	9	8	17
Adolescent	6	9	15
Child	6	8	14
Total	21	25	46

Table 6.7: The number of correct representations produced in each of the two drawing tasks by adults, adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

No equivalent analysis could be performed on the Rating of Intent data (shown in Table 6.8) as the expected frequencies associated with each individual cell fell below 5.

	Type of Road		
	Short	Long	Total
Adult	0	1	1
Adolescent	0	2	2
Child	0	0	0
Total	0	3	3

Table 6.8: The number of representations rated as correct produced in each of the two drawing tasks by adults, adolescents and children.

A series of Fisher's Exact tests performed on the component parts of this table, however, were not significant. No Binomial tests were performed on the response types for each individual age group.

Using the Actual Measurement data the experimenter assessed whether the number of incorrect representations produced in each of the two drawing tasks (short road versus long road) varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.54, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.9.

	Type of Road		
	Short	Long	Total
Adult	6	7	13
Adolescent	9	6	15
Child	9	7	16
Total	24	20	44

Table 6.9: The number of incorrect representations produced in each of the two drawing tasks by adults, adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Using the Rating of Intent data the experimenter assessed whether the number of representations rated as incorrect, produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this

notion (Chi-Square = 0.074, 2df, N.S.). The data on which this analysis was performed is shown in Table 6.10.

	Type of Road		
	Short	Long	Total
Adult	15	14	29
Adolescent	15	13	28
Child	15	15	30
Total	45	42	87

Table 6.10: The number of representations rated as incorrect produced in each of the two drawing tasks by adults, adolescents and children.

One should note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Discussion.

It had been predicted that the use of a longer model road would lead more subjects of all ages to produce 'converging perspective' representation of a model road. This prediction was not supported.

The results, based on the Actual Measurement scoring system, revealed that there was no significant difference between the response of subjects in the short and long road conditions: in both these cases approximately half the subjects produced correct representations whilst approximately half produced incorrect representations.

The results of the Rating of Intent scoring system also revealed no significant difference in the responses of the subjects in the two road conditions: the responses of subjects of all ages in both drawing tasks, were overwhelmingly rated as incorrect. Clearly, then, the actual convergence of the lines on the page, in the correct solutions as measured by the Actual Measurement scoring system, is on the whole slight, with the lines representing 'failed' as opposed to intended solutions.

Once again there were no significant differences in the types of representation produced by subjects of different ages (as measured by either scoring system). Why is it, then, that even with a longer model, adults, adolescents and children fail to produce visually realistic representations of the model road? One possible explanation is that the effect of apparent convergence of the side edges of the model roads is not readily apparent when the road of placed on the table in front of the subjects. How, then, would subjects respond if their vantage point was altered such that the convergence of the side edges of the road was made more readily apparent? The following experiment was designed to address this issue.

Experiment Seven.

Drawing a Model Road: Altering the Subject's Vantage Point.

Introduction.

The results of the previous experiment revealed that adults, adolescents and children drew rectangular representations of a long (60cm in length) cardboard model road. Very few subjects used the technique of drawing converging 'depth' lines in order to depict the way in which the side edges of the road appeared to converge into the distance. Why should this be so?

One possible explanation is that when the road was placed on the table, the 'convergence' of its side edges was not readily apparent. How, then, would the subjects respond if the model was raised up on a platform to just below eye level: a vantage point from which the effect of apparent convergence is enhanced?

In order to investigate this issue the experimenter asked groups of adults, adolescents and children to draw the longer model road (60cm in length) when it had been raised up on a platform to just below eye level. The responses of the subjects in this condition were compared with the responses of subjects in a separate condition who were asked to draw the model when it had been placed on the table top. It was predicted that subjects of all ages would produce more 'converging perspective' representations of the model when it was raised up on the platform than when it was placed on the table top.

Method.

Subjects.

Subjects were 30 adults (15 males and 15 females) aged between 22:0 and 24:0 years (Mean Age = 23:3), 30 adolescents (15 males and 15 females) aged between 11:10 and 12:10 years (Mean Age = 12:5) and 30 children (15 boys and 15 girls) aged between 6:6 and 7:11 years (Mean Age = 7:4).

Materials.

White A4 size paper and pencils were provided for the drawing tasks. Two models were used as stimuli. Model 1 = the cardboard model road used in Experiment 6. Model 2 = the cardboard model road used in Experiment 6 raised up (by means of a platform) to 5cm below the subject's eye-level.

Procedure.

Each subject was tested individually in a small room. The subject and the experimenter sat side by side at a table. Each subject was asked to complete one drawing task. Half the subjects in each age group drew Model 1 and half the subjects in each age group drew Model 2. The procedure and instructions given to the child were identical to those detailed in the road drawing task in Experiment 5.

Results.

The results, based on the scoring systems described in Experiment 5, were as follows.

Adult Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.11.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	8	7	15
Raised	9	6	15
Total	17	13	30

Table 6.11: The Adult Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

In the table top condition, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). In the raised condition, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Chi-Square = 0, 1df, N.S.).

Adult Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.12.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	0	15	15
Raised	0	15	15
Total	0	30	30

Table 6.12: The Adult Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

In the table top condition, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). In the raised condition, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 1$, N.S.).

Adolescent Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.13.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	7	8	15
Raised	9	6	15
Total	16	14	30

Table 6.13: The Adolescent Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

In the table top condition, 7 subjects produced correct representations and 8 subjects produced incorrect representations (Binomial Test: N.S.). In the raised condition, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Chi-Square = 0.1339, 1df, N.S.).

Adolescent Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.14.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	2	13	15
Raised	0	15	15
Total	2	28	30

Table 6.14: The Adolescent Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

In the table top condition, 2 subjects produced representations which were rated as being correct and 13 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.004$). In the raised condition, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.2414$, N.S.).

Children: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.15.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	9	6	15
Raised	9	6	15
Total	18	12	30

Table 6.15: The Children's Correct/Incorrect results based on the Actual Measurement scoring system.

In the table top condition, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). In the raised condition, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Chi-Square = 0.1389, 1df, N.S.).

Children: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.16.

	Type of Representation Produced		
	Correct	Incorrect	Total
Table Top	0	15	15
Raised	0	15	15
Total	0	30	30

Table 6.16: The Children's Correct/Incorrect results based on the Rating of Intent scoring system.

In the table top condition, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). In the raised condition, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). There was no evidence of an association between the road type (table top versus raised) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 1$, N.S.).

In addition to the analyses detailed above the experimenter also performed the following comparisons.

Using the Actual Measurement Data, the experimenter assessed whether the number of correct representations produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.13, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.17.

	Type of Road		
	Table Top	Raised	Total
Adult	8	9	17
Adolescent	7	9	16
Child	9	9	18
Total	24	27	51

Table 6.17: The number of correct representations produced in each of the two drawing tasks by adults adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

No equivalent analysis could be performed on the Rating of Intent data (shown in Table 6.18) as the expected frequencies associated with each individual cell fell below 5.

	Type of Road		
	Table Top	Raised	Total
Adult	0	0	0
Adolescent	2	0	2
Child	0	0	0
Total	2	0	2

Table 6.18: The number of representations rated as correct produced in each of the two drawing tasks by adults, adolescents and children.

A series of Fisher's Exact tests performed on the component parts of this table, however, were not significant. No Binomial tests were performed on the response types for each individual age group.

Using the Actual Measurement data the experimenter assessed whether the number of incorrect representations produced in each of the two drawing tasks (table top versus raised) varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.13, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.19.

	Type of Road		
	Table Top	Raised	Total
Adult	7	6	13
Adolescent	8	6	14
Child	6	6	12
Total	21	18	39

Table 6.19: The number of incorrect representations produced in each of the two drawing tasks by adults, adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Using the Rating of Intent data the experimenter assessed whether the number of representations rated as incorrect, produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this

notion (Chi-Square = 0.09, 2df, N.S.). The data on which this analysis was performed is shown in Table 6.20.

	Type of Road		
	Table Top	Raised	Total
Adult	15	15	30
Adolescent	13	15	28
Child	15	15	30
Total	43	45	88

Table 6.20: The number of representations rated as incorrect produced in each of the two drawing tasks by adults, adolescents and children.

One should note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Discussion.

It had been predicted that when the model road was raised up on a platform to just below the subject's eye-level, more subjects of all ages would produce 'converging perspective' representations of a model road. This prediction was not supported.

The results, based on the Actual Measurement scoring system, revealed that there was no significant difference between the responses of subjects in the table top and raised road conditions: in both these cases approximately half the subjects produced correct representations whilst approximately half produced incorrect representations.

The results of the Rating of Intent scoring system also revealed no significant difference in the responses of the subjects in the two road conditions: the responses of subjects of all ages in both drawing tasks were overwhelmingly rated as 'incorrect'. Clearly, then, the actual convergence of the lines on the page, as measured by the Actual Measurement scoring system, is on the whole slight, with the lines representing 'failed' as opposed to intended solutions.

Once again there were no significant differences in the types of representation produced by the subjects of different ages (as measured by either scoring system). Why is it, then, that adults, adolescents and children still fail to produce visually realistic representation of the model road? It may be that the subjects failed to realise that the main purpose of the task was the representation of the effect of the apparent convergence of the side edges of the model. So, how would the subjects respond if the verbal instructions were altered to make the purpose of the task more salient? The following experiment was designed to address this issue.

Experiment Eight.

Drawing a Road "Going Off" Into the Distance.

Introduction.

The results of the previous three studies have revealed that adult, adolescent and child subjects produced rectangular representations of the experimental arrays. The technique of drawing converging 'depth' lines in order to capture the appearance of the model roads was not employed. One possible explanation for this is that the subjects had failed to appreciate that they were supposed to be depicting the way in which the side edges of the road appeared to recede in to the distance. How, then, could one indicate to the subjects that this is in fact the main purpose of the task?

One possible method would be to alter the verbal instructions. Barrett and Bridson (1983) asked children (between the ages of 4:7 and 7:5 years) to draw a model house which had been positioned in an oblique orientation in order to display the front and one side of the house. Three different levels of explicitness of instructions were used, these are detailed below:-

(1) Please can you draw this for me. Do not touch it or leave your seat.
(2) Please can you draw this for me exactly as you can see it from where you are sitting. Do not touch it or leave your seat.
(3) Please can you draw this for me exactly as you can see it from where you are sitting. Look very carefully at it while you are drawing it so you can draw it just as you see it. Do not touch it or leave your seat.

It was found that the most explicit instructions resulted in the most accurate representations of the subject's own view of the model house, both in terms of the appropriate inclusion/exclusion of detail and the portrayal of the side edge of the house using a linear projection system.

Given this, the experimenter altered the instructions in this experiment to include a reference to the fact that the subjects should actually be representing the way in which the side edges of the road appear to converge into the distance. The responses of those subjects who received these more explicit instructions were compared with the responses of those subjects who received the standard instructions used in the preceding experiments. On the basis of Barrett and Bridson's findings one would predict that the more explicit instructions would lead subjects of all ages to produce more visually realistic representations of the model road.

Method.

Subjects.

Subjects were 30 adults (15 males and 15 females) aged between 22:0 and 24:0 years (Mean Age = 23:1), 30 adolescents (15 males and 15 females) aged between 11:10 and 12:10 years (Mean age = 12:4) and 30 children (15 boys and 15 girls) aged between 6:6 and 7:11 years (Mean Age = 7:2).

Materials.

White A4 size paper and pencils were provided for the drawing tasks. The cardboard model road used in Experiment 6 was the model in both drawing tasks.

Procedure.

Each subject was tested individually in a small room. The subject and the experimenter sat side by side at a table. Each subject was asked to complete one drawing task. Half the subjects in each age group were asked to draw the model using the standard instructions (detailed in Experiment 5) and half the subjects in each age group were asked to draw the model "going off into the distance" (explicit instructions). The procedure was identical to that detailed in the road drawing task in Experiment 5.

Results.

The results, based on the scoring systems described in Experiment 5 were as follows.

Adult Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.21.

	Type of Representation Produced		
Instructions	Correct	Incorrect	Total
Standard	8	7	15
Explicit	9	6	15
Total	17	13	30

Table 6.21: The Adult Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

With the standard instructions, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). With the explicit instructions, 9 subjects produced correct representations and 6 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Chi-Square = 0, 1df, N.S.).

Adult Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.22.

Instructions	Type of Representation Produced: Correct	Type of Representation Produced: Incorrect	Total
Standard	3	12	15
Explicit	3	12	15
Total	6	24	30

Table 6.22: The Adult Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

With the standard instructions, 3 subjects produced representations which were rated as being correct and 12 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.018$). With the explicit instructions, 3 subjects produced representations which were rated as being correct and 12 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.018$). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.6743$, N.S.).

Adolescent Subjects: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.23.

Instructions	Type of Representation Produced: Correct	Incorrect	Total
Standard	8	7	15
Explicit	8	7	15
Total	16	14	30

Table 6.23: The Adolescent Subjects' Correct/Incorrect results based on the Actual Measurement scoring system.

With the standard instructions, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). With the long road, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Chi-Square = 0.1339, 1df, N.S.).

Adolescent Subjects: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.24.

Instructions	Type of Representation Produced: Correct	Incorrect	Total
Standard	3	12	15
Explicit	3	12	15
Total	6	24	30

Table 6.24: The Adolescent Subjects' Correct/Incorrect results based on the Rating of Intent scoring system.

With the standard instructions, 3 subjects produced representations which were rated as being correct and 12 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.018$). With the explicit instructions, 3 subjects produced representations which were rated as being correct and 12 subjects produced representations which were rated as being incorrect (Binomial Test: $p = 0.018$). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.6743$ N.S.).

Children: Actual Measurement.

The results, based on the Actual Measurement scoring system, are shown in Table 6.25.

	Type of Representation Produced		
Instructions	Correct	Incorrect	Total
Standard	8	7	15
Explicit	7	8	15
Total	15	15	30

Table 6.25: The Children's Correct/Incorrect results based on the Actual Measurement scoring system.

With the standard instructions, 8 subjects produced correct representations and 7 subjects produced incorrect representations (Binomial Test: N.S.). With the explicit instructions, 7 subjects produced correct representations and 8 subjects produced incorrect representations (Binomial Test: N.S.). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Chi-Square = 0, 1df, N.S.).

Children: Rating of Intent.

The results, based on the Rating of Intent scoring system are shown in Figure 6.26.

Instructions	Type of Representation Produced: Correct	Incorrect	Total
Standard	0	15	15
Explicit	1	14	15
Total	1	29	30

Table 6.26: The Children's Correct/Incorrect results based on the Rating of Intent scoring system.

With the standard instructions, 0 subjects produced representations which were rated as being correct and 15 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). With the explicit instructions, 1 subject produced a representation which was rated as being correct and 14 subjects produced representations which were rated as being incorrect (Binomial Test: $p < 0.001$). There was no evidence of an association between the instruction type (standard versus explicit) and the type of response produced (correct versus incorrect) (Fisher's Exact: $p = 0.5$, N.S.).

In addition to the analyses detailed above the experimenter also performed the following comparisons.

Using the Actual Measurement Data, the experimenter assessed whether the number of correct representations produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.12, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.27.

	Type of Instruction		
	Standard	Explicit	Total
Adult	8	9	17
Adolescent	8	8	16
Child	8	7	15
Total	24	24	48

Table 6.27: The number of correct representations produced in each of the two drawing tasks by adults, adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

No equivalent analysis could be performed on the Rating of Intent data (shown in Table 6.28) as the expected frequencies associated with each individual cell fell below 5.

	Type of Instruction		
	Standard	Explicit	Total
Adult	3	3	6
Adolescent	3	3	6
Child	0	1	1
Total	6	7	13

Table 6.28: The number of representations rated as correct produced in each of the two drawing tasks by adults, adolescents and children.

A series of Fisher's Exact tests performed on the component parts of this table, however, were not significant. No Binomial tests were performed on the response types for each individual age group.

Using the Actual Measurement data the experimenter assessed whether the number of incorrect representations produced in each of the two drawing tasks (standard instructions versus explicit instructions) varied as a function of age. There was no evidence to support this notion (Chi-Square = 0.14, 2df, N.S.). The data on which this analysis was performed are shown in Table 6.9.

	Type of Instruction		
	Standard	Explicit	Total
Adult	7	6	13
Adolescent	7	7	14
Child	7	8	15
Total	21	21	42

Table 6.29: The number of incorrect representations produced in each of the two drawing tasks by adults, adolescents and children.

One should also note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Using the Rating of Intent data the experimenter assessed whether the number of representations rated as incorrect, produced in each of the two drawing tasks varied as a function of age. There was no evidence to support this

notion (Chi-Square = 0.22, 2df, N.S.). The data on which this analysis was performed is shown in Table 6.30.

	Type of Instruction		
	Standard	Explicit	Total
Adult	12	12	24
Adolescent	12	12	24
Child	15	14	29
Total	39	38	77

Table 6.30: The number of representations rated as incorrect produced in each of the two drawing tasks by adults, adolescents and children.

One should note that a series of 2x2 Chi-Square tests performed on the component parts of this table were not significant. Neither were the Binomial tests performed on the response types for each individual age group.

Discussion.

On the basis of past research (Barrett and Bridson, 1983), it was predicted that the more explicit instructions would lead subjects of all ages to produce more visually realistic representations of a model road. This prediction was not supported.

The results, based on the Actual Measurement scoring system, revealed that there was no significant difference between the responses of subjects in the standard and explicit instruction condition: in both these cases approximately half the subjects produced correct representations whilst approximately half produced incorrect representations.

The results of the Rating of Intent scoring system also revealed no significant difference in the responses of the subjects in the two instruction conditions: the responses of subjects of all ages in both drawing tasks, were overwhelmingly rated as 'incorrect'. Clearly, then, the actual convergence of the lines on the page, as measured by the Actual Measurement scoring system, is on the whole slight, with the lines representing 'failed' as opposed to intended solutions.

Once again there were no significant differences in the types of representation produced by subjects of different ages (as measured by either scoring system). Why is it, then, that adults, adolescents and children alike, persist in producing rectangular representations of the experimental arrays? One possible explanation is that the effect of apparent convergence of the side edges of the model roads is so slight that it is not even noticed by the subjects. Anecdotal evidence from an adult subject suggests that this may well be the case. Upon being asked to draw the road 'exactly as it looked' the subject commented that he realised that a perspective representation of a road had converging side edges. He then added that because he couldn't see the side edges of this particular model as converging he would not represent them in this way. This led the experimenter to contemplate whether subjects would in fact be able to depict the apparent convergence of the side edges of a road if the effect was more pronounced. The following experiment was designed to address this issue.

CHAPTER SEVEN.

Experiment Nine.

Drawing an Actual Road.

Introduction.

In the previous four experiments, in which cardboard models were used as stimuli in the drawing tasks, adults, adolescents and children produced rectangular representations of the experimental arrays. The technique of drawing converging 'depth' lines, in order to capture the appearance of the models was not used. Why should this be so?

Given that the models used in these experiments were relatively small in size (even the longer model was only 60cm in length) it is possible that the effect of apparent convergence was simply too slight to be noticed, let alone represented, by the subjects. This leads one to contemplate whether subjects of all ages would in fact be able to depict apparent convergence if the effect of convergence in the actual scene was more pronounced. The experiment detailed here addresses this issue.

In this study adults, adolescents and children were asked to draw from an actual road rather than a cardboard model. As can be seen from the photograph shown in Figure 7.1 (taken from the subjects' vantage point) from an adult's point of view the stimulus provides one with a striking example of the effect of apparent convergence. Whilst the use of an actual road, and not a cardboard model as used previously, may pose problems in terms of the comparability of this and the previous experiments, the change was unavoidable: it would not have been feasible to construct a cardboard model of the proportions necessary to render the effect of apparent convergence as marked as in this example.

Figure 7.1:The Actual Road Used in this Experiment.

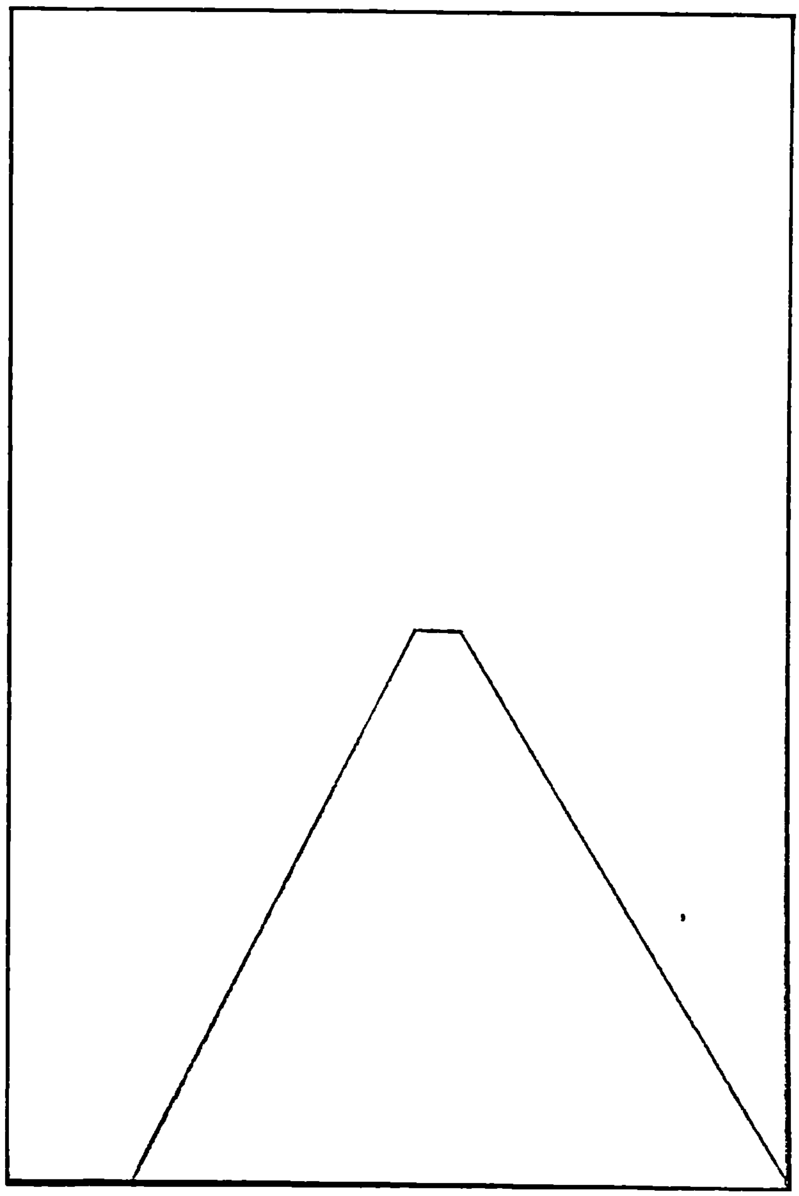


Figure 7.2(a):The Converging Oblique Alternative in the Selection Task.

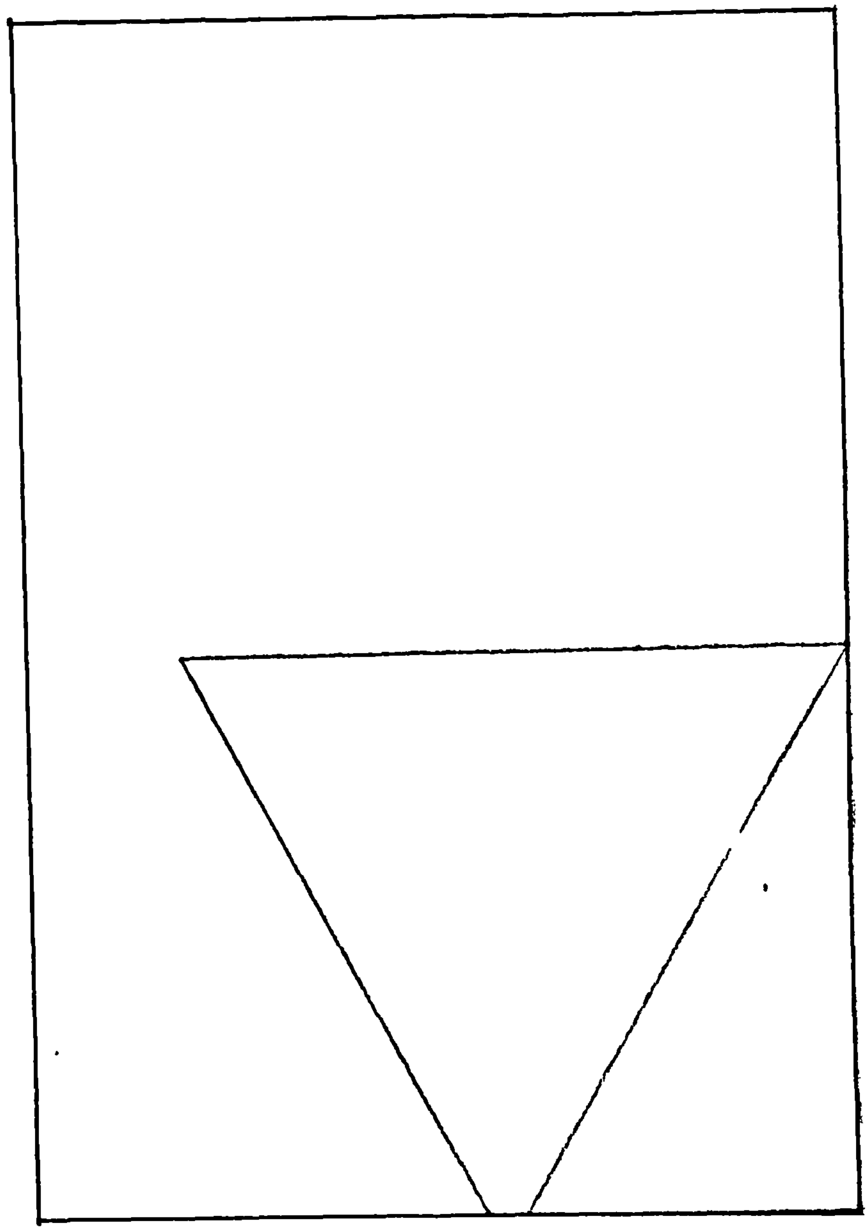


Figure 7.2(b):The Diverging Oblique Alternative in the Selection Task.

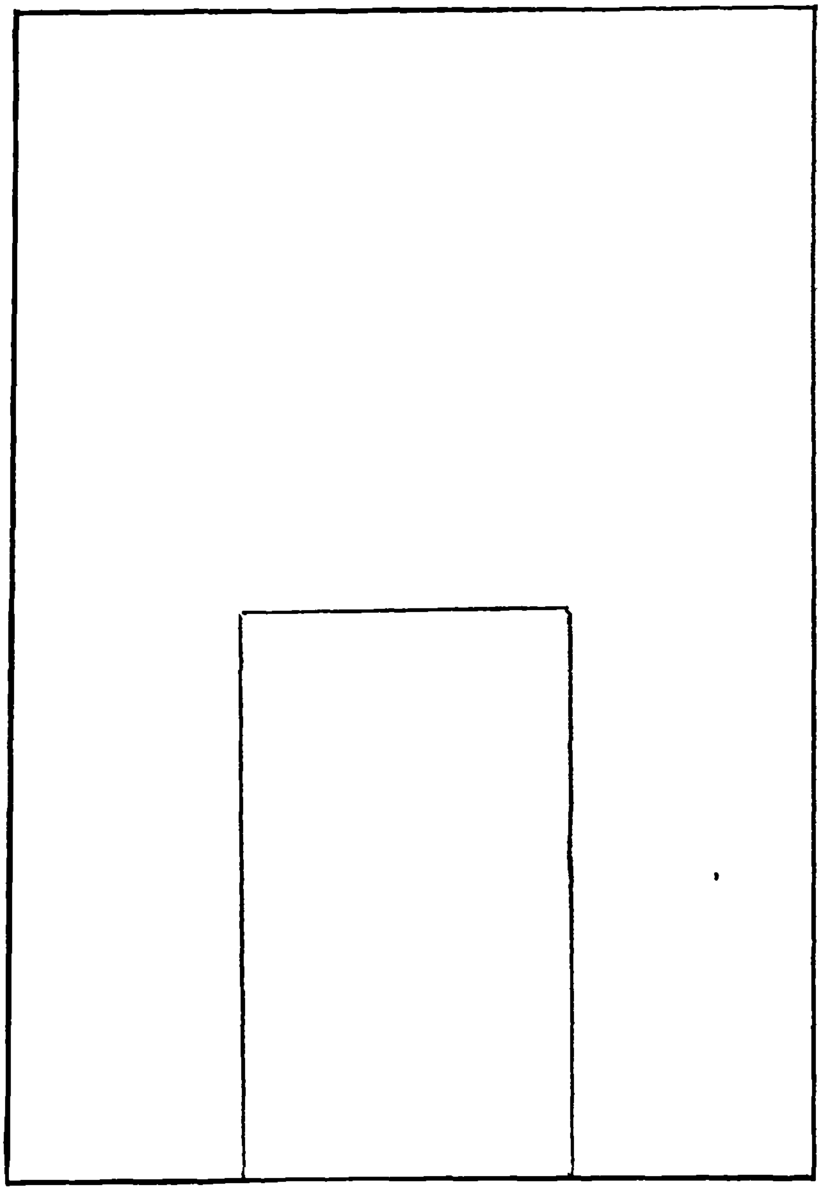


Figure 7.2(c):The Rectangular Alternative in the Selection Task.

With drawing tasks, such as those reported in the previous four experiments, it is not always clear what the subjects actually <u>intended</u> to draw. So, in this next study, in addition to gathering the opinion of the judges, the experimenter asked all the subjects to perform a selection task as well as a drawing task. It was hoped that the data from such a task, in which subjects were simply asked to select a drawing from a set of alternatives would help to clarify just what the subjects had been intending to produce during the drawing task. The subjects were restricted to choosing between a 'converging' oblique, a 'diverging' oblique and a rectangular solution (see Figure 7:2(a), (b) & (c)).

Method.

Subjects.

Subjects were 10 adults (5 males and 5 females) aged between 22:0 and 23:0 years (Mean Age = 22:7), 10 adolescents (5 males and 5 females) aged between 11:10 and 12:10 years (Mean Age = 12:3), and 10 children (5 boys and 5 girls) aged between 6:6 and 7:11 years (Mean Age = 7:1).

Materials.

A4 size paper and pencils were provided for the drawing task. Three pre-drawn figures were provided for the selection task :see Figure 7.2(a), (b) & (c). An actual road was used as the stimulus in both the drawing and the selection task (see Figure 7.1 for a photograph taken from the subject's vantage point).

Procedure.

Each subject was tested individually on a bridge above the road. The subject and the experimenter knelt side by side, at a premarked position, in the centre of the bridge. Each subject was asked to complete a drawing and a selection task. Half the subjects completed the drawing task first and the selection task second, whilst the other half completed the selection task first and the drawing task second. Each task was completed on a different day.

Drawing Task. The experimenter positioned the subject on the bridge, handed him/her a piece of paper and a pencil and said:- "Here is a road (experimenter pointed at the view from the bridge). Here is the road (experimenter pointed at the road only) and here is the pavement (experimenter pointed at the pavement). Now I want you to draw a picture of the road. Not the pavement, just the road...this bit here (experimenter pointed at the road only). Draw exactly what you can see. Draw the road exactly as it looks from where you are kneeling".

Selection Task. The experimenter positioned the subject on the bridge, and laid out the three pre-drawn figures in a row in from of him/her (the order in which these were laid out was randomised for each subject) and said:- "Here is a road (experimenter pointed at the view from the bridge). Here is the road (experimenter pointed at the road only) and here is the pavement (experimenter pointed at pavement). Now if you were going to draw a picture of the road, not the pavement, just the road...this bit here (experimenter pointed at the road only) and you were going to draw the road exactly as it looks from where you are kneeling which of these three pictures would your road look like (experimenter pointed at the pre-drawn pictures, taking care not to point to any one particular picture)?"

Results.

Adult and Adolescent Subjects.

Drawing Task.

The drawings produced by the adult subjects are shown in Figure 7.3 whilst the drawings produced by the adolescent subjects are shown in Figure 7.4.

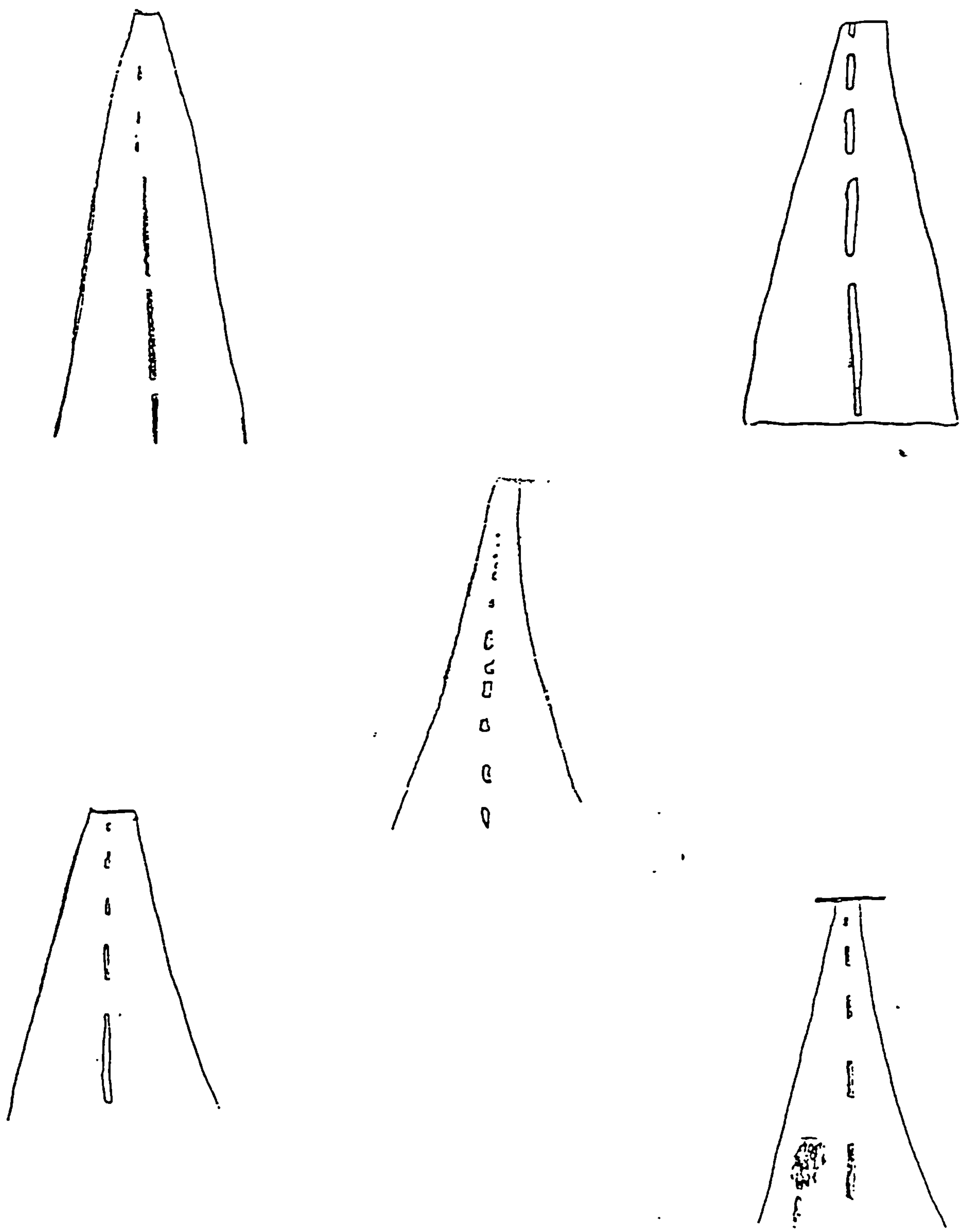


Figure 7.3: The Drawings produced by the Adults.

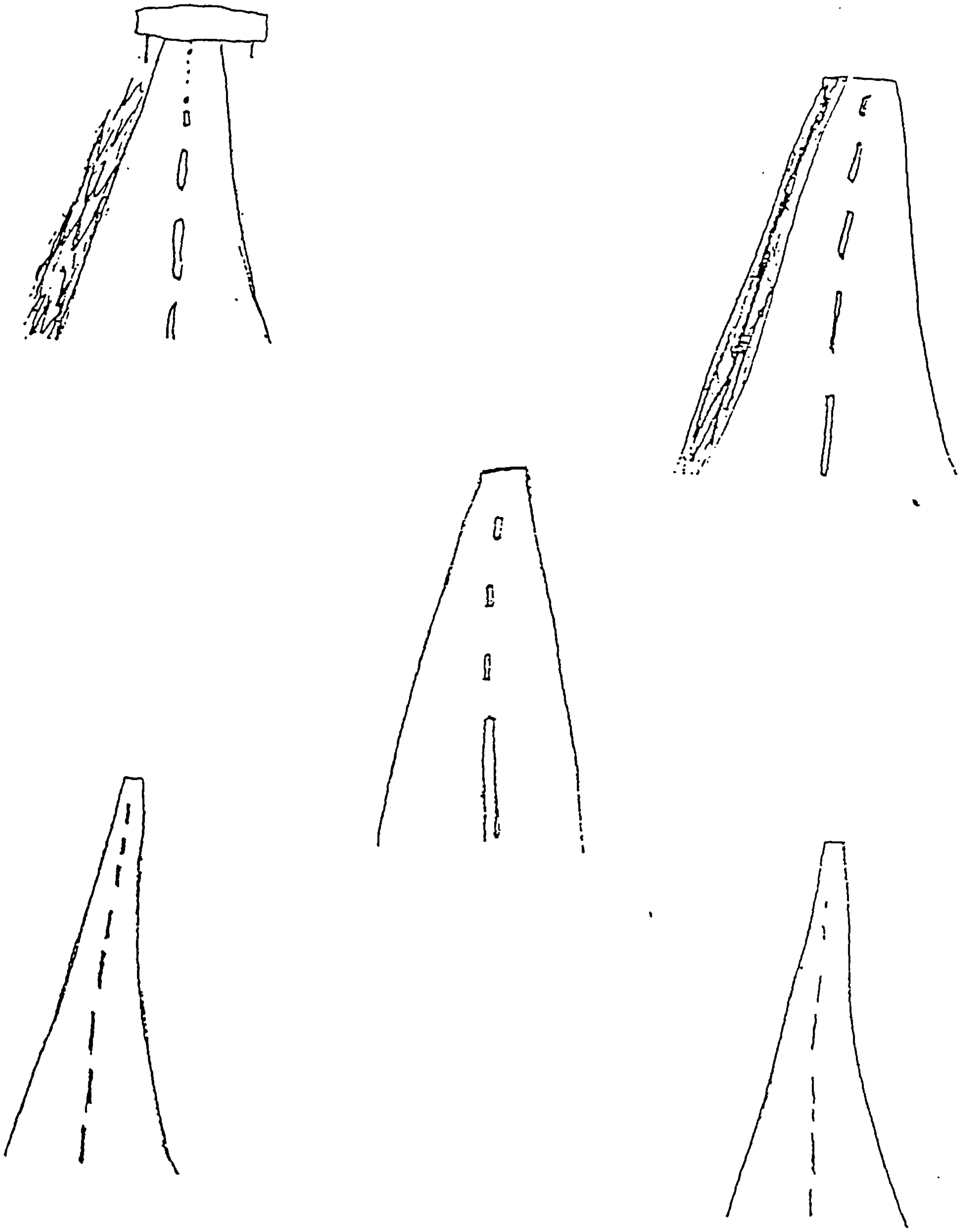


Figure 7.3: The Drawings produced by the Adults.

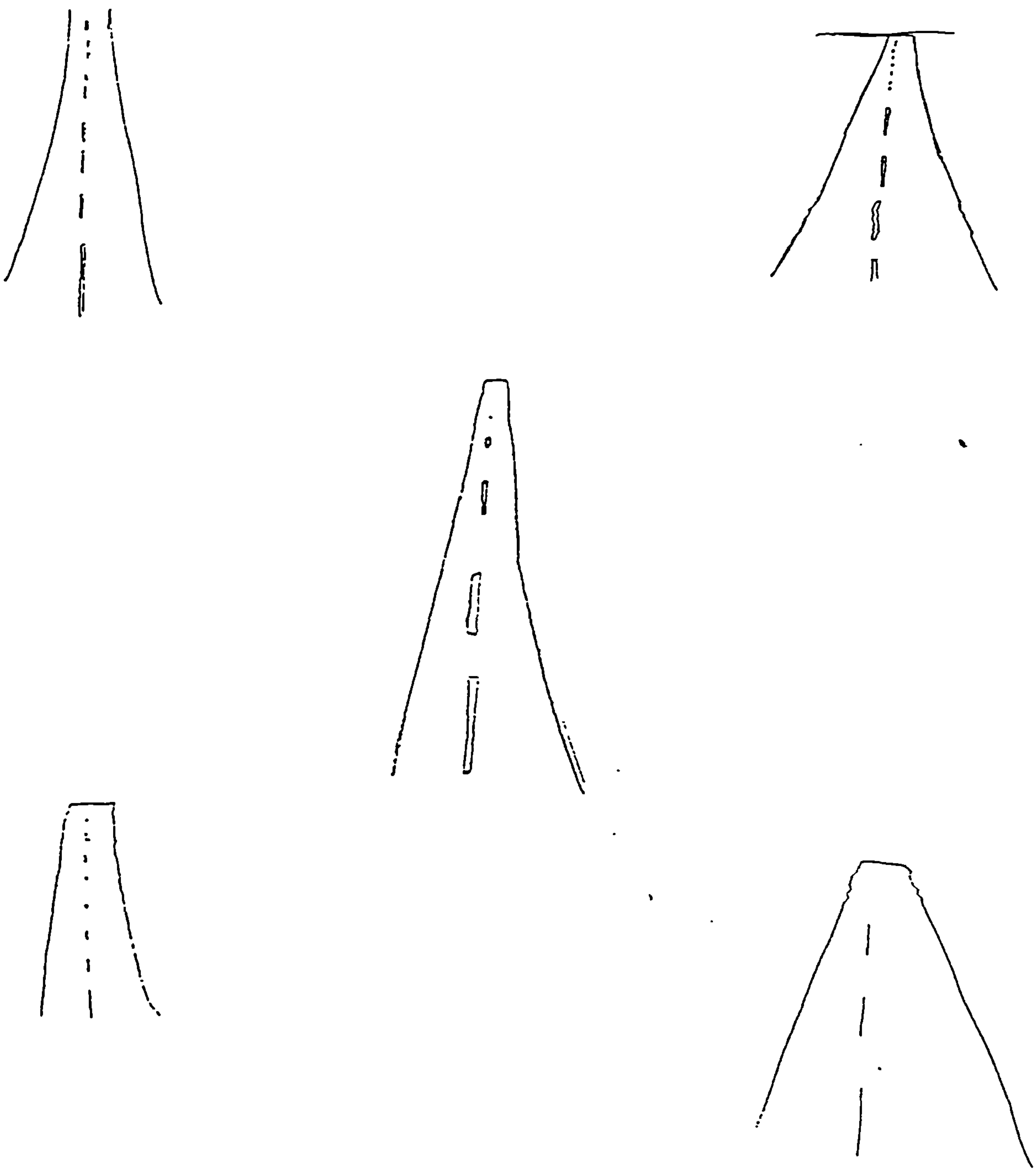


Figure 7.4: The Drawings produced by the Adolescents.

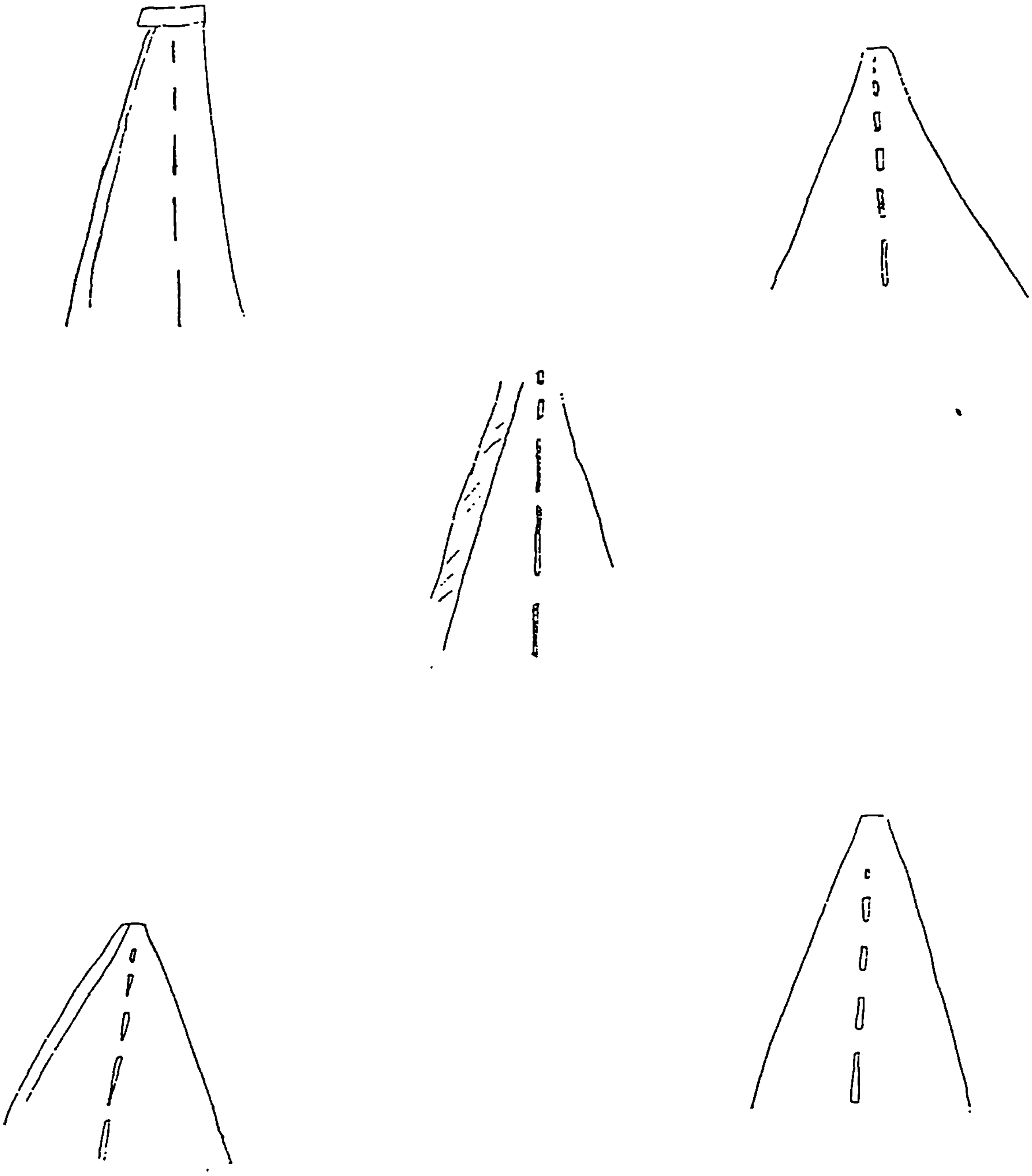


Figure 7.4: The Drawings produced by the Adolescents.

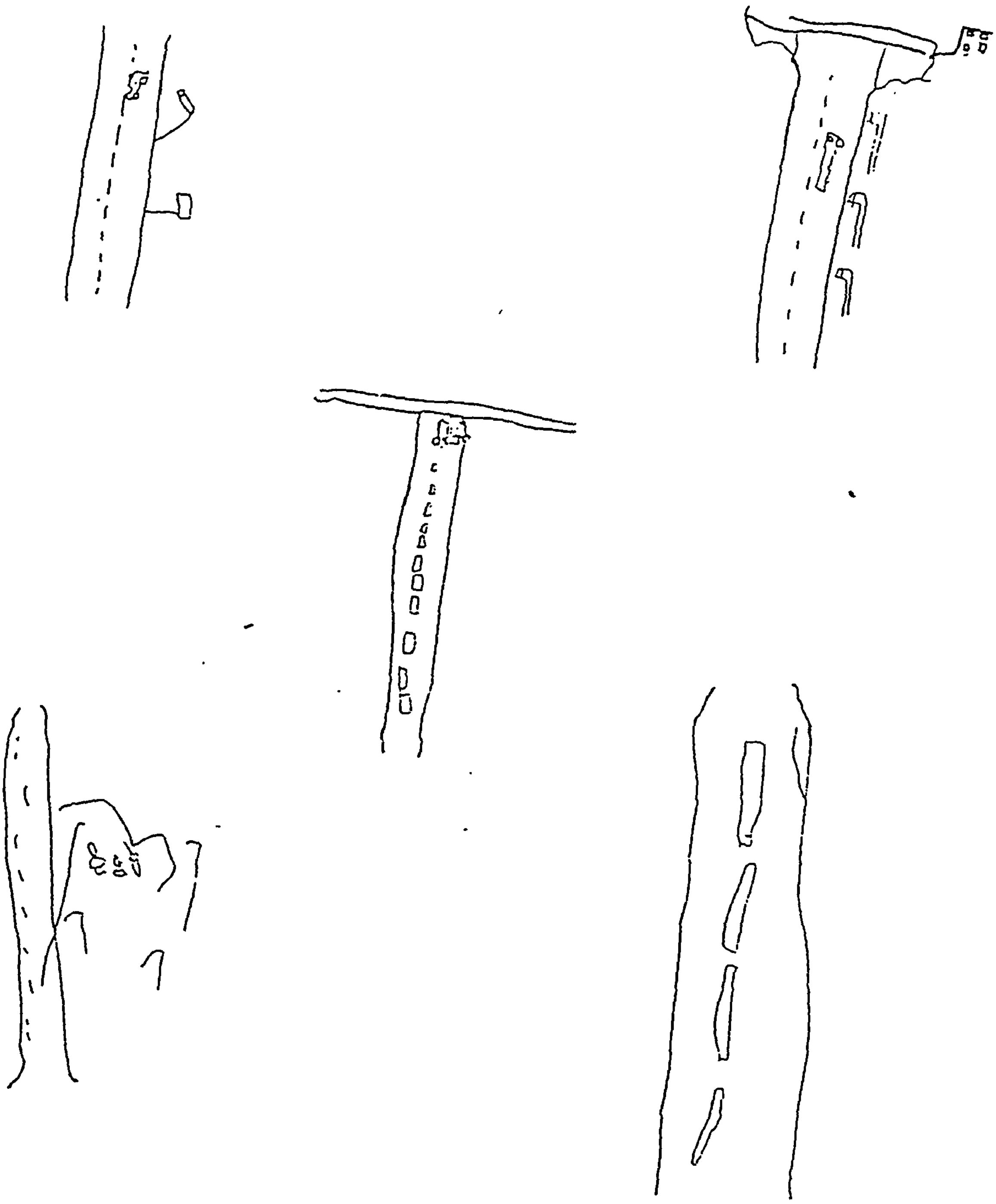


Figure 7.5: The Drawings produced by the Children.

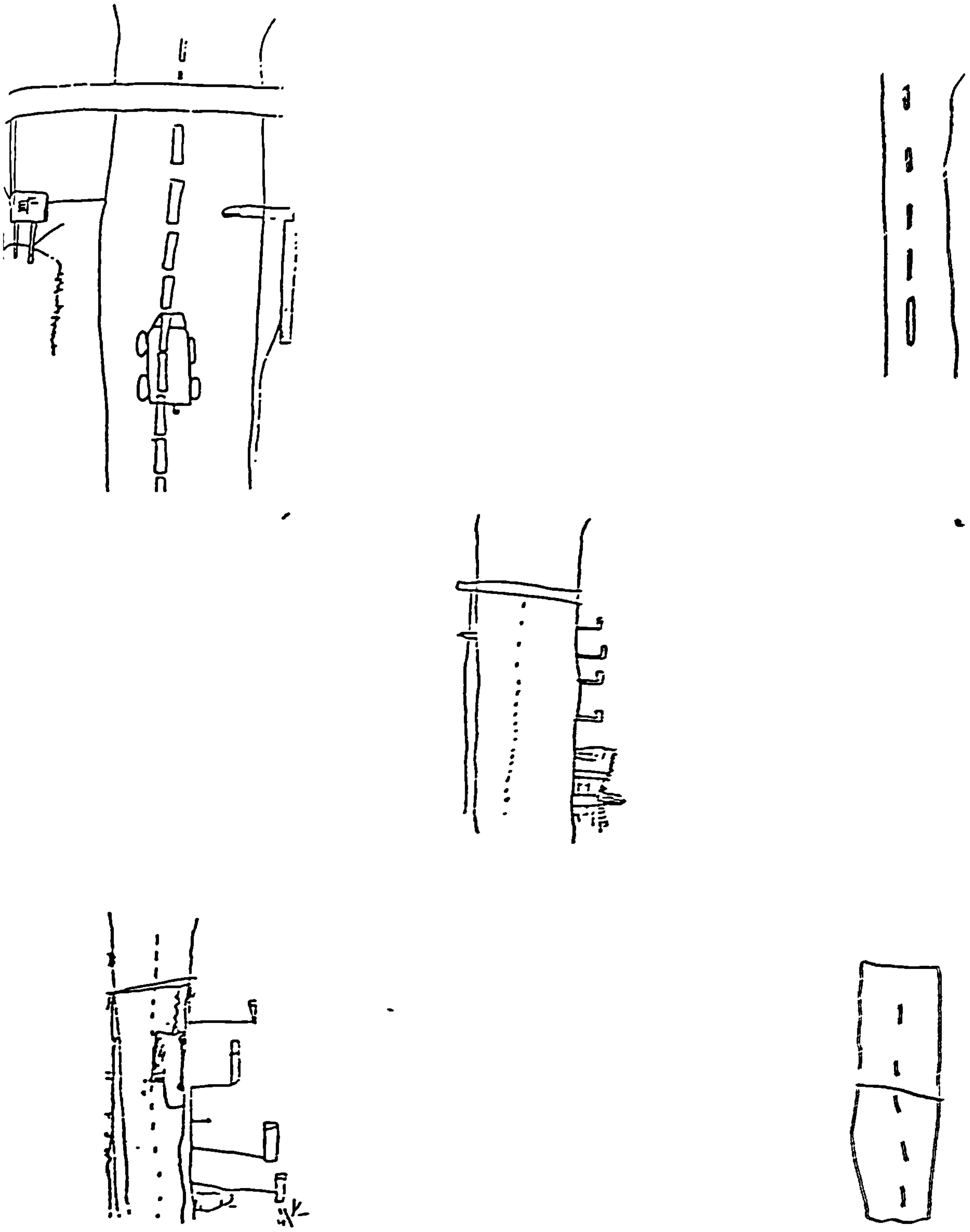


Figure 7.5: The Drawings produced by the Children.

The results, based on the Actual Measurement scoring system (described in Experiment 5), revealed that all 10 adult subjects and all 10 adolescent subjects produced correct representations. All 20 drawings were rated by the judges as correct representations.

Selection Task.

All 20 subjects selected the converging representation. Given that the converging representation = the correct representation, these selections were by definition correct.

Child Subjects.

Drawing Task.

The drawings produced by the children are shown in Figure 7.5. The results, based on the Actual Measurement scoring system (described in Experiment 5), revealed that 2 subjects produced correct representations. The remaining 8 subjects produced incorrect representations All 10 drawings were, however, rated by the judges as incorrect representations.

Selection Task.

All 10 subjects selected the parallel representation. Given that the converging representation = the correct representation, these selections were by definition incorrect.

Discussion.

When asked to draw from and select a view of an actual road, all the adults and adolescents drew and selected a 'correct perspective solution' where converging oblique 'depth' lines represented the way in which the side edges of the road appeared to converge into the distance (this finding was consistent across both scoring systems). Clearly then, the more obvious effect of apparent convergence afforded by the actual road has resulted in more subjects actually noticing and consequently representing the effect and/or it has resulted in more subjects realising that it is this effect they are supposed to be representing.

The chidren's responses, however, were different. The results, based on the Actual Measurement scoring system, revealed that only two of the ten children produced correct converging representations, whilst the remaining eight produced incorrect representations. This description of the results is, however, misleading. The actual convergence of the lines in the 'correct representations' is very slight (never more than two or three millimetres in each case) and thus it is highly likely that these representations were 'failed parallels' rather than 'intended correct' solutions. This notion is supported by two sets of evidence:- (1) all the children chose the parallel responses card in the selection task, and (2) all three judges rated all ten drawings as 'incorrect'.

Thus given the results of the selection task and the nature of the drawings themselves, this experiment reveals that even when the convergence effect is quite pronounced, as in the case of a real road, young children do not draw or select representations which depict the apparent convergence of the side edges. Why should this be so? One could actually invoke the Piagetian notion of conceptual immaturity to explain the young children's failure to represent the projective aspects of the scene, that is that the children have simply not yet developed concepts of projective and Euclidean space (Piaget and Inhelder, 1956, 1969). This explanation, however, is too broad: young children demonstrably can represent some projective aspects of a scene (e.g. the partial occlusion of one ball by another) even though they have difficulty with representing the apparent convergence of the parallel edges of the road. Thus, there is no abrupt, stage-like shift from a complete inability to represent any projective relationship to an ability to represent all projective aspects of a scene. Clearly, some projective aspects are easier to depict than others.

The depiction of partial occlusion may be easier than that of convergence because young children can more readily appreciate what they have to do. In the case of partial occlusion, children simply have to omit the part of the farther object which is hidden from their view; apart from that, they are not required to alter the shape of their normal depiction of the object. In the case of convergence, in contrast, children are required to alter the actual shape of the entire object, i.e. they have to change a rectangle into a trapezium. There are various possible explanations for their difficulty with this second task. One is that the children simply do not notice the apparent convergence of the parallel edges in the scene (Piaget and Inhelder, 1956) and are forced to draw the actual shape of objects such as the road. Another possibility is that they are aware of the apparent convergence but do not depict it because they cannot draw converging obliques, or because they do not realise that they are being asked to draw the projective as opposed to the actual shape of the object, or because they deliberately choose to draw parallel lines in order to show that roads actually do have parallel edges; an explanation akin to the ideas of Luquet (1913, 1927; Costall, 1989).

Having established that children do not produce visually realistic representations when asked to draw from an actual three-dimensional road, the experimenter began to contemplate how children would respond when asked to draw from various two-dimensional models of the same scene. Does the children's difficulty in representing a within-object depth relationship solely reflect problems of projection or does it also reflect problems of denotation: namely which parts of the model they should transform into contours? Whilst the presentation of a photograph would presumably solve some of the projective problems encountered by children attempting to draw a road, it would still leave the problem of denotation. A line drawing derived from a tracing of the contours on the photograph would, however, demonstrate the solution to both problems. The following experiment (Experiment 10) was designed to compare children's responses to these different modes of representation.

CHAPTER EIGHT

Experiment Ten

Drawing from Two-Dimensional Models (1)

Introduction

The results of the previous study revealed that adult and adolescent subjects both drew and selected visually realistic 'converging' representations of an actual road. In contrast to this, however, children drew and selected visually unrealistic rectangular representations.

Having ascertained that children do not depict the apparent convergence of the side edges of an actual road, the experimenter began to contemplate how they would represent two-dimentional models of the same scene. How would the children, and indeed adults and adolescents, respond if asked to draw (and select) pictures of a photograph or a line drawing of the actual road? The experiment detailed here was designed to address this issue.

Three two-dimensional models were used in this study. The first of these was the photograph (shown in Figure 7.1). Taken from the child's viewing position in Experiment 9, this photograph is a two-dimentional stimulus which is retinally matched to the actual model. The other two stimuli used were both line reductions of this photograph: one of the reductions was shaded (see Figure 8.2) and is referred to as the shape, the other was unshaded (see Figure 8.3) and is referred to as the line drawing.

The rationale underlying the use of these particular stimuli is as follows. As one moves from photograph, to shaded line drawing (shape), to unshaded line drawing (line drawing), the graphic solution to the problem of how to represent the road becomes increasingly more apparent. By examining children's responses at each of these levels of abstraction, one should be able to ascertain at which, if any, of these levels they encounter representational problems. Also, given that the photograph was taken from the subjects, vantage point in Experiment 9, one can compare the results of these two experiments and thus establish how children respond to a unified set of materials which span homographic (3-D to 2-D) and isographic (2-D to 3-D) tasks.

Previous research by Chen (1985), who adopted a similar approach to that detailed here, has revealed that many children (under the age of 9:6 years) who normally draw pictures of solid objects with little or no attempt to represent depth features (when drawing from a three-dimensional model) tend to draw more visually realistic pictures of the same objects when asked to copy from photographs or line drawings of them. Chen argues that one can account for this finding in terms of difficulties in translating the three-dimensional world onto the two-dimensional picture plane. It is, however, also important to note that when Chen asked the children to drawn cylinders and tetrahedrons, they found it more difficult to copy a photograph than to copy a line drawing. Chen suggested that when copying from a photograph of these particular objects, the children experienced difficulty in translating the edges of the objects (boundaries into lines); when copying from the line drawing, however, the children could clearly perceive the lines to be drawn.

By presenting the shape in two tasks, calling it a 'shape' in one task and a 'road' in the other (an by repeating this procedure with the line drawing), the experimenter sought to determine whether the children's knowledge of what the line reductions were supposed to represent influenced how they subsequently depicted them. Previous research by Phillips, Hobbs and Pratt (1978) has demonstrated that when young children know that a line drawing represents a cube they make more copying errors and draw the faces as squares. Similarly, Cox (1989) showed that children drew fewer converging obliques when the same line drawing of a cube was called a 'building block' (a rectilinear object) than when it was called a 'shape' or a 'house' (an object known to contain obliques). On the basis of these studies, one would predict that when the line reductions (i.e. the shape and the line drawing) are called shapes, the children would interpret the obliques as part of each shape and would thus copy and select them correctly, but when they are called roads (thereby representing an object known to be rectangular) the children would be less inclined to draw and select obliques. One would not expect the responses of the adult and adolescent subjects to be affected by the differential naming of the stimuli.

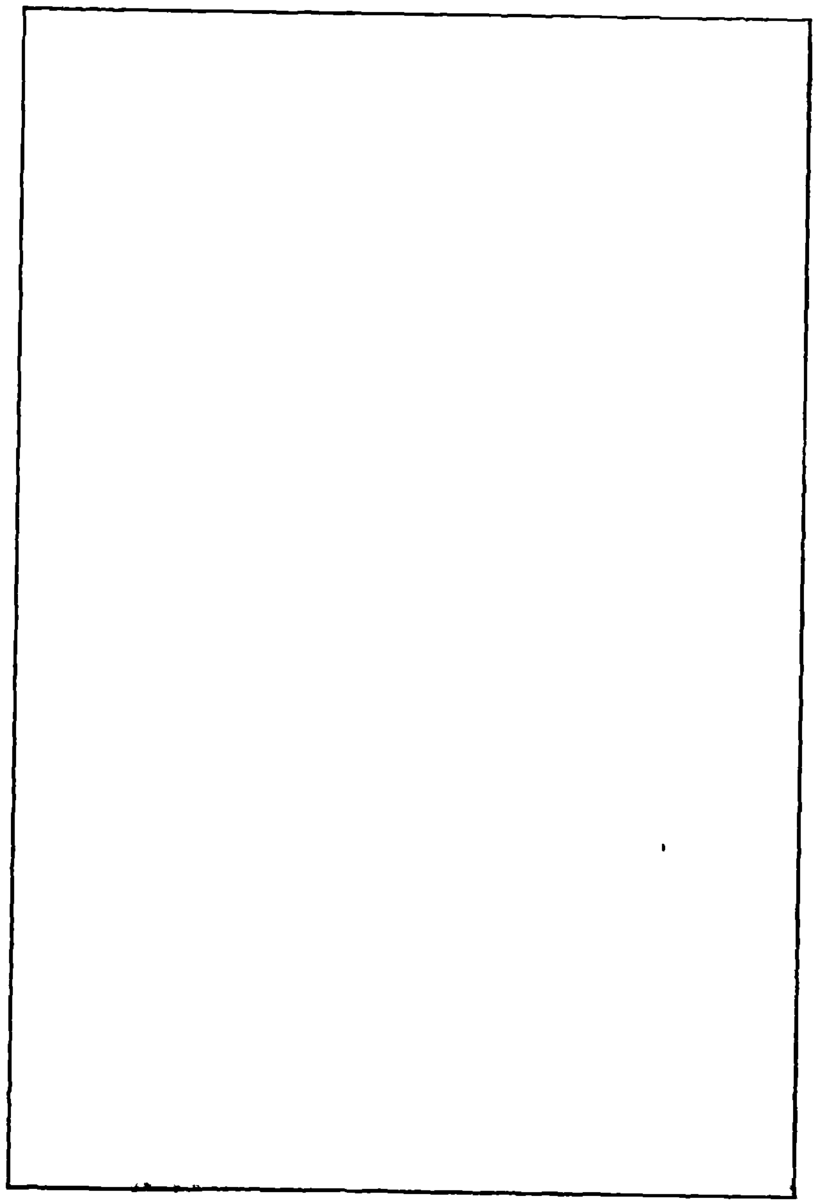


Figure 8.2: The Shape.

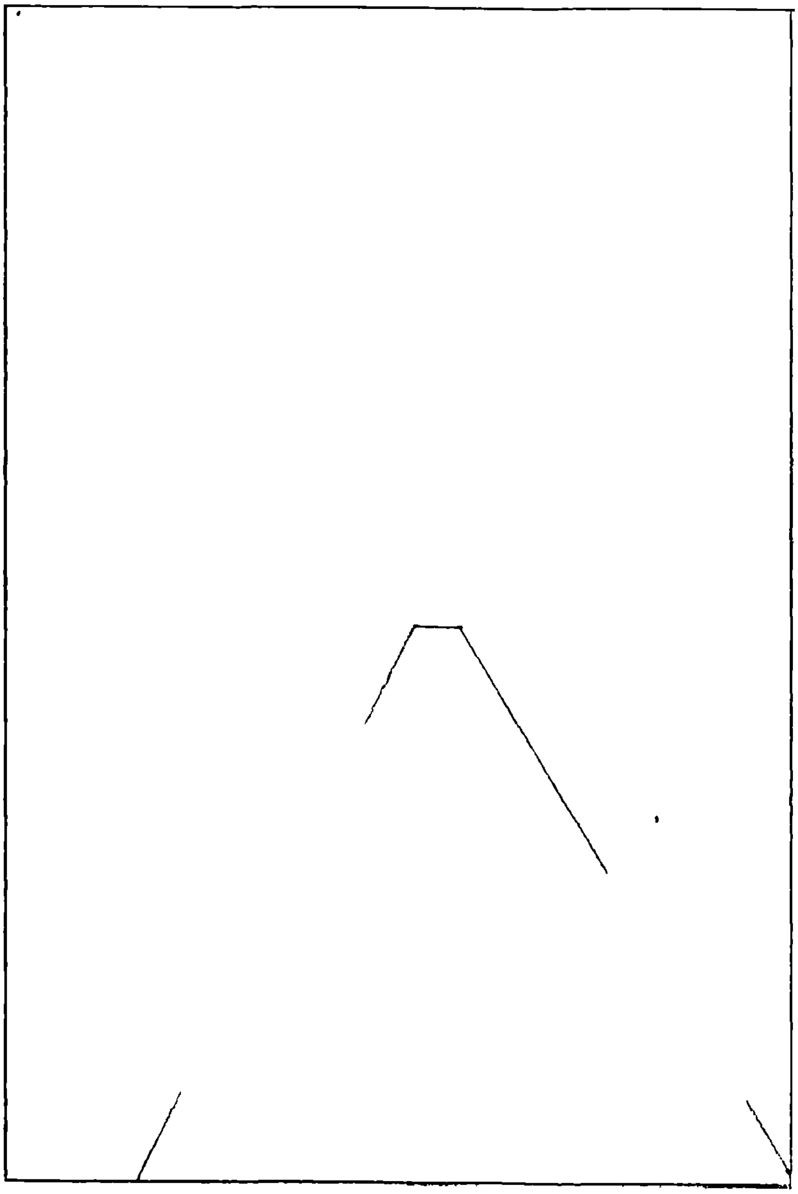


Figure 8.3: The Line Drawing.

Method.

Subjects.

Subjects were 100 adults aged between 22:0 and 24:1 years (Mean Age = 22:11), 100 adolescents aged between 11:10 and 12:10 years (Mean Age = 12:4) and 100 children aged between 6:6 and 7:11 years (Mean Age = 7:3). There were approximately equal numbers of males and females in each group.

Materials.

A4 size paper and pencils were provided for drawing. A photograph (see Figure 7.1) and two pre-drawn figures (see Figures 8.2 and 8.3) were used as stimuli in both the drawing and selection tasks. Three pre-drawn response cards were provided as alternative choices in the selection task only [see Figure 7.2 (a), (b) and (c)].

Procedure.

Each subject was tested individually in a separate room. The subject and the experimenter sat side by side at a table. Each subject was asked to complete one drawing and one selection task. Half the subjects in each age group completed the drawing task first and the selection task second, whilst the other half completed the selection task first and the drawing task second. Each task was completed on a different day. 20 subjects in each age group performed the photograph drawing and selection task, 20 subjects in each age group performed the shape called a road drawing and selection task, 20 subjects in each age group performed the shape called a shape drawing and selection task, 20 subjects in each age group performed the line drawing called a road drawing and selection task, and 20 subjects in each age group performed the line drawing called a shape drawing and selection task.

Drawing Task.

Each subject was asked to perform one of the following drawing tasks.

(1) Photograph Task.

The experimenter seated the subject at the table and handed him/her a piece of paper and a pencil. After some preliminary discussion to make the subject feel at ease, she placed the photograph shown in Figure 7.1 on the table and, using the instructions and procedure detailed in Experiment 5, asked the subject to draw the road.

(2) Shape called a Road Task. The experimenter seated the subject at the table and handed him/her a piece of paper and a pencil. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.2 on the table and said:- "Here is a road (experimenter pointed at the figure). Now I want you to draw a picture of the road...this bit here (experimenter pointed at the road only). Draw exactly what you can see. Draw the road exactly as it looks from where you are sitting".

(3) Shape called a Shape Task. The experimenter seated the subject at the table and handed him/her a piece of paper and a pencil. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.2 on the table directly in front of the subject and said:- "Here is a shape (experimenter pointed at the figure). Now I want you to draw a picture of the shape...this bit here (experimenter pointed at the shape only). Draw exactly what you can see. Draw the shape exactly as it looks from where you are sitting".

(4) Line Drawing called a Road Task. The experimenter seated the subject at the table and handed him/her a piece of paper and a pencil. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure

shown in Figure 8.3 on the table directly in front of the subject and said:- "Here is a road (experimenter pointed at the figure). Now I want you to drawn a picture of the road...this bit here (experimenter pointed at the road only). Draw exactly what you can see. Draw the road exactly as it looks from where you are sitting".

(5) Line Drawing called a Shape Task. The experimenter seated the subject at the table and handed him/her a piece of paper and a pencil. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.3 on the table directly in front of the subject and said:- "Here is a shape (experimenter pointed at the figure). Now I want you to draw a picture of the shape...this bit here (experimenter pointed at the shape only). Draw exactly what you can see. Draw the shape exactly as it looks from where you are sitting".

Selection Task. Each subject was also asked to select, from three pre-drawn response cards [see Figure 7.2 (a), (b) & (c)] a picture of the stimulus s/he was required to depict in the drawing task. The procedure was the same as that employed in the drawing task except for the mode of response. Instead of asking the subjects to make a drawing, three response cards were placed in a row in front of the subject (the order in which these were laid out was randomised for each subject) and s/he was asked to choose a picture from this set of alternatives. The instructions given to the subjects are detailed below:-

(1) Photograph Task. The experimenter seated the subject at the table. After some preliminary discussion to make the subject feel at ease, she placed the photograph, shown in Figure 7.1, on the table directly in front of the subject. The three pre-drawn response cards were then placed in a row directly beneath the photograph. Then the experimenter said:- "Here is a road (experimenter pointed at the photograph). Here is the road (experimenter pointed at the road only) and here is the pavement (experimenter pointed at the pavement). Now if you were going

to draw a picture of the road. Not the pavement, just the road...this bit here (experimenter pointed at the road only) and you were going to draw the road exactly as it looks from where you are sitting, which of these three pictures would your road look like (experimenter pointed at the pre-drawn pictures, taking care not to point at any one particular picture)?"

(2) Shape called a Road Task. The experimenter seated the subject at the table. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.2, on the table directly in front of the subject. The three pre-drawn response cards were then paced in a row directly beneath this figure. Then the experimenter said:- "Here is a road (experimenter pointed at the figure). Now if you were going to draw a picture of the road...this bit here (experimenter pointed at the road only) and you were going to draw the road exactly as it looks from where you are sitting, which of these three pictures would your road look like (experimenter pointed at the pre-drawn pictures, taking care not to point to any one particular picture)?"

(3) Shape called a Shape Task. The experimenter seated the subject at the table. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.2 on the table directly in front of the subject, The three pre-drawn response cards were then placed in a row directly beneath this figure. Then the experimenter said:- "Here is a shape (experimenter pointed at the figure). Now if you were going to drawn a picture of the shape...this bit here (experimenter pointed at the shape only) and you were going to draw the shape exactly as it looks from where you were sitting, which of these three pictures would your shape look like (experimenter pointed at the pre-drawn pictures, taking care not to point at any one particular picture)?"

(4) Line Drawing called a Road Task. The experimenter seated the subject a the table. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.3 on the table directly in front of the subject. The three pre-drawn response cards were then placed in a row directly beneath this figure. Then the experimenter said:- "Here is a road (experimenter pointed at the figure). Now if you were going to draw a picture of the road...this bit here (experimenter pointed at the road only) and you were going to draw the road exactly as it looks from where you are sitting, which of these three pictures would your road look like (experimenter pointed at the pre-drawn pictures, taking care not to point at any one particular picture)?"

(5) Line Drawing called a Shape Task. The experimenter seated the subject at the table. After some preliminary discussion to make the subject feel at ease, she placed the pre-drawn figure shown in Figure 8.3 on the table directly in front of the subject. The three pre-drawn response cards were then placed in a row directly beneath this figure. Then the experimenter said:- "Here is a shape (experimenter pointed at the figure). Now if you were going to draw a picture of the shape...this bit here (experimenter pointed to the shape only) and you were going to draw the shape exactly as it looks from where you are sitting, which of these three pictures would your shape look like (experimenter pointed at the pre-drawn pictures, taking care not to point at any one particular picture)?"

Results.

The results based on the scoring systems described in Experiment 5, were as follows:-

All the adult and adolescent subjects drew correct representations in all 5 tasks. This finding was consistent across both scoring systems. All the adult all the adolescent subjects also chose the correct 'converging' representation in all 5 tasks.

All the children drew correct representations in tasks 2-5. This finding was consistent across both scoring systems. In addition to this all the children also chose the correct 'converging' representation in tasks 2-4.

In task 1 (the photograph task) according to the Actual Measurement scoring system detailed in Experiment 5, 18 children drew correct 'converging' representations whilst 2 children drew incorrect representations (Binomial Test : $p < 0.001$). All possible combinations of 2x2 Fisher's Exact tests were run on the children's responses across all the drawing tasks (tasks 1-5) and the results revealed that there was no evidence of an association between task type and the type of representation produced (correct versus incorrect).

As noted previously, there were no differences in the responses of the adults, adolescents and children in tasks 2-5. One should also note that a series of 2x2 Fisher's Exact tests run on the Adult task 1 (photograph) responses versus Children task 1 (photograph) responses and the Adolescent task 1 (photograph) responses versus Children task 1 (photograph) responses revealed no evidence of an association between age and response type.

According to the Rating of Intent scoring system detailed in Experiment 5, however, only 14 children drew correct representations; the remaining 6 drawings were rated as incorrect representations (Binomial Test: N.S.). A series of Fisher's Exact tests for association run on the data from the subjects in task 1 versus task 2, task 1 versus task 3, task 1 versus task 4 and task 1 versus task 5 revealed evidence of an association between the task type and the type of representation produced by the subjects: the subjects in tasks 2-5 produced significantly more correct converging responses than the subjects in task 1 (Fisher's Exact: $p = 0.0202$). All other combinations of 2x2 Fisher's Exact tests revealed no evidence of an association between task type versus response type.

As noted previously, there were no differences in the responses of the adults, adolescents and children in tasks 2-5. One should note, however, that a 2x2 Fisher's Exact test run on the Adult task 1 (photograph) responses versus Children task 1 responses revealed evidence of an association between the type of representation produced by the subjects and age: the adults produced significantly more correct converging responses than the children (Fisher's Exact: $p = 0.0202$). A 2x2 Fisher's Exact test run on the Adolescent task 1 (photograph) responses and the Children task 1 (photograph responses) also revealed evidence of an association between the type of representation produced and and age: the adolescents produced significantly more correct converging responses than the children (Fisher's Exact: $p = 0.0202$).

When the children were asked to select a pre-drawn response card to show how they would draw a picture of the photograph used in task 1, 12 children correctly selected the 'converging oblique' response card whilst the other 8 incorrectly selected the parallel response card (Binomial Test: N.S.). A series of Fisher's Exact tests for association run on the data from the subjects in task 1 versus task 2, task 1 versus task 3, task 1 versus task 4 and task 1 versus task 5 revealed evidence of an association between the task type and the type of representation produced by the subjects: the subjects in tasks 2-5 chose significantly more correct 'converging' responses than the subjects in task 1 (Fisher's Exact: $p = 0.0032$). All other combination of Fisher's Exact tests revealed no evidence of an association between task type versus response type.

As noted previously, there were no differences in the responses of the adults, adolescents and children in tasks 2-5. One should note, however, that a 2x2 Fisher's Exact test run on the Adult task 1 (photograph) responses versus the Children task 1 (photograph) responses revealed evidence of an association between the type of representation chosen by the subjects and age: the adults chose significantly more correct converging responses than the children (Fisher's Exact: $p = 0.0032$). A 2x2 Fisher's Exact test run on the Adolescent task 1 (photograph) responses and the Children task 1 (photograph) responses also revealed evidence of an association between the type of representation chosen and age: the adolescents chose significantly more correct converging responses than the children (Fisher's Exact: $p = 0.0032$).

Discussion

The results revealed that all the adult and all the adolescent subjects both drew and selected correct converging oblique forms in all five tasks, a finding which was consistent across both scoring systems. The prediction that the adults and the adolescents would not be affected by the differential naming of the stimuli in tasks 2 - 5 was thus supported.

All the children were seen to draw and select correct converging oblique forms in tasks 2-5, a finding which was also consistent across both scoring systems. These results demonstrate that children experience no difficulty either drawing or selecting from two-dimensional line drawings of a road, be they shaded or otherwise. They also indicate that the children's knowledge of what the line reductions were supposed to represent had no effect on their subsequent responses; that is, converging oblique solutions were both produced and selected, irrespective or whether the line reductions were called shapes or roads. This finding is contrary to those of Phillips, Hobbs and Pratt (1978) and Cox (1989) which are detailed in the Introduction. One possible explanation for this apparent contradiction, is that in this particular experiment the children may not have associated the stimulus to be drawn with the label 'road': one child who had been asked to depict the line drawing insisted he was drawing a 'broken triangle' even though the line drawing was clearly referred to as a road by the experimenter.

According to the Actual Measurement scoring system, in task number 1 (the photograph task) 18/20 children produced correct converging representations. This would seem to suggest that when asked to copy from a photograph, virtually all the children were able to produce visually realistic representations which included converging oblique "depth" lines in order to capture the appearance of the model. This is, however, misleading for when the judges were asked to rate what they thought each child had intended to depict, only 14 of the original 18 representations were rated as 'intending to converge'. Given this, it would appear that whilst some children do in fact draw representations which correctly include converging obliques, the number that do so is not significantly different from the number that do not. A similar pattern of results was found in the selection task, where the number'of children selecting correct converging solutions did not differ significantly from the number selecting incorrect parallel solutions. Whilst the results of Experiment 9 demonstrate that children fail to produce visually realistic representations when asked to draw and select representations of an actual road, the results of Experiment 10 demonstrate that many children experience difficulty drawing a visually realistic representation of a photograph of the same road. It may well be the case, then, that some children not only experience problems in translating the depth information onto the picture place but that they also experience problems in transforming boundaries to lines: a problem which is eradicated when the graphic solution is made more apparent in a line drawing. It could also be the case, however, that some children simply did not <u>notice</u> and/or did not <u>realise</u> that they had to represent the apparent convergence of the road in the photograph. Alternatively, the children may have deliberately drawn a rectangular form in an attempt to depict the construction of the road shown in the photograph, or their knowledge of roads may have interfered with or prevented their attempts at drawing a perspective view. It is highly unlikely that difficulty in producing obliques mitigated against a perspective view: all the children who were asked to draw 'converging oblique' line reductions of this photograph (the shape and the line drawing) were able to do so.

The results of this experiment led the experimenter to contemplate whether one could facilitate children's production of visually realistic representations of a photograph of a road, by making the effect of apparent convergence even more pronounced. Experiment 11 was designed to investigate this issue.

Experiment Eleven

Drawing from Two-Dimensional Models (2)

Introduction

The results of the previous study revealed that not all the children who were asked to draw the photograph shown in Figure 7.1, were able to produce a visually realistic representation of the road. Given this, Experiment 11 was designed to ascertain how children (and adult and adolescent subjects) respond when asked to draw (and select) from a photograph of a road in which the apparent convergence of the side edges is even more pronounced than in the photograph used in the previous study (see Figure 8.4). Are children able to produce visually realistic representations of this road?

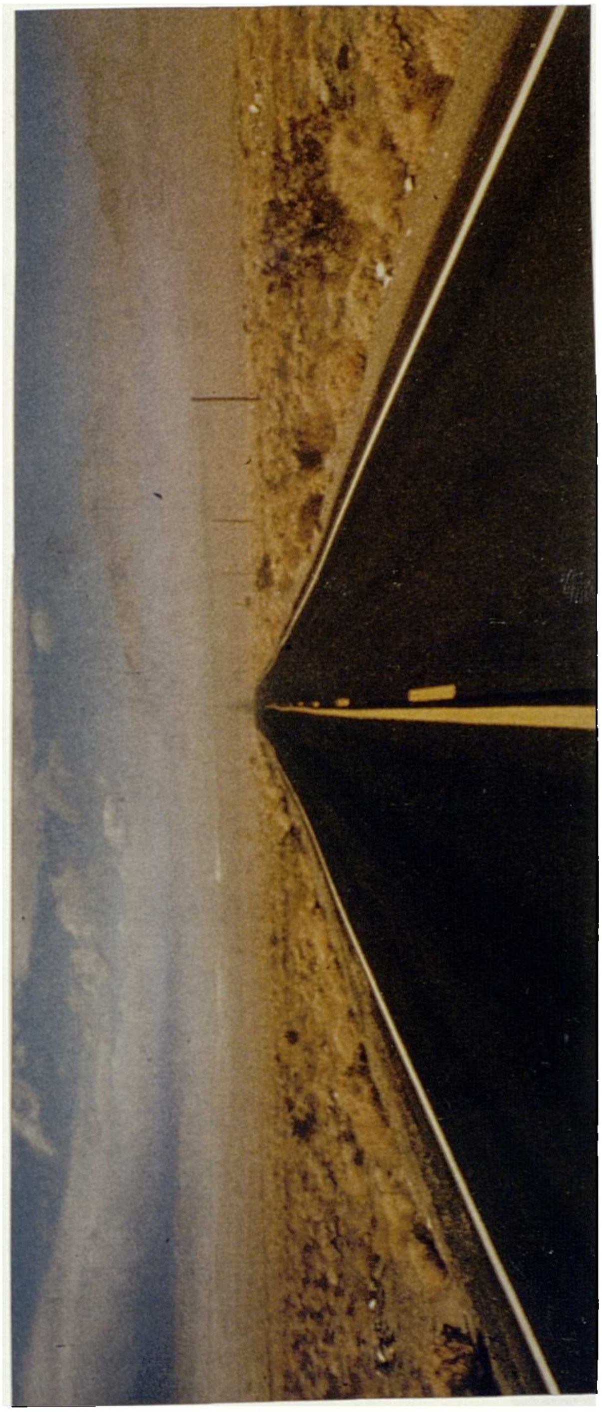


Figure 8.4: The Photograph Used in this Experiment.

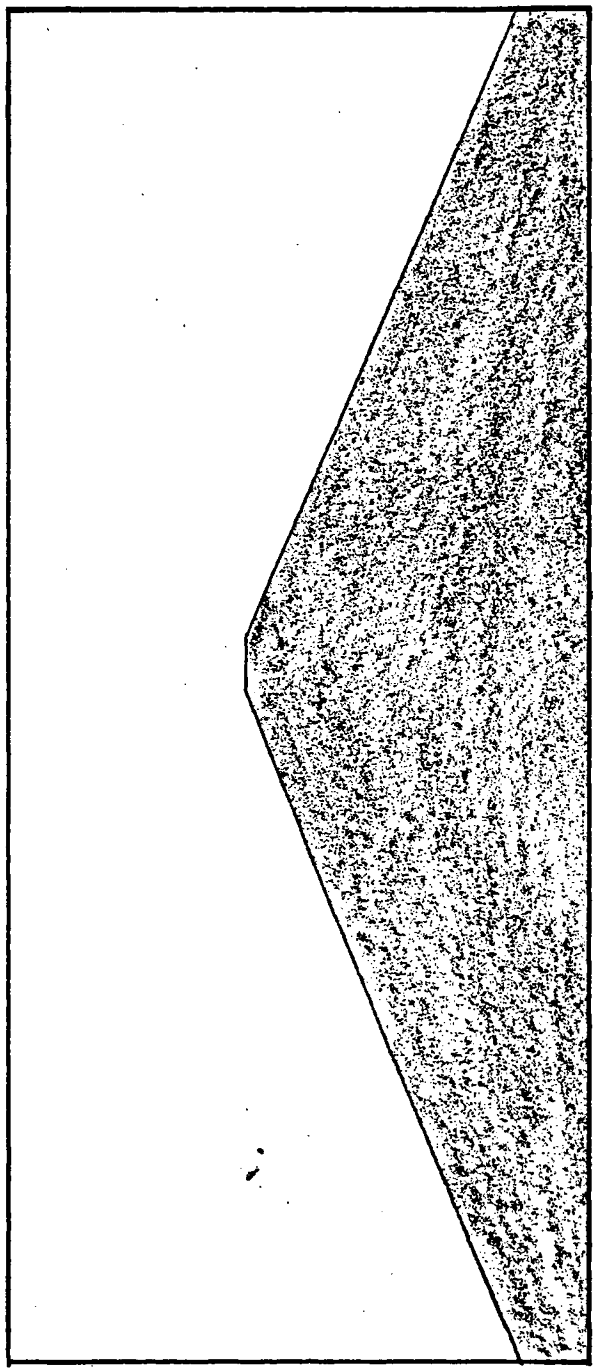


Figure 8.5: The Shape.

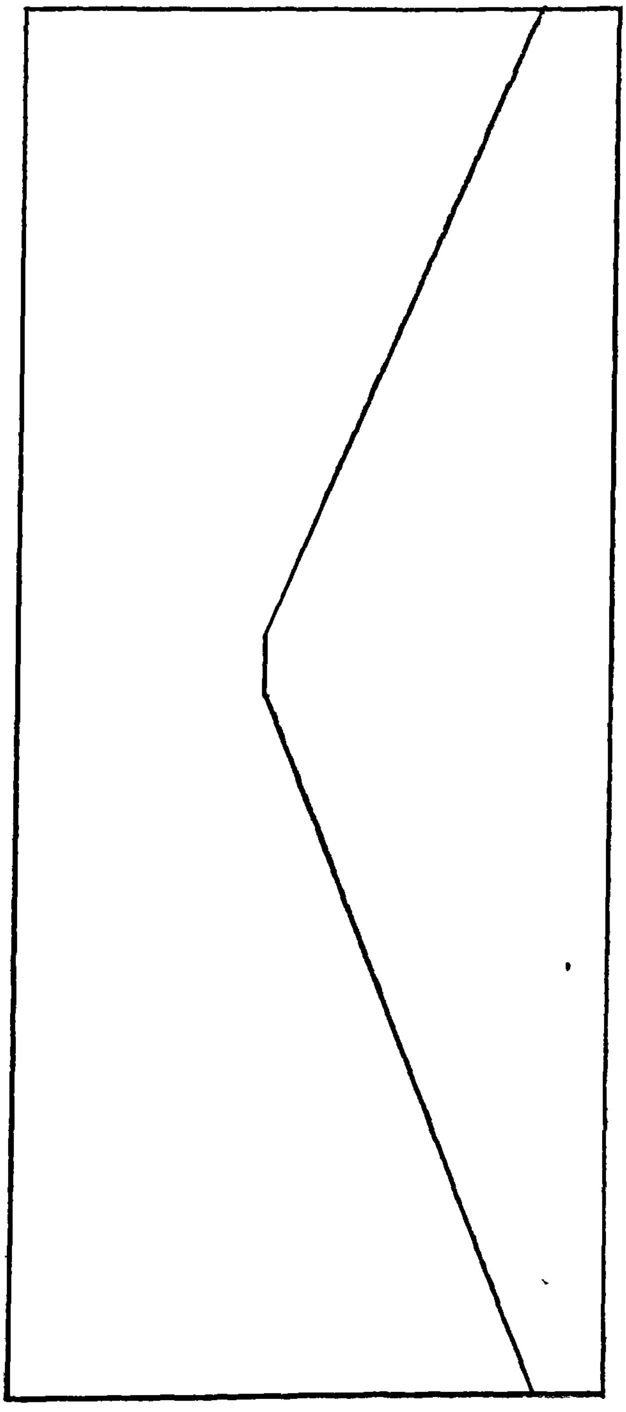


Figure 8.6 The Line Drawing.

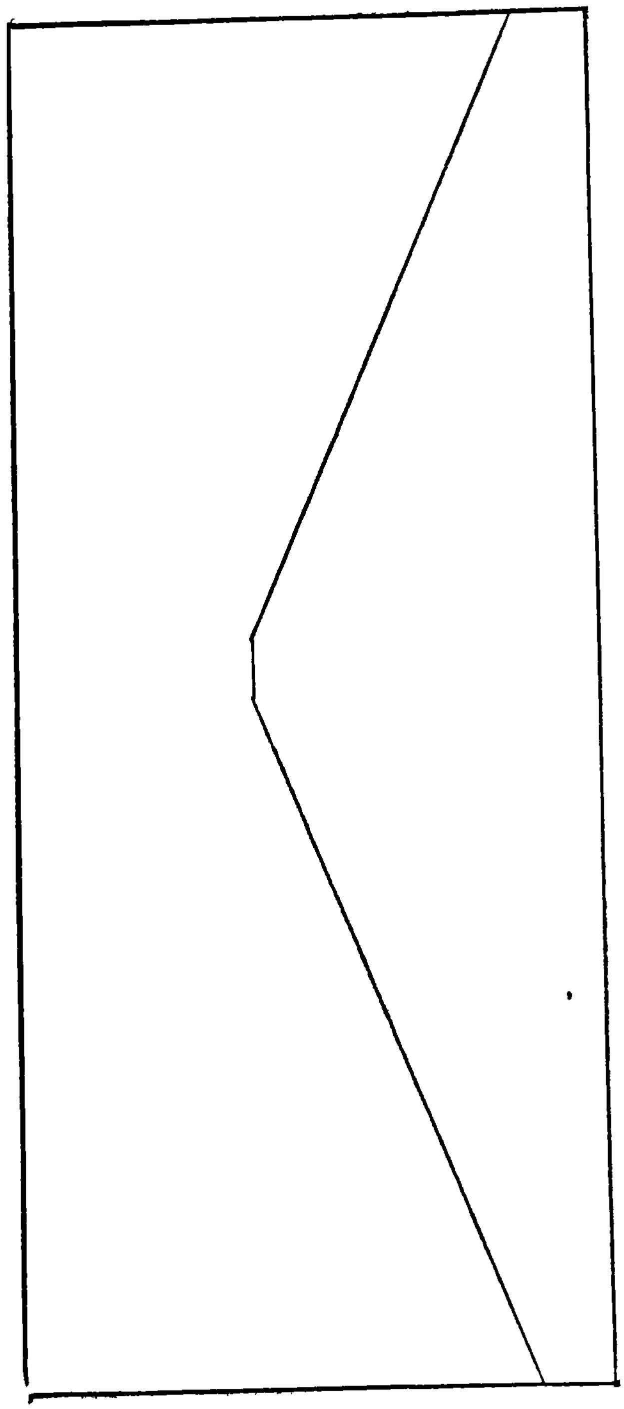


Figure 8.7(a):The Converging Oblique Alternative in the Selection Task.

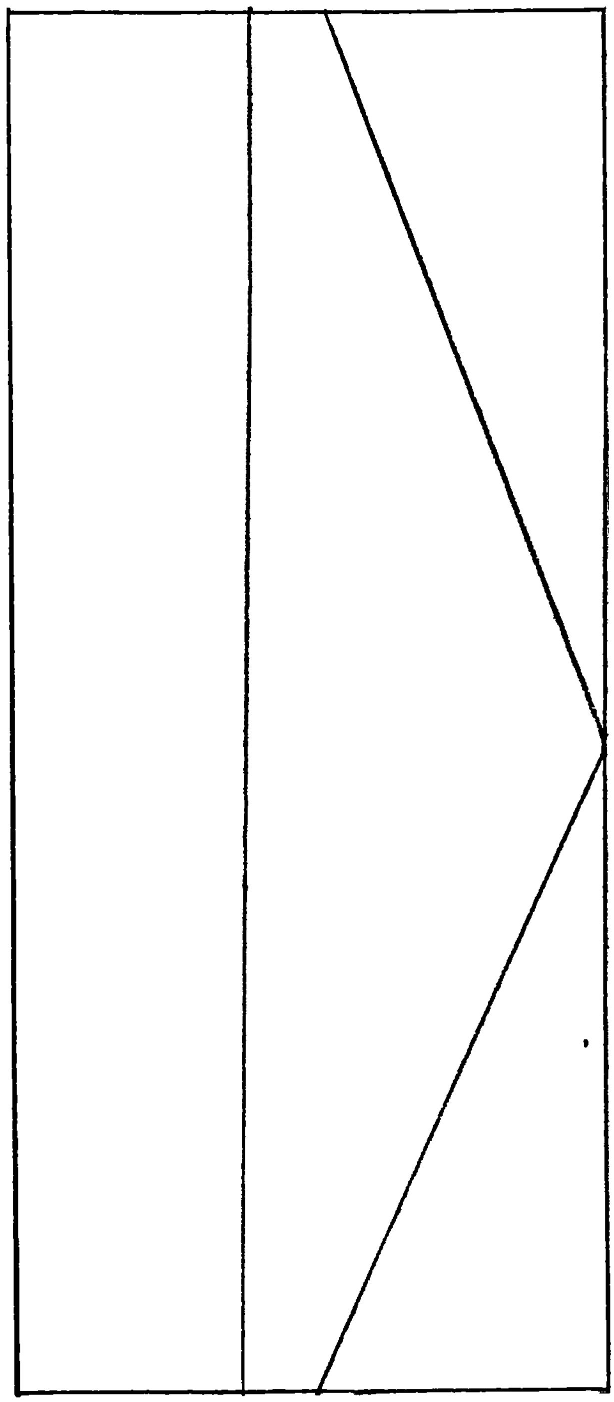


Figure 8.7(b):The Diverging Oblique Alternative in the Selection Task.

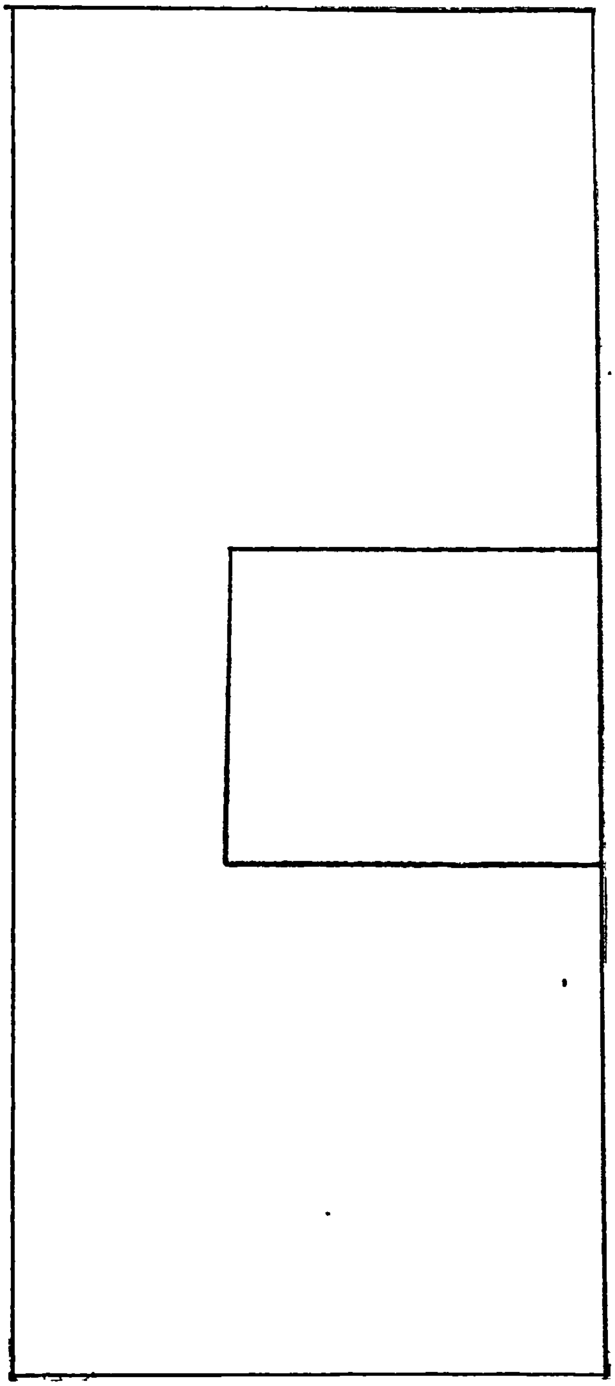


Figure 8.7(c):The Rectangular Alternative in the Selection Task.

The methodology employed in this study is identical to that used in the previous experiment. As in the previous study, two other stimuli were line reductions of the photograph: one of the reductions was shaded and was referred to as the shape (see figure 8.5), the other was unshaded and was referred to as the line drawing (see Figure 8.6). As in the previous study, by presenting the shape in two tasks, calling it a 'shape' in one task and a 'road' in the other (and by repeating this procedure with the line drawing), the experimenter sought to determine whether the subject's knowledge of what the line reductions were supposed to represent influenced how they subsequently depicted them.

Method

Subjects.

Subjects were 75 adults aged between 18:5 and 25:3 years (Mean Age = 21:6), 75 adolescents aged between 11:10 and 12:10 years (Mean Age = 12:6) and 75 children aged between 6:6 and 7:11 years (Mean Age = 7:5). There were roughly equal numbers of males and females in each age group.

Materials.

A4 size paper and pencils were provided for drawing. The A4 paper was orientated as shown in Figure 2.2. A photograph (see Figure 8.4) and two pre-drawn figures (see Figures 8.5 and 8.6) were used as stimuli in both the drawing and the selection tasks. Three pre-drawn response cards were provided as alternative choices in the selection tasks only [see Figure 8.7 (a), (b) & (c)].

Procedure.

Each subject was tested individually in a separate room. The subject and the experimenter sat side by side at a table. Each subject was asked to complete one drawing and one selection task. Half the subjects in each age group completed the drawing task first and the selection task second, whilst the other half completed the selection task first and the drawing task second. Each task was completed on a different day. 15 subjects in each age group performed the photograph drawing and selection task, 15 subjects in each age group performed the shape called a road drawing and selection task, 15 subjects in each age group performed the shape called a shape drawing and selection task, 15 subjects in each age group performed the line drawing called a road drawing and selection task, and 15 subjects in each age group performed the line drawing called a shape drawing and selection task.

Drawing Task. Each subject was asked to perform one of the following drawing tasks.

(1) Photograph Task.

The photograph shown in Figure 8.4 was used as the model in this task. The procedure and instructions used were identical to those detailed in the photograph task in the previous experiment.

(2) Shape called a Road Task.

The shape shown in Figure 8.5 was used as the model in this task. The procedure and instructions used were identical to those detailed in the shape called a road task in the previous experiment.

(3) Shape called a Shape Task.

The shape shown in Figure 8.5 was used as the model in this task. The procedure and instructions used were identical to those detailed in the shape called a shape task in the previous experiment.

(4) Line Drawing called a Road Task.

The line drawing shown in Figure 8.6 was used as the model in this task. The procedure and instructions used were identical to those detailed in the line drawing called a road task in the previous experiment.

(5) Line Drawing called a Shape Task.

The line drawing shown in Figure 8.6 was used as the model in this task. The procedure and instructions used were identical to those detailed in the line drawing called a shape task in the previous experiment.

Selection Task. Each subject was also asked to select, from three pre-drawn response cards [see Figure 8.7 (a), (b) & (c)] a picture of the stimulus s/he was required to depict in the drawing task. The procedure was the same as that employed in the drawing task except for the mode of response. Instead of asking the subjects to make a drawing, three response cards were placed in a row in front of the subject (the order in which these were laid out was randomised for each subject) and s/he was asked to choose a picture from this set of alternatives. The instructions given to the subjects in each task were the same as those detailed for the equivalent task in the previous experiment.

Results.

The results based on the scoring systems described in Experiment 5, were as follows.

Adult and Adolescent Subjects.

All the adult and adolescent subjects drew correct representations in all 5 tasks. This finding was consistent across both scoring systems. All the adult all the adolescent subjects also chose the correct 'converging' representation in all 5 tasks.

Child Subjects.

All the child subjects drew correct converging oblique forms in all 5 tasks. This finding was consistent across both scoring systems. The results from the selection task revealed that all the children also selected the correct converging oblique form in tasks 2-5. When the children were asked to select a pre-drawn response card to show how they would draw a picture of the photograph used in task 1, 12 children correctly selected the 'converging oblique' response card whilst the other 3 incorrectly selected the parallel response card (Binomial Test: $p = 0.036$). All possible combinations of 2x2 Fisher's Exact tests were run on the children's responses across all the selection tasks (tasks 1-5) and the results revealed that there was no evidence of an association between task type and the type of representation selected (correct versus incorrect).

As noted previously, there were no differences in the responses of the adults, adolescents and children in selection tasks 2-5. One should also note that a series of 2x2 Fisher's Exact tests run on the Adult task 1 (photograph) responses versus the Children task 1 (photograph) responses and the Adolescent task 1 (photograph) responses and the Children task 1 (photograph) responses also revealed no evidence of an association between the type of representation chosen and age.

Discussion.

The results revealed that all the adult and all the adolescent subjects both selected and drew correct converging oblique forms in all five tasks. The drawing tasks findings were consistent across both drawing task scoring systems. All the children were seen to select and draw correct converging oblique forms in tasks 2-5. Again, the drawing task findings were consistent across both drawing task scoring systems. These findings replicate those detailed in the previous experiment.

Such results indicate that the children experience no difficulty either drawing or selecting from two-dimensional line drawings of a road, be they shaded or otherwise. They also indicate that the children's knowledge of what the line reductions were supposed to represent had no effect on their subsequent responses, i.e. converging oblique solutions were both produced and selected, irrespective of whether the line reductions were called shapes or roads. This finding is contrary to those of Phillips, Hobbs and Pratt (1978) and Cox (1989) which are detailed in the previous experiment. One possible explanation for this apparent contradiction is that the children may not have associated the shape to be drawn with the label 'road'.

Some support for this notion comes from the anecdotal evidence of six children. Three children, who had not previously taken part in the experiment, were shown the line drawing (see Figure 8.6) and were asked what it represented. All three replied that it was a triangle with the point missing or snapped off. Similar responses were obtained from another three children who were shown the shape (see Figure 8.5) and asked the same question. One of these children did, however, add that the shape could be either a triangle or a roof. The experimenter then asked the first three children if the line drawing could be a drawing of a road. One child simply said "No", another said "Yes, a long one" and the third said "I don't know". Similar results were obtained from the second group who were shown the shape. These responses suggest that some children may not associate either the line drawing or the shape with the label 'road'. To some children the representation may quite simply be 'triangles'.

In the photograph task all the children drew correct converging oblique representations, a finding which was consistent across both drawing task scoring systems. Thus, when asked to copy from the photograph shown in Figure 8.4, all the children were able to produce visually realistic representations, namely, representations which correctly included converging oblique 'depth' lines in order to capture the appearance of the model. This contrasts with the results of the previous study, where the number of children producing visually realistic representations of the photograph shown in Figure 7.1 was not significantly different from the number of children producing visually unrealistic representations. It may well be the case that the presence of the solid white lines down the side edges of the road and/or this more pronounced illustration of apparent convergence enabled the children successfully to translate the boundaries (side edges) of the receding road into lines in order to produce a visually realistic representation. It could also be the case, however, that the sharper angle of convergence in this photograph results in more children noticing the effect and subsequently representing it in their drawings and/or it results in more children realising that it is the apparent convergence they are supposed to be representing.

It is interesting to note that in the photograph selection task, three of the fifteen children appeared confused by the task. They actually claimed not to know which of the two oblique forms to choose. It was only after much deliberation, that they finally opted for the 'diverging oblique' form shown in Figure 8.7 (b). One possible explanation for this behaviour is that the children did not understand why the experimenter was asking them to perform a second task. Each of the three children who experienced difficulty in selecting a representation had previously produced a correct depiction when asked to make a drawing of the road in the photograph. It is possible that the children thought that they had somehow got the task 'wrong' previously, and that this selection task was a chance for them to 'correct' their 'error'. Alternatively, the inclusion of a second task may in itself have suggested that a new response was required. Previous work by Blank (1973) and Rose and Blank (1974) would support such an interpretation.

CHAPTER NINE.

Summary and Conclusion.

Previous research (see literature review and Experiment 5) has revealed that when presented with an actual model, adults, adolescents and children have difficulty in producing visually realistic representations of simple solid three-dimensional objects such as cubes and tables. Why should this be so?

One could possibly invoke the Piagetian notion of conceptual immaturity to account for the responses of the young children. That is to say one could argue that the young children fail to produce visually realistic representations, as they have not yet developed concepts of projective and Euclidean space. It is, however, clearly evident that adults and adolescents, who should, according to Piaget have an understanding of projective and Euclidean space, also fail to produce visually realistic representations of objects such as cubes and tables. One must therefore consider the possibility that the young child's rectilinear representations of simple solid objects do not reflect an inability to represent a within-object depth relationship, rather they represent an artifact of the complex objects the children have been asked to draw. Furthermore, one could also argue that it is the stimulus complexity which results in adults and adolescents failing to depict the projective aspects of a scene. For, whilst a cube and a table are supposed to represent simple three-dimensional solid objects, they are in fact quite difficult objects to draw. In order to draw a cube 'in depth' (Cox, 1986b), the subject must represent two visible surfaces (the front and the top); in addition to this s/he must also depict these surfaces in a united configuration. Likewise, when drawing a table (Lee and Bremner, 1987), the subject must represent the table top correctly, as well as depicting and positioning the legs correctly. How, then, would subjects respond if they were asked to depict a less complex three-dimensional object?

Experiment 5 addressed this question and investigated whether adults, adolescents and children would in fact be able to produce visually realistic representations if asked to draw a very simple three-dimensional object: a model road. It was predicted that the simple nature of both the model and its depiction, would lead subjects of all ages to produce correct 'convergence' perspective representations of the experimental array. This prediction was not supported. The results from the Actual Measurement scoring system revealed that the children produced significantly more incorrect than correct (visually realistic) responses and that there was no significant difference between the number of correct and the number of incorrect representations produced by either the adult or the adolescent subjects. Moreover, the results from the Rating of Intent scoring system revealed that subjects, of all ages, overwhelmingly produced representations which were rated as incorrect. How, then, could one facilitate the production of visually realistic representations of the model road?

One possible method would be to alter the length of the model road. Since the model used in Experiment 5 was only 30cm long, the effect of apparent convergence may have been too slight to have been noticed let alone represented by the subjects. In Experiment 6, groups of adults, adolescents and children were asked to draw a longer model road (60cm in length). The responses of the subjects in these three age groups were compared with the responses of corresponding groups of adults, adolescents and children who had been asked to draw the short (30cm) road used in Experiment 5. It was predicted that the effect of apparent convergence in the longer (60cm) model would be more noticeable than in the shorter model and that this in turn would lead subjects of all ages in the 'long road' condition to produce more 'converging perspective' responses than those in the 'short road' condition. This prediction was not supported. The result, based on the Actual Measurement scoring system revealed that there was no significant difference between the responses of subjects in the short and long road conditions; in both these cases approximately half the subjects produced correct converging representations whilst approximately half produced incorrect representations. The results of the Rating of Intent scoring system also revealed no significant difference in the responses of the subjects in the two road conditions; the responses of subjects of all ages in both drawing tasks were overwhelmingly rating as 'incorrect'. Clearly, then, the actual convergence of the lines on the page as measured by the Actual Measurement scoring system, was on the whole slight, with the lines representing 'failed parallels' as opposed to intended solutions. Why is it, then, that even with a longer model, adults, adolescents, and children failed to produce visually realistic representations of the model road? One possible explanation is that the effect of apparent convergence of the side edges of the model road is not readily apparent when the road is placed on the table in front of the subjects. How would the subjects respond if their vantage point was altered such that the convergence of the side edges of the road was made more readily apparent? Experiment 7 was designed to address this issue.

In Experiment 7, the experimenter asked groups of adults, adolescents and children to draw the longer model (60cm) road when it had been raised up on a cardboard platform to just below eye-level, a vantage point from which the effect of apparent convergence is enhanced. The responses of the subjects in this condition were compared with the responses of subjects in a separate condition who were asked to draw the model when it had been placed on the table top. It was predicted that subjects of all ages would produce more visually realistic 'converging' perspective representations of the model when it was raised up on the platform than when it was placed on the table top. This prediction was not supported. The results, based on the Actual Measurement scoring system, revealed that there was no significant difference between the responses of the subjects in the table top and raised road conditions: half the subjects produced correct converging representations whilst approximately half produced incorrect representations. The results of the Rating of Intent scoring system also revealed no significant difference in the two road conditions: the responses of subjects of all ages in both drawing tasks, were overwhelmingly rating as 'incorrect'. Clearly, the actual convergence or divergence of the line on the page as measured by the Actual Measurement scoring system is on the whole slight with the lines representing 'failed parallels' as opposed to intended solutions. Why is it, then, that the subjects still fail to produce visually realistic representations of the model road?

It may be that the subjects failed to realise that the main purpose of the task was the representation of the effect of apparent convergence of the side edges of the model. So, how would the subjects respond if the verbal instructions were altered to make the purpose of the task more salient? Experiment 8 was designed to address this issue.

In Experiment 8, the experimenter altered the instructions to include a reference to the fact that the subjects should actually be representing the way in which the side edges of the road appear to converge into the distance. The responses of those subjects who received these more explicit instructions were compared with the responses of those subjects who received the standard instructions used in the preceding experiments. On the basis of past research (Barrett and Bridson, 1983) it was predicted that the more explicit instructions would lead subjects of all ages to produce visually realistic representations of the model road. This prediction was not supported. The results, based on the Actual Measurement scoring system, revealed that there was no significant difference between the responses of the subjects in the standard and explicit instruction conditions: in both these cases approximately half the subjects produced correct converging representations whilst approximately half produced incorrect representations. The results of the Rating of Intent scoring system also revealed no significant difference in the two road conditions: the responses of subjects of all ages in both drawing tasks were overwhelmingly rated as incorrect. Clearly, the actual convergence of the lines on the page as measured by the Actual Measurement scoring system, is on the whole slight with the lines representing 'failed parallels' as opposed to intended solutions. Why it is, then, that the adults, adolescents and children alike, persist in producing rectilinear representations of the experimental arrays? One possible explanations is that the effect of apparent convergence of the model roads is so slight that it is not even noticed let alone represented by the subjects. Given this, the experimenter investigated whether the subjects would in fact be able to depict the apparent convergence of the side edges of the road if the effect was more pronounced.

In Experiment 9, the subjects were asked to draw from an <u>actual</u> 'converging' road rather than a cardboard model. In addition to asking the subject to perform a drawing task, the experimenter also asked all the subjects to perform a selection task. It was hoped that the data from such a task, where the subjects were simply asked to select a drawing from a set of alternative, would help to clarify just what the subjects had been intending to produce during the drawing task. The subjects were restricted to choosing between a converging oblique, a diverging oblique and a rectangular solution. The results revealed that when asked to draw and select a view of an actual road, all the adult and adolescent subjects drew and selected a 'perspective solution' where converging 'depth' lines represented the way in which the side edges of the road appeared to converge into the distance (this finding was consistent across both scoring systems). Clearly then, the more obvious effect of apparent convergence afforded by the actual road had resulted in more subjects actually noticing and consequently representing the effect and/or it had resulted in more subjects realising that it was that effect that they were supposed to be representing. The children's responses were, however, different. The results, based on the Actual Measurement scoring system, revealed that only two of the ten children produced correct representations, whilst the remaining eight produced incorrect representations. This description of the results is, however, quite misleading. The actual convergence of the lines on the page was slight, and thus it is highly likely that these representations were 'failed parallels' rather than 'intended solutions'. This notion is supported by two sets of evidence:- (1) all the children chose the parallel response card in the selection task, and (2) all three judges rated all ten drawings as 'incorrect'. Given the results of the selection task and the nature of the drawings themselves this experiment revealed that even when the effect of apparent convergence was quite pronounced, as in the case of a real road, young children did not draw or select representations which depict this effect. Clearly, then, whilst the experimenter succeeded in designing a task which would lead adults and adolescents to produce visually realistic representations of a simple three-dimensional model, she did not succeed in her attempt to facilitate the production of visually realistic representations by young children. Why is it that the children fail to produce 'converging perspective' representations, even when the effect of apparent convergence is pronounced, as in the case of an actual road? Well, one could actually invoke the Piagetian notion of conceptual immaturity to explain the young children's failure to represent the projective aspects of the scene, that is that the children have simply not yet developed concepts of projective and Euclidean space (Piaget and Inhelder, 1956, 1969). This explanation, however, is too broad: young children demonstrably can represent some projective aspects of a scene (e.g. the partial occlusion of one ball by another) even though they have difficulty with representing the apparent convergence of the parallel edges of the road. Thus, there is no abrupt, stage-like shift from a complete inability to represent any projective relationship to an ability to represent all projective aspects of a scene. Clearly, some projective aspects are easier to depict than others.

The depiction of partial occlusion may be easier than that of convergence because young children can more readily appreciate what they have to do. In the case of partial occlusion, children simply have to omit the part of the farther object which is hidden from their view; apart from that, they are not required to alter the shape of their normal depiction of the object. In the case of convergence, in contrast, children are required to alter the actual shape of the entire object, i.e. they have to change a rectangle into a trapezium. There are various possible explanations for their difficulty with this second task. One is that the children simply do not notice the apparent convergence of the parallel edges in the scene (Piaget and Inhelder, 1956) and are forced to draw the actual shape of objects such as the road. Another possibility is that they are aware of the apparent convergence but do not depict it because they cannot draw converging obliques, or because they do not realise that they are being asked to draw the projective as opposed to the actual shape of the object, or because they deliberately choose to draw parallel lines in order to show that roads actually do have parallel edges; an explanation akin to the ideas of Luquet (1913, 1927; Costall, 1989).

Having established that children do not produce visually realistic representations when asked to draw from an actual three-dimensional road, the experimenter began to contemplate how children would respond when asked to draw from various two-dimensional models of the same scene. Does the children's difficulty in representing a within-object depth relationship solely reflect problems of projection or does it also reflect problems of denotation:

namely which parts of the model they should transform into contours? Whilst the presentation of a photograph would presumably solve some of the projective problems encountered by children attempting to draw a road, it would still leave the problem of denotation. A line drawing derived from a tracing of the contours on the photograph would, however, demonstrate the solution to both problems. Experiment 10 was designed to compare children's responses to these different modes of representation. Thus, adults, adolescents and children were asked to draw (and select) pictures of a photograph, or a shaded or unshaded line drawing of the actual road.

The results of Experiment 10 revealed that adults, adolescents and children experienced no difficulty either in drawing or selecting visually realistic representations from two-dimensional line drawings of a road, be they shaded or otherwise: this would imply that one cannot account for the findings of Experiment 9 in terms of difficulty in producing obliques. The results also indicated that the subject's knowledge of what the line reductions were supposed to represent (a shape or a road) had no effect on their subsequent responses; that is, converging oblique solutions were produced irrespective of whether the line reductions were called shapes or roads. When the children were asked to draw a photograph of the road 14/20 representations were rated by the judges as 'correct': thus, whilst some children do in fact draw representations which include converging obliques, the number that do so is not significantly different from the number that do not. A similar pattern of results was found in the selection task: the number of children selecting 'converging' oblique solutions did not differ significantly from the number who did not. Adults and adolescents, however, overwhelmingly selected and produced visually realistic representations of the photograph. So, whilst the results of Experiment 9 revealed that children did not produce visually realistic representations of an actual road, the results of Experiment 10 demonstrate that many children experience difficulty drawing from a photograph of the same road. It could be the case that some children actually experience problems of 'denotation' that is to say they may have problems translating the side edges of the road, as shown in the photograph, into lines: a problem which is eradicated when the graphic solution is made more apparent in a line drawing. It could also be the case, however, that some children simply did not notice and/or realise that they had to represent the apparent convergence of the road in the photograph. Alternatively, the children may have deliberately drawn a rectangular form in an attempt to depict the construction of the road shown in the photograph, or their knowledge of roads may have interfered with or prevented their attempts at drawing a perspective view. It is highly unlikely that difficulty in producing obliques mitigated against a perspective view: all the children who were asked to draw 'converging oblique' line reductions of the photograph (the shape and the line drawing) were able to do so. The results of Experiment 10 led the experimenter to contemplate one could facilitate the production of visually realistic representations of a photograph of a road by children, if the effect of apparent convergence was even more pronounced than in the photograph used in this experiment. Experiment 11 was designed to investigate this issue.

Experiment 11 was designed to ascertain how children (and adults and adolescents) respond when asked to draw and select from a photograph of a road in which the apparent convergence of the side edges is even more pronounced than in the photograph used in Experiment 10. The methodology employed in Experiment 11 was identical to that used in Experiment 10. As in Experiment 10 two other stimuli were used, these being line reductions of the photograph: one of the reductions was shaded whilst the other was unshaded. The results revealed that adults, adolescents and children experienced no difficulty either in drawing or selecting visually realistic representations from two-dimensional line drawings of the road, be they shaded or otherwise. The results also indicated that the subject's knowledge of what the line reductions were supposed to represent (a shape or a road) had no effect of their subsequent responses; that is, converging oblique solutions were produced irrespective of whether the line reductions were called shapes or roads. When asked to draw a picture of the photograph, all the adults, all the adolescents and all the children drew visually realistic converging oblique representations: a finding which was consistent across both drawing tasks scoring systems. Thus when asked to draw the photograph used in Experiment 11, all the children were able to produce (and 12/15 were able to select) visually realistic representations which included 'converging oblique' 'depth' lines. This contrasts with the results of Experiment 10, where the number of children producing visually realistic representations of the photograph was not significantly different from the number of children producing visually unrealistic representations. It may well be the case that the presence of solid white lines down the side edges of the road and /or this more pronounced illustration of apparent convergence enabled the children successfully to translate the side edges of the receding road into lines in order to produce a visually realistic representation. It could also be the case, however, that the sharper angle of convergence in this photograph resulted in more children <u>noticing</u> the effect and subsequently representing it in their drawings and/or it resulted in more children <u>realising</u> that it was the apparent convergence they were supposed to be representing. Further work is needed to resolve this issue. Further research should consider whether children would be able to represent the effect of apparent convergence of a very sharply converging actual road (such as the one shown on the photograph used in Experiment 11). One should also investigate whether more explicit instructions regarding the representation of the 'convergence' of an actual road would lead more children to depict the effect of apparent convergence in their drawings.

CHAPTER TEN

An Overview

As noted in Chapter One, perhaps the most commonly used 'adult' solution to the problem of representing the three-dimensional world on the two-dimensional surface of the page is the system of linear perspective. This system essentially involves producing a view-specific or visually realistic representation by depicting the projective image of a scene from a particular fixed point of view. More specifically, however, the projective portrayal of depth is achieved mainly by the use of two drawing devices: the partial occlusion technique and perspective 'depth' lines (Langer-Küttner, 1990). It is important to note that each of these devices is used to denote a particular type of depth relationship. The partial occlusion technique, for example, is used to indicate that from the observer's viewpoint part of an object is obscured by one that is nearer; it is thus a technique for depicting between-object depth relationships. In contrast to this, perspective 'depth lines' are employed ostensibly to depict within-object depth relations, and are used predominantly to represent the three-dimensionality of a single object. These, then, are the two important conventions used by adults. How do children deal with the problem of representing depth in their drawings? Are they able to, or can they be induced to, use these same adult conventions? These were the questions which motivated the empirical work detailed in this thesis.

A review of the literature revealed a wealth of research relating to the representation of depth in children's drawings. One notable characteristic of this work is that the studies tend, on the whole, to address themselves either to how children represent between-object depth relationships or to how they represent within-object depth relationships. Very seldom is the use of the partial occlusion device considered alongside the use of perspective 'depth' lines (one exception to this being Willats, 1977). This characteristic undoubtedly reflects the general concern that if one were to study the use of the two types of drawing device together in the same task, one would be unable to guarantee that the use of one device had not exerted an undue influence over how the other was subsequently employed (Freeman, 1980). For research purposes then it is preferable that each drawing device is studied in isolation. So, given that it was the experimenter's intention to investigate how the young child portrays depth generally in her/his drawings she focused on young children's use of partial occlusion to represent between-object depth relations, and then, separately on their use of perspective depth lines to represent within-object depth relations.

The work reported in the opening chapters, considered whether children use, or can be induced to use, the partial occlusion drawing device. The work detailed in the literature review revealed that a general finding with young children, below about 8 years of age, is that they do not readily use the 'adult' technique of partial occlusion in order to represent a between-object depth relationship. Instead they tend to depict two complete and separate objects positioned one above the other on the page. This tendency is especially marked when they are asked to draw a scene comprising two similar or identical objects. Only when the importance of the relationship between the two objects is made more salient do the children actually use the partial occlusion technique to produce visually realistic representations and even then only a few studies (e.g. Barrett *et al,* 1985; Light and Simmons, 1983; Ingram, 1983) have succeeded in inducing children to use the technique to represent the between-object depth relationship between two similar or identical objects. However, the fact that one can actually identify tasks in which there has been some success in facilitating the production of partial occlusions calls into question one possible explanation for children's frequent non-use of this particular drawing device: the Piagetian explanation that, until the development of the understanding of projective and Euclidean relations at about 8 to 9 years, young children are simply <u>unable</u> to represent the projective aspects of a scene. The experimenter was particularly interested in pursuing this line of inquiry, hence the reason why the initial experiments reported in this thesis attempted to facilitate children's use of the partial occlusion drawing device to represent the between-object depth relationship between two balls. The specific rationale underpinning the design of the experiments was simple: if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the use of the partial occlusion technique. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of partial concealment more salient may serve to elicit the production of projective representations of a partial occlusion scene.

The results of this work revealed that a task in which the balls were given faces was successful in eliciting partial occlusion responses from young children. Thus the fact that, like Barrett *et al* (1985) and also Light and Simmons, (1983) and Ingram, (1983), the experimenter was able to identify a task in which children do attend to the projective as opposed to the invariant aspects of the scene effectively enabled her to rule out one of the explanations for children's non-use of partial occlusions: the Piagetian explanation (e.g. Piaget and Inhelder, 1956, 1969) that young children have not yet developed concepts of projective and Euclidean space is no longer tenable. The findings are in fact more congruent with Luquet's argument (1913, 1927; Costall, 1989) that young children are not conceptually immature and incapable of considering the projective aspects of a scene, even though they may prefer to emphasise its invariant aspects.

A review of the literature relating to the use of perspective 'depth' lines revealed that studies have typically required subjects to make a drawing of either a cube or a table. This choice of stimuli undoubtedly reflects the fact that depth is an important if not defining property of both these objects. Taken as a whole, the studies demonstrate that young children tend to depict both these objects as rectilinear forms: the table top being drawn as a rectangle, the cube being represented by a single square or a configuration of squares. Now is it the case that young children cannot use (Piaget and Inhelder, 1956, 1969) the converging 'depth lines' drawing device in order to represent the fact that these objects are solid and possess depth or is it that they do not (Luquet, 1913, 1927)? Although children tend not to produce visually realistic representations of objects like cubes and tables they may actually be capable of doing so; if this is the case then one should be able to identify the particular circumstances which would elicit the production of projectively accurate drawings. In light of this, the studies detailed in the latter part of the thesis constituted an attempt to design a task which would lead young children to produce visually realistic representations of a simple three-dimensional object. As is the case with the studies addressing children's ability to represent a between-object depth relationship, the experimenter was seeking to address the Piagetian claim that, until the development of projective and Euclidean relations at about 8-9 years, young children are are unable to represent the projective aspects of a scene. Again, the specific rationale underpinning the design of the experiments was that if the absence of view-specific information in children's drawings reflects their conceptual immaturity (Piaget and Inhelder, 1956) then no amount of task manipulation should facilitate the production of visually realistic representations. If, on the other hand, the lack of view-specific information reflects a lack of concern rather than lack of cognitive ability, then restructuring the drawing task in order to make the notion of view-specificity more salient may serve to elicit the production of projective representations of the scene. Given that older subjects, as well as younger subjects, often experience problems producing visually realistic representations of simple solid objects (e.g. Willats, 1977; Cox, 1986b; Lee and Bremner, 1987) the experimenter also investigated whether the tasks designed for use with children would facilitate the production of visually realistic representations by adults and adolescents.

The results of this work, which required subjects to draw model roads and eventually an actual road, revealed that whilst the experimenter was ultimately successful in her attempts to facilitate the production of visually realistic representations by adults and adolescents, she was not successful in her attempts to elicit similar responses from children. It may be that it is simply more difficult for children to perceive the projected shape of a road (a trapezium) than it is for them to perceive the partial occlusion of one ball by another. On the other hand, it may be that children can perceive these equally well but that the roads tasks used in the studies reported here were relatively less successful than the balls tasks in conveying the notion that it is the projective and not the invariant aspects of the scene which should be depicted. Whichever of these specific explanations is eventually supported, they both rest on the underlying assumption that young children between the ages of 6:6 and 7:6 are basically capable of seeing and representing the projective aspects of a scene even though they do not always do so. This notion, supported at least by the work detailed in the earlier part of this thesis, owes more to the theoretical framework outlined by Luquet (1913, 1927; Costall, 1989) than to the more rigid stage-like theory of Piaget (Piaget and Inhelder, 1956, 1969).

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