


THE DEVELOPMENT OF THE OBJECT CONCEPT
IN INFANCY

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I hereby declare that this thesis is my own work,
having been completed within the normal terms of reference
and of supervision in the Faculty of Social Sciences,
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ABSTRACT

Piaget first observed and described the problems which young infants have in understanding the nature of objects forty years ago. Both his description and his analysis of the development of the object concept are still widely supported today. This thesis, while accepting the Piagetian description of the behaviours involved, suggests that Piaget's account of the underlying cognitive processes is no longer tenable. Alternative theories of object concept development which have been put forward in recent years are also examined and rejected. An identity theory of object concept development is proposed and a series of six interlinked experiments presented in an attempt to provide support for this theory. On the basis of these and the many other experiments reported in the literature, it is suggested that an identity theory alone can adequately cover the variety of appropriate and inappropriate object-related behaviours seen in the first two years of life.

TABLE OF CONTENTS

	page
 <u>CHAPTER ONE : INTRODUCTION</u>	
Aim of this thesis	1
The problem of understanding the nature of objects	2
The observations and theory of Piaget - the traditional analysis of the problem	5
Piaget's description and interpretation of the six stages	10
Accounting for the six stages : preliminary reservations on Piaget's interpretation	21
A more fundamental question	28
 <u>CHAPTER TWO : A FUNDAMENTAL QUESTION : IS THERE A DEVELOPING OBJECT CONCEPT?</u>	
Are the behaviours of the six stages linked to a single, underlying concept?	30
The acceleration paradigm	31
Experiment 1 (Acceleration Study I)	33
Are the six stages truly related?	42
Is development stage-like?	44
The dynamics of development	45
 <u>CHAPTER THREE : ALTERNATIVES TO THE TRADITIONAL ANALYSIS OF THE PROBLEM</u>	
Reasons for rejecting the traditional analysis	49
Imitation and intentional behaviour	53
The perceptual constancies and behaviour towards unseen parts of objects	55
Possible alternatives to the traditional analysis	59
1. Intersensory co-ordination explanations	61
Acceleration studies	64
Other experimental studies relevant to the intersensory hypothesis	69
Reasons for rejecting the intersensory co-ordination explanation of object concept problems	75
2. Motor skill/action explanations	77
Motor skill explanations	77
Experiment 2 (Transparent Cups Study)	80
Other motor skill experiments	85

	page
Action explanations	86
Experiments focusing on the role of action in object concept development	88
How should we define action?	97
Reasons for rejecting motor skill/action explanations of object concept problems	100
3. Representation/memory explanations	101
Representational analyses	101
Memory explanations	104
Memory experiments	106
Experiment 3 (Reaching in the Dark Study)	110
Further evidence that invisibility alone is not the source of the infant's problems	115

CHAPTER FOUR : IDENTITY THEORIES

A shift of emphasis - the rule forming infant	122
Bower and the identity hypothesis	127
Object perception and object permanence in the first six months : a re-assessment	129
The identity theory of object concept development in the first six months	135
The place rule for identifying objects	136
The movement rule for identifying objects	138
The co-ordination of place and movement rules	139
The development of object knowledge after six months	142
Conceptual versus perceptual analyses of object concept problems	148
Boundedness and the relation "placed upon"	155
Experiment 4 (Platform Study)	163
Discussion	172

CHAPTER FIVE : A FURTHER INVESTIGATION AND EVALUATION OF THE IDENTITY HYPOTHESIS

Outline of the identity hypothesis and its proposed identity rules	178
Experiment 5 (Longitudinal Tracking and Reaching Study - Acceleration Study II)	186
The effects of different kinds and amounts of training : an extension of Experiment 5	218
Discussion	224
Moore's Identity Theory	227

CHAPTER SIX : SPATIAL UNDERSTANDING IN INFANCY

The identity theory : a resumé	234
Spatial localisation theories of object concept errors	239
Understanding spatial relations between self and object	250
Experiment 6 (Egocentrism Study)	251
Discussion	265
Conclusions	269

APPENDICES
REFERENCES

CHAPTER ONE - INTRODUCTION

Aim of this thesis

This thesis intends to examine the development of the understanding of the nature of objects in the human infant. It is generally agreed that development of a mature object concept spans a period of approximately 18 months. According to Bower (1971):

"discovery of the object concept must simplify the world of the infant more than any subsequent advance".

The idea that a notion so basic to any understanding of the world has in fact to be developed is perhaps initially hard to accept. Nonetheless, there is ample evidence that this is the case.

It is perhaps necessary at the outset to define what is meant by development of the object concept. Observation of the behaviours shown by infants in response to objects and events involving objects strongly suggests that they have great problems in understanding the true nature of objects. According to the traditional analysis, these problems arise from their failure to appreciate that objects persist independently in space, time and form irrespective of whether or not they themselves are perceiving or acting upon them. According to this view, the infant does not seem to believe - as adults do - that objects are:

"permanent, substantial, external to the self, and firm in existence even though they do not affect perception".

(Piaget, 1937)

For the young infant, objects and actions are inextricably linked in his early understanding of reality and no differentiation is made between the self and external reality.

While this thesis does not seek to deny that objects do in fact present infants with enormous problems of understanding, it suggests that both the traditional and other analyses of object concept development cannot fully explain the range of inappropriate behaviours found during this period of development. It is hoped that the work to be reported in this thesis may help to clarify the true source of the infant's difficulties. An alternative account of the cause and nature of these problems (the identity theory of object concept development) will be forwarded.

The problem of understanding the nature of objects

With new and ingenious research techniques constantly increasing our knowledge of the previously unsuspected capacities of infants, it may seem improbable that it takes nearly 18 months on average for an infant to develop a fully-fledged concept of the object. It is now accepted that infants only a few weeks old can quickly learn to interpret and control various aspects of their environment - both physical and social. Infants of only 12 hours have been shown to move in precise synchrony with the segmentation of adult speech (Condon & Sander, 1974). Infants will imitate behaviours such as tongue protrusion and mouth opening in the second week of life (Meltzoff & Moore, 1977). A newborn baby can learn

that, in order to get sucrose, he must turn his head to the right on the sound of a buzzer but not when a tone sounds. This complex learning task can even be successfully reversed by babies of only a few hours old (Lipsitt, 1969). Why then does development of a mature object concept seem to be such a laborious process for the human infant? Although we all intuitively accept that there are all sorts of things that a baby must learn, it is somewhat surprising to find that a concept of an object is one of them.

Nevertheless, it is very easy to demonstrate the primitive nature and inadequacies of the infant's early understanding of objects. They very clearly do not think of objects in the way we do. A 4 month old, for example, shows no surprise if an object moves along a track, goes behind a screen and re-emerges on the same path of movement completely transformed in all respects - size, shape and colour (Bower, Broughton & Moore, 1971, Goldberg, 1976). He is equally unsurprised if this transformation of the object takes place before his very eyes (Bower, 1974a). To an adult, it is obvious that a substitution has taken place or some sort of deception been carried out; in both cases, however, the infant will continue to track the transformed object as if it were the same object. Similarly, a moving object which suddenly disappears mysteriously into thin air will not produce any evidence of surprise in 5 month old babies (Moore, Borton & Darby, 1978 - but see Chapter 5).

Even if we use an object as significant to the baby as his own mother, we again fail to elicit any signs of surprise when we show him a display which would be impossible in the real world of

objects. (1) A simple arrangement of mirrors has been used to produce the simultaneous appearance of three mothers (Figure 1.1). Contrary to adult prediction, this produces no surprise or puzzlement in a baby under 5 months of age. He will, in fact, interact happily with each of the 'mothers' in turn. At a later age, as the baby's understanding of objects develops, the knowledge that the same thing cannot be in three places at the same time will lead to distress and confusion in this situation (Bower, 1971, Shiomu, 1977 (pers. comm)).

Figure 1.1



The multiple mother

(1) Gouin-Décarie (1965) has, however, verified Piaget's hypothesis that significant persons will achieve cognitive permanence for the infant before inanimate objects. Other evidence that person permanence may precede object permanence is presented by Bell (1970), Brossard (1974) and Paradise & Curcio (1974). These experiments have, however, recently come under fire (Jackson, Campos & Fischer, 1978). It has been suggested that such results are experimental artefacts, attributable to the experimenters' failure to equate factors such as the demands of the two search tasks and the familiarity and attraction of the person and object involved. Any differences found need not therefore reflect any true differences in levels of understanding.

It is indeed surprising to discover that, unlike adults, infants do not perceive objects in any coherent fashion. An infant has to learn the seemingly simple principle that if an object is covered by a cup, it still exists while covered; he also has to learn that, if that cup is moved, the object inside it will share all of its movements. This latter is in fact one of the final acquisitions of object knowledge; more basic notions must first be acquired. Fortunately, as the research on early learning has shown, the human infant seems to be particularly motivated to learn for learning's sake (e.g Papousek, 1969). Even in a fairly impoverished environment, a normal infant in his everyday activities can hardly fail to come across the problems posed by his limited understanding of objects. From this conflict between his own rather restricted and egocentric conception of reality and the reality evidenced by commonplace events, we might expect the development of increasingly more comprehensive notions of the true nature of objects to emerge.

The observations and theory of Piaget - the traditional analysis of the problem

Developmental psychologists have been slow to appreciate the subtlety, breadth and significance of the observations on the development of the object concept made by Piaget nearly forty years ago (Piaget, 1936, 1937, 1946). Even today, he is still widely misunderstood and misrepresented. He was probably the first to recognise the importance of studying cognitive development in

infancy; to most of Piaget's contemporaries, infancy was irrelevant to later intellectual growth and infant research (what little there was) directed itself to charting physical development and the more obvious social behaviours, such as smiling. Piaget, however, claimed that the symbolic processes necessary to later cognitive development were in fact built on the acquisitions of infancy. Only by studying infancy, the period of 'practical' intelligence, could we truly understand the nature and development of later intelligence. To Piaget, development of the object concept is the prototype of cognitive development in general; it is the foundation from which mathematical reasoning and logical thought will develop. Until the infant attributes substantiality and permanence to objects, he obviously cannot understand spatial and causal relations between objects. Development of the object concept is therefore central to the construction of reality according to Piaget.

As early as 1936, Piaget observed that the infant's understanding of objects and object interactions goes through a regular, invariant sequence of development. Despite the many criticisms of the inadequacy of his observational techniques and the use of only his own three children as subjects, his descriptions of the behaviours involved have survived the rigorous examination of present-day researchers (e.g Uzgiris & Hunt, 1975).

As the volume of experimental research on the object concept grows, however, it has become increasingly obvious that Piaget's explanation for this sequence of behaviour is more susceptible to

criticism than his descriptions. Piaget's epistemological position is that all knowledge is, in infancy (and, indeed, later), derived from action. A long practice period of pure action is necessary before the symbolic function can appear and even then, thought will be closely tied to its sensori-motor origins. Actions are believed to be the starting point for all future operations of intelligence:

"... operations must be carried out materially in actions, in order to be capable afterwards of being constructed in thought. That is why there is such a long sensori-motor period before speech ... During this first year, every later substructure is precisely constructed: the notion of the object, that of space, that of time, in the form of temporal sequences, the notion of causality, in short, the important notions later to be used by thought and which are developed and used by material action as early as its sensori-motor level".

(Piaget, 1972)

In infancy, everything that is perceived is tied to the infant's own activity; there is no real 'awareness' or 'idea' of objects as external to the self for the infant during this period.

Objects are treated as if they were extensions of the self, there being no true differentiated awareness of either. For Piaget, development is seen as resulting from a continuous process of extension and co-ordination of these schemas ⁽²⁾ of actions into

(2) In Piagetian terminology, a 'schema' is an organised set of actions. Although Piaget & Inhelder (1968) later attempted to restrict use of this term to organisations of images, preferring to use 'schemes' for organised actions, this distinction has not been widely adopted. The traditional terminology will therefore be used in this thesis.

hierarchical structures. The infant strives to construct a working conception of reality - a state of relative equilibrium between the accommodatory and assimilatory functions, one which differentiates the activity of the subject from the state of the object. Exercise of these schemas is inherently satisfying, resulting in a dynamic system which is never absolute nor closed. The infant has what Flavell (1963) describes as 'a need to cognize'.

Cognitive development is therefore seen as a continual process of organising and reorganising of structures. It is, however, a continuous process with discontinuous results, according to Piaget. Development, for Piaget, is stage-like with each stage incorporating preceding stages and preparing the way for the next, more comprehensive and stable stage.

Piaget's model of development has been criticised on the simplest of grounds - that it neither significantly illuminates any of the problems nor does the use of it result in any great saving. It assumes more than it explains and cannot therefore meet the criteria for a scientific model. Nor can his 'experiments' be regarded and assessed as scientific experiments - they are designed to illustrate a point of view rather than to increase our understanding and knowledge of development. Small, probably unrepresentative samples, scanty (if any) statistical data and somewhat varied procedures make many of his 'experiments' unacceptable in any strict scientific sense. It is not therefore surprising that his model and experimentation have been met with hostility in many scientific circles, a hostility only fostered by

Piaget's apparent belief that he is being scientific.

By adopting the language of symbolic logic for his model, Piaget further encouraged resistance to its acceptance. The use of symbolic logic to describe development does not make for an easy model: logicians (e.g Parsons, 1960) have suggested that Piaget's own grasp of the complexities of such a system is not beyond criticism. By adopting this more metaphysical than scientific model, there is little need for confirming the model against external reality since internal consistency is sufficient proof of the validity of the model. Even to the relatively new science of psychology, this cannot be sufficient (see e.g Bruner, 1959). Far too much is assumed in the construction of this extremely complex model of thought; argument too often takes the place of experiment and the model moves further and further from requiring empirical verification. The model threatens to become more important than the phenomena it is supposed to describe and explain.

Despite these and other more practical objections to Piaget's theorising (which I shall discuss later in this chapter), it will be useful to look both at Piaget's descriptions and at his analysis of the development of the object concept. His observations of the behaviours involved have, as stated, survived varied and thorough scrutiny over the years and though possibly an incomplete description, (3)

(3) There are some researchers who feel that Piaget has underestimated the number of stages involved and confused certain sub-stages as real and separate stages. They blame the inadequacies of Piaget's theory on an incomplete sampling of the developmental sequence (e.g Moore, 1975). There are others who feel that the more elaborate descriptions of such researchers are essentially reducable to Piaget's main stages, other 'stages' being an artefact of the testing sequence (Miller, Cohen & Hill, 1970).

are still an extremely useful tool for investigating the cognitive status of any infant. Piaget's stage tasks will be used extensively throughout this thesis. The dispute is rather over what determines the behaviours of each stage and what they reflect of the infant's cognitive structure. Since opposing accounts of this period of development will be both considered and proposed in later chapters, it will therefore also be necessary to consider Piaget's own interpretation of these behaviours.

Piaget's description and interpretation of the six stages

It would indeed seem that the inference that an object has an independent existence beyond our immediate perception of it is by no means an instantaneous acquisition. A belief in the permanence of objects is undoubtedly fundamental to any understanding of objects and events. According to Piaget, object concept development in the sensori-motor period may be classified into six clear stages (e.g. Piaget, 1936, 1937, 1972). With success at each stage, it is assumed that the infant has a more comprehensive and powerful concept of the object than in the earlier stage. The six stages are most easily identifiable by the infant's reaction to objects which disappear from his visual field. As with so many other aspects of cognitive development, it would seem that we can learn more of the structure of the infant's thinking from his failures than from his successes.

STAGE I The exercising of ready-made schemata (0 - 1 months) (4)

This is a period of reflexive behaviours only. These inherited adaptations are the only 'given' in Piaget's account of the development of the understanding of objects. Reflexes such as sucking or grasping constitute 'a sort of anticipatory knowledge of the external environment' but all other advances are and must be constructed from action upon objects according to Piaget.

During this stage, there is 'no special behaviour relating to vanished objects'. If, for example, a ball is held in front of the baby and then dropped, the baby will continue to stare at the place where the ball was. (This place error is also carried over to some extent into the next three stages).

STAGE II Primary circular reactions (1 - 4½ months)

While in this stage of development, the infant uses reflex-based schemas, integrating the reflex schemas of Stage I into habits and perceptions. Actions are repeated for their own sake. The infant,

(4) The age-span for each stage varies somewhat in differing presentations of the theory. The ages given here are taken from 'The Child and Reality' (1972). Age of attaining each stage can in fact vary quite widely so these age-spans can only be taken as approximate. In our sample of babies, the later stages in particular are generally attained well in advance of Piaget's guidelines to age of success. Order of passing through the six stages is, however, not subject to individual variation and is rigid.

for example, can now suck his thumb at will. For Piaget, these circular reactions represent the first acquired adaptations of the infant to his surroundings. His universe is still highly egocentric, however, and he has no notion of objects as being external to his actions.

The infant will now follow the trajectory of an object which disappears from his visual field. For Piaget, this represents only accommodatory adjustments of the sense organs and not true search. It does not in any way reflect any real idea of objects and their continued existence when not perceived. The infant is merely 'pursuing the trajectory delineated by the movements of accommodation peculiar to the immediately preceding perception' and cannot therefore be said to be knowingly pursuing the disappearing object. The fact that an infant in this stage will continue to track a moving object when it stops has been taken to lend weight to the validity of this interpretation. (This error is known as the 'movement' error).

STAGE III Secondary circular reactions ($4\frac{1}{2}$ - 8/9 months)

Here the infant's interest begins to expand to relations between objects. We see the beginnings - but only the beginnings - of means-ends behaviours. He knows how 'to make interesting sights last' by reproducing sequences discovered by chance. Here we also have the earliest indication of a primitive understanding of the permanence of objects. If the infant is holding an object and it is pulled gently

away from him, he will follow the beginning of its trajectory with his hand, even if he cannot see where the object has moved to. Similarly, if an object goes behind a screen, the infant will now look back to the point of disappearance or the starting point of the object's movement. For Piaget, neither of these latter behaviours imply any awareness of the continued existence of the object as such when behind the screen. It is only the 'beginning of permanence extending the movements of accommodation'. It is very much a subjective permanence; the object still exists only in connection with the action itself - it is believed to be at the disposal of the act. The tracking behaviours which follow the disappearance of the object from sight are seen as actions which the baby believes will make the object reappear. The baby's understanding of the event is completely determined and limited by his own, personal action-history up to that time. There is no invention of new procedures for rediscovering vanished objects and accommodatory extensions are soon given up if not quickly successful.

While in this stage, the infant will succeed in recovering a partially covered object. He will, however, most likely pull it from under the cloth rather than remove the cloth as he has no real understanding that the object is under the cloth. He will be unable to recover a toy when it is completely covered by a cloth in his sight. If in the act of reaching for it as it is covered, he will stop in mid-reach and may show signs of distress. He acts as if the object no longer exists; it is 'lost' as far as he is concerned.

Such behaviour has been interpreted by many researchers as evidence that 'out of sight is out of mind' for infants of this age.

Other hiding games at this stage lend support to Piaget's theory that the infant's understanding of objects is firmly rooted in his previous actions upon them. If, for instance, we play peek-a-boo with a Stage III baby, he will remove a cover from his own face to find the adult but does not remove the cover if it is over the adult's face. It is looking that is freed rather than the absent object. The infant's knowledge of an object is inextricably tied to his possible actions upon it. There is no true understanding of the continued existence of any object when covered.

With Stages IV and V comes a new level of understanding of objects. With co-ordination of the secondary schemas, subject and object begin to be differentiated. This increasing differentiation is evidenced by the appearance of imitation and play in these stages and we also see the appearance of the first invariants of object knowledge - size and shape constancy.

STAGE IV The co-ordination of secondary schemas (8/9 - 12 months)

When the infant moves into Stage IV, we see a true separation of means and ends. The same secondary schemas may be co-ordinated as means or as ends according to the demands of the situation. We get a shift of interest from mere 'extension of the movements of accommodation' to the effects of that action. Behaviour becomes

intentional. The infant becomes interested in objects as such rather than as mere fodder for his actions. He will apply familiar schemas to new situations.

Unlike the Stage III baby, he can now recover a toy when it is completely hidden by a cloth. This success, according to Piaget, is attributable to the co-ordination of the visual permanence and the tactile permanence evidenced in Stage III. Although a Stage III baby will try to grasp an object which has fallen from his hands or will follow the former trajectory of an object which has disappeared from his visual field, these earlier indicators of a primitive form of permanence are not co-ordinated. He will not try to grasp an object that disappears from his visual field unless it has been in contact with his hands immediately before it disappeared. With the combination of visual and tactual search, dissociation between object and action is fostered.

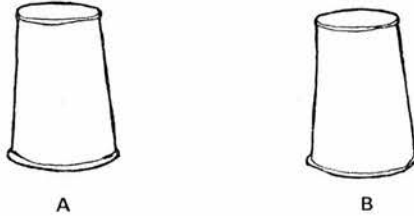
The infant still, however, conceives of the object in terms of his behaviour patterns. On successfully finding a toy which has been hidden in a given place on two or more trials, the Stage IV baby will continue to search in that place on the next trial, even if he sees it hidden in another different place:

"Jacqueline is seated on a mattress without anything to disturb or distract her. I take the parrot from her hands and hide it twice in succession under the mattress on her left, in A. Both times Jacqueline looks for the object and grasps it. Then I take it from her hands and move it very slowly before her eyes to the corresponding place on her right, under the mattress, in B. Jacqueline watches this movement very attentively but at the moment when the parrot disappears in B she turns to her left and looks where it was before, in A".

(Piaget, 1937. Obs. 40)

This AAB or place error is commonly tested for by use of the Stage IV - V transition task (Figure 1.2)

Fig. 1.2



The Stage IV - V transition task: the object is hidden twice under cup A and then under cup B.

Even although successful in the one cloth task then, the Stage IV baby still has an incomplete understanding of objects - the place (or AAB) error clearly reveals the inadequacy of the baby's conceptualisation of objects at this stage. An object is only an object in a very limited sense; the object

"is not yet, at this stage, a substantial thing remaining in the place to which it was moved but a thing at disposal in the place where the action made use of it ... the child looks for and conceives of the object only in a special position, the first place in which it was hidden and found".

(Piaget, 1937)

He is seeking at a place rather than seeking an object. He still has a subjective view of the object, confusing the reality of the object itself with his actions upon it. For Piaget, he does not imagine the toy in its absence; the object is still a practical rather than a substantial thing. Having found the object in a certain location on several occasions, he will repeat this 'successful'

strategy even when he sees it hidden in an entirely different location.

Another commonly occurring behaviour demonstrates how egocentric and action-based the infant's conception of objects and space is at this stage. If an object is placed on a cloth such that the object but not the cloth is out of reach, a nine month old baby will typically pull in the cloth and retrieve the object. If, however, we now place the object out of reach but to the side of the cloth, the baby will still pull in the cloth - fully expecting the previously successful action to be successful again (Figure 1.3).

Figure 1.3



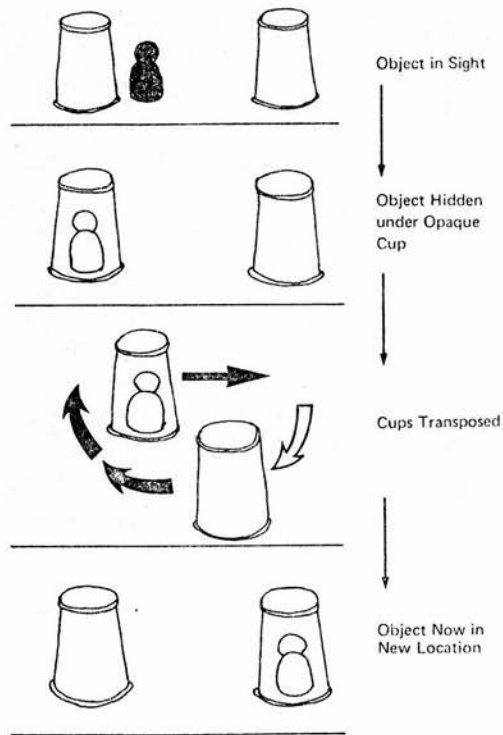
Although successful in obtaining the object in the top situation, the use of a support to get an object which is out of reach is still 'magic' at this stage. The baby seems unable to understand the spatial relationship necessary between cloth and object if this strategy is to work.

STAGE V Tertiary circular reactions (12 - 18 months)

In this stage, the infant can modify familiar schemas to new situations. Behaviours are varied rather than merely repeated. New means are discovered through active experimentation. We see the infant beginning to perform 'experiments in order to see'. The stereotyped behaviour of the earlier stages is replaced by systematic variations in behaviour as the infant investigates his world and the objects that populate it.

According to Piaget, however, he is still unable to represent objects in their absence. He can only relocate an object where he has actually seen it disappear. He can only make allowances for observed displacements and positions in which the object has actually been seen. He no longer makes the AAB error of Stage IV but is unable to cope with an invisible displacement of an object, failing to realise that the object must have shared the movements of the occluder (Figure 1.4).

Fig 1.4



The Stage V - VI transition task - the Aronson-McGonigle 'switching' test.

STAGE VI Invention of new means through mental combinations
(18 - 24 months)

In this, the final sensori-motor stage, the infant's action schemas are organised into reversible schemas and the infant can represent himself and objects in a common space. Experience can therefore be 'interiorised' and possible courses of action mentally enacted prior to carrying them out. Invisible displacements no longer cause problems. Systematic intelligence replaces empirical intelligence in Piaget's terms.

By this stage, the infant's understanding of objects has come a long, long way. It is much closer to the adult concept and must represent a considerable cognitive achievement. From a fragmented, episodic and overpopulated world of objects, the infant has moved into an orderly stable world of objects where everyday appearances and disappearances of objects are no longer totally mysterious and unpredictable - his world is no longer centred about his own activity. Objects are now substantial, permanent and constant in form; they can interact both with the infant and each other without altering their intrinsic nature.

Table 1.1 summarises the characteristic failures and successes of the six stages.

TABLE 1.1 Piaget's six stages of object concept development

<u>STAGE</u>	<u>AGE IN MONTHS</u>	<u>ACHIEVEMENT</u>	<u>FAILURE</u>
I	0 - 1	No special behaviour in relation to objects which have left the visual field	
II	1 - 4½	Will follow trajectory of object which leaves visual field	Continues to follow moving object when stops (movement error)
III	4½ - 8/9	Successfully retrieves partially hidden object	Unable to retrieve completely hidden object
IV	8/9 - 12	Successfully retrieves completely hidden object	Searches for hidden object in place where previously found - even when sees hidden in new location (the AAB or place error)
V	12 - 18	Searches for hidden object in new place if displacement visible	Unable to find hidden object if invisibly displaced (the 'switching' error)
VI	18 - 24	Can find object regardless of where or how hidden	

These then are Piaget's six stages. His original observations, although undoubtedly thorough, were obviously not strictly controlled; the occurrence and sequentiality of all the

stages have, however, been confirmed longitudinally, cross-sectionally and cross-culturally in systematic experimental studies using large numbers of subjects (Gouin-Décarie, 1965, Casati & Lézine, 1968, Boyle, 1969, Corman & Escalona, 1969, Piaget, 1972, Dasen, 1973, Kramer, Hill & Cohen, 1975, Uzgiris & Hunt, 1975). Woodward (1959) and Wohlheuter & Sindberg (1975) have found that the same sequence of development also occurs in severely retarded children although, not surprisingly, over a longer period. (5) Gouin-Décarie (1969) and Kopp & Shaperman (1973) have found that infants with a severe degree of physical handicap also evidence the same six stage pattern of development. Comparative studies with monkeys and kittens show that the sequence is not peculiar to the human infant, although the highest stages are less readily demonstrable in non-humans (Gruber, Girgus & Banuazizi, 1971, Vaughter, Smotherman & Ordy, 1972, Wise, Wise & Zimmerman, 1974).

Accounting for the six stages: preliminary reservations on Piaget's interpretation

There is then little argument that infants everywhere and of every level of intelligence must pass both through the six stages and

(5) Recent work by Morss (1979) suggests that object concept development in mentally retarded infants is not just simply 'slower'. His longitudinal studies with Down's Syndrome infants show that important qualitative differences underlie the poorer performance of such infants, a finding which raises enormous difficulties for any simple assessment programme.

in the order I - VI; there is, however, considerable disagreement and speculation as to what the problem actually is for the infant at each stage, what produces the characteristic errors of each stage and what exactly these stages represent.

Piaget has put forward his account of the development of the object concept in many lengthy books and articles. Unfortunately, as Piaget himself acknowledges, his theorising is very complex, occasionally vague and often rather obscure (see e.g Lorenz, 1960). Much of it presupposes a fairly knowledgeable acquaintance with the facts and principles of biology, psychology, philosophy and logic. Such an interdisciplinary approach is not often found in present day psychological researchers and must account for much of the misunderstanding and misapplication of Piaget's theory. It must be borne in mind that Piaget is primarily an experimental philosopher rather than a psychologist. He studies the mental evolution of the child in order to answer epistemological questions and his interest in the developing child was always more theoretical than practical. Although much educational research is done in the name of Piaget, he himself has rarely commented on the practical implications of his observations. He is much more interested in constructing a logical model of thought which will have psychological validity.

It is also important to remember that Piaget's writings extend to some 400 books and articles and cover a period of some 50 years. It is hardly surprising then that there are occasional inconsistencies

from book to book as emphases and terminology change. (6) Some present Piaget's theory as if it were cut and dried. On the contrary, it is still evolving; as Elkind (1968) points out in his editorial foreword to Piaget's 'Six Psychological Studies', the date of Piaget's theorising is always a relevant variable and any evaluation can never be absolute. Too many researchers base their theoretical objections to Piaget's account of development on his early trilogy only (1936, 1937, 1946) and ignore his vast output since then.

While bearing the above points in mind, there are still however several points, relevant and important to this thesis, on which it seems that Piaget's theorising on development in the sensori-motor period is susceptible to criticism. These shall be touched on below and considered more fully in the appropriate sections of later chapters.

For Piaget, development of the object concept is the most important advance of infancy and can be described and understood in terms of the acquisition and co-ordination of behaviours into progressively more mobile and complex action schemas. The

(6) In 1940, for example, Piaget referred to the thought of children under seven as being 'prelogical'. Many took this to mean that children of this age were not logical. Piaget, on the contrary, meant only that a child of seven is not in possession of a complete logical system of thought. This term was later corrected to 'preoperational'. It is easy to see how minor terminological difficulties can lead to major misinterpretations of Piaget's theory.

increasing flexibility of the schemas allows the invariant attributes of objects to be recognised and objects to be placed in an external world. The practical and subjective notions of the object of the early stages are gradually replaced by an understanding of objects as being both substantial in space and time and independent of the infant's own activity. By Stage VI, the infant's conceptualisation is finally freed from immediate perception and action alike by the advent of representation. The 'physical groping' for solutions to new problems can be replaced by 'internalised groping', or what is more often called hypothesis testing. Reality can now be manipulated, albeit initially in a rather limited way, without recourse to overt action sequences.

"The child henceforth imagines the whole of the object's itinerary, including the series of invisible displacements. Thus it can be said that the object is definitely constituted; its permanence no longer depends at all on the action itself but obeys a totality of spatial and kinematic laws which are independent of the self".

(Piaget, 1937)

This new ability to evoke objects and events in their absence is not only of significance to the development of the concept of the object. According to Piaget, emergence of the symbolic function, and in particular the ability to imitate in the absence of a model, makes possible the subsequent appearance of symbolic play (i.e games of pretend), drawing, mental imagery and, most important of all, language.

It seems to me that a theory of development in infancy which is so totally dependent on the restructuring of knowledge through schemas of actions is neglecting and underestimating the cognitive

aspect of many of the advances of this period. For Piaget, there can be no mental representation of objects until approximately 18 months, Stage VI. Object knowledge, until then, is entirely a function of immediate perceptions and actions. On Piaget's theory, the whole of infancy is characterised by doing rather than thinking. I find this hard to accept.

The theory also seems severely to underestimate the initial abilities the baby brings to the situation. Flavell, one of the best known interpreters of Piaget, has even gone as far as describing the neonatal infant as "essentially a vegetable with reflexes" (Flavell, 1963). As mentioned at the beginning of this chapter, however, neonates have been shown to be capable of both imitation and intentional behaviour. On Piaget's analysis of the process of development, neither should or can appear until approximately 8 months of age. Similarly, Bower (1974a) has shown that many of the problems of space perception and intersensory co-ordination are also solved much earlier than Piaget's action-based theory would allow. The implications of these findings will be discussed more fully in Chapter 3.

According to Piaget's analysis, the infant cannot differentiate between his actions on an object and the object itself until his repertoire of behaviours in relation to that object becomes sufficiently large and flexible for object invariances to be recognised. Consequently, until then, there is neither understanding of objects as existing independently of his activity upon them nor of himself as one object amongst others in a spatially organised

universe. Development is therefore seen as a progressive and roughly synchronous differentiation of self and object.

"Intelligence thus begins neither with knowledge of the self nor of things as such but with knowledge of their interaction, and it is by orienting itself simultaneously towards the two poles of that interaction that intelligence organises the world by organising itself".
(Piaget, 1937)

This thesis, on the contrary, will work towards establishing that the infant's main problem in understanding the nature of objects lies, not in discovering their independent existence and thereby discovering the self, but rather in understanding the spatio-temporal relationships which underlie the identity of any object. The identity theory of object concept development will be elaborated in following chapters and attempts made to justify it. Essentially, I believe a basic understanding of objects to be present very early in the sensori-motor period, as is a basic notion of the self. The problem is assumed to be one of elaborating these rather primitive and limited notions so that they will be able to cope with the spatio-temporal transformations which occur when any object (and here we must include the self) participates in an event sequence.

It will be suggested that the infant works out a progressively comprehensive set of rules for maintaining and recognising the identity of an object over time. These rules will direct the infant's attempts to relocate any object and, in their earlier forms, are responsible for the erroneous behaviour seen in the standard object permanence tasks. Eventually, these rules will be

sufficiently elaborated to allow an object to interact in common space with any other object in virtually any event sequence without risk to its unique identity; 'object permanence' type errors will then disappear.

It will also be suggested that, during this final stage in the comprehension of object-object relations, the infant turns to the problem of locating himself objectively in the physical world. To say this does not imply that the infant does not have any differentiated awareness of the self in earlier stages of development, as Piaget believes. Recent studies of imitation, defensive responses to approaching objects and other visual motor co-ordinations clearly imply that this cannot be the case (Meltzoff & Moore, 1977, Bower, Broughton & Moore, 1970a, Bower, 1974a). It is suggested, rather, that with an increasing understanding of the spatial interrelations which are possible in the world of objects, the infant will move on from these object-object relations to elaborating his understanding of the ever-changing spatial relations which exist between himself and other objects. The self is, after all, only one other object in the physical world and holds no special spatial privileges. This development of self-object understanding seems to coincide with the period of greatest advances in mobility, a time at which such understanding will become essential if the infant is to interact successfully with the objects in his environment. The importance of mobility to the construction of a truly objective reality may well have been underestimated in previous investigations. Not only does it allow elaboration of subject-object spatial

understanding but it provides another source of confirmation of object-object hypotheses.

A more fundamental question

Both the identity theory and other theories which have been offered as alternatives to Piaget's analysis of object concept development will be considered in more detail in later chapters. Perhaps the more basic theoretical question to be addressed first, however, is whether in fact there is one, underlying concept involved in the characteristic sequence of errors displayed during infancy. With most of the alternative theories forwarded, it is assumed that the various behaviours involved do reflect and are directed by a single, developing object concept. This assumption, mild though it may seem, is not necessarily true. Certainly such an assumption should be treated with caution in the absence of any substantial body of confirmatory evidence. After all, the stimulus conditions and responses used to reveal the errors typical of the various 'stages' of development vary enormously from stage to stage. Even within investigations of any single stage, the task used may seem more a function of the particular theoretical bias of the researcher than a direct descendant of the original Piagetian test. Is it reasonable, then, to assume that the behaviours elicited in so many different ways are in some basic way related? Labelling the behaviours in terms of stages of a developing object concept may be convenient but is it justifiable?

The next chapter will consider this fundamental problem and present some evidence which may help towards its resolution.

CHAPTER TWO - A FUNDAMENTAL QUESTION : IS THERE A DEVELOPING
OBJECT CONCEPT?

Are the behaviours of the six stages linked to a single, underlying concept?

Is there a single concept underlying the behaviours described by Piaget? For Piaget himself, there can be no doubt. The construction of a concept of the object which is not tied to the actions of the subject is the major attainment of the sensori-motor period. According to Piaget, this concept of an object is achieved via the stage-like development of an increasingly complex and mobile repertoire of behaviours for the infant to apply in interactions with objects. On achieving Stage VI, the baby is finally freed from "a world of inconsistent pictures gravitating around his own activity"; he moves into a more objective universe where reality and his personal conception of the basic facts of that reality will coincide.

"As the activity of the baby develops and the causal, temporal and spatial sequences which this activity creates becomes more complex, objects are detached more and more, and the body of the subject becomes one element among others in an ordered ensemble".

(Piaget, 1946)

Surprisingly, even though many researchers reject Piaget's analysis of object concept development as inadequate, few bother to question his basic assumption that the various age-linked behaviours which can be so reliably demonstrated do, in fact, have a common origin in a developing concept of the object. The behaviours which

are taken as indicators of achievement of new levels of understanding of this single concept vary enormously from stage to stage, from no reaction to falling objects in Stage I to successful reaching for and recovery of an object which has undergone an exceedingly complex series of invisible displacements in Stage VI. Many researchers have extended the tasks used to investigate each stage but few have, in general, paused to question whether it is valid to assume that the various levels of 'understanding' indexed at the different 'stages' by such diverse measures as heartrate, sucking, reaching in the dark etc. are in fact tied to a single, developing concept. Such an assumption may be parsimonious and have commonsense merit but should not be accepted on face value alone.

The acceleration paradigm

The problem of establishing a connection (at any level) between an early behaviour and a later behaviour is one for which psychology, in particular, has few available resources. In wishing to assert the development of an object concept we have additional problems. These are the apparent repetitions, at a formal level at least, of the same errors at different stages in the sensori-motor period. Bower & Paterson (1973) have demonstrated, for instance, that an infant in Stage II will look for a 'missing' object (with his eyes) in the place where he last saw it. If, for example, an object moves regularly between two places, A and B ($A \leftrightarrow B$), and then changes

direction, moving off to a new location, C ($C \leftarrow A \leftrightarrow B$), the Stage II infant typically looks for the object at B, its usual position on leaving A. An infant in Stage IV - V, in committing an AAB error, is also searching for an object in the place where he last saw it, this time with his hands. If we claim to be looking at a unitary, developing concept, why should such errors occur again at a later point of development? Bower, Broughton & Moore (1971) have similarly shown that a 5 month old infant will anticipate the reappearance of a moving object from behind a screen; why then does an 8 month old act as if the object has ceased to exist when it is covered by a cloth? Why is the knowledge which seems to be available to the eye apparently not available to the hand if the behaviours are supposedly directed by the same underlying object concept? Such repetitions may seem to weaken the case for a single, developing concept. I would like to argue later, however, that this seeming repetition is, in some cases at least, artefactual and arises from an incomplete analysis of the early tracking behaviour. If, for example, analysis in the screen situation is extended to cover the behaviour after the apparently successful anticipation, the infant himself will demonstrate how limited his understanding of the situation really is (see Chapter 5).

Leaving these formal repetitions aside for the moment then, how are we to establish if early object concept behaviour is truly related to later object concept behaviour? As Bower (1974b) has cogently pointed out, acceleration studies are, in fact, about the only investigatory method we have at our disposal. If we attempt to

accelerate a behaviour and that programme of acceleration (in the absence of any further intervention which might be presumed to be facilitatory) results in the accelerated appearance of a later behaviour, we can have some reason to believe that the two behaviours are causally related (see e.g Zelazo, Zelazo & Kolb, 1972, Bower, 1979). The experiment below was designed to elucidate the relationship (if any) between early object tracking behaviours and later traditional object search behaviours by the use of just such a paradigm.

EXPERIMENT 1 (7)

Following the analysis of Bower (1971), Bower, Broughton & Moore (1971) and Bower & Paterson (1973), a tracking task was chosen which it was assumed would facilitate co-ordination of the two earliest responses to moving objects - continuing to track a moving object which stops (known as the movement error) and looking for a moving object in the place it is usually to be seen (the place error). In cross-sectional samples, these errors normally disappear completely

(7) This study has already been published (Bower, T.G.R & Paterson, J.G - see Appendix D).

at around 23 weeks of age. According to the Bower analysis, these complementary errors reflect the infant's early, primitive conceptualisation of objects. In these early weeks, the infant does not appear to realise that a moving object which stops is the same object and vice-versa. This is a viewpoint which will be discussed in considerable detail later in this thesis (see Chapter 4) but need not detain us here. The object search tasks used were the transition tasks for Stages IV - V (see p 16) and V - VI (see p 18).

SUBJECTS

Sixty-six infants served as subjects. (8) They were divided into an experimental and a control group, matched for birth order, sex and parental occupation.

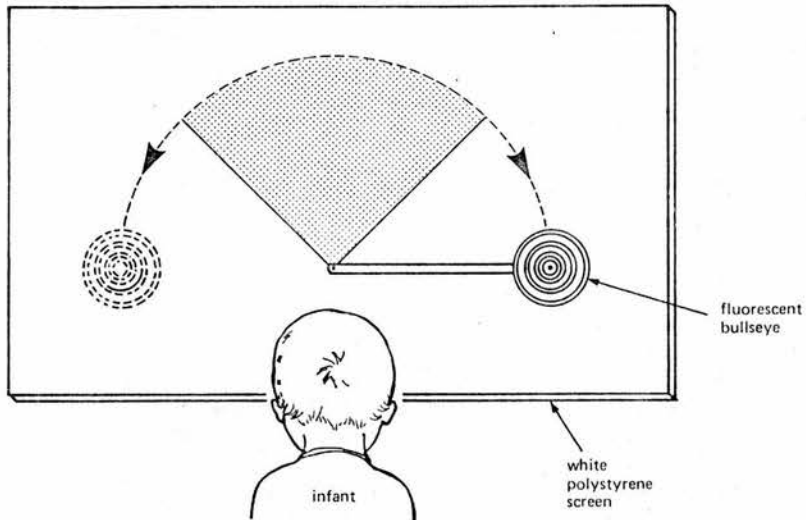
(8) Subjects were chosen from our pool of babies. These babies are volunteered by their mothers in response either to a leaflet from their health visitor, the National Childbirth Trust or the maternity hospital or to an advertisement in the 'Scotsman'. Being self-selected, they tend to be from the more middle-class, better educated sections of the community. This is a bias which we can unfortunately do little about.

PROCEDURE

Tracking task

The object to be tracked was a 10 cm diameter bullseye, painted in fluorescent pink, white and orange. It was mounted at the end of an arm 30 cm in length, driven by a sweep generator at .24 cycles per second, through an arc of 180° (Figure 2.1)

Fig. 2.1



Tracking task used in Experiment 1.

The infant sat on his mother's lap, at a distance of one metre from the display. Object position was monitored by a T.V. camera mounted behind the infant. Head and eye movements were monitored by a T.V. camera mounted behind the display and out of sight of the

infant. The output of the two cameras was combined and fed into a VTR, thus providing a simultaneous record of object position and head and eye position for subsequent frame-by-frame analysis.

The object was set in motion before the infant was brought in. The presentation 'began' when the infant first looked at the display. Twenty movement cycles were presented. The last cycle and a random three others incorporated a stop in which the object stopped moving for a period of ten seconds. These stops were always made in the central 90° of the arc.

Frequency of tracking was scored for all trials. Behaviour on the stop trials was scored on the following features:

1. Did the infant stop and fixate the stopped object?
2. If yes to 1, for how long?
3. If yes to 1, did the infant after the time given in 2,
 - (a) continue to track the trajectory of the object, or
 - (b) look back to starting point, or
 - (c) look away?
4. If no to 1, did the infant continue to track the trajectory of the object?
5. If no to both 1 and 4, did the infant
 - (a) return to starting point of movement, or
 - (b) look away?

Records were scored by two observers.

The experimental group was given weekly exposure to the tracking task from 12 weeks to 16 weeks. The control group was given an

equivalent number of laboratory visits that did not involve tracking and then tested on tracking at 16 weeks.

After this test no further tracking experiments were carried out with either group. All of the infants, however, were brought in ten times to participate in experiments on reaching before the object permanence testing was begun and repeated weekly. At this point, 12 mothers felt unable to commit themselves to the extended period of laboratory visits necessary for completion of the study. The number of infants who were tested on manual object search tasks was therefore reduced to 54.

Object search tasks

Object permanence testing for the remaining infants began at 36 weeks. It was originally intended to continue this testing until all of the infants had reached Stage VI. Unfortunately, financial considerations forced us to stop at approximately 15 months. As will be seen, all but 4 of the experimental group had attained Stage VI by this time although only 6 of the control group had done so.

In the object permanence testing situation, the infant sat on his mother's knee at a table which had a semi-circular cut-out on the infant's side in order to facilitate reaching. Object permanence testing was always begun with a simple Stage IV test in which the object was covered by a cloth in view of the infant. If necessary, the infant would be restrained by his mother from attempting to take

the object before the hiding sequence was completed. No other time restraint on onset of search was applied. If the infant succeeded in obtaining the hidden object, the Stage IV - V transition test was given. Two cloths were placed on the table, one to the right of the infant and one to the left, at equal distances from him; the object was then hidden under one of them, A. After the infant had successfully retrieved the object, it was recovered from him and hidden under the same cloth, A. After retrieval and recovery a second time, the object was then hidden under the second cloth, B. After this, new cloths and a new toy were introduced, and the AAB procedure repeated. After each AAB sequence, different cloths and toys were introduced. Any toy which failed to produce any signs of interest in the infant was discarded and a new choice made. Six AAB sequences were run through, three in the order LLR, three in the order RRL. The side chosen as the A side was varied randomly from trial block to trial block.

Stage V - VI testing was begun when the criterion of six errorless B trials in the AAB test situation was reached. On each week thereafter, the infant was given one AAB trial before the testing proper began. The testing procedure was as follows. Two cloths were again placed on the table, one to either side of the infant and at an equal distance from him. With the baby watching, an object was placed under one cloth. The positions of the two cloths were then transposed. Six trials were given, with starting position (left or right) being varied randomly from trial to trial (with the restriction that there be three instances of each).

Testing was terminated after two sessions without errors .

RESULTS

As can be seen from Table 2.1, the experimental group showed accelerated performance in all three parts of the study. Their advantage over the control group in the tracking study was maintained in the Stage IV - V testing and was even increased in the Stage V - VI testing.

TABLE 2.1 Development of stages of the object concept in experimental and control groups of infants

	<u>Accelerated</u>	<u>Control</u>
Probability of errors in tracking at 16 weeks	0	.51
Number reaching Stage V	28	26
Mean age of attainment (in weeks) of Stage V	39.3	48.6
Number reaching Stage VI	24	6
Mean age of attainment (in weeks) of Stage VI	43.7	59.5

On closer examination, the data from this study provided an unexpected confirmation of Piaget's belief that development in this period is discontinuous and stage-like. Table 2.1 presents the results as a hybrid of measures, probability of errors at a particular age in the tracking study and age of attainment of zero

errors in the object permanence study. It was originally intended to treat the results in terms of errors at a particular age only; examination of the raw data showed however that such a summary would be misleading. Such a comparison necessarily assumes that performance will improve continuously with age and that errors will decrease steadily until performance is perfect. The pattern of errors found in this study did not fit with such an assumption. Figure 2.2 shows a typical infant's performance in the weeks up to and including the last error in the Stage V - VI transition test. Contrary to expectations, there is no continuous decline in errors.

Figure 2.2

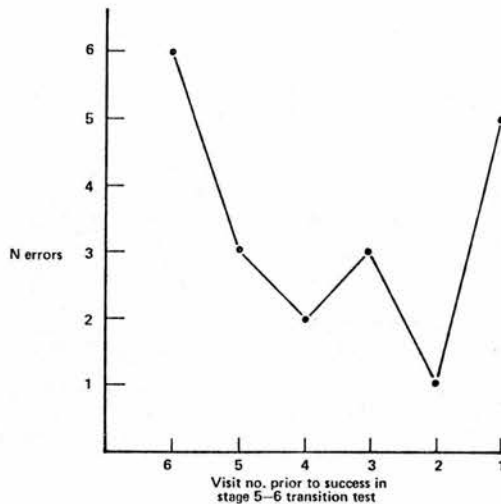


Table 2.2 shows the distribution of errors for all infants on the last day on which they made an error in the Stage IV - V transition test; it also gives the expected distribution on the assumption of random responding.

TABLE 2.2 Expected and obtained distributions on last error trial of Stage IV - V transition test

<u>N errors</u>	<u>f expected</u>	<u>f obtained</u>
6	0	1
5	5	6
4	13	14
3	18	14
2	13	12
1	5	7

chi-square = 2.09, .90 > p > .75

Table 2.3 shows the expected and observed distribution of errors on the last error trial of the Stage V - VI transition test for those infants who reached Stage VI. In neither case is the difference significant.

TABLE 2.3 Expected and obtained distributions of errors on the last error trial of Stage V - VI transition test

<u>N errors</u>	<u>f expected</u>	<u>f obtained</u>
6	1	3
5	3	1
4	7	6
3	9	12
2	7	6
1	3	2

chi-square = 6.9, .25 > p > .10

DISCUSSION

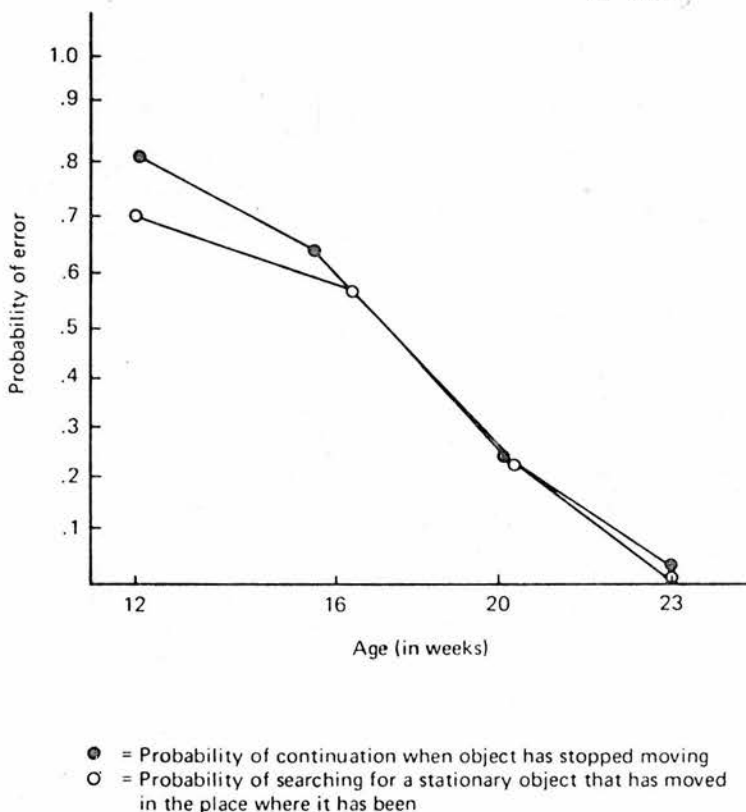
The above results lend support to the hypothesis that a developing object concept does in fact underlie four of the behaviours frequently assumed to index different levels of the object concept. They demonstrate that facilitatory intervention at one point in the process will accelerate development of later, higher levels of understanding. The pattern of errors found prior to success in the various tasks also lends support to Piaget's contention that development is stage-like and discontinuous. This study also highlights the need for caution in interpreting data in simple terms of reduction of errors over time. Lumping data together may result in a completely false picture of a continuous decrease in errors, masking a true step-like progression which only finer analysis will reveal.

Are the six stages truly related?

Experiment 1 seems to indicate the presence of a genuine relationship between the tracking behaviours of Stages II - III and the hiding tasks of Stages IV - V and V - VI. What other evidence is there to support the contention that Stages I - VI represent six stages of a developing concept of the object? Unfortunately, very little. As mentioned at the beginning of this chapter, the relationship between the stages is all too often taken for granted.

Bower (1974a) would appear to have found evidence of a single process underlying Stages II and III. In his cross-sectional study, the two errors typical of Stage II, continuing to follow a moving object which stops and looking for a stationary object which has moved in its usual place, showed a remarkably similar pattern of decline, a similarity suggestive of a common underlying developmental process (Figure 2.3)

Fig 2.3 The decline in place and movement errors



There is little other evidence in the literature of studies designed to elucidate the relation between Piaget's six stages. Gouin-Décarie (pers. comm) has found that training in intersensory co-ordination will promote accelerated development of the later stages of the object concept. White has made similar claims (White, 1969). Both of these studies will be considered in

a later section (see pp 64 - 68). Experiment 5 of this thesis will attempt to show that training at Stage II has facilitatory effects on all later stages of object concept development. Experiment 6 will hope to show that, in addition to facilitating the articulation of a fully-fledged object concept, such training also facilitates the overcoming of the infant's egocentric notions of space.

Is development stage-like?

Although not overwhelming, the evidence does seem to point to the behaviours of the six stages being truly related. What evidence do we have then that Piaget's other contention - that development is stage-like - is tenable? This aspect of Piaget's theorising is far less rapidly accepted than the first. Our natural intuition is to believe that cognitive development, like physical development, is continuous - cumulative and gradual. Piaget, on the contrary, insists that development is step-like; development is stationary for a period with no new responses occurring. Development consists of:

"successive steps or levels of equilibrium,
separated by a phase of transition or crisis, and
each characterised by a momentary stability".
(Piaget, 1956, in
Tanner & Inhelder, 1960)

While in any given stage, performance will not essentially change; there will be no regular decline in errors until perfection is reached. Alternate methods of responding will be applied more or less randomly until the infant recognises the inherent contradiction between

the opposing responses to the same situation, co-ordinates the responses and moves suddenly into the next, higher stage.

"Reaction to a stage n are released by the dissatisfactions, conflicts or disequilibria belonging to the previous stage n - 1".
(same source)

Alien though such a description of development may seem, it nevertheless seems to have some empirical support in relation to cognitive development in infancy. Experiment 1 showed that progression through Stages IV - VI of the object concept was indeed stage-like and discontinuous. Bower (1974a) similarly found that although average performance in terms of reduction of errors showed a steady decline in Stage II - III tracking tasks, individual records again showed discontinuities of performance. Gratch & Landers (1971) also found evidence of random-like application of alternate strategies in their longitudinal study of the developmental course of the Stage IV (AAB) error, a finding confirmed by Butterworth (1977). The stage model of development does, therefore, seem to have some validity within the sensori-motor period although its more general applicability is still very much a matter of controversy (see e.g. Tanner & Inhelder, 1960, Wohlwill, 1966, Pinard & Laurendeau, 1969, Strauss, 1972, Brainerd, 1973).

The dynamics of development

The evidence presented above may be taken then to support two of Piaget's claims about development:

1. that there is a concept of the object which develops
2. that development of this concept is stage-like and discontinuous.

His third claim, that the mechanism of development is a process of progressive equilibrium with its twin components of assimilation and accommodation working towards an ever-increasing level of stability, is not so easily validated.

Although on a simple level, equilibrium is a most useful and acceptable concept in most sciences, Piaget's use of the term has come in for a great deal of criticism. Bruner, for example, has accused it of being inherently circular (Bruner, 1959): development is seen by Piaget as occurring as a result of recognition of a state of disequilibrium (or conflict) between the processes of assimilation and accommodation - but the structure must be sufficiently developed in the first place if it is to recognise the inadequacies of the existing structure. Others, while recognising the descriptive usefulness of Piaget's notion, have criticised its inadequacies and vagueness as a dynamic model, claiming that it cannot be used to make any useful predictions about development (e.g Carey, 1969). This seems to be a valid criticism. Since each new advance is necessarily constructed out of the preceding structures, any reconstructionist (or 'revolutionary') (9) model of development will have trouble in

(9) Piaget's view of development has been summarised as a process of 'conceptual revolution rather than gradual evolution' (Bower, 1974a). This seems to capture the essence of Piaget's thinking very well although there are occasions when he tends to discuss development in more 'capitalistic' (Riegel, 1972) terms.

making anything other than short-term predictions. This is a fairly severe limitation to be built into any developmental theory and makes wholehearted acceptance of Piaget's model difficult.

To go into the dispute over the notion of equilibrium in detail would be a thesis in itself. I myself find aspects of Piaget's model of development to be extremely useful. My main concern will be to clarify what the problem is for the infant at each successive stage of the object concept. Once we have a better idea of this, the mechanisms of transition from stage to stage may be easier to identify. It is interesting to note, however, that some support for the importance of conflict to cognitive development comes from a study by Bower (1974a). Two different forms of tracking training were given to two groups of Stage II infants. The first group was given weekly exposure to a continuously moving object while the second was given weekly exposure to an object which both moved and stopped, a presentation specifically designed (as in Experiment 1) to induce conflict between the infants' two early (and inadequate) definitions of objects - objects as places and objects as movements. The first group did not show any acceleration of Stage III behaviour; the second group did. From these results it would seem that conflict does play a role in cognitive development. More research is needed, however, before we shall have a clearer idea of the importance and exact nature of that role.

Now that we have established that there is an object concept that does indeed develop, we can go on to examine further the nature of that development. It has already been suggested in Chapter 1 that Piaget's theory of the development of the object concept does not fit with the findings of more recent developmental studies. The next chapter will consider more closely the implications of these studies. Alternative accounts of this period of development will then be discussed and evaluated.

CHAPTER THREE - ALTERNATIVES TO THE TRADITIONAL ANALYSIS OF
OBJECT CONCEPT DEVELOPMENT

Reasons for rejecting the traditional analysis

The preceding chapter would seem to indicate that Piaget has correctly identified a process of stage-like development in the acquisition of the concept of an object. We should now turn to attempting to identify the reasons for this step-like progression in understanding - in other words, to discovering what exactly it is in the nature of objects that poses such a problem for infants at each level of development.

Piaget, as we have seen, believes the notion of permanent, independent objects to be the end product of an inherited process of adaptation, one which increasingly differentiates and equilibrates the twin functions of assimilation and accommodation. According to Piaget, as the behavioural repertoire of the infant grows, he will enter into increasingly more complex interactions with his surroundings; these self-object interactions will in turn lead to an increasing comprehension that objects have an existence quite independent of the activity of the observer. Development in the sensori-motor period is thus seen as a general decentering process, with the infant eventually realising that he himself is only one other object in a spatially and temporally organised universe.

Why should we reject this analysis of the problem? It does, after all, fit well with Piaget's observations of infants and would

seem to explain many otherwise puzzling instances of behaviour reliably found during this period. The reason is simply that it no longer fits the facts as we now know them. It must be borne in mind that the theory was originally constructed very much on the basis of observation, with experimentation of only a very limited sort being employed. Examples of behaviour (either observed or elicited) were always used more as illustrations to the theory than as attempts to confirm its validity. The ratio of theory to example was always high and in the case of the early stages, many of the statements are no more than educated guesses extrapolated backwards from observations and theorising on subsequent stages. In common with most researchers of his time, Piaget believed early infancy to be beyond experimental investigation.

Unscientific though Piaget's investigatory methods may seem to present-day researchers, it is important not to underestimate the skill and vision which Piaget brought to his observations. Few psychologists today could match the quality of Piaget's observations if stripped of film or video records of their test sessions. Although much of his theorising is now regarded as inadequate, Piaget's valuable insights into development still hold good on many aspects and in their time, represented a truly remarkable achievement. Nonetheless, it is hardly surprising that at least some of Piaget's notions of development seem to have been overtaken by today's research. There now exists a considerable body of experimental findings which cannot be accommodated by Piaget's intricately constructed model.

Many researchers in addition feel that such an action-oriented account of the development of object knowledge is too narrow, overestimating the directive role of maturational processes and underestimating the importance of environmental variables. It would seem that experience can be much more efficient than Piaget would accept; every thought need not at some stage have been an action, as Piaget would have it.

Although Piaget insists that development is the result of an interaction between subject and environment, experience would indeed seem to have been given a rather ill-defined and secondary role in his model. This is hardly surprising. Piaget would maintain that experience cannot simply be categorised, being, as it is, selectively transformed according to the structures in existence in the particular infant at any given time. Experience must be considered in the historical context of the individual and attempts to evaluate experience without such referents would be necessarily misleading and, indeed, futile. Development for Piaget is a process of adaptation with the organising activity of the subject the major influence on that process.

Many see this approach as resulting in an ill-advised and unwarranted neglect of the role of both social and physical environmental variables on development. Piaget's interpretation of the failure of young infants to react to objects which fall out of sight provides a good example of the consequences of such neglect. As both Bower (1967) and Michotte (1955, 1962) have demonstrated, stimulus variables can be an all-important factor in determining both infant and



adult responses to disappearing objects. It would seem that all disappearances are not cognitively equivalent, a possibility which Piaget does not seem to have considered; rate as well as manner of disappearance seems influential in determining responses. Piaget's somewhat vague and rather anti-empiricist position would deny that any great attention need be paid to such precise descriptions of environmental variables, a feature of his theory which also has the effect of making it very difficult to pin down in any useful way. The same criticism could apply to the notion of equilibration, a notion central to Piaget's theory and one which seems to me almost inaccessible to experimental investigation, to be accepted on face value alone. Others admittedly have reinterpreted the concept in more practical and meaningful terms and found it to be useful (e.g Bower, 1974a - see p 47) but this in itself cannot excuse the problems inherent in the original definition of the concept.

The above remarks could perhaps be dismissed as matters of theoretical taste. The findings below, however, are, in general, accepted facts and cannot be so easily set aside by any would-be theory-builder. They were obviously unavailable to Piaget in the initial formulations of his theory but there is little evidence in any of his writings, including his most recent works, of any attempt to interpret and incorporate such work into the body of his theory. Such insularity is a rather long-term failing of Piaget and his co-workers and, coupled with his difficult style and complex model, has furthered resistance to its acceptance. As a result, much that is excellent is rejected with that which no longer fits the experimental facts.

Some of the work on early infancy which contradicts a Piagetian position was alluded to in the introductory chapter. I shall deal with four areas of research which seem to me to have unfortunate implications for the theory. These examples are by no means exhaustive but are in themselves sufficient to necessitate a re-thinking of the object concept problem. Two of them, imitation and intentional behaviour, are central to the construction of Piaget's model. The other two, the perceptual constancies and behaviour towards unseen parts of objects, are typical of much of today's research in that they demonstrate the early presence of some knowledge of objects, knowledge which should not, on Piaget's analysis, be present until much later in infancy.

Imitation and intentional behaviour

On Piaget's analysis, imitation of unseen parts of the body cannot appear until after a long apprenticeship with much lesser levels of imitation, not in fact emerging until Stage IV and soon thereafter becoming the primary means of acquisition of new behaviours. Such imitation has, however, been unequivocally demonstrated in neonates (Dunkeld, 1978) and even in a baby who was only 60 minutes old (Meltzoff & Moore, 1977). Carefully controlled experiments such as those of Meltzoff & Moore and Dunkeld have shown that this behaviour is truly imitation and not, as has been suggested, the artefactual result of the mother first imitating the baby (Papousek, 1976, Uzgiris, 1978). Since imitation plays a

central role for Piaget in the unfolding of development, such findings are not a minor embarrassment to the theory.

The notion of intentionality is also important to Piaget's account of the development of the object concept. For Piaget, the growing intentionality of behaviour is a direct indicator of the developing differentiation between subject and object. In order to attribute intentionality to any behaviour, Piaget insists that it should fulfil three requirements:

1. the behaviour should be outward-directed, i.e oriented towards influencing the external world
2. there should be the possibility of other actions intervening between the means and the goal (as in e.g 'detour' behaviours)
3. it should represent a deliberate adaptation of behaviour rather than a simple repetition of previous behaviour.

Contrary to Piaget's account, evidence of behaviour fulfilling all three of those requirements has been found in studies of learning ability in very young infants - again at an age far earlier than Piaget's analysis of development could allow.

Take, for example, the behaviour of the babies described by Papousek (1969). Babies in his conditioning experiment soon learned that, if they made the appropriate head-turn, a light would come on (Piaget's first criterion is therefore fulfilled). Quite complex series of head-turns could in fact be learned by even very young infants (Criterion 2 fulfilled). In addition, if the requirements of the situation were changed, e.g the light no longer came on as a result of a left - left sequence, but now required a right - right - left sequence, the babies soon coped with the new

demands, thereby showing themselves able to fulfil all three of Piaget's criteria for intentional behaviour. According to Piaget, such intentionality, implying as it does a differentiation of means and end (and therefore differentiation of the immediate actions of the subject from the eventual activity of the object) just cannot be possible at such an age. It seems to me impossible for the theory to be stretched to cover such findings.

The perceptual constancies and behaviour towards unseen parts of objects

Even if the late appearance of imitation and intentionality were not crucial to Piaget's model of development, there is a good deal of other experimental evidence which undermines his position. In particular, very young infants have demonstrated a far greater knowledge of the inherent properties of objects than Piaget's analysis of development in this period could possibly allow. I shall take only two examples ⁽¹⁰⁾ - the perceptual constancies and behaviour towards unseen parts of objects.

On Piaget's analysis, size and shape constancy can only develop as a result of the co-ordination of vision and touch, a co-ordination

(10) To be fair to Piaget, these abilities, as with many of the others which do not fit with his analysis, could never have been detected in younger infants by simple observation. Sophisticated recording apparatus and strictly controlled presentations are essential to this type of investigation.

which does not take place until Stage IV. By acting on objects and simultaneously observing these actions, an infant can build up notions of those aspects of objects which in fact remain constant in the face of contrary perceptual information. The theory allows for no earlier appearance of such understanding. Using a conditioning paradigm, Bower (1966), however, found evidence of shape constancy in 6 - 8 week old babies. He found that a response that had been conditioned to a given object would be shown again in response to that same object when presented in different orientations, even although the retinal images produced in such cases were entirely different from that of the conditioned stimulus. A different object presented in such a position as to project the same retinal image as the original conditioned stimulus did not produce the conditioned response. Such behaviour could be taken to demonstrate an ability to recognise the real shape of an object irrespective of its orientation and retinal image. Habituation experiments by Day & McKenzie (1973) confirm this finding, as does work reported recently by Caron, Caron & Carlson (1977). A further conditioning experiment by Bower (1966, op.cit.) similarly demonstrated the apparent presence of size constancy at around the same age.

Objections have been made that these experiments may demonstrate only differentiation of the associated mediating proximal variables and not true discrimination of the distal stimuli involved. If, however, infants are induced to act on the basis of their discriminations and a distally appropriate behaviour is produced, it

is reasonable to assume that the infant is responding to distal and not proximal variables. By making use of reaching and grasping, responses which occur naturally in neonates given adequate postural support, Bower (1972) found evidence of true perception of solidity, size and distance in infants of only two weeks. Reaching was adjusted to the true distance of the object and finger-thumb separation showed anticipatory adjustment to the true size and shape of an object seen at a distance. Bruner & Koslowski (1972) also noted this phenomenon in 10 week old babies, an age again too young to fit with Piaget's analysis.

It is interesting to note that Piaget himself observed instances of distally appropriate behaviour prior to Stage IV. He observed that an infant who is just learning to reach will refrain from reaching when the object is far away but will begin to reach out as soon as the object comes within reaching distance. As such observations did not fit with Piaget's conceptions of the nature of early perceptual experience - a viewpoint which emphasised sequential perceptual tableaux and the undifferentiated nature of experience - these responses tended to be ignored in the theory-building and instances of inappropriate behaviour centred upon.

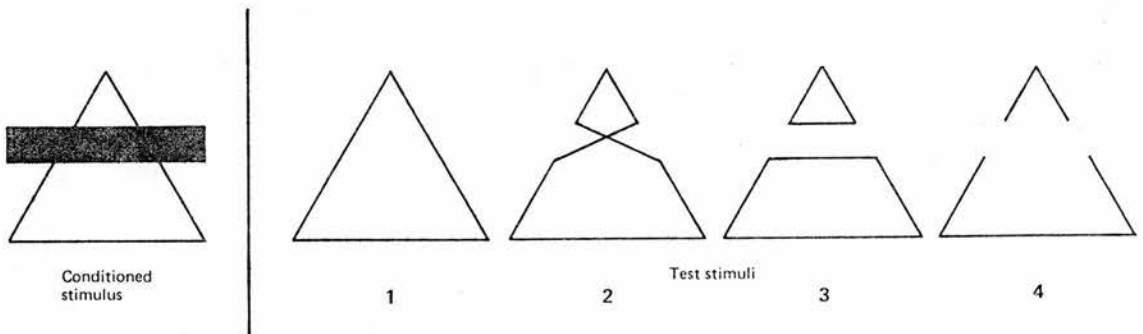
In his experiments on size constancy, Bower attempted to isolate the factors that determine the infant's response. It seemed that motion parallax and binocular parallax were being used. This suggests that the infant's perceptual system is already organised to allow for a three-dimensional world long before reaching and grasping is truly established. Such activity does not therefore seem

essential to the construction of reality, as Piaget would maintain. Order is already present in the infant's perceptual system. It is pre-organised to specify basic invariants directly; there is no need for the infant to construct order out of perceptual flux via action. Such 'structuralism without genesis' would obviously be anathema to Piagetians.

There is also reason to dispute Piaget's interpretation of his observation of the inability of the young infant to rotate a feeding bottle into the correct position unless some part of the nipple is visible. According to Piaget, success in this task coincides with acquisition of Stage IV. From this behaviour Piaget inferred that the Stage III baby has no knowledge of unseen parts of objects. Recent research again indicates that Piaget has underestimated the understanding present in the young infant.

Bower (1966, op.cit.) has shown that infants of six weeks of age who are conditioned to respond to a black wire triangle with a bar over it will also produce the conditioned response in the presence of a complete, unoccluded triangle (Figure 3.1).

Fig. 3.1



The response is far less likely to be carried over to any of the three other test stimuli shown in Figure 3.1, however, despite the fact that 3 and 4 look most like the original conditioned stimulus. In a similar vein, it has been shown that infants of 4 - 5 months will appropriately shape their fingers in anticipation of contact with the far side of an object which they are trying to grasp, even although they obviously cannot see it (Bower, 1975). Such experiments strongly suggest that Piaget is wrong in believing that the infant does not understand that the parts of objects he cannot see nevertheless exist. An experiment will be presented later in this thesis which hopefully demonstrates that out of sight is not indeed out of mind for infants in Piaget's Stage III, even if the whole of the object disappears from view (Experiment 3 - p 110).

POSSIBLE ALTERNATIVES TO THE TRADITIONAL ANALYSIS

If, then, there are rather too many experimental findings which embarrass the Piagetian analysis of the problem of understanding the nature of objects - and the above is only a fairly representative sample of these - what alternative explanations have been offered by other researchers? Alternatives fall into four main categories:

1. intersensory co-ordination explanations
2. motor skill/action explanations
3. representation/memory explanations
4. identity explanations.

I, myself, favour the last of these categories and will attempt to justify this in later chapters. The other three categories of explanations and experiments undertaken in relation to these will be presented below.

It should firstly be pointed out, however, that although these four categories have been described as alternatives to Piaget's account, this is not strictly speaking an accurate description. They are neither truly discrete categories nor are any of them entirely distinct from Piaget's own formulations of the problem facing infants in this period of development. All four are, in fact, derived to a greater or lesser extent from Piaget but seek to emphasise one particular feature of his description of the developmental sequence, while denying, or at least underplaying, the role of other possible factors.

There is therefore a certain degree of overlap between the various theories. As will be seen below, evidence which seems to refute one of the four main classes of explanation also usually has negative implications for at least one of the other contenders. Finding positive evidence in support of one or other explanation is considerably more difficult than disproving any of the alternatives. Temporary ascendancy of any particular theory is more often by default in the others than on the basis of its own merits.

The problem with Piaget's theory perhaps lies in its very multifacetedness. Almost every facet seems to have some validity but it seems impossible to reconcile them all in the one theory. Even without the embarrassment of today's research data, this presented a

problem to Piaget himself. His viewpoint would tend to shift focus according to the particular topic under consideration and, to many, such shifts of perspective come too close to undermining the integrity of his carefully constructed model for comfort.

1. INTERSENSORY CO-ORDINATION EXPLANATIONS

Failure to retrieve a desired object when it is covered by a cloth is indeed a strange and most unexpected error to discover in otherwise extremely competent infants. Perhaps because of this, Stage III - IV of the object concept has received more than its fair share of attention from researchers. Many seem to feel that if they can elucidate the Stage III - IV problem, the problem of explaining all subsequent errors will be a relatively minor one - that is, that understanding of the infant's difficulty with the Stage III - IV test will illuminate the entire sequence of development. This does not seem an unreasonable assumption and is, indeed, a necessary one if we are to maintain the notion of a single concept underlying the six stages. So far, however, none of even the more plausible explanations of the Stage III - IV error have proved to have any usefulness when it is attempted to extend them to the more complex errors found later in development. Explanations in terms of intersensory co-ordination suffer from this pitfall, as do explanations in terms of both motor skill deficits and representational problems, as we shall see later.

Adherents of the intersensory co-ordination hypothesis of the object concept problem would maintain that, in some way, the fragmentary items of object knowledge acquired by the various separate senses come together with development to form a more complete and satisfactory object concept. Piaget himself suggested that success with the Stage III - IV test meant that the infant somehow appreciated that although the object had disappeared from the visual field, it was still available to the hand.

Observations of infant behaviour would seem to support such an interpretation. A longitudinal study by Schofield & Uzgiris (1969), for example, noted an increase in combined manual and visual inspection of objects just prior to achievement of success in the manual search tasks while Piaget himself found a period just before this success when the infant will not search for an object unless he has been touching it before its disappearance. More direct evidence that the object concept is derived from the co-ordination of schemas is, however, thin on the ground. A significant correlation between performance on a ring-and-cube test of visual-manual co-ordination and performance on object search tasks at 8 and 10 months of age was found by Kohen-Raz (1966) but little other work has reported any significant relationship to exist between the two.

Such intersensory explanations have, however, the virtue of being able to account for the seeming contradiction between evidence of early object knowledge in eye tracking tasks and lack of what seems to be the very same knowledge when the task is later presented

manually (see Chapter 2). On the basis of evidence from discrimination studies, Schaffer has suggested that the disjunctive nature of human development results in the appearance first of a self-contained perceptual learning mechanism which is not immediately capable of exerting control over productive behaviour (Schaffer, 1971, 1975, Schaffer & Parry, 1969, 1970). The knowledge available to the eye control system is in some way 'compartmentalised' and not initially available to the infant's hand control system.

Such an explanation, tempting though it may be, is not without problems. How, for instance, can such an interpretation cover the results of acceleration studies such as that presented in Chapter 2? Experiment 1 found that training on tracking tasks from 12 - 16 weeks accelerated appearance of Stages IV - VI of the object concept. Such transfer would not be possible if the knowledge indicated by tracking performance was compartmentalised in the absolute fashion Schaffer would have it. We have already seen that 4 - 5 month old infants will show differential and appropriate hand shaping to the invisible side of an object (see p 59). How could this be possible if eye and hand are controlled by different cognitive subsystems? Experiment 3 of this thesis will also demonstrate that such separation of object knowledge does not occur. Infants in this experiment were able to reach out in darkness and find an object which had been visible but was no longer so, evidence surely that the perceptual learning system communicates with and can control reaching behaviour.

Other researchers (e.g Harris, 1971) have adopted a less extreme position on the role of intersensory co-ordination but nonetheless maintain that intersensory co-ordination is a prerequisite for achievement of the higher levels of object understanding.

Acceleration studies

Supporters of the intersensory co-ordination explanation have used acceleration studies in an attempt to validate their hypothesis. As was discussed in Chapter 2, this would indeed seem to be the only valid investigatory tool available. Behaviours which are assumed to encourage the co-ordination of information from the various senses are promoted and the effects of this intervention on subsequent development of the object concept examined.

On the basis of longitudinal observations of the behaviour of institutional infants in the first six months, White (1969) carried out an experiment in which he varied the rearing conditions of a group of such infants. He suggested that simple modifications such as increased handling, the introduction of viewable and touchable objects and the routine placement of the infants in the prone position from the third month on would produce acceleration in the appearance of later object-related behaviour by providing greater opportunity for exercise and co-ordination of the infant's early action schemas.

By introducing such variations into the infants' normal environment, White produced differences in the age of appearance of viewing behaviour (i.e holding an object and glancing at it), of bringing an object to the mouth and of what he called 'mutual monitored play', i.e bringing an object to the midline where it is simultaneously viewed and tactually explored by the other hand. Each of these behaviours involves two or more schemas, according to White.

Although all of these behaviours undeniably involve objects, it is not necessary to insist that they are related to the development of the object concept. White neither tested the longevity of his experimental group's superiority nor ascertained their level of competence on less contentious indicators of object understanding, e.g recovering a partially covered object. The fact that the appearance of visually-guided reaching was accelerated by two months in his experimental group is interesting and obviously related to the topic of intersensory co-ordination but it is in no way evidence for the role of intersensory co-ordination in the development of the object concept. The infants may well have followed the course of development described by Piaget, and in an accelerated manner, but this does not prove the importance of these behaviours to object concept development. Indeed, the work of Gouin-Décarie (1969) and Kopp & Shaperman (1973) with thalidomide infants would suggest that the co-ordination of looking, reaching and grasping does not in fact play an irreplaceable role in this development.

A student of Gouin-Décarie has recently completed an acceleration study designed to study the effects of the early promotion of intersensory co-ordinations on later object concept development (Sobey-Simoneau, 1978). Three groups of infants were used, two experimental groups and one control group. All three groups were given a 7-item object permanence test at three months; there was no significant difference between the groups at this point. For the next month, one group were given training on a tracking task in which a train moved round an oval track, passing through a tunnel and occasionally stopping either in the tunnel or at some point close to the tunnel (i.e in sight). The other experimental group were given training designed to promote co-ordination of the schemas of vision, prehension and sucking. This training consisted mainly of reaching practice, both passive and voluntary. When retested on the object permanence tests at four months, this second group were found to be significantly superior in performance to both other groups whose performances were approximately equivalent.

At first glance, this training study may seem to give strong support to the intersensory hypothesis. However, there are several points which should be considered. For reasons of convenience, the period of development studied was limited to 3 - 4 months (cf. Exper.1). This meant that the object permanence testing was, of necessity, restricted to Stages II and III of the object concept. These stages are generally characterised by poor or absent response to disappearing objects; what can be accepted as more positive indicators of these

stages is highly controversial. The items chosen by Sobey-Simoneau were drawn from a variety of sources - Piaget (1937), Gouin-Décarie (1965), Uzgiris & Hunt (1975), Corman & Escalona (1969) and Gratch (1972) - all theorists who have emphasised the importance of intersensory co-ordination to object concept development. At present, there is no direct experimental evidence that such items necessarily indicate Stage II and Stage III object knowledge. That these behaviours co-exist at this time cannot be disputed but their relevance and importance to the construction of the object concept has yet to be demonstrated. The tests of object permanence used by Sobey-Simoneau are therefore open to the criticism that they are derived from the very theory she is using them to prove. Item 3, for example - interrupted audition - is a direct test of intersensory co-ordination. Success on this item in no way implies a direct link between intersensory co-ordination and development of the object concept, as is suggested, but only that training in the co-ordination of schemas promotes intersensory co-ordination, a fact which should not surprise us.

An additional and similar problem lies in the fact that three of the seven items used to test the level of object concept development before and after training involved reaching - the very behaviour being promoted in the co-ordination of schemas training group and one which would not otherwise be expected to be either common or proficient in infants of only 4 months. It is also interesting to note that, even in spite of this training, the two

least contentious items in the test battery - recovery of a partially covered object and removal of a cloth from a hand which is holding an object - were passed by only 8.9% and 4.4% respectively of all subjects at 4 months.

Taking these points into account, it does not seem to me that this study can, therefore, be taken as evidence either that the co-ordination of schemas is essential to object concept development or that perceptual experience is irrelevant to that development. Less contentious indicators of early object knowledge or a longer-term study which could empirically attest to the validity of these early measures would be required.

The amount of acceleration found in the two above studies is neither impressive nor proven to be lasting. This suggests that the role played by intersensory co-ordination in the development of the object concept is in fact minor. As intersensory co-ordination is an extremely difficult, if not impossible, variable to isolate and control, it is possible that what these studies in fact provide is no more than a general increase in experience with objects, promoting the infant's interest and thereby stimulating development. To design an experiment which excludes this possibility seems to me to be impossible.

Other experimental studies relevant to the intersensory hypothesis

A cross-sectional study by Harris (1971) which has been taken to lend support to the intersensory hypothesis is also subject to the above criticism. Harris found that prior visual-manual inspection promoted persistence of search in 8 month olds whereas visual-only inspection did not. Both conditions were effective in promoting search in older infants. These results could be interpreted as evidence that visual-tactual experience of an object is necessary for search in young infants. Such a strong conclusion is not necessary, however; it is equally likely that it is only interest itself which is promoted. Although Harris claims that there was no significant effect of duration of visual-manual examination on persistence of search, his data in fact show that for both younger (7 - 9½ months) and older (11 - 13½ months) groups, a 20 sec. presentation of an object for visual-manual inspection resulted in almost double the amount of subsequent search behaviour when compared to relocation efforts shown after a 5 sec. inspection period.

There is another factor to be considered in evaluating Harris' experiment. Search in the younger age group used often may occur only in the context of extension of a previous reaching movement (see p 12). There is, however, no indication of any attempt to equate behaviour in the two conditions in the period immediately prior to withdrawal of the object. It is therefore not surprising

that the inspection situation which encouraged reaching (i.e the visual-manual condition) should result in more persistent search in young infants. Harris later described the results of this experiment (Harris, 1975) as evidence that manual search cannot at first be guided by visual data alone, that tactual inspection is 'a precondition for search', that search involving the manual system requires a 'manual prime stimulus'. Data is, however, only presented in terms of persistence of search; there is none presented on what would surely be more relevant to the intersensory co-ordination hypothesis, comparative number of search attempts in the two situations. Inspection of the data shows that search must in fact have occurred in the younger group to the visual-only presentation, albeit not persistent search.

Gratch, too, seems determined to prove that intersensory co-ordination is a prerequisite for manual search (Gratch, 1975). He believes that the difference found by Harris between persistence of search in visual versus visual-manual conditions could be attributed to the $8\frac{1}{2}$ month olds not appreciating that the visible object was in fact 'handleable'. He noted with interest that the older infants in the longest visual-only inspection period (80 secs.) appeared to search longer than older infants who had a chance to handle the toy for the same amount of time. This, he suggests, could be attributable to the development of the ability to represent objects cross-modally and to more rapid onset of boredom in the visual-manual condition. Ingenious though such an explanation may be, it seems equally likely that the various differences in behaviour

found by Harris could be traced back to the extremely unnatural conditions of presentation in both conditions. There seems little need to resort to complicated intersensory explanations.

Gratch also seems determined to fit his own data into the intersensory co-ordination hypothesis. Gratch discovered during the course of a longitudinal study of object concept development that infants who were at the stage of being able to retrieve a partially hidden object but who could not yet uncover a fully hidden object (Stage III - approximately 6 months) were also unable to retrieve an object when it was covered immediately after they had grasped it, i.e if it was in their hand but both their hand and the object were covered (Gratch & Landers, 1971).

"When the infants failed to remove the cover from the hand which had just grasped a toy, they held onto the object and looked about, as if unaware that they had an object in hand, or they dropped the object, removed their hand and made no effort to gain the object. However, the infants immediately reached for and grasped the object upon seeing it".

(Gratch, 1972)

This seemed, and is, contrary to Piagetian and traditional views of the role of touch in the development of reaching (Piaget, 1937, Gibson, 1966), views which seemed to have been confirmed by Bruner (1968), White (1969) and White, Castle & Held (1964). It was, of course, possible that the infants' inconvenient difficulty was the result of motor skill problems or attributable in some way to the action of covering their hands. A further, well-designed experiment using both transparent and opaque cloths was therefore carried out and eliminated both of these possible explanations of the infants'

problem. Stage III infants succeeded with transparent cloths but continued to fail to obtain the object when opaque cloths were used (Gratch, 1972).

It seems an almost unavoidable conclusion that the difficulty in the opaque cloth situation must be due to the invisibility of the object, the continued visibility in the transparent cloth situation helping the infant to success. Bruner (1969) observed similar behaviour in 7 month old babies, finding however that the infant did not maintain his grasp when his hand was covered by an opaque cloth but withdrew the hand and began the reach again, this reach stopping in mid-track, the result, according to Bruner, of the loss of visual contact. Gratch insists, however, on the basis of the behaviour of only three babies, that 'looking and manual touching are relatively poorly co-ordinated at this age' and that 'the infants' failure to remove the opaque cloth in response to the feel of the toy in their hand was the result of their being visually and not tactually attentive' - and not due to any simple failure to derive object information from tactual cues. Maintaining the intersensory hypothesis is indeed a difficult process.

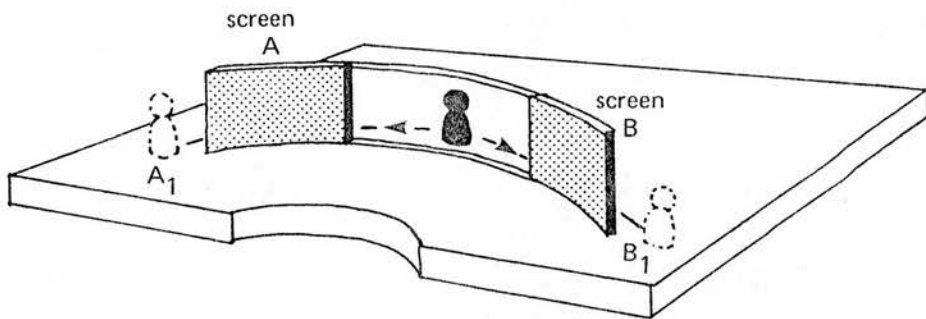
Attempts have been made to elucidate the role of intersensory co-ordination from the other direction. Instead of focusing on evidence of the presence or absence of co-ordination of information from the various senses, these experiments investigate the possibility of any loss of competence being shown in response to a visual search task when the task is altered in such a way that eye-hand co-ordination comes prematurely - and presumably inefficiently -

into play. If the problem for the Stage III infant is a problem of co-ordinating the activity of the eye and the hand, then the competence demonstrated in visual search tasks from an early age should be disrupted if co-ordinated activity is encouraged during the visual task.

Experiments by Neilson (1977) attempted to investigate the intersensory hypothesis in this way.

Two conditions were used. In the first condition, the object moved from the central window, behind screen A, reappearing at A' and stopping there for 7 seconds (Figure 3.2)

Fig. 3.2



The Neilson (1977) apparatus.

It then returned to the central window, via screen A. This sequence was repeated. On the third trial, the object moved off in the opposite direction, passing behind screen B and reappearing at B'. Tracking responses to each disappearance of the object were noted.

In the second condition, the apparatus was appropriately reduced in all relevant dimensions and moved closer to the infant so as to be in such a position that the infant could reach positions A' and B' if he wished. The sequence was as in Condition 1 with the difference that the infant was allowed to reach for and touch the object on the two occasions it stopped at A' and on the catch trial at B'. Again it was tracking responses which were scored.

Following the analysis of Bower (1971), we would expect young infants to fail to anticipate a reappearance of the object from behind either screen A or screen B while older infants would succeed in anticipating the reappearance from behind A but not from behind B, in all likelihood looking in the direction of A' for the object. Condition 1 is theoretically the easier task, involving only eye movements. Condition 2, however, encourages the activation of both visual and manual schemas of coping with objects and should therefore prove more difficult for infants who are in Stage III. Unfortunately for intersensory co-ordination explanations of object concept difficulties, no differences were found in level of responding in the two conditions in babies of $6\frac{1}{2}$ - $8\frac{1}{2}$ months of age. Condition 2 neither disrupted the behaviour of the youngest infants who were in Stage III nor improved the performance of the older infants who were already in Stage IV.

It is always possible that such experiments are taking the intersensory co-ordination hypothesis too literally, assuming that co-ordinations cannot be made centrally and must be expressed overtly

in action. In the experiment above, it could be argued that it was impossible to ensure that only visual schemas were in operation in Condition 1, particularly if, as Piaget would have it, a Stage III infant would not appreciate the difference in distances used. Such a criticism is difficult if not impossible to refute and is a retreat increasingly being adopted by supporters of the intersensory hypothesis. Other evidence, however, makes it unnecessary to linger long over such defences of the intersensory hypothesis.

Reasons for rejecting the intersensory co-ordination explanation of object concept problems

Firstly, there is an increasing body of evidence which points to the early appearance of intersensory co-ordinations, far earlier than Stage IV. Visual-tactual co-ordination, for instance, has been demonstrated in neonates; they reach to touch objects and show surprise and distress if the visible object has no tangible properties (Bower, Broughton & Moore, 1970b). Auditory-visual co-ordination is now well established as existing very early on (Aronson & Rosenbloom, 1971, Alegria & Noirot, 1978, Turkewitz, Birch, Moreau, Levy & Cornwall, 1966) and has, in fact, been demonstrated at birth (Wertheimer, 1961). Auditory-manual co-ordination is similarly evidenced at a very early age in both normal (Wishart, Bower & Dunkeld, 1978) and blind infants (Urwin, 1973).

Less direct but equally persuasive indications of the presence of early intersensory co-ordination comes from experiments on imitation and classical conditioning in neonates. The appearance of imitational abilities in neonates is now well documented and points to the presence at a very early age of rather complex intersensory co-ordinations (Valentine, 1930, Zazzo, 1957, Gardner & Gardner, 1970, Maratos, 1973, Meltzoff & Moore, 1977, Dunkeld, 1978). Similar evidence comes from studies of classical conditioning. If the conditioning situation involves association of the conditioned stimulus (CS) and the unconditioned stimulus (UCS) across different modalities, it should not be within the capacities of young infants and certainly not neonates, according to supporters of the intersensory hypothesis (e.g. Sameroff, 1971). Just such CS - UCS association has however been shown in day old babies (Clifton, 1974, Stamps & Porges, 1975).

A second reason for rejecting this type of analysis is that any explanation of the solution of problems of object permanence in terms of the development of intersensory co-ordinations does not seem to fit in with the general picture of that development itself. All of the co-ordinations mentioned above in fact decline with age (Bower, Broughton & Moore, 1970c, Wishart, Bower & Dunkeld, 1978, Maratos, 1973). The developmental history of the intersensory co-ordinations seems to be one of initial integration of the senses (Dunkeld & Bower, 1976, MacFarlane, 1977), soon to be replaced by a process of progressive differentiation - in other words, a process exactly opposite to the requirements of this explanation (Bower, 1974b).

This differentiation could account for some strange behaviours found around six months. Bruner (1969) noted that 7 month old infants would often close their eyes to reach for an object, particularly if the previous visually-directed reach had failed. I have myself noted a similar phenomenon in object permanence testing situations. Younger infants will often watch the hiding event but look away to perform the reach. This behaviour could easily mistakenly be attributed to inattention and the consequent successful search discounted because the infant was not watching what he was doing. Such behaviours point to the importance of not judging infant behaviour by adult criteria. In addition, such behaviours suggest to me an attempt to reduce information overload and focus the infant's (limited) attentional capacities; they certainly lend no support to claims for the importance of intersensory-co-ordination to success in such situations.

Even if an explanation in terms of intersensory co-ordination had been semi-feasible for Stage III - IV - and it would seem that the pattern of decline in the various co-ordinations sets in either well before or at this very point in object concept development - there is no way such an explanation can cover the other errors which occur so reliably in subsequent development. How, for example, could one explain the place (or AAB) error of the Stage IV - V infant in terms of developing intersensory co-ordinations? How could the switching problem possibly be interpreted to fit in with this type of analysis? As with the traditional analysis of

the infant's problems, it seems that we must also reject the intersensory co-ordination explanation on the grounds of inadequacy. Any explanation which could only hope to account for such a small part of the developmental sequence will clearly not do.

2. MOTOR SKILL/ACTION EXPLANATIONS

Motor skill explanations

The same problem crops up with motor skill explanations of the object concept. If we try to maintain that the reason that the infant fails to recover a desired object when it is covered by a cloth is because he cannot yet perform such a response, we will have great difficulty in explaining the Stage IV - V error in similar terms. If, after all, the infant can now show us that he is capable of removing a cloth in a Stage III - IV situation, why should a new location of the object under an identical cloth pose additional problems for him?

Although Piaget's theory is couched in terms of elaboration and co-ordination of schemas of action, he himself never adopted the rather simplistic viewpoint that the source of the infant's problem lay only in his inability to perform the requisite action. He carefully observed that an infant who was quite capable of lifting up a cloth when it only partially covered an object would not do this when faced with a completely covered object (Piaget, 1937, p 30). There have been others, however, who have attempted to dismiss the

infant's problems as being essentially motor rather than conceptual (e.g Charlesworth, 1969).

As with the intersensory hypothesis, adoption of motor skill explanations allow reconciliation of the apparent contradiction between the demonstration of early object knowledge in tracking situations and failure to demonstrate that same knowledge in later manual search tasks. It is not the case that the older infant no longer knows that the object which has disappeared continues to exist - what he does not know is how to remove the cloth to obtain the object. Using transparent cups to 'hide' the object, Bower (1967) presented some evidence which seemed to favour such an interpretation. Infants who failed in the traditional test also failed if a transparent occluder was used. If the object is fully visible under the transparent cup, failure to recover the object cannot be explained, as many of Piaget's interpreters would have it, as a result of 'out of sight being out of mind'. Lack of success, it is argued, must be due to motor failings rather than conceptual problems.

Others have attempted to replicate Bower's finding without success (Yonas (pers. comm to Bower), Gratch, 1972), their infants failing with opaque covers but succeeding when transparent ones were used. No one, however, has presented conclusive and systematic evidence to substantiate one or other set of findings. Experiment 2 is designed to fill this important gap.

EXPERIMENT 2 (11)

Object permanence testing is usually done under somewhat relaxed conditions, elicitation of appropriate behaviour depending very much on establishing rapport between the subject and the experimenter. It is therefore essential to have very precise definitions of what constitutes a failing or a passing response. Performance in the Stage III - IV task is particularly difficult to assess. The infant will still be relatively unskilled in reaching and may well knock over the occluder in his excitement; it is not therefore enough that the infant at some point ends up with the object that was hidden in his hands. We must devise criteria which will allow us to separate accidental retrievals of the object from truly intentional recovery behaviour.

First of all, of course, we must be certain that the subject can in fact pick up an object from a flat surface. If the baby cannot pick up any object at all, there is little point in checking whether or not he can pick up an occluder to get at another object. If the subject can pick up an object, then it follows that he can pick up an

(11) This study has already been published (see Bower, T.G.R. and Wishart, J.G. - Appendix D.)

occluding object, provided it is not too large. Picking up an occluding object is not, however, the same thing as picking up an occluding object in order to get at an object that has been hidden underneath that occluder, and it is the latter action that we wish to consider criterial in this situation. Piaget himself has never denied that infants who do not have object permanence can nevertheless pick up objects; as mentioned above, he also does not seek to deny that such infants have been seen to remove a cloth from a partially covered object. In such a situation, however, Piaget maintains that the more typical behaviour found is pulling the toy from under the cloth, a behaviour with implications very different from the first in terms of object understanding. The special characteristic of picking up an occluder in the Stage III - IV test is that the occluder is not picked up for its own sake but is removed in order to allow the infant to get at the object that has been occluded. It is this ability to conjoin actions rather than the mere ability to pick up an occluder which Bower (1967) thought was lacking in the infants who failed the standard object permanence test. The problem is thus to decide whether an infant who picks up an occluder is picking it up for its own sake or in order to get at the object inside or underneath the occluder.

The criterion decided on was as follows. Prior to the beginning of object permanence testing, the infants were presented with a toy placed on the table top before which they sat. The time from presentation to successful capture of the object was recorded; this time interval will be referred to as free capture time. It

was determined that if an infant removed an occluder and then picked up the object that had been under the occluder, with the time from removal of the occluder to picking up the object less than that infant's free capture time, the infant would be recorded as having picked up the occluder to get the object, a successful response. Picking up an occluder without getting the object that had been occluded or only succeeding in getting it after an interval longer than free capture time was scored as a failure. This represents a rather strict criterion for success but, in attributing intentionality to the responses of infants, it is perhaps better to be conservative.

Subjects

16 twenty-one week old infants served as subjects, 8 male, 8 female.

Procedure

Subjects sat on their mother's lap at a plain brown wooden table. A stylised doll, painted fluorescent pink and measuring 4.0 cm high x 1.5 cm in diameter, was used as a toy. Previous work had found this to be a desirable enough toy. The transparent occluder was a plastic cup 6 cm high x 3 cm in diameter, with a transmission ratio of .7 (this allowed both the object within the cup and the cup itself to be clearly seen). The opaque occluder was a white, plastic cup of equal proportions and perfectly opaque.

The infants were presented with the toy, placed within reach, and their free capture time recorded. After 15 seconds, the toy was taken away from the baby and one of the occluders placed in the same location, the opaque for 8 babies, the transparent to the remaining 8. Free capture time for the occluder was also recorded. The occluder was then taken away and the toy replaced in its original location. Before the baby could take the toy again, the opaque occluder was placed slowly over the toy. The baby was then given three minutes to recover the object before the trial was terminated. If the infant was unsuccessful, the occluder was removed at the end of the trial, revealing the object which the infant was then allowed to pick up and retain for 15 seconds. At the end of this time the toy was removed and replaced in its original location, this time being covered by the transparent occluder. Trial duration was again three minutes, save that if an infant had a hand on the occluder at the end of the three minutes, he was given a further two minutes to complete his response. If at the end of this period the infant did not have the toy, the occluder was removed and the infant allowed to take and retain the toy for 15 seconds. A second opaque occluder trial was then conducted, with a trial duration equal to that given with the transparent occluder.

Results

The results are summarised in Table 3.1.

TABLE 3.1 Results of Experiment 2

Condition	N. picked up occluder	Mean time taken to pick up occluder	N. picked up toy	Mean time to pick up toy	N. within free capture time
Opaque 1	0	-	0	-	-
Transparent	14	115 secs	10	40	8
Opaque 2	2	125 secs	2	35	2
Mean free capture time for object				45 seconds	
Mean free capture time for occluder				55 seconds	

As can be seen, the hypothesis that there is no difference between an opaque and a transparent occluder as obstacles in a manual search task can clearly be rejected. The opaque occluder was far more difficult than the transparent occluder. On the other hand, it cannot be concluded that the transparent occluder presented no difficulties at all. As can be seen, latency of picking up the transparent occluder when there was a toy inside it was far greater than latency of picking up the occluder itself, indicating that the conjoined response was more difficult. In addition, only 8 of the 14 infants who successfully removed the transparent occluder succeeded in picking up the object within their free capture time, 4 of them failing entirely to pick it up at all.

Discussion

The above experiment demonstrates clearly that the problem for the Stage III infant is not simply reducible to lack of the appropriate motor skills. Behaviour sequencing, on the other hand, does seem to play a role but again the results suggest that this role is a secondary one. The more important difference between the two object search tasks used seemed to be the visibility or non-visibility of the object to be recovered. It is, of course, possible that this difference does not necessarily mean that 'out of sight is out of mind' in the standard Piagetian object permanence test. The difficulty shown in such a situation could be attributable to motor difficulties summing with the difficulty created by the fact that the object is no longer visible, which is not the same thing. The role of visibility will be discussed extensively in the next major section of this chapter; further consideration of the implications of the results of this experiment will therefore be postponed until then.

Other motor skill experiments

Three other findings are relevant to the role of motor skill in object permanence situations. In a continuation of the experiment above, babies were given intensive practice in removing the transparent cups. No transfer of success to opaque cups was seen; no matter how long the infants were given, they did not remove the opaque cups. The experiment of Gratch (1972) has already been

mentioned. He found that 6 month old infants who were able to remove a transparent cloth if it was placed over their hand as they grasped an object merely sat and looked about if an opaque cloth was used to cover the object; it was as if they were unaware that they had an object in their hand. Obviously lack of appropriate motor skills alone cannot be held responsible for the infants' difficulties in either of these experiments. Thirdly, as Experiment 4 of this thesis will demonstrate, behaviour very similar to that seen in the standard Stage III - IV task appears in a task in which the infant must recover an object which has been placed on top of a platform. Retrieval of the object in this situation obviously does not involve removal of any occluder and the object is perfectly visible throughout; nonetheless, infants may stop in mid-reach and do not seem to realise that the object is still available to be reached for. As there is very little difference in terms of motor requirements between reaching for a dangling object - something well within the capabilities of these infants - and picking up an object from a platform, it is unlikely that lack of the appropriate motor skill can be blamed for the apparent difficulty in this situation either. Some more complex problem clearly underlies this apparently simple task.

Action explanations

Piaget's attitude to the role of action in development is considerably more complex than has so far been considered.

According to Piaget, object knowledge is firmly rooted in action; an object only exists in connection with an action as far as the infant is concerned. The infant has, as yet, no way of recreating his world except via the repetition of his personal action schemas. This incomplete understanding of the relationship between his actions and the activity of the objects around him results in some very peculiar behaviours.

"Laurent, at 0;7 (5) loses a cigarette box which he has just grasped and swung to and fro. Unintentionally, he drops it outside the visual field. He then immediately brings his hand before his eyes and looks at it for a long time with an expression of surprise, disappointment, something like an impression of its disappearance. But far from considering the loss as irremediable, he begins again to swing his hand, although it is empty; after this he looks at it once more. For anyone who has seen this act and the child's expression it is impossible not to interpret such behaviour as an attempt to make the object come back".

(Piaget, 1937, Obs. 16)

The inappropriateness of the infant's search behaviours are, for Piaget, the best indication of the limitations and inadequacies of his conception of reality. Objects only exist when being acted upon and are not conceived of as having any existence outside the infant's direct interactions with them.

The Stage IV (AAB) error is very important to the integrity of Piaget's model. His explanation is not implausible and gives a reasonable account of what is a most peculiar but firmly established error (Uzgiris & Hunt, 1975, Gratch & Landers, 1971, Butterworth, 1975). Emphasising, as always, that the construction of knowledge is a process rooted in the activity of the infant,

Piaget maintains that the Stage IV error appears as a result of the infant's failure to assimilate the new position of the object. The object is identified entirely in terms of the infant's previous successful search activity and the position in which that activity occurred (A); the movement of the object to a new position (B) is not even registered. The object is defined as 'the-object-I-find-at-A' - even although the infant quite clearly sees the object being moved and hidden at B. According to Piaget, this is a result of the infant's inability to hold in mind a sequence of actions, itself the result of his inability as yet to relate them to a single coherent spatial and temporal structure.

EXPERIMENTS FOCUSING ON THE ROLE OF ACTION IN OBJECT CONCEPT DEVELOPMENT

Several attempts have been made to find empirical support for Piaget's belief that action is central to the construction of the object concept. Boynton & Uzgiris (1975), for example, found that infants of $8\frac{1}{2}$ - $9\frac{1}{2}$ months did not make the expected AAB error if the object was hidden successively in near (reachable) space and a delay of 2 seconds interposed between hiding and search. If, however, the object was hidden at a location out of reach of the infant, the hiding apparatus then moved into reach and a 2 second delay in search again imposed (the method generally adopted by Gratch and his co-workers), performance was significantly poorer. This finding was interpreted as supportive evidence of Piaget's contention that formation of

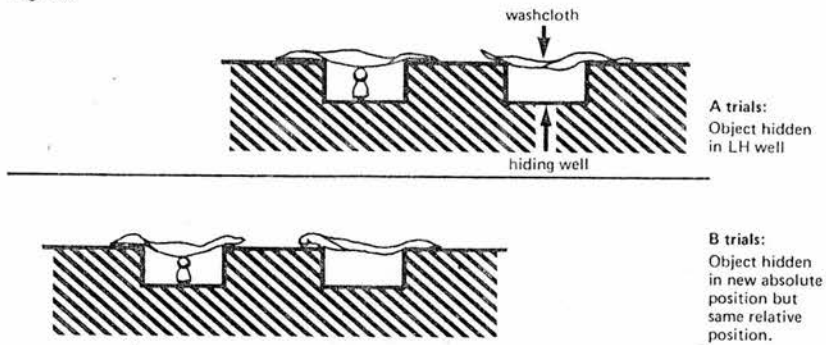
coherent spatial relationships (a process intimately bound up with object concept development) is first achieved in near space, the result of the infant's direct interactions with objects in his immediate (near) surroundings. A further result of the study, that a hiding task in which the object was hidden successively in two locations which stood in a vertical spatial relation to each other proved to be more difficult than a task in which the object was relocated in another, horizontally different location, also seemed to point to the role of experience in the organisation of search behaviour, vertical spatial relations presumably being more unfamiliar than horizontal ones.

Further work by Flory & Uzgiris (1975), however, pointed to these results being an artefact of the apparatus used by Boynton & Uzgiris. The hiding apparatus used was a replica of the Gratch box. This consists of a rectangular box (26" x 16" x 2"), containing two hiding wells (7" x 7" x 1½") spaced 12" apart. Two identical white wash cloths (12" x 12") are used to cover the wells after the object has been placed in one or other of them. If, as in the Boynton & Uzgiris experiment, this apparatus is used at a distance, the perceived separation of the two wells will obviously be reduced. Flory & Uzgiris therefore made use of a skeletal apparatus: two wells - identical in dimensions and separation to the Gratch apparatus - joined together by a thin metal rod. Using this, the difference in success between the near and far conditions was virtually eliminated.

Failure to control for perceptual discriminability between the two locations could also account for Boynton & Uzgiris' results with horizontally and vertically aligned locations. Although the horizontally arranged locations were separated by a distance of 12", the vertical hiding box which was used had essentially no spatial separation between the two locations. Such an arrangement is almost bound to lead to confusion in infants who have as yet only poorly formed notions of space. It is quite unnecessary to invoke theories of action to explain such results.

Other experiments also suggest that action is not, in fact, the major determining factor in object concept development. Harris (1973), for example, pointed out that AAB errors need not necessarily result from the infant conferring an absolute position on the object on the basis of his previous actions, as Piaget would claim. The AAB task confuses two types of position change, absolute and relative. Searching again at A when the object is hidden at B could be the result of the change in the relative (left-right) position of the container hiding the object rather than being the result of the infant defining the location of the object absolutely, i.e as that position in which he last successfully searched for it. By moving the containers between trials at A and trials at B, Harris found that a change in absolute position did not, as Piaget would predict, lead to error in nine month olds - provided the relative position of the two containers was kept constant (see Figure 3.3).

Fig. 3.3



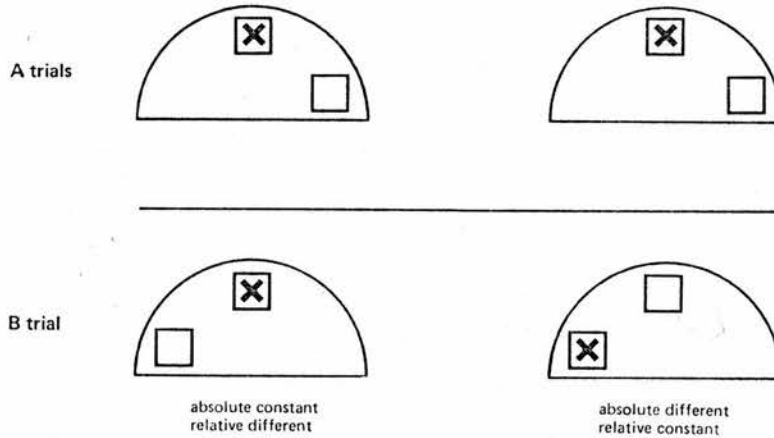
Harris' (1973) variation of the AAB task

Butterworth (1975) rightly criticised Harris on two points which he suggested could account for the apparent reversal in competence found by Harris:

1. there is evidence that AAB errors occur only after a delay between hiding the object and allowing search (Gratch, Appel, Evans, Le Compte and Wright, 1974) - Harris allowed immediate search
2. it is possible that some or even all of the infants used might not have made errors in the standard situation either - Harris used only one age band of infants and did not compare their performance with performance in a standard situation.

When these factors were taken into consideration, Butterworth found that infants tended to err in both a condition where relative position was held constant and a condition in which absolute position was held constant, a finding lending support to neither Harris' nor Piaget's interpretation of the problem (see Figure 3.4).

Fig. 3.4



Butterworth's (1975) variation of the AAB task

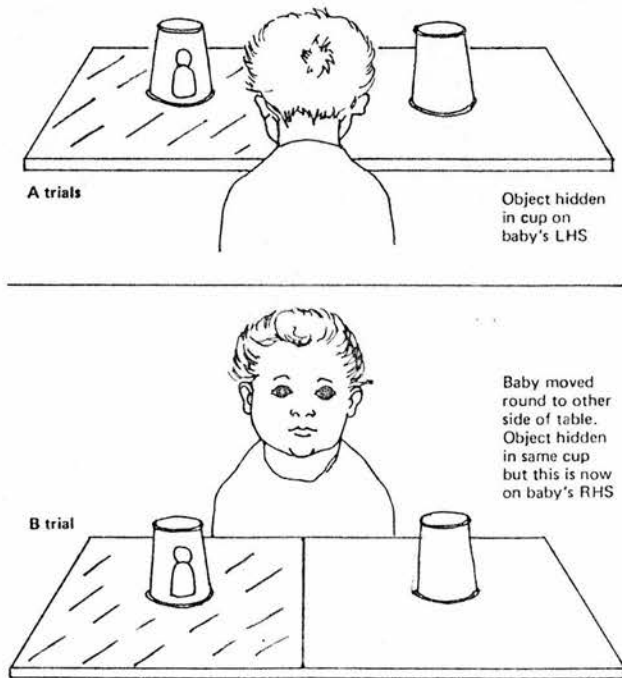
Butterworth himself attributes the infant's difficulty in the Stage IV - V test to a conflict between two co-existing spatial location codes, one egocentric and one allocentric. This conflict, he believes, gives way with development to reliance on broader, visual frames of reference which remain invariant with movement. This interpretation of the AAB error will be considered more fully later (see Chapter 6).

As we have seen, Piaget's account of the AAB error contains two interlinked elements: (1) response perseveration and (2) place perseveration: the infant searches for the object in the location

at which it was last found. We have already seen that Harris' belief that place perseveration alone could account for the errors found in standard testing situations cannot be upheld. Bremner & Bryant (1977), on the other hand, contend that it is in fact response perseveration which lies at the base of the errors shown in Stage IV; spatial reference systems, whether interpreted in relative and/or absolute terms, are not involved.

In their experiment, infants were given two A trials in the normal manner. After the second A trial, they were then moved round to the other side of the table and the toy again hidden in position A (Figure 3.5). Infants, however, tended to search for the object in B on this trial, even although the absolute position of the object was constant over the three trials. They therefore conclude that 'perseveration (in the AAB test) is of responses rather than to places'.

Fig. 3.5



Bremner & Bryant's (1977) 'AAB' task

Evans & Gratch (1972) also believe that the AAB error could be explained in terms of repetition of a successful action. They found that infants would search at A on the 'catch' trial even when a totally different toy was hidden at B, thus seemingly disproving Piaget's suggestion that the AAB error is a result of the infant identifying an object in terms of the place where he last successfully searched for it. They conclude that position A in some way represented a 'toy-box' to the infant, and that search there would always provide an object.

The findings of both these experiments are perhaps more limited in their implications than the authors would like to think and in no way justify their firm conclusions that the source of the AAB error lies in response rather than place perseveration. Gratch & Evans in particular would like to maintain that the AAB error is simply a place-going error which occurs irrespective of the particular object involved. To my mind, substitution experiments such as theirs can give at best only ambiguous results. Returning to A when a new toy is hidden at B is as likely to reflect a perfectly reasonable attempt to locate the original (and, who knows, possibly preferred) toy as search for the new toy at the old hiding place. If, too, we were to take Gratch & Evans' interpretation to its logical conclusions, how could we ever explain why all the infant's search activities are not restricted to one particular place?

Bremner & Bryant's study is also not without problems. They too wished to explain the occurrence of the AAB error in terms of

simple response perseveration. Unfortunately, however, in attempting to hold place constant, they failed to take account of an important factor. Although the absolute or geographically defined location of the object would not have changed between trials, any egocentric coding (i.e. to the left or right of the baby) or relative coding (i.e. to the left or right of the other cup) of that location would in fact have changed. Their results therefore cannot provide definitive support for their conclusions. As far as I know, no resolution of the place versus response argument has yet been made - nor, I believe, can it be. I shall return to this problem in Chapter 6.

Other researchers have investigated the role of action in an even more direct fashion. In regard to Stage III - IV behaviour, we have already considered Harris' (1971) experiment in which, at first glance, it seemed that visual-manual inspection of the object was a precondition for search. It was decided that Harris' data did not warrant such a strong conclusion (see p 69). In considering Stage IV - V, if prior successful action is assumed to be the determining factor in producing errors, one might expect to find differences between infants who make large numbers of successful searches at A before the object is hidden at B and infants who merely observe the A hidings before being required to search at B. Although Piaget is careful not to commit himself on this point, it would seem that looking and doing are not given equivalent status in development.

Landers (1971) varied the number of A trials (2, 8 or 10) for three groups of nine month old infants; two further groups were given 6 or 8 observation-only A trials which were then followed by two standard, active A trials. Although all groups tended to err on the first B trial, the group who had 8 or 10 active A trials made longer runs of searches at A on the B trials than the other groups.

It is important to note, however, that in this experiment the infants were in fact given the toy after it had been uncovered in the observational-only trials and also on erring on B trials. It is therefore possible that observational trials were not as 'inactive' as Landers might like to think. Observation may still elicit a rehearsal of overt search or active orientation and it could even be maintained that, from the infant's point of view, this (albeit limited) action was successful since the experimenter eventually uncovered the toy and gave it to the infant. Without a clearer definition of what constitutes activity, it is impossible to rule out such objections. The longer run of errors found in the active 8 or 10 trials at A groups could simply be a result of their becoming set in their ways of searching - wrong search still resulted in obtaining the object, thereby reinforcing an already well established habit of going to A, even when the object was seen being hidden at B.

The major flaw of Landers' study is, of course, that no group was given exclusively observation-only A trials; all groups had at least two active A trials. A study by Evans (1974) attempted to replicate Landers' findings, using all active or all observation-only

A trials, thereby making it possible, subject to the reservations outlined above, to evaluate more clearly the role of active experience in determining the appearance of the Stage IV error. Infants were not given the toy if they erred. Evans found that comparable numbers of infants in both groups tended to err on the first B trial and runs of errors on subsequent B trials were also very similar in length, a finding confirmed by Butterworth (1974, 1977). To my mind, runs of errors in any condition in themselves weaken the action argument in its strong form. If search is directed on the basis of previous successful actions, why should the infant continue to respond at A after, say, 4 unsuccessful searches there? Further evidence of search at a prior location in 8 month olds in a situation in which 'action perseverance' theories could not be forwarded is given by Lucas & Uzgiris (1977).

How should we define 'action'?

Perhaps the most striking - and problematic - evidence on the role of action in object concept development comes from Gouin-Décarie's (1969) study of its development in thalidomide babies. Obviously these babies could not have had the same kind or indeed amount of active experience that normal infants have. Nonetheless, their development of the object concept was more or less on par with the normal ages of acquisition of each stage. Similar results have been found by Kopp & Shaperman (1973).

This brings us back to the problem of the ambiguity of the notion of activity in the sensori-motor period. How literally do we define 'action'? Gouin-Décarie herself would maintain that the normal development of the object concept in thalidomide children does not embarrass the Piagetian formulation of the source of the infant's problems in this period, that Piaget was emphasising central activity rather than peripheral actions. From such a stance, the above results are not irreconcilable with the importance of action in object concept development. This is not, however, a position which Piaget himself has clearly taken as far as I know. As I have already said, it is not at all clear whether looking and doing can perform the same functions in the construction of notions of reality - this period of development is, after all, referred to as the sensori-motor period and is never discussed as if this could be taken to include sensori-perceptual in its meaning.

The concept of action as used by Piaget is indeed rather vague and ill-specified. Particularly during his analysis of the sensori-motor period, there is little indication whether 'activity' literally means physically-expressed actions or whether it is a more subtle notion, involving more covert, centralised organisation of behaviours. The looseness of the concept is no doubt intentional. Piaget considered activity as being ultimately involved in all levels of cognitive functioning; the form and nature of this activity in fact constitutes the main defining characteristic of each of the stages. Development seems to be described as progressing from organisations of mainly overt, sensori-motor activity to more

internalised schemas which, with development, are capable of becoming totally abstract in nature. Even this highest level of functioning is, however, rooted in simple sensori-motor beginnings.

Interpreters of Piaget have attempted to shake off evidence of the irrelevance of simple overt action in early cognitive development with accusations of insensitivity to the complexities and subtleties of Piaget's notion - simple coarse action was never what Piaget intended at all. Whether this stance is defensible in relation to the sensori-motor period is however questionable. In this period, the infant is assumed to have no differentiated awareness of self and objects; it therefore seems an unavoidable conclusion that all object knowledge must be constructed via direct interactions with objects. In particular, Piaget's explanation of the Stage IV error is hard to interpret in terms of other than overt motor response and more central possibilities are neither elaborated nor hinted at. It would therefore seem to me that although Piaget may not have meant to give such a literal interpretation to the notion of activity in sensori-motor intelligence, this is in fact what it comes out as, particularly when it is considered in relation to his treatment of the nature of activity in later stages. It is the very overt nature of activity in this period that distinguishes it from the later phases of development.

Reasons for rejecting motor skill/action explanations of
object concept problems

On the whole the evidence seems to point to action, as commonly defined, being of relative unimportance in the development of the object concept. Action and motor skill obviously have roles to play in development but what seems to be more important is the ability to control and appropriately apply newly acquired motor behaviours once established. Certainly, the experimental evidence would seem to undermine the importance of the role of straightforward physical action to development. As Gouin-Décarie would suggest, however, such negative conclusions may be the result of our inadequate definitions of what constitutes activity. When it comes down to it, the main objection to present motor skill/action theories of cognitive development is probably that they place too much emphasis on overt actions without sufficient regard to the less obvious, internalised activity which undoubtedly takes place in search tasks. (12)

It is always possible that more sensitive interpreters of Piaget's position may come up with a more acceptable and less vague version of the action hypothesis. In the meantime, however, this theory too must be set to one side.

(12) Take, for example, the behaviour of a baby who has just made an AAB error. Having confidently picked up what turns out to be the wrong cup, the baby may well examine this cup thoroughly, shaking it and putting his hand inside it to check that the object is definitely not there, looking most surprised throughout. Such behaviour does not merely represent the repetition of a previously successful action; it is surely evidence that the baby 'thought' that he would find the object under that cup.

3. REPRESENTATION/MEMORY EXPLANATIONS

The third and probably most popular category of object concept explanation assumes that the problems shown in object permanence tasks stem from either representation or memory difficulties. Recent evidence suggests, however, that these forms of explanation are also inadequate.

Representational analyses

According to Piaget, the culmination of development in the sensori-motor period is the appearance of the ability to respond to the environment without having to resort to overt action. The infant's "sensori-motor apprenticeship" (Flavell, 1963) is over and new means are now invented through internal, mental co-ordinations. This ability to represent frees the child spatially and temporally, allowing reorganisation of earlier schemata without recourse to externalised actions. Graduation from the sensori-motor stage is a direct result of the appearance of this ability.

Many interpreters of Piaget have maintained on the basis of this that the problems that the infant has in object concept tasks must be due solely to his inability to represent objects in their absence (see e.g Hunt, 1969). In its simplest form, this argument would maintain that 'out of sight is out of mind' for the sensori-motor infant, his behaviour in search tasks being based on repetition of actions which have previously led to successful

recovery of the object. Depending on the complexity of the search task and the level of development of the infant, these behaviours will or will not be appropriate.

The infant's inability to represent an object in its absence could in theory account quite satisfactorily for the behaviours seen in traditional object permanence situations. If the infant's understanding of objects is inextricably linked to his actions upon them, he would not, while in Stage IV for example, understand that an object can change position without there having been some activity on his part. This view could be modified later to allow the object to change position as long as it had been seen to move but would not, until Stage VI and the advent of representation, allow for invisible displacements of objects.

It should be immediately pointed out that Piaget's complex theorising on development in the sensori-motor period is by no means reducible to one element, not even one so important and central to his model as representational ability. As was stated at the beginning, although the alternatives to Piaget's account of this period have been divided into four categories, all are essentially extensions or modifications of ideas which Piaget himself considered in constructing his theory and none of which was given absolute importance in his presentation. He has at no point stated a belief that 'out of sight' is 'out of mind', more guardedly stating that the infant in such situations 'acts as if the object no longer existed'.

Nevertheless, many investigators have concentrated on the role of representation in object concept development, assuming that the infant's difficulty in the search tasks must be attributable to their inability to represent the object in its absence. It is perhaps understandable how researchers arrived at the conclusion that visibility/invisibility must be the key to object concept problems. Information of object location given through any of the other senses does not seem able to compensate for loss of visual information. Ringing, squeaking, rattling or similar audible clues from the hidden object do not persuade the Stage III infant to attempt to relocate it (Fraiberg, Siegel & Gibson, 1966, Freedman, Fox-Kolenda, Margileth & Miller, 1969, Piaget, 1937). Tactual information as to object location is similarly ineffectual (Piaget, 1937, Gratch & Landers, 1971, Gratch, 1972, Brown, 1973).

"At 0.7 (28) Jacqueline tries to grasp a celluloid duck on top of her quilt. She almost catches it, shakes herself, and the duck slides down beside her. It falls very close to her hand but behind a fold in the sheet. Jacqueline's eyes have followed the movement, she has even followed it with her outstretched hand. But as soon as the duck has disappeared - nothing more! It does not occur to her to search behind the fold in the sheet, which would be very easy to do (she twists it mechanically without searching at all). ... I then take the duck from its hiding place and place it near her hand three times. All three times she tries to grasp it, but when she is about to touch it I replace it very obviously under the sheet. Jacqueline immediately withdraws her hand and gives up. The second and third time I make her grasp the duck through the sheet and she shakes it for a brief moment but it does not occur to her to raise the cloth".

(Piaget, 1937, Obs. 28)

Such findings do not, however, mean that visibility by default must be crucial to the maintenance of object knowledge in early infancy. Visibility of the object will obviously simplify any object problem, particularly if that problem involves relocation of the object. As Experiment 2 showed, however, making the object visible does not entirely remove the infant's problems in search tasks. Lifting the occluder in the transparent cup situation still took approximately twice as long as it normally would.

Memory explanations

Other researchers have emphasised the role of visibility because they believe the errors shown in the standard test situations to be attributable to simple memory deficiencies in the young infant. Such researchers deny the need for recourse to any over-elaborate theory of a developing object concept. In the Stage III - IV situation, for example, they would maintain that out of sight is literally out of mind, the Stage III infant simply having no memory of the object to direct his search. In the Stage IV - V task, search at A when the object has been moved to B is due to a lapse of memory, a sort of absent-mindedness. Put in more technical terms, the AAB error is the result of proactive interference between visual memory of a recent event and action-based memory for a successful action (Harris, 1973, Webb, Massar & Nadolny, 1972); it is not, as Piaget would have it, caused by the

infant's failure to register the hiding at B - it is registered but is then forgotten. Such seemingly straightforward explanations can also account for residual errors in the Stage IV - V task, errors found when search in the correct, new location is unsuccessful or frustrated. On the memory hypothesis, unsuccessful search leads to 'a resampling of the available cues' and the infant quite naturally looks in the object's prior location. It is important to note that such explanations do not concern themselves with the possibility that the infant has problems in understanding the nature of objects - his only problem is remembering where to find them.

Attractively simple though memory explanations of the infant's difficulty in object concept testing situations may be, they somehow lack conviction. They seek to deny that a misunderstanding of the nature and properties of objects is at the base of the inappropriate search behaviour shown and yet it seems unlikely to me that mere forgetting could explain away all the infant's difficulties in such tasks. Common, everyday observations of the behaviour of even young infants suggest that memory just cannot be so short-lived. Gratch, Appel, Evans, Le Compte & Wright (1974), for instance, found that although a delay between hiding and search was necessary for elicitation of the AAB error, that delay need not be greater than 1 second. Observations in the Stage IV - V testing situation suggest further that the error is not a result of lack of attention. Infants who are raptly attentive to each part of the hiding sequence nevertheless go straight back to A on the catch trial. Surely

infant memory cannot be so limited nor proactive interference so powerful as to eradicate entirely the memory of an object seen only an instant beforehand? Evidence that memory for an object which has been occluded is of at least 5 seconds duration in infants as young as 8 weeks has been presented by Bower (1967) while Fagan (1973) has found evidence of recognitive memory of a static visual array still being present in 5 month old infants after a period of two weeks. (13)

Memory experiments

Gratch et al (1974) performed a series of experiments to test the memory explanation of the AAB error. If errors are a result of forgetting the new hiding place, the length of the delay in onset of search should be a significant factor in production of errors. They found, however, that 9 month old infants were likely to err equally in all of their delay conditions (1, 3 and 7 seconds), although errors were virtually absent in an 0-second delay condition.

(13) Such a finding could be taken as embarrassing both Piaget's and Bruner's theories of memory. It is difficult to see how memory for a static visual display could be based on motor schemas or enactive representation. One could resort to insisting that eye movement activity is at the base of such memory. As no comparisons have as yet been made of the relations between visual scanning patterns during first exposure and those during subsequent recognition or non-recognition, it is impossible to refute such an explanation (Haith & Campos, 1977).

This latter fact does seem to suggest that the infant does in fact register the new hiding place and then forgets but the authors suggest that success in the no-delay condition is an artefact, a result of 'motor set' or the infant being frozen into the correct orientation. As soon as this set is broken (and this can only happen when there is a delay in search), the infant will assimilate the hiding of the object at B into his schema of finding the object at A. Such an interpretation represents an attempt to maintain the essential features of Piaget's description of the Stage IV - V problem.

Harris, one of the original proponents of the memory hypothesis, also found that a delay was necessary for elicitation of the error and further maintained that the error was only produced when a particularly distracting hiding sequence was employed: toy hidden in new position, that position covered and then the former position covered (Harris, 1973). Gratch et al (1974) did not, however, find that such a complicated and distracting sequence was necessary for production of the error while Butterworth (1974) has even found that it is not necessary to hide the object at all to produce evidence of confusion.

As I have said, attentiveness does not seem to influence behaviour in the AAB situation at all. Gratch et al (1974) found no evidence of correlation between attention during presentation or delay on the B trial and errors on that trial. Direction rather than amount of attention seems more important in determining success

or failure in young infants in the Stage IV - V task. Forgetting in the traditional sense does seem to play a role in older, less attentive infants but it is not at the base of the errors when first manifested.

Harris (1975) has suggested a modification to the memory hypothesis which might make it more acceptable. He suggests that it is not the invisibility of the object in itself which causes problems but the fact that the object was visible and then became invisible. Piaget (1937) and White (1969) have noted that an object which is put in the infant's hand while outside the visual field will be carried into the visual field for inspection. Yet both Bruner (1969) and Gratch (1972) found that a 6 month old infant would typically be unable to retrieve an object if his hand was covered by an opaque cloth as he grasped it. Success in both of these tasks would seem to depend on derivation of object knowledge from tactual information yet in one case, the infants are successful while in the other they fail. Harris believes that it is the fact that the object was at first visible to the infant and then became invisible that causes the difficulty in the second situation. In support of his claim, he cites Gratch's finding that infants could easily cope with this problem if a transparent cloth were used to cover the hand that was grasping the object. This finding fits in with the result of Experiment 2 although the infants in that task, while succeeding with transparent cups, by no means found it an easy task, a fact which surely casts some doubt on claims that loss of visibility alone causes the infants problems in

the standard situation. Since Experiment 2 showed that the problem did not lie in motor skill deficiencies either, this surely suggests the presence of a third factor. I shall return to this in the next section on identity.

Experiment 2 was ambiguous on the point of whether out of sight is out of mind for Stage III infants. The in-sight condition, the transparent cup situation, still proved to have associated difficulties, albeit less disabling than those associated with the opaque condition. We have seen that these could not be dismissed as mere motor problems. To assess the true importance of visibility/invisibility it is necessary to have an out of sight condition which carries with it near minimal behavioural problems. If out of sight is indeed out of mind, the absence of behavioural problems will be of no help to the infant. If on the other hand, out of sight is merely an (additional) problem in retrieving the object, then the absence of the behavioural problems posed by the standard situation might allow the infants to succeed. Experiment 3 was designed to investigate this question.

EXPERIMENT 3 (14)

SUBJECTS

12 twenty week old infants, 6 male, 6 female, served as subjects.

PROCEDURE

The subjects were given a standard Piagetian object permanence test as described in Experiment 2 (p 83). All of them failed to remove the occluder. A different out of sight condition was then presented. The table used in the standard situation was removed and the doll was presented on the end of a string, dangling in front of the baby. The infant was restrained by his mother from reaching out for the toy (a precaution necessary to ensure that any subsequent reaching could not be dismissed as mere 'extension of the movements of accommodation') and the room lights were extinguished. Since the room was light-tight, this left the baby in total darkness. The toy was thus out of sight, as was everything else in the environment.

(14) This study has already been published (Bower, T.G.R. & Wishart, J.G - Appendix D).

The babies' behaviour was recorded with an infra-red T.V. system, the vidicon of which was sensitive to light between 850 and 875 millimicrons. Illumination in this spectral band, which is totally invisible to the human eye, was provided by a specially constructed light source using multiple crossed polaroid filters.

The babies were left alone in the darkness for three minutes unless persistent distress warranted termination of the experiment prior to the elapse of that time. The standard object permanence test was then repeated.

RESULTS

None of the infants passed the standard object permanence test on either presentation. All of them were able to reach out to obtain the object out of sight in darkness. The reaching in the dark was accurate (Figure 3.6). The hands went straight to the object locus even after initial periods of distress lasting as long as 90 seconds.

Figure 3.6



The 20 week old infant shown here is sitting in complete darkness. Despite this, he is able to reach out and obtain the object he had seen before the lights were switched out.

DISCUSSION

The above experiment seems to demonstrate that out of sight is not out of mind, not even that part of mind that controls hand movements (see p 32), provided the transition to out of sight is accomplished by plunging the room into darkness.

The first published account of this experiment caused two objections to be raised to the claim that success in this task demonstrated that out of sight was not out of mind for the Stage III infant (Haith & Campos, 1977). Both, I think, can be shown to be invalid. The criticisms were:

1. the infants may have been in the act of reaching when the lights went out, in which case successful capture in the dark would merely be an instance of the "extension of the movements of accommodation", a recognised Stage III accomplishment
2. some tactile groping to retrieve a perceptual experience may occur even in Stage III. (Obs. 17, Construction of Reality (Piaget, 1937) was cited as evidence for this claim).

As can be seen from the account given above, infants were in fact restrained from reaching until the lights were extinguished. Although this makes it unlikely that subsequent reaches represent no more than extension of accommodatory movements, it is not possible to refute the suggestion that the reaching schema had nevertheless been activated centrally prior to the lights going out. It would be difficult to design any experiment which could refute such objections - it would be equally difficult to design an experiment to prove that this was in fact the case. I feel,

however, that the latency in some cases of the initial reach very much diminishes the force of any such argument.

The second criticism is, I feel, based on a rather inadequate inspection of Piaget's observation 17, one of five observations which Piaget groups together as instances of response to 'interrupted prehension'.

"Obs. 17. As early as 0.4 (6) Laurent searches with his hand for a doll he has just let go. He does not look at what he is doing but extends his arm in the direction toward which it was oriented when the object fell.
At 0.4 (21) also, he lowers his forearm in order to find under the sheet a stick he held in his hand and which he has just let go.
Same reaction at 0.5 (24) with all sorts of objects. I then try to determine how extensive his search is. I touch his hand with a doll which I immediately withdraw; he is satisfied to lower his forearm without really exploring the surrounding area ..."

The tactile groping in this observation is not to retrieve a perceptual experience but, more specifically, to retrieve a tactual experience - instances of what Piaget later refers to as 'tactile permanence'. As none of the infants in this experiment were allowed to touch the object prior to the lights going out, the behaviour shown in the dark cannot legitimately be compared to this form of behaviour.

These criticisms aside, one could infer from this experiment that out of sight is not out of mind in the standard situation either, the difficulties of the motor task simply summing with difficulties created by the fact that the object is no longer visible. One should, however, be beware of equating all the changes in stimulation that result in disappearance of an object. Michotte

(1955, 1962), as we know, has given a careful account of the psychophysics of disappearance, an account which has not unfortunately been given the attention it deserves by many infant psychologists (including Piaget). Michotte clearly demonstrated that, in adults, all disappearances are not perceptually and conceptually equivalent. He has specified in some detail the necessary stimulus conditions for existence constancy. An abrupt, wholefield disappearance (as in this experiment), for instance, will lead to existence constancy whereas an abrupt, local disappearance (such as that caused by an explosion) will not.

Bower (1967) found evidence that babies operate in a similar fashion to adults on at least 4 of Michotte's categories of disappearance. It could be argued that disappearance under a cloth is a disappearance of the second sort (i.e abrupt and local) in the hands of an experimenter who covers the object too quickly for the infant's information-processing apparatus to register those very aspects of the disappearance sequence which will allow for existence constancy. Bower found evidence of existence constancy in 7 week old infants in a task in which a moving screen occluded an object. This existence constancy disappeared, however, if the speed at which the screen moved over the object was raised from 25 to 75 cm/sec., a fact which suggested to Bower that the infant's visual system had a rather low temporal resolution. It seemed to be unable to detect such an occlusion as gradual, registering it instead as abrupt. It seems unlikely, however,

given the evidence that Bower presents on the rapid development of capacity to process occlusion information and the age of the babies used in this experiment, that the slow, gradual covering of the object used in the traditional testing situation did not allow for processing out of the requisite information. Obviously some other factor, absent from the reaching in the dark situation, must be contributing to the infant's difficulty in the standard situation. This factor seems to be reducible to neither motor problems, problems presented by the invisibility of the object nor, as was suggested in Experiment 2, to a combination of these.

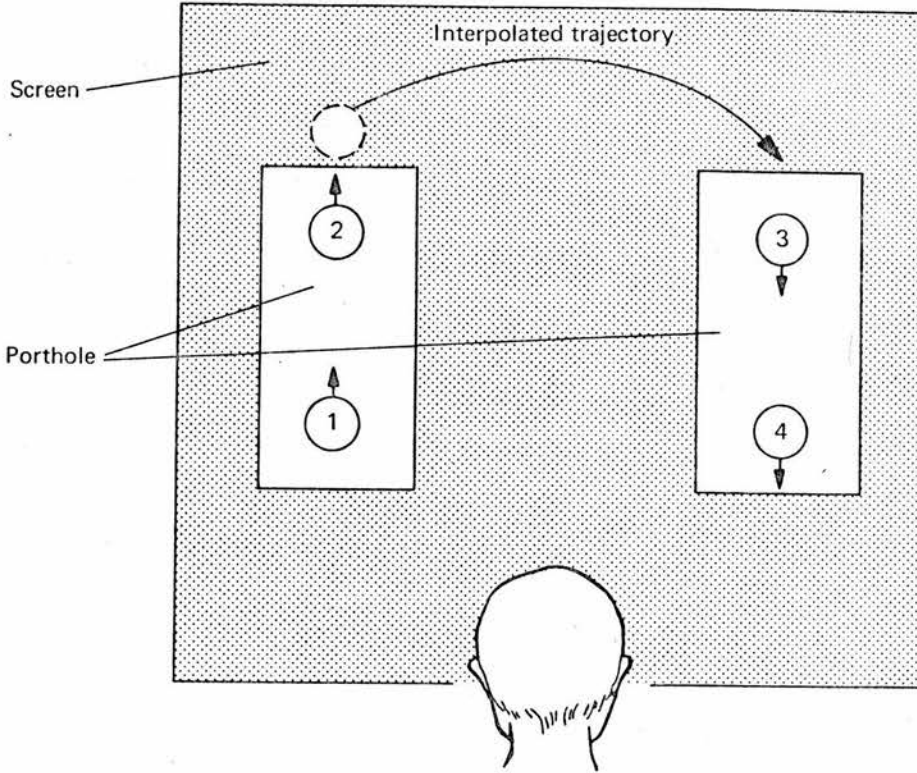
Further evidence that invisibility alone is not the source of the infant's problems

The above experiment lends weight to the view that invisibility and the associated problems of memory and representation are secondary in any analysis of the infant's problem with objects. When it comes down to it, all memory and representation explanations depend on the errors occurring only when the object is out of sight. Obviously, if the object is still in sight, neither memory nor representation difficulties can be responsible for the failure to produce appropriate search behaviours. We have already seen in Experiment 2 that an object 'hidden' inside a transparent cup presents a measure of difficulty which is not attributable to motor skills alone; it can obviously not be attributed to failure of memory either.

There is an increasing body of evidence which suggests that focusing on problems of representation in sensori-motor development has led to an over-emphasis on the study of infant's reactions to objects which have disappeared. An object which is out of sight seems only to be a special case of a more general problem infants have in constructing a working object concept. We shall now consider some of this evidence.

We have already seen that infants are able to demonstrate functionally some knowledge of those parts of an object which they cannot see (see p 58). There is also evidence from tracking studies that very young infants can represent the path of an object which goes behind a screen (Bower, Broughton & Moore, 1971, Gardner, 1971). The experiment of Mundy-Castle & Anglin (1973) is perhaps the most impressive of such studies and the most damaging to those who would wish to assert that object problems can be reduced to either memory or representational deficits. The apparatus used by Mundy-Castle & Anglin is shown in Figure 3.7.

Fig 3.7 The Mundy-Castle & Anglin apparatus



The object would move up through the left window, disappearing at the top of this window, reappearing at the top of the right-hand window after a time delay of variable length and moving down through that window. This cycle was repeated several times. Young infants would typically respond only retroactively, following the trajectory of the object to the top of the left-hand window and staring at that point until noticing the reappearance in the right-

hand window. With development, anticipatory looking across to the second window would be shown on disappearance at position 2. Finally, and most interestingly, infants of around 16 weeks would interpolate a curvilinear trajectory between positions 2 and 3 of the display which would match the speed of the object and vary in height according to the length of time the object was out of sight. This is a truly remarkable achievement. Since the trajectory is not simply a continuation of the trajectory the object was on before going out of sight, it is not possible to dismiss this behaviour as 'mere extension of the movements of accommodation', as has been suggested (Haith & Campos, 1977). It surely reflects an ability to infer the position of the invisible object from the information given and severely undermines any claims that infants are unable to represent an object in its absence.

Let us look now at behaviour in standard object permanence testing situations. Here too we see evidence that the source of the infant's problems does not lie in the invisibility of the object. As mentioned, Gratch & Landers (1971) noted that infants who err in the AAB task will often look across to A before the object is fully hidden at B, i.e while it is still perfectly visible at B. Bower (1974a) also noted that if, after several hidings, an object is placed beside the cup rather than inside it, Stage IV infants will lift, examine and shake that cup, even although the desired object is in full view and easily obtainable. Butterworth (1977) similarly found that AAB errors were shown in a situation in which the object changed position but remained perfectly visible

throughout the entire sequence - the containers into which the object was placed were not covered and yet, on the B trial, infants would still search at A.

Equally unfortunate for memory/representation explanations are those experiments which modify the standard test situation by using transparent cups or cloths. All essentially come to the same conclusion: search tasks in which the object remains visible throughout the entire 'hiding' sequence still pose problems for the infant, although such problems do tend to be solved earlier than their opaque counterparts.

Experiment 2 has already been discussed. It was found that hiding an object under a transparent cup, while easier than a similar task using an opaque cup, still presented difficulties to Stage III infants. Gratch (1972) found no trouble with transparent cloths but used older infants (6 - 7 months) and gave no indication of how long it took the infants to succeed in the transparent situation.

A cross-sectional study of object concept development using both transparent and opaque cups was carried out by Neilson (1977). She used infants of 7 - 15 months of age and compared their performance on both tasks. Success with transparent cup problems followed exactly the same sequence of development as success with opaque cups. While the majority of infants were in the same stage with both opaque and transparent cups, 5 did better with transparent than opaque cups while no infants showed the reverse pattern. These results suggest that while disappearance plays a role in

Stages III - VI of object concept development, that role is a minor one. Butterworth (1974) has replicated and confirmed these results. His finding that runs of B errors in the Stage IV - V transparent condition were less consistent than runs of B errors in the opaque condition lends support to the view that visibility of the object can facilitate search but is not the whole answer to the infant's difficulties in these problems.

Harris (1974) also examined the role of visibility in object search and was forced to modify greatly his view of the role of memory in object concept development. Using fixed transparent screens and an AAB procedure, Harris found that one year old infants, although attempting to search first at the new location of the object (B), would then approach the prior location of that object (A), even when the object was still perfectly visible in its new location. (Three infants were in fact seen to approach this visibly empty location first). Residual errors such as these obviously cannot simply be the result of memory problems since the object was clearly in view throughout. They seem to indicate that the infant does not treat the two positions of the object as mutually exclusive. Such a finding supports the view that the errors shown in object concept tasks result from conceptual naiveté and are not reducible to mere memory deficiencies.

Although it seemed unlikely that approach to the visibly empty location was an artefact of the experimental procedure, the experiment was repeated with both doors now openable and door B opaque. This control dealt with any objection that approach to the

visibly empty location was caused by the fact that it was impossible to open door B. When the object disappeared at B, it was removed by the experimenter in order to see if residual errors could still be elicited. In this situation too, infants were found to approach door A on B trials even although it was quite obviously empty.

All of the above points to visibility/invisibility playing only a secondary role in object concept problems. Experiments focusing on infant reactions to disappearing objects, while yielding useful information, cannot tell us the whole story. The infant's difficulties in traditional object concept tasks seem to be determined by some much more general misunderstanding of what is happening in these situations. These difficulties are not simply attributable to the object having disappeared from sight. Perfectly visible objects still cause the infant problems. As a result, it seems that representation/memory explanations must, along with intersensory co-ordination and motor skill/action explanations, be rejected as unsatisfactory. The next chapter will consider the fourth alternative, the identity hypothesis.

CHAPTER FOUR - IDENTITY THEORIES

A shift of emphasis - the rule-forming infant

The preceding chapters would seem to suggest that the problems that infants have in dealing with objects are not simply reducible to problems of representation or motor skill. It also seemed that neither the absence of intersensory co-ordination nor deficiencies in memory could satisfactorily account for the surprising behaviours so reliably found in standard object permanence testing situations.

All of these explanations were in part derived from Piaget's analysis of development in this period. However, the explanation which centred on the most essential ingredient of Piaget's theorising - the importance of the infant's own activity to his construction of reality - was the one theory which could not be emphatically rejected. It seemed as though the ambiguity inherent in the notion of 'activity' ensured that no firm, negative conclusions could be drawn from any experiments seeking to demonstrate that sensori-motor activity was not important to object concept development.

As was pointed out, it is doubtful whether Piaget himself would have considered it legitimate to dismiss these results by claiming object knowledge in the sensori-motor period to be a construction of more 'central' activity than was (or could be)

examined by such experiments. It is doubtful in fact whether even visual activity could be substituted effectively for more direct action on Piaget's formulations (see p 98). Perception for Piaget is only a 'figurative' process and cannot specify important object properties directly: it is the action schemas which provide the source of any continuity and meaning in perceptual experience. Bearing this in mind, it does not seem feasible to assume that he would have been willing to extend his notion of activity to include mental activity of a productive and directive nature during this period.

It is this unwillingness to entertain the notion of constructive mental activity in the young infant which makes Piaget's theorising hard to accept. His central tenet - that the infant has no differentiated awareness of self from objects - makes it impossible (or so it seems to me) for any meaningful knowledge of reality to be constructed from perceptual experience alone; the infant must interact directly with objects if he is ever to understand their true nature.

By emphasising the role of activity in the construction of reality, the level of object understanding attributed to infants prior to the development of the behavioural skills necessary to such interactions (i.e prior to Stage III) must be minimal on Piaget's theory. As Experiment 1 of this thesis has already shown, such pessimism is unjustified; Experiment 5 (to be presented later) will hopefully add weight to the evidence that an infant does not have to participate in an event sequence in order to be able to learn

something about the nature of the objects involved in that sequence. All of the evidence from anatomical and neurophysiological research points to the visual system being relatively mature at birth in comparison to other systems (see e.g Mann, 1964); this alone should lead us to suspect that visual activity would be an important source of information for the young infant.

Following the analysis of Bower (1971, 1974a), I would like to maintain that the infant's difficulty lies, not in differentiating himself and his actions from other activity in the external world, but rather in understanding the unique nature of objects themselves. Firstly, and surprisingly, he will have to discover the relationship between the spatio-temporally separated appearances of any single object; having achieved this, the infant must then work towards an understanding of those spatial relationships which can exist between any one object and another without affecting the independent and continuing existence of either. In working towards such an understanding, it is suggested that the infant will formulate a series of increasingly elaborated identity rules. Eventually, these rules will enable him to maintain the unique identity of an object throughout any event sequence. This theory of object concept development will be elaborated below and attempts made to justify it.

On the identity analysis, the baby is not seen to have any problem in differentiating himself from objects; there is evidence that his understanding of the differentiated properties of single, static objects is present very early on and may even be innate. (see below). Nor does he have problems in understanding the continuing

existence of objects when unperceived; again, it seems that at a very early stage in development, an object is attributed an existence which is quite independent of the baby's perception and actions upon it. The problem which arises in 'object permanence'-type situations is seen rather as one of maintaining this understanding in an event sequence which contains another object. This problem can be reduced to a problem of maintaining the identity of a particular object throughout any event sequence in which it interacts in and/or shares common space with another object. Direct activity on the part of the baby is secondary in this understanding process although it must serve a useful confirmatory function in many instances.

It is important here to distinguish between the concept of activity and the question of the role of experience in object concept development. No one would seek to deny that experience must play a role in all cognitive development. I wish only to maintain that direct action upon objects is not the necessary source of all experience pertinent to object concept development in infancy. It is to be hoped that the experiments to be presented in this and following chapters will throw some light on the role of experience in object concept development and allow us to derive some practical implications from it.

The interpretation of the infant's difficulties in dealing with objects outlined above is obviously not compatible with Piaget's analysis. On this analysis, the source of the problem does not lie in lack of differentiation of the self from objective reality nor is

direct, overt activity on objects seen as the only route to a true understanding of objects and their defining properties. As we might suspect by now, however, the element central to such an interpretation - the notion of object identity - can be found in Piaget's original theorising; Piaget, however, believed it to be of only secondary importance in understanding the infant's behaviour.

Piaget first introduced the notion of identity in his analysis of the Stage IV error. In making the AAB error, the infant is primarily seen by Piaget as repeating that action which had previously been successful in recovering the object - i.e search at A. While unwilling to relinquish the importance of activity to all stages of the construction of the object concept, his analysis of the Stage IV error suggested that another factor might also be influencing the infant's bizarre behaviour, the infant's failure to realise that an object retains its unique identity when in a different location. He suggested that the Stage IV infant identifies the object simply as the object-I-found-at-A, the object and its location being inseparably linked in the same definition, in terms of the infant's previous successful activity. Identification and location of an object by means of such restricted rules of identity would obviously lead to error in an AAB situation.

Bower and the identity hypothesis

Although it seems very likely that spatial factors do play a very important role in the infant's developing rules of object identity, it seems rather less likely that these are so necessarily linked to the infant's activity. Bower (1971, 1974a) was the first to suggest that the infant's problems did not lie, as Piaget would have it, in differentiating objects from the self via a long apprenticeship of interactions between self and object, but rather in understanding the continuing identity of an object throughout an event sequence. On Bower's analysis, it is immaterial whether that event sequence actively involves the perceiver or not. The infant's problem is one of understanding, for example, that an object seen in one position and then seen to move to another position is one and the same object when in that second position, that an object when hidden inside a cup does not lose its unique identity and is still recoverable even although occupying the same space as another object (the cup), and so on.

Bower's view of the development of the object concept as being development of increasingly comprehensive notions of object identity does not necessitate direct actions on the part of the infant (although direct action may, of course, be used at later stages of development to test out the validity of newly-formed identity or search rules). Development of the object concept is seen rather as a process of conceptual development. The first identity rules arrived at by the

infant are, unsurprisingly, inadequate; they are responsible for the characteristic errors we see in object permanence tasks. Nevertheless, each new rule obviously signifies some advance in cognitive organisation and out of these identity rules probabilistically-determined search strategies will emerge. This emphasis on the development of rules and strategies rather than errors makes Bower's theorising compatible with our knowledge of the competences shown by the young infant in so many other areas of development (see e.g Chapter 1).

In contrast, Piaget defined development in this period very much in terms of failures - failure to follow moving objects, failure to recover partially covered objects etc. In addition, his belief that infants prior to Stage VI are unable to represent an object in its absence caused him to concentrate on the development of infant reactions to objects that went out of sight in one way or another. All simple out-of-sight conditions were, however, considered to be equivalent - a ball falling to the ground under the force of gravity was taken as presenting the same disappearance problem as an adult passing through a doorway or an object being covered by a cloth. No allowance was made for the differential information-processing and response demands such differing stimulus situations might present.

Piaget's emphasis on the role of activity in development does not allow him to make any clear distinction between competence and performance - performance is the only possible expression of competence. Poor performance in the early stages was taken as

prima facie evidence of lack of object knowledge. Any behaviour which might superficially - or even more easily - have been explained in terms of awareness of an external reality was quickly dismissed as involving 'a most improbable power of spatial representation and intellectual construction' (Piaget, 1937). After all, if the infant at 9 months cannot be taken to show any differentiated awareness of self from object or knowledge of the independent existence of objects, how could his behaviour at, say, three months possibly indicate any such understanding? As a result, development in the first two stages was given only minimal attention.

Bower believed that Piaget had seriously underestimated the amount of object understanding present in young infants. By using test situations which were not sufficiently sensitive to their limited response and information handling capacities, Piaget had given them little opportunity to demonstrate their knowledge. In a series of interlocking experiments, Bower produced a new analysis of the source of the infant's difficulties in the standard tests and forced a revision of our estimates of the cognitive capacities of young infants.

Object perception and object permanence in the first six months - a re-assessment

According to Piaget, young infants act as though objects only exist when perceived. Even then, it is not really 'objects' that are perceived.

"During the first months of existence, there are no permanent objects, but only perceptual pictures which appear, dissolve, and sometimes reappear".
(Piaget, 1970)

As if this wasn't bad enough, this unstable world of perceptual tableaux shows no differentiation between the self and the outside world; no distinction is made between perceptual impressions which originate from action of the self and perceptions which should properly be attributed to independent events in the outside world. For the young infant then, objects cease to exist the instant they leave the perceptual field and even those objects which remain in view do not exist in any differentiated, three-dimensional way. According to Piaget, it is only by acting in and on the real world that the infant will gradually impose order on this random and undifferentiated experience and construct a surrounding world of objects, existing in three-dimensional space and interrelated temporally and causally. Only through his own physical efforts will the child arrive at the concept of an ordered and permanent universe from these elusive and jumbled impressions, a world which will be accorded an existence independent in space, time and causality from the perceiver.

Piaget's evidence for the existence of such limited perceptual organisation in young infants is suspiciously circular and at best indirect. His main contention is that there is no way young infants could have any understanding of the three-dimensional arrangement of the world or of the continuing and independent existence of objects while unperceived. Their limited behavioural

repertoire means that they are not yet capable of interacting in any positive fashion with the external world; they simply cannot therefore have had the experience necessary for attainment of that understanding. The inadequacies and inappropriateness of their later behaviour is taken as evidence that this is indeed the case. Such backward inference is extremely risky. It requires three basic assumptions, all of which can be questioned. It must assume:

1. that development is necessarily cumulative - i.e that a younger baby will necessarily perform more poorly than an older baby in equivalent situations
2. that the test situations which produce evidence of little or no object knowledge in young infants (situations which require visual search for an object which has gone out of sight) are in fact equivalent to those test situations which produce evidence of at least some understanding in older infants (situations requiring manual search for a hidden object), and
3. that perception of the third dimension can only be acquired through active experience within that dimension.

Bower (1974b, 1976) has presented and reviewed a great deal of evidence which undermines the first assumption; I shall return to this topic later but it need not be considered further at this point. Assumptions of the equivalence of the various object permanence tests has already been questioned and the need for tasks which are within the behavioural and information-processing capacities of the infants to be tested cannot be over-emphasised. It is very possible, for example, that Piaget's test for object

permanence in Stage II (holding an object in front of the baby and then dropping it) is quite inappropriate for the response skills available to babies in that age group. Work by Bower (1967) pointed to the importance of both rate and manner of disappearance of the object to production or non-production of evidence of existence constancy. An object falling under the force of gravity may well be moving too quickly for the young infant to track successfully; the rate of information change may in addition be too fast for the infant to process in a meaningful way. Because the infant does not act in this situation as if the object continues to exist does not mean that he is unable to understand a hiding event when presented in a more appropriate manner (see e.g. Experiment 3). Under certain conditions, Bower in fact found evidence of existence constancy in infants as young as seven weeks.

Piaget's last assumption - that the third dimension must be constructed - has already been touched upon (Chapter 3). Under certain circumstances, infants are able to demonstrate distally appropriate behaviour within the first few weeks of life - long before they can possibly have had enough experience to construct a third dimension through interactive experience with objects. Newborns, for example, reach out to touch and grasp objects. They seem visually to identify objects as solid although they must have had little or no opportunity to learn to associate visual clues with tactile impressions, a process which Piaget considers essential to the construction of such knowledge; if presented with virtual

objects, objects which look perfectly real but are in fact intangible, they soon begin to fuss and cry (Bower, Broughton & Moore, 1970c). Early reaching behaviour is also adjusted to size, shape and distance (Bower, 1972) - a finding which surely confirms that the infant is responding to the veridical dimensions of objects and not to flat retinal images. Young infants will not, however, reach for an object if it is not defined parallaxically, nor if it does not have well-specified front and rear boundaries (Bower, 1966, 1972, Bower, Dunkeld & Wishart, 1979).

Other evidence that the third dimension need not be constructed comes from studies investigating defensive responses to approaching objects. Week old babies will pull their heads back and interpose their hands between an approaching object and their face, again even if the object's approach is defined only visually (Bower, Broughton & Moore, 1970a, Ball & Tronick, 1971, Dunkeld & Bower, 1979). If the young infant's world consisted only of everchanging, 2-dimensional perceptual tableaux, as Piaget would have it, no such response should occur; the approach of an object would be seen only as a series of visually similar but essentially unrelated pictures which were increasing in size, a sequence which could hardly be interpreted as threatening. The presence of such behaviours so early in life led Bower to suggest that perception of real objects seen in an external, three-dimensional space must be built into the organisation of the human nervous system at birth. From the start, an object is identified as a bounded volume of space (Bower, 1974a); there is no need to postulate any laborious process of construction.

If the three assumptions underlying Piaget's argument for poor and undifferentiated object knowledge in the first six months are all suspect then, how should we view this period? A series of experiments by Bower suggest that this is indeed a very busy period in terms of conceptual organisation. Since Piaget believed both young and old infants to be incapable of representation and limited to understanding objects in terms of their own activities with respect to these objects, it is not surprising that he emphasised differentiated search behaviour for a hidden object as the criterion for the attainment of true object knowledge. This emphasis on the visibility or non-visibility of the object has, as we have already seen, led us off in completely the wrong direction. Hidden objects undoubtedly cause infants problems. Perfectly visible objects can, however, as we shall see, cause equal and very similar problems throughout this entire segment of development (see Experiments 2, 4 and 5). According to Bower, these difficulties all stem from the rules which the infant has developed for identifying an object throughout an event sequence; these identity rules determine the infant's search activity, in certain circumstances producing very similar responses in both situations in which the object disappears from view and situations in which it does not. This approach to understanding the infant's difficulties has become known as the identity theory of object concept development. Bower's work on this can conveniently be broken down into two main parts:

1. the development of object knowledge prior to six months, and
2. the development of object knowledge after six months.

The identity theory of object concept development in the first six months

If the mistakes that older infants make in the later manual object permanence testing situations are surprising, the visual behaviour of infants under six months to apparently simple movements of perfectly visible objects is even more unexpected. Take, for example, an object which moves and then stops. Although apparently perfectly able to follow the movement of an object and perfectly able to stop with that object when it stops, a 12 week old will nevertheless then go on to look along the path on which the object would have continued to move had it not stopped - even although the object he had been tracking is very obviously still stationery (Bower & Paterson, 1973). This error is known as the movement error. In another, related situation, a baby of the same age may soon learn how to keep track of an object which moves regularly from the centre of a track to the right, pausing a few seconds there before returning to the centre again. If, however, after its usual pause in the centre location, the object moves off in the opposite direction (to the left), the infant will typically again look to the right, as if fully expecting to see the object in its usual place after movement from the middle (Bower, Broughton &

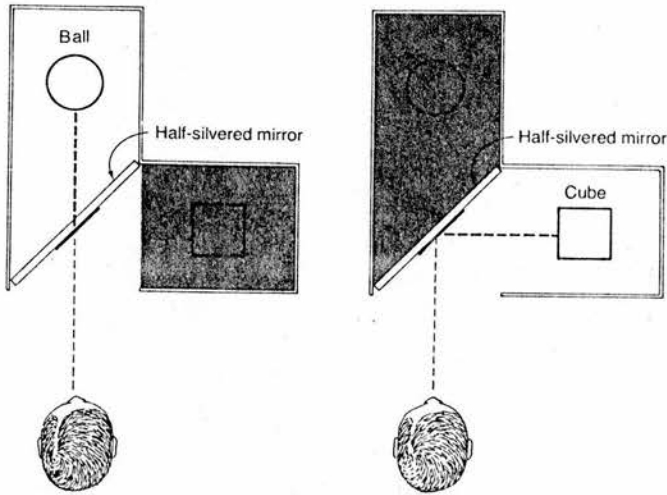
Moore, 1971, Bower & Paterson, 1973). He will ignore its perfectly obvious location at the opposite end of the track, making what is known as a place error.

These are most peculiar errors. How are we to explain them? Bower has suggested that babies of this age identify an object only in terms of either its location or its motion; its features are completely ignored. According to these early identity rules, an object is a bounded volume of space in a particular place or on a particular path of movement. Such limited rules for identifying objects, although representing an early attempt to organise information into more manageable and meaningful units, would obviously lead to the place and movement errors seen in the situations described above.

The place rule for identifying objects: According to the place rule, an object is the same object as long as it is in the same place. Such a rule does not allow the baby to understand that the same object can appear in different places and still be the same object. Adoption of this rule would also mean that all objects in the same place are the same object, regardless of featural differences.

If this is indeed the case, young infants should show no surprise when a stationary object is completely transformed before their very eyes. This is in fact exactly what happens. If shown such an event sequence, they make no attempt to relocate the original object and seem happy to accept the totally transformed object as the same object (Bower, 1974a - see Figure 4.1).

Fig 4.1



When the tunnel containing the ball is illuminated and the tunnel on the right is dark, the baby sees the ball through the half-silvered mirror. If this light is put out at exactly the same moment as the RH tunnel is illuminated, the baby sees the ball mysteriously transformed into a cube.

Similarly, if a static object is defined solely by its place, simultaneous appearance of that same object in several locations should also be possible on the place rule. As we have already seen, babies below six months of age indeed show no surprise on presentation of such a display - even when the object in question is his own mother (see p 4).

This emphasis on place in the infant's early definition of objects should not surprise us. Work by Michotte (1962) showed that continuity of place plays a role in adult identification of objects and can even override a simple featural change in the object being watched. If, however, more than one feature of the object is changed, adults, unlike infants, will no longer believe that they are looking at the same object. The adult version of the place rule is not as limiting as the infant's rule; it is not an all-or-nothing rule.

The movement rule for identifying objects: The other rule which Bower suggests young infants seem to apply in identifying an object as the same object is the movement rule: an object is the same object as long as it continues on the same path of movement. Such a rule would mean that all objects on the same path of movement must be the same object.

Four month olds behave exactly as if working in accordance with just such a rule. If a moving object changes all its dimensions in mid-track - size, colour and shape - these infants will ignore the changes and continue to track the completely transformed object as if it were the same object they were originally tracking. If, however, the characteristics of the movement change, it is an entirely different matter; the infant will look back and forth between the old and new trajectory as if searching for the 'original' object (Bower, Broughton & Moore, 1971).

The net result of the two above mutually exclusive rules is that the infant below six months of age does not identify a stationary object with itself when moving nor a moving object with itself when stopped. Although well able to register featural differences between objects (Fantz, 1964, Carpenter, 1975), any change in features in a stationary or moving object is seen as a change in one and the same object, however impossible such a transformation might be; infants below six months of age do not seem to consider the possibility of a new object having entered the sequence. Such a strategy may reduce to information-processing limitations; this is a possibility we shall return to later.

This initial neglect of distinctive featural characteristics is not perhaps as illogical as it may seem at first glance. Even for adults, featural identity alone is no guarantee that an object is the very same object as one which was seen previously in either the same or a different location - it could equally well be another, identical object. Any attribution of true identity between two appearances of an object can only be an educated guess; spatio-temporal criteria seem to carry more weight in any such decision than simple, featural identity, no matter how distinctive these features may be (Michotte, 1962).

The co-ordination of place and movement rules: By around twenty weeks, the infant seems to have co-ordinated his place and movement rules for identifying (and consequently re-locating) objects. He now seems able to understand that an object can move from place to place and yet remain the same object at all times during this

sequence. This may not seem to represent a great advance in object knowledge but it must simplify the infant's experience considerably. Events become unified sequences involving fewer 'objects'. Previously, the limitations of the infant's rules for identifying objects meant that a simple event, say an object moving from A to B, was seen as an event involving three separate objects: the stationary object at A, the object that moved from A to B and the stationary object at B.

What evidence is there for this claim that the infant co-ordinates his place and movement rules around this time? For a start, both the place and movement errors described above disappear around the same time (Bower & Paterson, 1973). Their decline shows a very similar pattern (see Figure 2.3). The multiple mother display now produces upset (Bower, 1971, Shiomi, pers. comm). Transformation of the features of a moving object begins to elicit search behaviours for the original object (Bower, Broughton & Moore, 1971, Gardner, 1971, Moore, Borton & Darby, 1978), as will substitution of a replacement object for the mother in a stationary display (Bower, 1974a). Neither place nor movement now suffices for identification of an object. The infant will be forced to depend on featural characteristics to differentiate between two objects seen on the same path of movement or in the same place at different times.

The most conclusive evidence that some amalgamation of place and movement must have taken place comes, however, from the changes in behaviour in the Mundy-Castle situation (see Figure 3.7). Around

five months of age, anticipatory side-to-side (place) tracking is replaced; instead of simply looking to the other porthole when the object disappears, infants begin to interpolate a trajectory between the two portholes - evidence surely of awareness that an object can move from place to place and in order to do so, must follow some sort of pathway. As we have seen, if the time between disappearance and reappearance is lengthened, infants will increase the height of the interpolated trajectory while maintaining a speed of tracking consistent with the speed of the disappearing object. The object knowledge which such behaviour reflects is indeed quite sophisticated; it shows not only an awareness of the continued existence of the object while out of sight but also rather exact knowledge of where it must be while unseen, a fact which can only be inferred from the information present before disappearance. Piaget, remember, suggested that such high-level cognitive activity was not possible prior to Stage VI.

Bower suggests that the co-ordination of place and movement rules may be attributed to the infants increasing attention to the featural information contained in any display. Once, for example, the baby is able to notice not only that the moving object has stopped, but that the stopped object is featurally identical to the moving object, he will soon arrive at the economical conclusion that the moving object and the stopped object are one and the same object. He will therefore have arrived at a Stage III definition of an object incorporating the following elements:

"an object is a bounded volume of space of a particular size, shape and colour which can go from place to place along a path of movement".
(Bower, 1974a)

Such a rule implies two corollaries:

1. two objects cannot be in the same place at the same time
2. two objects cannot be on the same path of movement at the same time.

The development of object knowledge after six months

Can the postulation of the identity rule and its two corollaries given above account for the difficulties found later in development? It would seem that it can. Take the Stage III - IV task for example: if we cover a toy with a cup, two objects are now in the same place at the same time. There is therefore nothing in the Stage III infant's identity rules which will allow him to maintain a belief in the continued existence of the original object. There is nothing in such a rule to help him to re-locate the object in the Stage IV - V task either; it has effectively been replaced by another object, the cup, and to further confusion, there are now two cups in the visual field. The Stage V - VI task represents an even greater violation of the infant's identity rules; by hiding the object under a cup and then transposing the two cups, not only are two objects in the same place but they also share the same path of movement at the same time. It is small wonder, then, if the infant does in fact work on such rules, that such hiding events are

totally incomprehensible to him. His identity rules place severe limitations on the type of spatial relationships that one object may go into with another while retaining its individual identity.

It is all very well to postulate such an explanation for the difficulties shown in object permanence situations. How though are we to explain eventual success in these situations? Even babies raised in what would be considered impoverished environments succeed in coping with the highest level tasks approximately on schedule (Golden & Birns, 1968, Corman & Escalona, 1969). Nor does severe mental or physical handicap prevent acquisition of the final stages of object knowledge (Woodward, 1959, Gouin-Décarie, 1969). This would suggest that simple, commonplace experience, be it passive or self-initiated, must be sufficient to account for the progress found.

On Bower's analysis, the main obstacle to completion of object concept development seems to be acquisition of the knowledge that one object can, for example, go inside or under another object without being 'lost'; in other words, that an object continues to exist and retains its unique identity while in a spatial relationship to another object. Although the infant's identity rules lead him to believe otherwise, his expectations must be frequently confounded. If, for instance, the covering object which so mysteriously replaces the original object is removed, either deliberately by some other person or accidentally by the infant, the 'lost' object will be

re-revealed. The infant, remember, already uses features to identify objects; he can therefore recognise the reappearing object as being the same as the object which disappeared earlier in the area of that cup. Eventually, the infant must come to understand that it must have been somewhere while out of sight, that it was not in some way annihilated when covered by the cup, that one and only one object is involved in the entire event sequence.

Common, everyday situations must, then, provide endless instances of objects disappearing inside, under and behind other objects and yet reappearing unchanged at some later point in time. This, it is suggested, could lead to the formation of a search rule of the sort:

"to recover an object that has disappeared mysteriously, remove the object which replaced it".

Such a rule necessitates no comprehension of the spatial relationship between the object and occluder but would lead to success in the Stage III - IV task. In order to succeed in the Stage IV - V task, however, experience would have to modify such a rule to take into account the presence of two, featurally identical occluders in the visual field. Since the object has disappeared in the area of both of these occluders on different occasions and their identifying features are the same, the rule would have to be something of the sort:

"to recover an object that has disappeared mysteriously, remove the object which is now in the place where it was last seen".

Prior to this modification, the infant will be thrown into conflict when presented with an AAB type task. There are two identical objects in view, both of which have been seen to replace the original object. Should he look for the object in the place where he has previously been successful in finding it (A) or should he look for it in the place where he last saw it (B)? Such a conflict would lead to just the equiprobable pattern of search that was found in Experiment 1.

The rule above, though highly efficient in Stage IV - V type hiding situations, is far from helpful in the Stage V - VI task. Looking for the original object where it was last seen will obviously make no allowance for the fact that both occluder and object have been moved. An identical cup now stands in the original position and there is nothing in the infant's identity rules to allow him to understand that the original cup and object have moved together to a new location. Again, experience will lead the infant to integrate the relevant information; he recognises the uncovered object as the same object but in a different position and will eventually deduce that in order for this to be possible, not only must the object have continued to exist in the same place as the cup but that it must have shared its movements during the transposition. Two objects can be in the same place and can move on the same path of movement provided they bear an appropriate spatial relation to each other; in this particular case, the appropriate relationship is 'inside'.

Does this reduction of the infant's problems to problems of maintaining the identity of an object throughout spatio-temporal transformations represent an advance over the alternative explanations for the behaviour found in this period of development? For a start, unlike its competitors, the identity hypothesis attempts to provide an explanation which can be applied to all six stages of object concept behaviour. This is an essential requirement of any explanation since, as Experiment 1 has demonstrated, the behaviours of the six stages do reflect some single, common underlying process. The early stages, frequently neglected by other theorists, are seen as representing the infant's first attempts to impose identity rules on the events in his environment. From early primitive definitions focusing only on paths of movement or spatial location, the infant moves, through the use of featural information, to identity rules which co-ordinate the place, movement and features of any object into one definition. Thereafter, an object that disappears mysteriously is recognised as the same object on reappearance. It is this ability to recognise an object as being the same that will lead the infant through the later stages of the object concept. Although unable to understand that an object retains its identity when in a spatial relation to another object, the equally mysterious reappearance of that very same object when the spatial relationship no longer holds will cause the infant to produce progressively more elaborated rules of search. Eventually, through passive experience and/or active experimentation, he will arrive at the

understanding that an object must continue to exist while in a spatial relation to another one, retaining its unique identity throughout the period.

Support of this interpretation does not necessitate denying any importance whatsoever to those other factors which have been suggested as being at the root of the infant's problems - factors such as motor skill, interactive experience and difficulties of intersensory co-ordination, memory or representation. According to the identity hypothesis, however, none of these factors alone can account for the characteristic series of errors found during this period of development. Evidence of the secondary nature of these factors has already been presented. Experiment 1, for example, showed that visual training could accelerate manual success; direct interactive experience with objects cannot therefore be all-important to development. Similarly, Experiment 2 showed that simple motor difficulties could not alone account for the characteristic errors seen early in development. In Experiment 3, infants in Piaget's Stage III showed themselves perfectly able to recover an object that had disappeared from sight, even after a delay of 90 seconds between disappearance and search, a finding which also therefore undermines any attempt to invoke either memory, intersensory co-ordination or representation difficulties as the determining factor in object permanence behaviour.

Conceptual versus perceptual analyses of object concept problems

Both Experiment 1 and an acceleration study which will be presented later (Experiment 5) also suggest that development is not merely reducible to any straightforward increase in capacity to process the relevant perceptual information involved at each level of testing, a viewpoint which has recently been gaining considerable support. It has, for example, been suggested that the source of the infant's difficulties lies in the fact that each stage of object concept testing represents an increase over the previous task in terms of the amount of information the infant must handle in order to relocate the object: The Stage III - IV task, for example, only involves one object and one cup; Stage IV - V, one object and two cups; Stage V - VI, one object and two moving cups. Attractively simple though such a theory may be, it implies that there is no conceptual development underlying the sequence of behaviours commonly found. It would deny, for example, that the infant is unable to understand the spatial relations involved in the Stage III - VI tasks, asserting rather that his problems arise only from the fact that his capacity to process the relevant information is overloaded by these tasks; his performance will not therefore reflect his true competence.

Although the view presented here does not support Piaget in maintaining that the infant must construct his entire body of object knowledge, it nevertheless insists that truly conceptual

development does occur during this period. Problems of perceptual processing are not considered to play a primary role in the infant's difficulties. The identity theory would also agree with Piaget's that development is stage-like in character. On an information processing model, however, processing capacity should simply increase gradually with age. (15) How then would such theories explain the fact that a 9 month old is as likely to make an AAB error as a 6 month old? Experiment 1 also poses problems for the information processing argument. In that experiment, early visual experience was found to accelerate acquisition of the later stages of the object concept. How could this be explained in terms of information processing ability? It could conceivably be argued that such experience acted to increase information processing capacity. Why then did the same amount of experience in

(15) Pascual-Leone (1970) is one of the few information processing theorists whose model will allow for stage-like development. His theory also allows for assessment of the complexity of the task from the subject's point of view, a novel feature in an information processing model since such models typically seek to downgrade the role of the perceiver. Pascual-Leone postulates the existence of a central computing space, M, (or mental operator), which is responsible for the transfer and co-ordination of all information. This mental capacity construct is not far removed from Piaget's (1928) notion of 'attention span' or 'field of centration' but the emphasis in Pascual-Leone's theory is on functioning schemas rather than general structures. He is attempting to provide a quantitative measure for the qualitative phenomena described by Piaget (whose influence he readily acknowledges). M is a measure of the maximum number of schemas that can be activated and co-ordinated by the child at any one time; this capacity is assumed to grow in an all-or-none manner (If $M = a + n$, $M = a + 1$ at age 3, $M = a + 2$ at age 5 and so on - where n = the number of activated schemas which can be combined and a = the space taken up by the executive schema which effects the co-ordination). Work by Pascual-Leone & Smith (1969) has

a tracking situation which was perceptually similar in terms of information processing demands but conceptually very different - practice on a tracking task in which the object did not stop - not also produce acceleration? (Bower, 1974a)

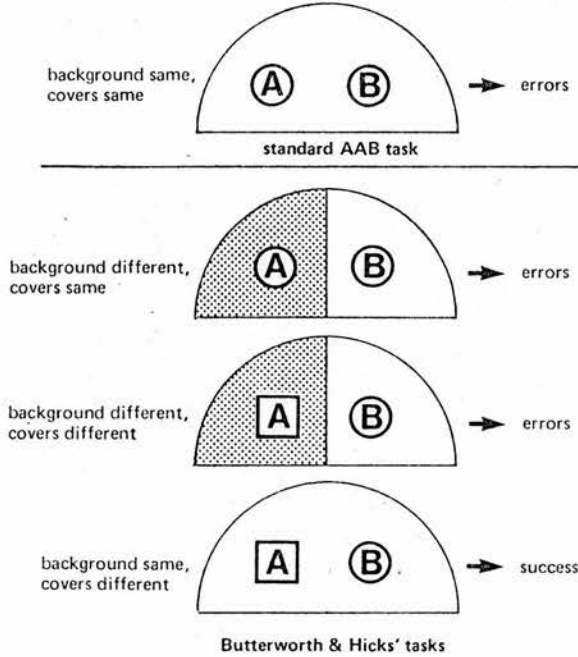
Information theorists are not alone in suggesting that perceptual processes can adequately explain 'object concept' errors. Butterworth (1978) has recently suggested that attention to immediately present perceptual clues will help the infant to overcome the difficulties presented by the Stage IV - V test. Like Bower (and, to some extent, Piaget), he suggests that the infant's problems lie in his limited understanding of spatial relations. Unlike Bower, however, he does not see the problem as being one of understanding the spatial relations between the objects themselves.

shown growth in M to coincide with the major substages of development described by Piaget. It is also claimed that the theory has proven predictive value in relation to children's performance on Piagetian-type tasks (see e.g. Case, 1972).

So far as I know, only Case (1978) has attempted to apply this type of approach to the sensori-motor period. (It would indeed appear impossible for Pascual-Leone to do so since there seems to be no positive measure of M before the age of 3). On Case's 4-stage model of object concept development, each new stage is interpreted as representing an increase in the size of the infant's 'working memory'. Case admits, however, that he has as yet no empirical justification for his unit-by-unit analysis of the increasing demands on memory of each of the Piagetian search tasks and it does seem, to me at least, somewhat arbitrary. His 4-stage model in addition appears to neglect the well-documented problem that infants have in dealing with invisible displacements. Until further work on this type of approach has been completed, however, it seems impossible to evaluate its usefulness and validity.

While not agreeing with Piaget that the infant is unable to distinguish between external reality and his own activity, he does agree that the AAB error may be explained by reference to the spatial codes being used by the infant at this stage to identify an object. According to Butterworth, while in Stage IV, the infant, as on Piaget's analysis, is beginning to shift from subjective to objective notions of spatial position. He makes equal use of two codes - an egocentric code (in which object position is defined in relation to himself) and an allocentric code (in which object position is defined in terms of a visual frame of reference which remains invariant with movement of either object or observer). The latter frame of reference is stable for all positions of an object; the former, on the other hand, will require updating with any change in object position. It is the conflict between these two codes which causes the equiprobable pattern of search generally found in the Stage IV - V task. Butterworth found that the AAB error could in fact be eliminated if the two positions A and B were made distinctively different (by using a blue cover at A and a white cover at B) and were connected by a common, continuous background (Butterworth & Hicks, 1978) - see Figure 4.2.

Fig. 4.2



Variations of AAB task used by Butterworth & Hicks (1978)

Does this finding embarrass the identity hypothesis? We already know that background information influences the ability of infants to maintain visual contact with a moving object (Harris, Cassel & Bamborough, 1974). It should not therefore surprise us then that continuity of background should be relevant to success in a manual object location task. Nor should we be surprised that different coloured covers also improve performance. It has, after

all, been suggested that the Stage IV infant's identity rules lead him to adopt a search strategy of the form 'to recover an object that has disappeared mysteriously, remove the object which replaced it'. Use of this rule in the Butterworth & Hicks situation would obviously lead to success since there can be no room for confusion between the two occluders. This is clearly not the case in the standard task; there, we would fully expect - and reliably do find - clear evidence of confusion. Butterworth seems to suggest, however, that success in this situation must be due to the fact that the infant can update his egocentric code by reference to the original A cover which, being quite different from the B cover, will serve as a landmark for monitoring the change in object position from A to B. This monitoring is presumably also facilitated by the presence of the common background to both positions. By this means, the infant can co-ordinate egocentric and visual space. For Butterworth, this means that processes in immediate perception can lead the infant to success in the AAB task. Presence or absence of a fully developed concept of the object is irrelevant to understanding of the infant's performance in this task.

Highly plausible though such an explanation may first seem, it will have enormous difficulty in explaining those Stage IV - V errors found in situations where the object is perfectly perceptible in its new location - as in the case of transparent cups, a phenomenon which has been investigated and confirmed by Butterworth himself (1974, 1977). Furthermore, work by Lucas & Uzgiris (1977) has shown that the presence of a distinctive marker at the original

location of an object is far from helpful at this age in a situation which is less readily open to alternative explanations. Another point should be considered. Butterworth found runs of up to 5 errors on repetition of unsuccessful B trials in the standard situation. Although a non-correction procedure was used, it is unlikely that the infant did not see the experimenter retrieve the object from B before replacing it there for another B trial. Research already reported (including Experiment 1 of this thesis), has shown just how useful such visual information can be. If the problem is one of updating the egocentric code of reference, why should repeated B trials produce continued search at A?; the infant has already seen the object retrieved from B at least once and on Butterworth's analysis should have updated his egocentric code on the basis of this experience to cover this new position of the object.

Any analysis of the infant's responses to objects that go out of sight which focuses purely on perceptual processes will also have difficulty in explaining away the findings of Michotte (1962). He found adults to have conceptual override over perceptual input; their reaction to the transformation or disappearance of an object was very much determined by their knowledge of the type of object involved. Since it has already been shown that the infant seems to behave in a very similar way to adults when faced with Michotte-type displays (Bower, 1967), it would seem possible that his behaviour may also be conceptually rather than perceptually directed, a function of how the infant defines the identity of the object.

BOUNDEDNESS AND THE RELATION 'PLACED UPON'

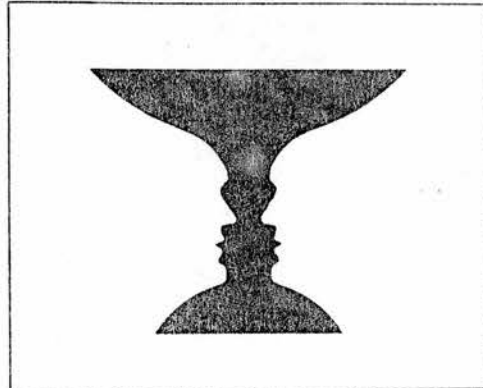
Recall the definition of an object which Bower suggests the infant of Stage III works with: 'an object is a bounded volume of space of a particular size, shape and color which can go from place to place along a path of movement'. It was suggested that the corollaries to this definition - 'two objects cannot be in the same place at the same time' and 'two objects cannot be on the same path of movement at the same time' - could account for the failure to relocate the object both in the Stage III - V tasks (where the object has been covered by a cup - violation of the first corollary) and in the Stage V - VI task (where the object is moved to another location while inside the cup - violation of both first and second corollaries). It was suggested, therefore, that all of the infant's problems in these later standard object permanence tests could be reducible to a problem of understanding the spatial relations between the objects involved in these tasks. Certainly, on the basis of Experiments 2 and 3, it seemed unlikely that these difficulties stemmed from an inability to represent an object when no longer visible.

At this point in the discussion, the important part of the identity rule given above is 'an object is a bounded volume of space'. If this is the sort of definition being used from Stage III on, any close spatial relation between two objects in which they share common space should be problematic. Since 'boundedness'

is assumed to play an essential part in the identification of objects, any object will lose its unique identity if it shares its spatial boundaries with another object. If this is the case, the infant will obviously have difficulty in relocating an object in any such situation. Whether entering into the spatial relation results in the loss of sight of the object or not should be secondary in importance and possibly even irrelevant.

The importance of boundaries in determining visual behaviour is already well researched, both in adults (Michotte, 1950, Gibson, 1966) and infants (Salapatek & Kessen, 1966, Kessen, Salapatek & Haith, 1972, Karmel & Maisel, 1975). Adults and children, for example, almost invariably perceive the stimulus array shown in Figure 4.3 as consisting of two, separate parts; the boundary is considered to belong to the figure while the ground is seen as extending in existence indefinitely behind this. Boundaries also seem to play a very important role in the looking behaviour of infants.

Fig. 4.3



The figure-ground effect

Newborns will fixate the contour of a display within 3 to 4 seconds of its presentation, and it is not until the age of 4 - 10 weeks that internal detail will be attended to (Salapatek, 1969).

Haith (1976) puts forward an impressive argument that the newborn infant in fact enters the world with certain rules of perceptual functioning which will cause his visual activity to focus on contours. Such an analysis, besides being able to cover most of the findings of visual behaviour in this period, makes sound neurophysiological sense. It will ensure a high rate of visual cortical firing, activity believed to be crucial to the growth and maturation of neural pathways (Riesen, 1961, Hubel & Wiesel, 1962, Wiesel & Hubel, 1974). In addition, application of such rules would, according to Gibson (1966), expose the infant to what are generally the most highly informative aspects of any visual stimulus, its edges.

The importance of boundaries in determining reaching behaviour has also been examined. Michotte has demonstrated how both the position in space and even the shape of rear (and therefore indirectly perceived) boundaries of unfamiliar objects can be accurately predicted by adults (Michotte, 1962); he also demonstrated, however, that an object which does not have such properties will not be seen as graspable - i.e. in order to be seen as obtainable, an object must have discernible or inferable boundaries. It seems likely that texture and parallax variables provide the information necessary to perception of the potential graspability of objects in both infants and adults. Infants will

not reach for a representation of an object - only for an object that is defined parallaxically (Bower, 1966, 1972, Bower, Dunkeld & Wishart, 1979). Nor will they reach for a luminous disc having no texture (Bower, Broughton & Moore, 1970c).

Michotte's work also suggested that an object will only be seen as a separate, obtainable object if it is perceptibly separate from any other object in its locality; this depends in turn on the amount of common boundary shared by the two objects. A sphere sitting on a platform, for example, should be more readily perceived as a separate (and therefore obtainable) object than a cube in the same situation since the common point of contact is minimal.

Bearing all this in mind, the obvious candidate for examination now is the spatial relationship 'on'. If the infant's problem is understanding spatial relations between objects, 'on' should also pose problems - even although the object will not be out of sight. In investigating the spatial relationship 'on', we can examine not only the validity of the identity rules postulated above but also the claim that object concept development is a perceptual rather than conceptual problem. By varying the amount of contact between the two objects, it will also be relatively easy to investigate the importance of amount of common boundary to the infant's definition of object identity.

As early as the 1920s, it was noted that retrieval of an object which had been placed on top of another object caused problems (Szuman, 1927, Baley, 1932). Piaget himself confirmed that this spatial relationship presented infants with difficulty.

"At 0.6 (22) Laurent tries to grasp a box of matches. When he is at the point of reaching I place it on a book; he immediately withdraws his hand, then grasps the book itself. He remains puzzled until the box slides and thanks to this accident, he dissociates it from its support".

(Piaget, 1937, Obs. 101)

He attributed this difficulty, as we would expect, to the fact that the infant can only understand objects in terms of his own actions upon them. As a result, spatial understanding is limited to rather elementary practical interrelations between self and objects. The infant has no understanding of interrelations between objects which occur without his intervention. He has not yet achieved the notion of himself as being only one object in a space that is common to both himself and the objects he perceives around him.

Piaget paid slight attention to the parallels between the behaviour in the placed upon situation and behaviour in the standard cloth situation, save to re-emphasise how limited a value we should place on success in that task in the light of behaviour in the placed upon situation. Piaget's main purpose was to establish that the infant's problem lay in differentiating between himself and the external world and he was particularly keen to establish that this came about as the result of the development of representational ability, an ability which would free the infant from the limitations of his purely practical intelligence. Understanding of interrelations between objects was therefore very secondary to his purpose. Furthermore, problems in retrieving an object which was perfectly visible could be construed as an embarrassment to a theory

whose main tenet was that inability to represent absent objects was responsible for the retrieval difficulties found when an object was covered by a cloth. As we saw in Chapters 2 and 3, focusing on the visibility or non-visibility of objects has been a red herring; a perfectly visible object can cause all sorts of problems throughout the sensori-motor period.

Although Piaget's analysis of object difficulties in 'The Construction of Reality' focused on representation, his analysis with Inhelder (1948) of the development of spatial concepts dealt more specifically with the spatial factors which might influence the infant's search patterns. This work is probably far more relevant to the viewpoint forwarded in this thesis than the more frequently quoted account of object concept development given in the three infancy books. According to this, the young infant is limited to understanding relations between objects in terms of their topological properties (e.g proximity, closure, spatial succession etc). Proximity in particular seems to dominate the infant's early understanding of the spatial relations between objects, indeed to such an extent that two neighbouring objects may be fused into a global, syncretic whole. Such a viewpoint is obviously not irreconcilable with the notion that the infant's identity rules, by emphasising the 'boundedness' of any object, will constrain the spatial circumstances in which an object will retain its unique identity. The latter analysis too would maintain that in certain situations, two objects will be treated as a single, new object by the infant.

It is, of course, possible that any problems caused by placing one object on top of another will be of a lesser nature than those found in more standard object permanence situations. There are three possible reasons for this. In the case of spatial relationships such as 'inside' 'under' or 'behind', the object is not only in a mysterious relationship with the other object but is, in addition, out of sight. There are therefore no featural clues left behind as to the possible location of the object. In the case of an 'on' relation, however, the object is still visible; although the infant may not understand that it still represents the same, separate and obtainable object, the 'new' object now present - the platform-and-toy - does at least have some features in common with the original object. While seeking to deny that non-visibility of the object lies at the source of the infant's difficulties, it would be foolish to deny that visibility of the object could be helpful in arriving at a solution (though not necessarily an understanding) to the problem. Experiment 2 showed that while an object 'hidden' inside a transparent cup produced difficulties which could not be put down to motor problems alone, this task was easier than a search task in which an opaque cup was used. Work by Neilson (1977) indicated that the 'inside' relation with transparent cups was also problematic in the later stages of object concept development. Her finding that passage through Stages III - VI was faster with transparent cups suggests, however, that visibility of the object does influence eventual success. Both Neilson's study and a related study by Brunskill (1971) in which a special,

distinctively colored opaque cup was used to provide an additional visual clue to the location of the object further suggest, however, that such clues, while leading to success, do not lead to any true understanding of the spatial relations involved in these tasks; there is no transfer of success when tested with identical opaque cups (see also Experiment 2).

It is also possible that differential motor requirements might lead to a 'placed upon' spatial relationship between two objects being easier than an 'inside' relationship. Recovering an object from a platform does not require any motor behaviour in relation to the platform. In order to recover an object from a cup, however, the cup must first of all be removed; behaviour sequencing problems could therefore adversely affect age of achievement of success (see Experiment 2). It could not, however, be held responsible for any differences in age of achievement between the two situations in a Stage IV - V type task since by then any behavioural difficulties would have been overcome.

The third - and obviously favoured - possibility is that any evidence of accelerated success in object concept type tasks using an 'on' relation could arise from the fact that the amount of boundary loss is minimal in such a situation - only the boundary in contact with the platform is lost. We might still expect some evidence of identity confusion but would suspect that this particular spatial relationship would pose fewer problems.

It is always possible of course that an object placed upon another object may not actually be visible to the baby, that, as far as the baby is concerned, it effectively disappears in such a situation. This would be quite likely, for example, if the contrast between the two objects were minimal or if the perceptual system were relatively insensitive to contrast relations, as the infant perceptual system probably is.

The purpose of the next experiments conducted was therefore two-fold:

1. to examine the suggestion that the spatial relationship 'placed upon' would pose problems to infants
2. to investigate whether these difficulties are conceptual, perceptual or motor in origin.

EXPERIMENT 4

SUBJECTS

A. Cross-sectional. 14 infants between 16 and 32 weeks served as subjects. All were able to reach out and touch a dangling object.

APPARATUS AND PROCEDURE

The platform for all objects was an 8" x 8" x 2" piece of unpainted chipboard. The objects presented were:

1. a $2\frac{1}{2}$ " diameter sphere
2. a cube of side $2\frac{1}{2}$ " presented on one vertex
3. a cube of side $2\frac{1}{2}$ " presented on one surface
4. a section of an identical cube, $2\frac{1}{2}$ " x $2\frac{1}{2}$ " x $1\frac{1}{4}$ " presented on one of its $2\frac{1}{2}$ " x $2\frac{1}{2}$ " surfaces
5. a cube of side $\frac{1}{2}$ " presented on one surface
6. a hemisphere of a $2\frac{1}{2}$ " diameter sphere presented on its flat surface.

All of the objects were painted fluorescent red. The baby sat on his mother's lap at a white table which had a semi-circular cut-out on the baby's side to facilitate reaching. The objects were placed on the platform out of sight of the infant and positioned so that their top edge was visually within the frame of the platform. The platform-and-object was then presented to the baby. Order of presentation of the six objects was random.

RESULTS

A successful trial was defined as one in which the baby took the object from the platform within one minute of presentation. The latency of grasping was measured for each baby with each presentation

It is obvious from the above that all six objects did not present the infants with equal retrieval difficulties; success rates did not shift suddenly with age from zero to complete success and latency times for the different objects varied enormously. In an attempt to determine the relative difficulty of recovering each object from the platform, the latency scores were placed in rank order for each infant and then summed across infants for each of the six objects. (Scores were ranked from 1 - 6, with 1 representing the shortest retrieval time; tied latencies were given the average of the combined ranks). These summed ranks were then meaned and ranked again in order of difficulty. The ranks thus obtained are shown in Table 4.2.

TABLE 4.2 Order of difficulty of retrieval of the six objects used in Experiment 4

Object	Order of difficulty (1 = easy, 6 = difficult)
Sphere	1
Cube on vertex	5
Cube	2
$\frac{1}{2}$ cube	3
Small cube	4
Hemisphere	6

From this it would seem that there is no straightforward relationship between ease of retrieval and amount of common boundary. Although, as might be expected on the Michottian hypothesis, the

ball proved easiest and the $\frac{1}{2}$ ball most difficult, the cube on its vertex proved to be the second most difficult presentation, a finding which is quite contrary to such an hypothesis. The data presented in Table 4.2 is, however, perhaps deceptive. Inspection of the latency scores showed enormous individual differences in relative difficulty of the six objects, the $\frac{1}{2}$ cube, for example, proving to be the easiest object for one 20 week old but the most difficult presentation for the 22 week old. It was therefore considered prudent to investigate the problem more closely in a small longitudinal study.

Before considering the results of the longitudinal study, however, one other finding from the cross-sectional group is worth discussing since it casts doubt on any claim that success in the above tasks is determined by purely perceptual factors. After completion of the trials already described, the objects were re-presented to four of the younger, unsuccessful infants, this time with the placing of the object on the platform being done in full view of the infant, care being taken that the infant attended to the entire placing upon procedure. The assumption was that seeing the two objects separately prior to reaching would assist understanding of the possible separability of the two objects when in the placed upon relation; if this turned out to be the case, it would point to success being conceptually rather than perceptually mediated. In the case of the two youngest Ss (16 and 18 weeks), this procedure made no difference to their success rate; they were still completely unable to remove any of the objects from the platform. The 16 week old

did, however, behave quite differently in the presentation in which the transformation was seen. Previously unconcerned, he now became quite agitated, flapping his arms up and down and scrabbling at the platform. The behaviour of the two older Ss was even more interesting. In both cases, seeing the transformation led to success in presentations which had previously resulted in complete failure to remove or even touch the object. The longitudinal study will also therefore investigate further the possibility that seeing the act of 'placing upon' facilitates success.

SUBJECTS AND PROCEDURE

B. Longitudinal group. Seven infants were run longitudinally, from the time they were first reported as starting to reach at home until the point at which they could successfully retrieve all six objects from the platform. Age of onset of testing varied from 17 - 22 weeks and age of termination from 22 - 27 weeks. Number of test sessions varied from three to eight with mean number of sessions being five. Procedure was as above, with order of presentation varied each week. Where possible, all infants went on to repeat the series, this time with the transformation seen.

With this group an additional object was occasionally used. It was a cone, height 6", of which the top 2" was removable. When the top was on, in place, it was perceptually inseparable from the rest of the cone, even to an adult eye. It thus represented a problem

which development of perceptual acuity alone could not possibly solve.

RESULTS

Once again, all infants showed retrieval difficulties in a placed upon situation. These difficulties persisted over several weeks. Order of difficulty of retrieval of the six objects was determined in the same way as in the cross-sectional group. Table 4.3 shows the order of difficulty on that week in which each infant was first successful in retrieving all six objects from the platform within the given time limit.

TABLE 4.3 Order of difficulty of retrieval in the longitudinal group

<u>Object</u>	<u>Order of difficulty on first all-successful week</u>
Sphere	1
Cube on vertex	2
Cube	3
$\frac{1}{2}$ cube	6
Small cube	4
Hemisphere	5

This order of difficulty fits well with claims that amount of common boundary is relevant to success in object retrieval tasks. The two objects which had essentially no surface in common with the platform (the ball and the cube presented on its vertex) proved less difficult to remove than those objects which did share extensive boundaries with the platform. Other, simpler perceptual factors seemed less important; diminutions in the amount of parallax contrast with the

platform, for example, did not appear to influence greatly the difficulty of the tasks (see, e.g. cube v. small cube).

It could be claimed that Table 4.3, like Table 4.2, is deceptive. In this group too, order of difficulty for some of the objects did show wide individual differences. Unlike the cross-sectional group, however, some statements about the relative difficulty of at least some individual objects can legitimately be made since they did hold true for most infants. The ball, for instance, invariably proved to be the easiest object to recover. It was equally true that the $\frac{1}{2}$ cube and $\frac{1}{2}$ ball were always amongst the most difficult of objects. This patterning of difficulty also held true to a lesser extent in the weeks prior to successful removal of all six objects. More rigorous statements about order of difficulty are not, however, possible. These results cannot, therefore, be said to provide conclusive evidence for Michotte's claim that amount of common boundary determines whether an object will be seen as separable and obtainable or not. They do, however, fit well with the lesser claim of the identity hypothesis that boundary violation influences performance on object search tasks.

The effects on performance of seeing the act of placing upon also lend support to a conceptual analysis of the infant's difficulties in the placed upon task. Table 4.4 shows the effects of perception of the placing upon at various stages in the study.

TABLE 4.4 The effects of perceiving the transformation at various ages

	<u>NUMBER OF INSTANCES OF CHANGE IN PERFORMANCE</u>				
	<u>Positive</u>		<u>Negative</u>		
	Absolute failure converted to success	Latency of recovery reduced	Success converted to absolute failure	Latency of recovery increased	Probability (sign test)
Week 1	2	4	4	6	.23
Middle week	1	8	0	1	.01
Last week *	0	11	0	2	.01

(* last week in which performance in the earlier tasks allowed for any improvement on the transformation trials - i.e week before all objects retrieved instantaneously from platform).

Perception of the act of placing upon obviously does have an effect, though initially it would not seem to be the effect expected. In Week 1, perception of the act of placing upon was more likely to increase the difficulty of the task, 10 out of 16 changes in performance producing reversals in competence. This is most puzzling. A possible ad hoc explanation would be that the infant's initial success on the task when the transformation was not seen was purely due to chance; although seeing the object and platform as a single object, some reaches by chance landed on the object part of the combined object. This would be less likely to occur in the transformation task since the baby now had the problem of working out what had happened to the

original object when it was placed in a spatial relation with another object; he would not therefore be so ready to accept the object-and-platform as the object to reach for. Success rate for recovery of the object in this first week was in any case only around 25%; infants typically failed to recover the object at all, irrespective of whether or not the transformation was seen.

Fortunately for the identity hypothesis, the negative effects of seeing the transformation were quickly reversed. By the last week in which differences in performance were possible, the effect of seeing the transformation was almost universally beneficial. Thereafter, all of the infants succeeded in all of the presentations. At this point, they could also succeed with the cone, provided they saw the placing upon action.

DISCUSSION

The results of Experiment 4, while not producing conclusive evidence of Michotte's claim that amount of boundary is crucial to object perception, do suggest that boundaries are indeed relevant to success or failure on object retrieval tasks. On an identity analysis, such information would also be highly relevant since boundedness is, as we have seen, presumed to be central to the infant's definition of objects and crucial if he is to retain the identity of an object throughout an event sequence; amount of shared boundary could well determine whether two objects will be regarded as separable or not. This type of conceptual analysis would also gain support from the finding

that knowing that the two objects could be separated facilitated retrieval, even when the amount of shared boundary was quite extensive, a finding which surely detracts from any attempt to give a straightforward perceptual explanation of difficulties in such tasks.

Further support for the viewpoint that the difficulty in the placed upon situation is conceptual rather than perceptual will come from the results of Experiment 5, to be presented in the next chapter. Infants in that study were also presented with objects on platforms. Testing again began in the week in which the infants were first able to demonstrate that they could reach and consisted of both Stage III - IV and Stage IV - V tasks. In spite of the massive acceleration in object concept development later shown by these infants, difficulties in retrieving the object from a platform were frequent in the early weeks of testing and virtually all infants showed clear signs of confusion in the AAB situation, some taking seven (weekly) sessions before being able to succeed in this task. Although only 7 out of 24 infants went to the wrong - and clearly empty - platform, introduction of a second platform obviously posed new problems for these infants, problems evidenced by rapid checking back and forth between previous and present object positions, occasional frowning and almost universally increased retrieval times on the B trial. This evidence that Stage IV - V platform errors occur poses considerable problems to claims that perceptual or motor difficulties underlie the difficulties observed in the placed upon task. If the baby has already passed the Stage III - IV task (as these infants all

had), he must certainly have overcome any hypothesised perceptual problems and there can be no doubt that he can both see (and reach for) the object when on the platform. Why, then, should the AAB error be produced on the next trial? It seems more reasonable to assume that the problem is a conceptual problem, with the two objects being treated as one object, 'the platform-and-object'; as far as the infant is concerned, the original object has disappeared mysteriously, despite the fact that it remains in sight throughout the entire sequence. It should be noted, however, that errors in the placed upon situation in this group did drop out earlier than errors in the equivalent inside and behind tasks, the screen and cup tests (see Table 5.2).

This analysis of the infant's difficulties would not be acceptable to many researchers. Bresson and de Schonen (1977), for example, would prefer to regard the infant's problems in the 'placed upon' situation as being rooted in perceptual-motor difficulties. Problems are caused by 'the presence, in the same visual field, of two systems of boundaries (object and support) that differentially regulate the movement of reaching and that conflict one with the other' (de Schonen, 1977) and are not the result of the two objects being treated as one, the platform-and-toy. On their interpretation, however, amount of boundary held in common with the support should be irrelevant. Bresson et al's own data suggest that this is not the case (Bresson, Maury, le Bonniec & de Schonen, 1977). Four different forms of support were used: the palm of the hand, the tips of the fingers, a 5 cm. cube and a board 21 x 29 x 0.5 cms. The same object, a 2 cm. cube, was used in all presentations. Reaching for the support

rather than the object was found to be almost twice as likely in the condition in which the 2 cm. cube was placed on top of the 5 cm. cube as when that same cube was placed on the large board. It was also found that success of reaching for the small cube on the larger cube remained steady at 60% from 21 - 32 weeks while success in the board condition shot up to over 90% by 32 weeks (see also Cardow, 1978). These differences fit well with a conceptual analysis of the infant's difficulties in the placed upon situation but are difficult to reconcile with Bresson et al's analysis in terms of the development of perceptual-motor co-ordination.

In support of their argument that the problems found in 'placed upon' situations are perceptual-motor rather than conceptual, Bresson and de Schonon point out that between 17 and 21 weeks, prior to any visual guidance of reaching, infants will make a ballistic reach toward the platform and object and will at times succeed in removing the object. This, they feel, is evidence that the infant is perfectly well aware of the continued separateness of the two objects involved. Since the success rate in this period is only 20% however, (16) it would be equally possible to interpret such reaches as reaches for the platform-and-object which happen to make contact with the toy 'part' of that object. A tendency to mouth the object as it sat on the platform was also taken as evidence that the infant is well aware that the two objects exist quite separately. I would prefer again to

(16) Inspection of Bresson et al's criterion for a successful reach for the object - 'either the palm or at least a finger covered part of the object ... and remaining on it (whether moving, fingering, seizing or picking it up)' - suggest that even this low figure may be an overestimate of early success.

maintain that it is equally likely that the infant merely sees the object, not as a separate, obtainable object, but as some sort of projection on the platform; his attention to it is hardly surprising since, in most cases, it is the brighter and more attractive 'part' to begin with. In my observations of this sort of behaviour, the infant is most likely to be grasping the platform as he mouths the object, a fact which surely must detract from Bresson and de Schonen's interpretation.

Even if there were nothing to choose between these two conflicting interpretations, it is hard to see how supporters of perceptual or motor interpretations of the difficulty in the placed upon situation could reconcile their position with the evidence of continuing errors in the two platform situation. The infant has already proved himself capable of dealing with one platform in the Stage III - IV task and must therefore have overcome the hypothesised perceptual and/or motor problems. Why, then, should the introduction of a second platform cause confusion? Consider also an experiment by Neilson (1977). She found that an 'in front of' relation between two objects could cause retrieval difficulties in infants between 22 and 30 weeks - but only if the distance of separation between the two objects was sufficiently small. Obviously, motor difficulties cannot be invoked here; it seems rather as if the two objects must be seen as sharing a common boundary for the problem to arise. An experiment by Lucas & Uzgiris (1977) also found separation to be an important factor in object retrieval. Such results confirm the suggestion that what determines response or non-

response in a situation in which two objects bear a spatial relation to each other is whether they are seen as sharing a common boundary or not. Problems of motor skill, visibility or perceptual preference, although they may influence response, are of secondary importance only. They may influence which of the spatial relations will be mastered earliest but do not hold the key to the problem.

It will now be useful to look again at the infant's responses in a variety of situations involving a spatial relation between two objects. Chapter 5 will examine further the suggestion that an infant is unable to maintain the identity of an object throughout any event sequence which involves close spatial interaction with another object. Although perceptual information would lead adults to conclude that one and the same object interacts throughout the sequence, it is suggested that the young infant will not arrive at this economical and generally valid conclusion, the result of the incompleteness of his rules for attributing identity to objects.

CHAPTER FIVE - A FURTHER INVESTIGATION AND EVALUATION OF THE
IDENTITY HYPOTHESIS

Outline of the identity hypothesis and its proposed identity rules

According to the identity hypothesis, the sequence of behaviours seen in traditional object permanence testing situations can be understood and explained in terms of the infant's developing understanding of object identity. The infant's problem is not one of differentiating between himself and external reality; his problem lies in elaborating a comprehensive notion of object identity, one which will allow an object to participate in an event sequence and yet retain its unique identity throughout. According to the identity hypothesis, an object need not have disappeared from sight for its identity to be threatened. In fact, in the early stages of development, movement of an object which was previously stationary will be sufficient to cast doubt on its continued sameness. Later, although simple movement will no longer cause problems, any situation in which an object interacts in common space with another object in such a way that the integrity of its boundaries is either threatened or obscured will lead to identity confusion in the infant.

The identity hypothesis forwards a series of rules which it believes can cover the characteristic sequence of search behaviours found in standard object permanence testing situations. As one identity rule is replaced by the next, the infant comes closer to a true appreciation of the unique and independent properties of

individual objects. The following sequence of rule acquisition was hypothesised in Chapter 4:

Rule 1 - Stages I and II

An object is a bounded volume of space in a particular place or on a particular path of movement.

Corollaries to such a rule would be:

Two objects cannot be in the same place.

Two objects cannot be on the same path of movement.

Any violation of these corollaries (e.g replacement of a stationary object by a totally different object) will be interpreted as a transformation in the original object rather than as its replacement by another object.

Adoption of the above rule and its corollaries leads to the following search behaviours:

To find a stationary object, look for it in the place where it is usually to be seen. (This may result in a place error if the object is in fact in a new place).

To find a moving object, look for it along its usual path of movement. (This may result in a movement error if the object in fact stops).

Rule 2 - Stages III - V

An object is a bounded volume of space of a certain size, shape and colour which can move from place to place along trajectories.

Here, place and movement rules have been co-ordinated and the features of an object, ignored in applications of Rule 1, are now included in the definition of an object. The corollaries of Rule 1 still apply but with one important modification:

Two objects cannot be in the same place nor on the same path of movement simultaneously.

Since featural information is now incorporated in the rule for identifying an object, any event sequence violating these new corollaries will be treated by the infant as the replacement of the original object by another object rather than a transformation process, as on Rule 1. As a result, search behaviour will be directed first by the rule:

To find an object that has disappeared mysteriously,
remove the object which has replaced it,

and later by the more specific rule:

To find an object that has disappeared mysteriously,
remove the object which is now in the place where
it was last seen.

Rule 3 - Stage VI

Here, the identity rule essentially remains the same as in Rule 2 but the corollaries are modified to fit with the infant's experiences of the consequences of interactions between objects. The corollaries will now be:

Two or more objects cannot be in the same place nor on the same path of movement simultaneously unless they bear a spatial relationship to each other which involves a sharing of common boundaries.

To an infant working with only Rule 1 or Rule 2, an object which moves then stops or an object which enters into a spatial relationship with another object in such a way as to lose or mask its identifying boundaries will have disappeared mysteriously. Not until acquisition of Rule 3 can the infant truly understand that a spatial relationship between two objects does not violate the identity of either. Prior to this understanding, he may succeed in 'solving'

problems involving spatial relations between two or more objects. These successful search strategies are, however, highly specific to particular problem situations and do not lead to success in other, conceptually similar tasks.

An investigation of the identity hypothesis

The next experiment was designed to investigate the validity of the above rules. Infants were tested longitudinally between 12 and 28 weeks (Stages II and III on Piaget's analysis). Both visual and manual competence in object search tasks were assessed. Both sets of tasks used three spatial relationships which violated object boundaries - 'on', 'in' and 'behind'; the tracking presentations also included stops in sight.

The simultaneous and longitudinal investigation of three, differing spatial relations may shed light on various topics. Firstly, it may help to determine whether amount of boundary violation is, as suggested by Experiment 4, influential in attribution of identity to successive appearances of the same object. If so, 'on' might be expected to be considerably easier than either 'behind' or 'inside'. It is also possible that 'behind' could conceivably prove easier than 'inside', since front but not rear boundaries suffer violation: it is doubtful though whether the infant would be able to appreciate this rather fine distinction, particularly since the rear boundaries, although unviolated, are still out of sight in a 'behind' situation. Secondly, and

relatedly, this study will allow evaluation of the claim that 'behind' holds a privileged position in the infant's understanding of spatial relations, a suggestion made by Bower (1974a) and Neilson (1977). Bower has suggested that the infant's perceptual system is able from birth to transduce the information specifying a behind relationship between two objects, while allowing for the continued existence of the occluded object. He believes that such an ability is an essential prerequisite for perception of three-dimensional space: unless the infant could correctly interpret occlusion information, he would be unable to disambiguate the spatial information provided by motion parallax and optical expansion patterns.

If Bower is right, the apparent *décalage* between visual and manual competence in object permanence testing (see p 31) would be easily explained. Young infants are able to demonstrate existence constancy in visual tracking tasks because these tasks, almost without exception, use a presentation in which the object goes behind a screen (e.g Gardner, 1971, Bower, Broughton & Moore, 1971). The apparent later loss of this knowledge in manual tasks can be attributed to the fact that the standard manual object permanence tests typically use 'under' or 'in' relations between occluder and object, the object being covered with a cup or cloth. According to the Bower/Neilson analysis, the infant would have no difficulty in recovering the object manually if a screen were used to cover the object instead of a cup or cloth. Similarly, a young infant who was able to show anticipatory behaviour in a visual tracking task

involving a screen would presumably 'lose' this competence if a tunnel or platform were substituted as occluder.

Experiment 5 will allow investigation of the Bower/Neilson theory. The use of longitudinal testing will also allow the relation between early and later performance to be more clearly examined. Tracking studies are generally only performed with infants who are not old enough to reach. Experiment 1 demonstrated the important interrelationship between the early and later tasks. It therefore seems essential to monitor tracking and reaching competence simultaneously in the same infant if we are to understand this interrelation more fully.

What explanation could the identity hypothesis give of the *décalage* usually found between visual and manual competence in object permanence testing? Like Bower and Neilson, I would like to suggest that the *décalage* is an artefact of the testing situations used. I do not, however, believe this stems simply from the use of differing spatial relations between object and occluder. It seems much more likely to me that the competence attributed to young infants in visual tasks is, in fact, an overestimate. First or criterial responses only are generally reported (e.g Moore, Borton & Darby, 1978). More detailed analysis may reveal that this precocious 'knowledge' is far less stable and complete than is generally assumed. Knowing that something will continue to exist when occluded as demonstrated, e.g by the work of Bower (1967) and Mundy-Castle & Anglin (1973), is not the same as being able to identify the reappearance of that object as the

reappearance of the same object as was seen previously. This is not to deny that the young infant may well expect something to reappear. Repeated presentations of the event sequence will confirm this expectation. The work of Bower (1971) has shown, however, that the infant will not at first have a very specific idea of exactly what will appear, since a total featural transformation in the reappearing object produces no surprise until around 20 weeks of age (see also Goldberg, 1976).

Experiment 5 will investigate the identity hypothesis' claim that entering into a spatial relationship with another object leads to identity confusion. Such a hypothesis would predict that even if the infant can anticipate the reappearance of a moving object from behind, inside or on top of another object, his subsequent looking behaviour will reveal that he is by no means sure that this object is the same object that disappeared behind/in/on the occluder in the first place. Data from the 'on' tracking condition will be of especial interest since visual competence in a 'placed upon' situation has not previously been investigated.

A further line of investigation which Experiment 5 may allow us to pursue is the possible acceleratory effects of visual tracking experience on subsequent development - both on eventual attainment of visual tracking competence and, more interestingly, on attainment of competence on conceptually related manual tasks. Experiment 1 would lead us to suspect that a study of this type (involving weekly exposure to an object which moves and stops), would

lead to accelerated manual competence. The effect of introducing another object, the screen, platform or tunnel, is an unknown. On the basis of the identity rules suggested above, it might be expected that this too would have an acceleratory effect on acquisition of higher-order identity rules. Regular exposure to an object which emerges unscathed from assorted spatial interactions with another object should help to promote understanding of the idea that one object can go into a spatial relation with another object and yet retain its unique identity. On the identity hypothesis, it might be suspected that the information yielded by this aspect of the presentation would not be particularly useful in the early weeks since the infants would not yet have acquired Rule 2; they would not therefore be registering the featural identity of the objects seen on either side of the occluder. These infants would still be struggling to co-ordinate their rules for maintaining contact with the object while in sight, their place and movement rules. With acquisition of Rule 2, however, we might expect much more attention to that part of the display which now contradicts their newly acquired identity rule.

EXPERIMENT 5

SUBJECTS

24 subjects, 11 male, 13 female, were divided into two groups, E 1a and E 1b. All were twelve weeks of age on beginning the experiment.

DESIGN AND PROCEDURE

Both groups, E 1a and E 1b, visited the laboratory at weekly intervals from 12 - 28 weeks. Any sessions which had to be prematurely terminated were resumed in the same week where possible. Two sessions took place in the final (28th) week of testing. (17) Tracking tasks were begun at 12 weeks and given at weekly intervals thereafter. Reaching tasks were started on the week in which the baby first demonstrated the ability to reach and touch a dangling object within 2 minutes of its presentation. From then on, both tracking and reaching tasks were given in each session. The tracking tasks always preceded the reaching tasks.

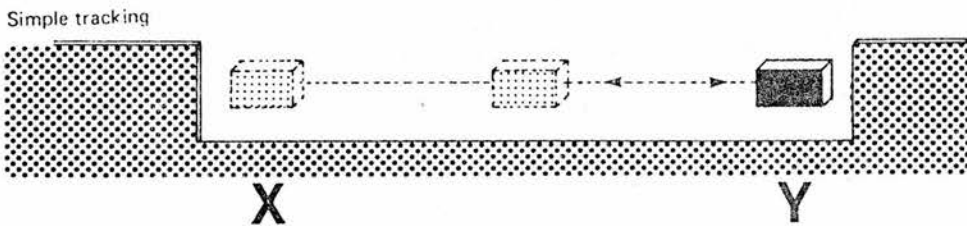
(17) At the end of this study, half of the subjects went on to participate in a related study undertaken by Neilson (1977). The other half were monitored monthly on Stage IV - VI manual tasks.

A. Tracking tasks

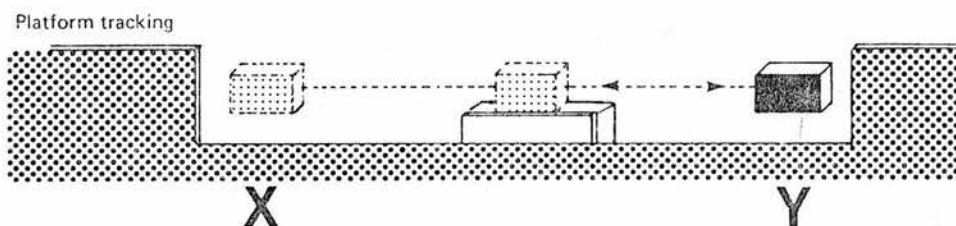
In the tracking tasks, infants sat on their mother's lap, facing the display and at a distance of 3 feet from it. Where necessary, the mother would support the infant's head under the chin. Mothers were instructed not to direct the baby's attention in any way but to allow him to look at whichever part of the display he chose. Sessions were video-recorded for subsequent frame-by-frame analysis. A T.V. camera mounted behind the display and out of sight of the infant monitored head and eye movements while object position was simultaneously monitored by a camera above the display.

Four tracking presentations were used.

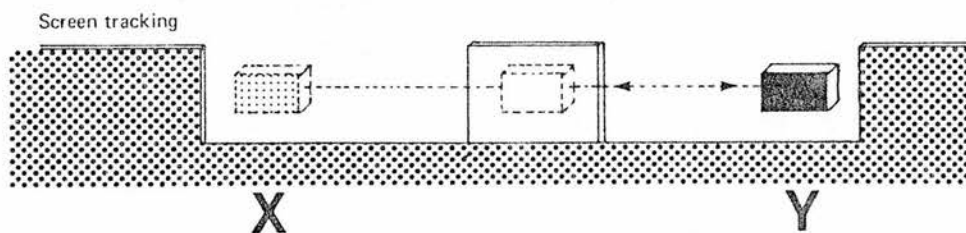
1. Simple tracking: The object travelled from X to Y, paused for 3 seconds (Trial 1), travelled back to X, paused at X for a further 3 seconds (Trial 2), and so on.



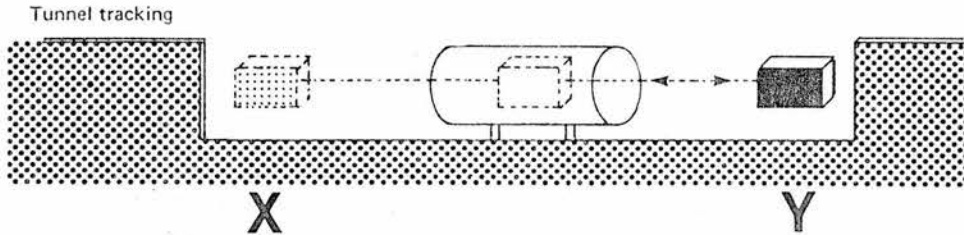
2. Platform tracking (on): As in 1, but passing over a platform positioned midway between X and Y. The platform was constructed out of the same material as the tracking apparatus (chipboard) and was 8" long. It was of such a height that the base of the object just touched it as it passed over it. The object therefore effectively lost its bottom boundary on crossing the platform.



3. Screen tracking (behind): As in 1, but passing behind a screen positioned midway between X and Y. The screen was constructed of the same material as the tracking apparatus, measured 8" x 8" and stood $\frac{1}{2}$ " in front of the track.



4. Tunnel tracking (in): As in 1, but passing through a tunnel positioned midway between X and Y. The tunnel was made of lightweight, opaque, grey plastic, was 8" long and 3" in diameter.



The same object, a red, fluorescent polystyrene block, 2" x 1½" x 1", was used in all presentations. The object was carried on a fine link chain, driven by a Bodine motor. Speed of movement of the object was 3.2 ins/sec. The length of the track was 36". Each trial therefore lasted 11.25 seconds, with a 3 second pause at either end of the track. In conditions 2 - 4, the length of the occluder ⁽¹⁸⁾ was 8"; duration of occlusion was therefore 2.5 seconds. The process of occlusion itself took 0.6 seconds.

(18) I would like to use the terms 'occluder' and 'occluded' in reference to Condition 2, as well as Conditions 3 and 4. In Condition 2, the platform condition, the object is not 'occluded' in the true sense of the word; it would appear, however, that something comparable or equivalent is happening as far as the infant is concerned. There is a degree of conceptual, if not perceptual, disappearance when an object goes over a platform. For ease and economy of description, I shall therefore use 'occluded' to refer to all 3 conditions.

Presentation began when the infant first noticed the moving object or after 4 full excursions, whichever was the lesser. Presentation of any one condition consisted of 8 complete trials thereafter. On alternate weeks, two stop trials were incorporated, one after the 4th trial, one after the 8th trial. In the 1st stop trial, the object stopped in approximately the middle of the first section (A) of unoccluded track (i.e. before entering the tunnel, going on to the platform etc); on the 2nd stop trial, it stopped in approximately the middle of the second section (B) of unoccluded track (i.e. after emerging from the tunnel, coming off the platform etc). The stop position was not more exactly controlled since it was felt necessary to introduce a degree of flexibility in order to cover those instances where the infant did not track section A or B in its entirety. Stop duration was 5 seconds.

Each baby saw two of the four tracking conditions weekly. All possible pairs of conditions were used, in both orders of presentation. Conditions were paired and sequenced such that a total of 12 babies saw each of the 4 conditions at each week-level and each individual baby on average saw all 4 conditions every fortnight, the maximum separation between two presentations of the same condition being 3 weeks (see Appendix A). For Group E la, stop trials took place on even-age weeks; for E lb, on odd-age weeks. There was therefore stop data for 6 babies on each of the 4 conditions at each week-level. At 28 weeks (the final visit), each baby saw his appropriate pair of conditions and then returned later that week to see the remaining two conditions.

Analysis : tracking tasks

Condition 1, simple tracking, was analysed for two features only: complete or partial tracking and smooth or confused tracking. For Conditions 2 - 4 (platform/screen/tunnel tracking) tracking trials were divided into five periods for analysis as follows:

1. object on first section of unoccluded track (A)
2. disappearance of object, i.e from when object first goes onto platform/behind screen/into tunnel until it is completely occluded
3. object completely occluded
4. reappearance of object, i.e when object first reappears from platform/screen/tunnel until completely reappeared
5. object on second section of unoccluded track (B).

Using frame-by-frame analysis, records were scored for the following 9 responses:

1. looks off
2. tracks forward (terminus of track noted)
3. tracks forward to exit
4. tracks forward past exit (terminus of track noted)
5. tracks back (terminus of track noted)
6. tracks back to entry
7. tracks back to exit
8. stops at exit
9. stops at entry.

Although several of these responses are appropriate responses to demonstrate when the object goes out of sight (e.g 3, or 1 followed by 7), none are appropriate when the object is on either unoccluded section of the track (since all involve looking at some point other than the current position of the object).

Frame-by-frame analysis was also used to analyse behaviour on the stop trials. When the object stopped it was noted whether:

1. the infant's eyes stopped with the object, either remaining on the object for the entire duration of the stop or looking off at some point during the stop, or
2. tracked forward after the stop and, if so, whether immediately or after a pause on the stopped object, or
3. tracked backwards after the stop and, if so, whether immediately or after a pause on the stopped object, or
4. a combination of 2 and 3.

Behaviour on the rest of the stop trial, while noted, was not added to the tracking trials analysis as it was felt that the stop could well confuse subsequent tracking, making stop trials quite different in nature from the other trials.

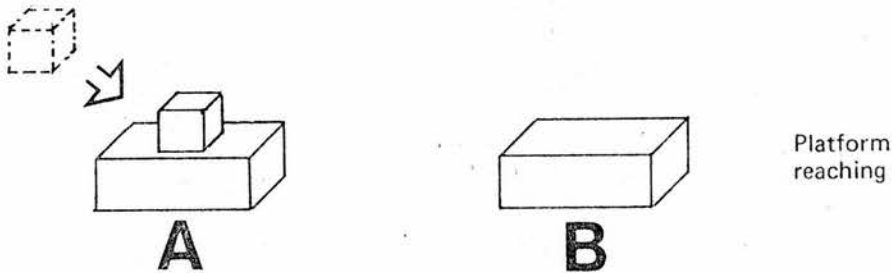
B. Reaching tasks

Reaching tasks were started in the week the baby first demonstrated the ability to reach and touch a dangling object within a time-limit of 2 minutes. In the reaching tasks, infants sat on their mothers' laps at a table which had a semi-circular cut-out on

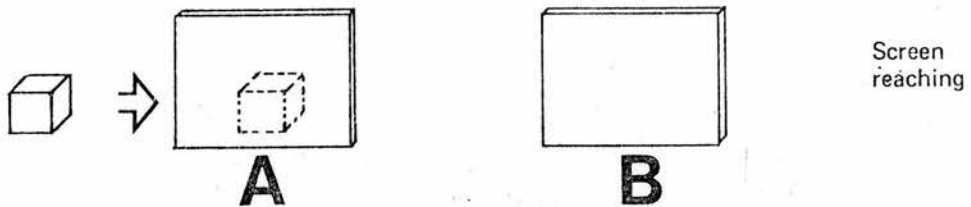
the infant's side to facilitate reaching. Mothers were asked to support the infants in such a way as to neither restrict nor direct their reaching and to restrain their infants from reaching while the object was in the process of being hidden.

Three reaching tasks were used:

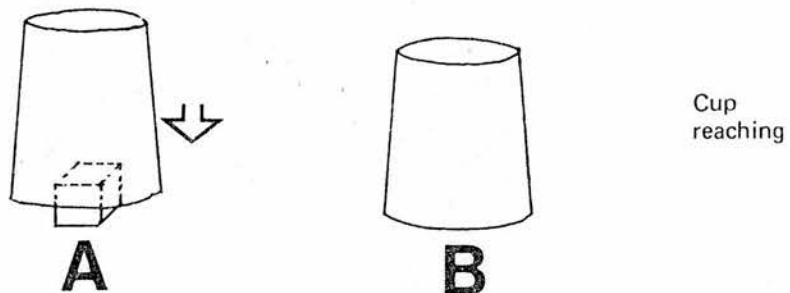
1. Platform reaching (on): The object was placed slowly on one of two platforms made of white, high-density, plastic foam, 4" square and 2" high, positioned 6" apart and at an equal distance from the baby. If the baby was successful in removing the object from the platform within 2 minutes, the same object was again placed on that platform (A). If again successful, the object was then placed on the other platform (B). (i.e a Stage IV - V (AAB) sequence, with the first trial constituting a Stage III - IV test in the event of Stage V failure.) Care was taken that the infant attended to each part of the sequence.



2. Screen reaching (behind): AAB sequence as in 1 but object hidden behind one of two screens made of white, non-reflective card and measuring 5" x 5" (a size which made it impossible for the infant to see the object over the top of the screen but was still relatively easy to remove).



3. Cup reaching (inside): AAB sequence as in 1 but (19) object hidden inside one of two cups made of blue cardboard, 4" high and 3" in diameter.



(19) White cardboard cups could not be found and alternative white plastic or polystyrene cups proved to be either too difficult to remove or texturally too interesting in themselves. Home-made white cups were demolished too easily.

These three reaching tasks obviously involve the same three spatial relationships between object and occluder as in the tracking presentations.

The aim was to give each baby two AAB sequences, one starting on the baby's left, one on his right, of each of the three reaching tasks. In the early weeks of reaching, however, reaching or attempting to reach is a laborious and difficult process for infants and they rapidly become very tired. Consequently, order of presentation of the tasks was chosen to maximise the possibility of at least some response (though not necessarily successful recovery of the object) occurring to more than one condition. Order was therefore reduced to a function of two rather than three variables, platform and cup or screen, the assumption being that, in the case of the platform, as the object was still in sight, attention would at least be retained to some extent although reaching might not necessarily follow. It was hoped that such a procedure would increase the chance of being able to test more than one condition in these early weeks. Half of the infants therefore did the task in the order platform, followed by cup or screen, half doing the reverse order. Within the cup or screen variable, half would start with cup, half screen. There were therefore 6 babies in each of the four groups, PS, SP, CP and PC, chosen equally from the two original tracking groups E 1a and E 1b (where P = platform, S = screen and C = cup).

Two AAB sequences of the first task would be given, one starting on the left, one on the right (randomly assigned). Then,

one AAB sequence of the next task would be given. If the baby was still interested and responsive, one AAB sequence of the remaining task (always a cup or screen task) would be given starting on the side opposite to the previous task. If, after all this, the baby was still attentive and happy, the remaining tasks would be given. The following week, the infant would start with the other of the two possibilities and proceed as above. (If the first condition was screen or cup, the infant would do whichever one had been third in the previous week. (Week 3 was as Week 1 and so on.)

As it turned out, infants were soon able to get through all three conditions in the one session so the above precautions became superfluous. Adoption of this procedure did, however, mean that a reasonable spread of data was obtained during the early weeks of reaching.

Where possible, the same object, a brightly coloured wooden doll, was used throughout the reaching presentations. When it became obvious that this no longer interested the baby, another object would be substituted. All objects were brightly coloured, flat-based and approximately $1\frac{1}{2}$ - 2" in height and 1" in width. If an infant lost interest in the object while within any AAB sequence, that sequence would be abandoned and a new sequence and new object introduced.

Analysis : reaching tasks

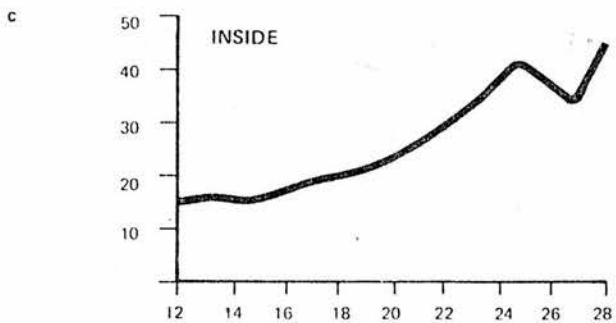
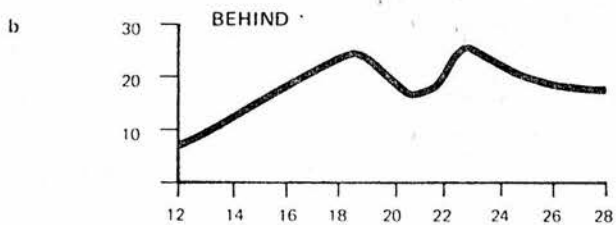
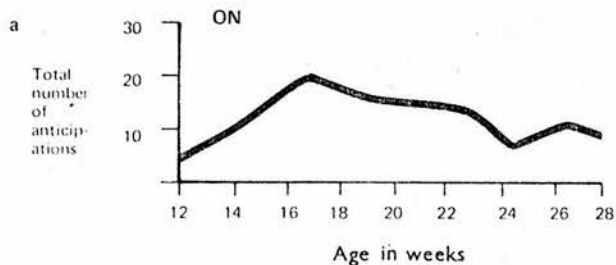
All three conditions were analysed in the same way. All behaviour was noted and divided into three time periods: behaviour prior to search, during removal of the occluder and during retrieval of the object (see Appendix B). For each trial, time taken to remove the occluder was recorded and any delay between removal of the occluder and retrieval of the object noted.

In the cup and screen tasks, the criterion adopted for Stage IV success was removal of the correct occluder within the two minute time limit and recovery of the object within 10 seconds of its reappearance. (This is a less exact criterion than that used in Experiment 2 but proved to be quite satisfactory since no infant with an initial free capture time of greater than 10 seconds in fact succeeded in removing either cup or screen within the allowed time.) In the case of the platform task, recovery of the object from the platform within the two minute time limit was taken as successful Stage IV behaviour. To be credited with being in Stage V, all tasks required successful recovery of the object on all three (AAB) trials. Any attempt to remove or inspect the wrong occluder on the B trial was scored as a failure as was any trial on which the infant displayed surprise on reappearance of the object.

RESULTS : TRACKING

All tracks to the exit which occurred while the object was still on/behind/in the occluder and which incorporated a discernible pause were counted as anticipations as were responses in which the infant caught the object within 300 msec of its reappearance. Graphs 5.1A - 1C show the total number of anticipations for each condition between 12 and 28 weeks.

Graphs 5.1a - 5.1c Total number of anticipations in each spatial condition



In the case of 'behind' and 'in', such anticipations could be (and usually are) taken as a measure of object understanding, as an indication that the infant understands that the object continues to exist while occluded and will reappear in due course from behind or in the occluder. Why, then, should there be any anticipations in the 'on' condition? The infants' behaviour in this condition is very bizarre; they act very much as if the object 'disappears' on going onto the platform, checking over to the far end, as if expecting to see it reappear there. In this case, the object is in sight throughout; any anticipations here must surely represent confusion over the identity of the object (or objects) involved in the sequence. In light of the fact that there is no substantial difference in the number of anticipations in the three conditions in the first 6 - 8 weeks, we should perhaps, then, reconsider our interpretation of the meaning of anticipations in the behind and inside conditions. There is already evidence that anticipations to the exit will occur even when the object stops before going behind a screen (Bower, Broughton & Moore, 1971). Such behaviour does make sense in terms of the identity hypothesis. If the infant has identified the object only in terms of its movement, he will continue to look for it on its path of movement when it stops, a response which, had the object not stopped in sight, could easily be mistaken for anticipation.

Could it be that the 'anticipation' found above represents an attempt to catch the appearance of the 'other' object, the object which usually appears at B after the first object has gone into a

(mysterious) spatial relationship with the occluder - and not an attempt to anticipate the reappearance of the same object? From Graphs 5.1A - 5.1C, it is obvious that at no time is the number of anticipations very high, considering the number of infants and trials involved (12 infants x 8 trials at each week) and the rather generous criterion for what was counted as an anticipation; if premature, unsuccessful anticipations had been excluded, the number of anticipations would have been very small indeed. If, as suggested, these anticipations represent only a form of event prediction rather than true object understanding, there are certain patterns of response which should be seen. Event prediction in these situations requires no understanding of what is going on in the centre of the track, nor of the fact that only one object is involved but could, however, be expected to increase in accuracy over the weeks. The actual number of successful first anticipations might not vary greatly over time (since capture within 300 msec represents a very stringent measure of event prediction as opposed to object understanding) but the time taken to catch the appearance of the 'other' object should decline appreciably with increasing exposure to the situation. This is precisely what happens; performance improves between sessions and even, occasionally, within the course of a single session (Table 5.1 - see also Nelson, 1974).

TABLE 5.1 Capture times of typical subject in tracking tasks of Experiment 5

Subject: D.D

Mean time to capture reappearing object (secs)

Week	ON	BEHIND	IN
1	x	2.46	2.14
2	-.41	x	1.36
3	x	.65	x
4	x	x	.66
5	-.32	.78	x
6	x	.81	.51
7	-.78	x	x
8	x	-.04	x
9	-.16	x	1.21
10	.40	-.32	x
11	x	x	-.38
12	.25	x	x
13	x	.70	-.32
14	.02	x	-.50
15	x	1.05	x
16	x	x	-.03
17	0	-.14	x

Time to capture reappearing object (secs)

<u>Week 3 (14 wks) - 'behind'</u>	
Trial 1	3.40
2	1.36
3	-.36
4	.88
5	1.14
6	.22
7	-1.14
8	-.16

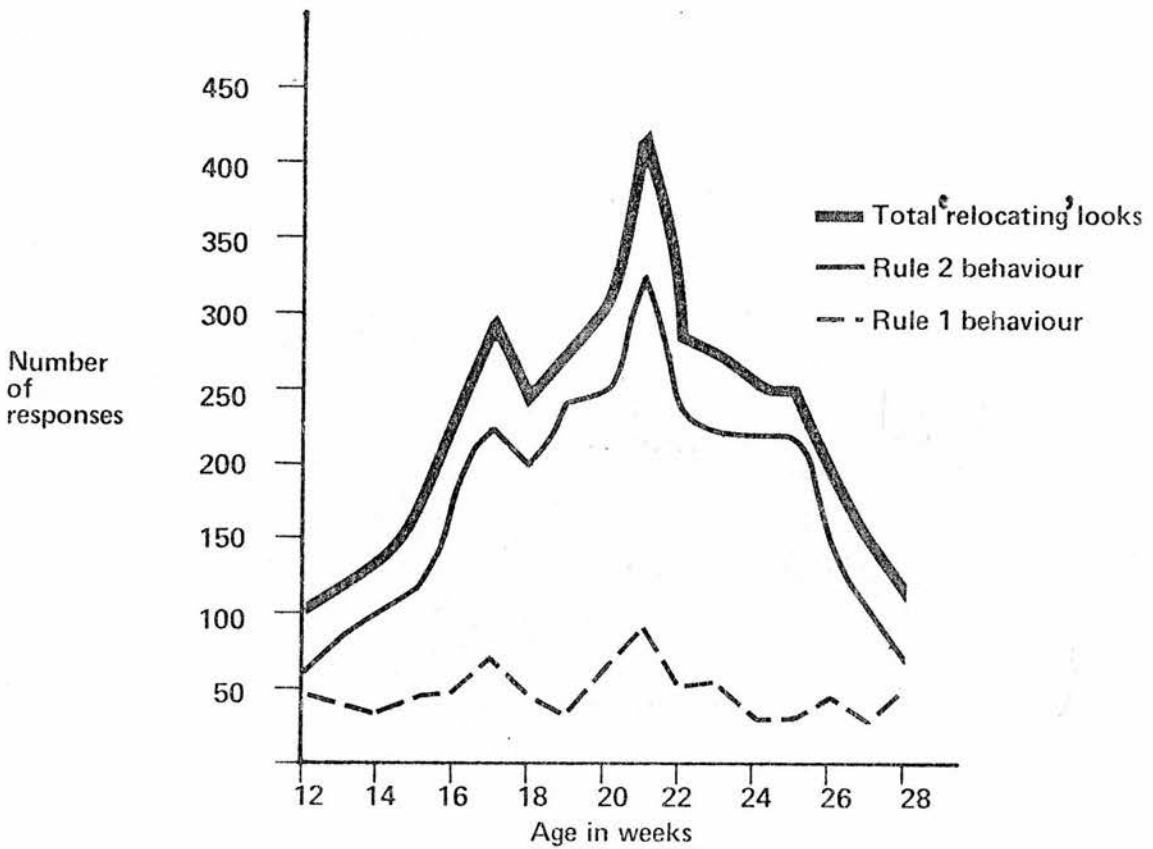
The suggestion is that all the infant is anticipating is the appearance of an object on the other side; this anticipation is heightened with increasing exposure to the situation. Anticipation of the appearance of an object and anticipation of the reappearance of the same object as was seen to disappear are not the same thing. The pattern of anticipations in the 'on' situation are probably the

most obvious indication of the limitations of the infant's understanding; these false anticipations must reflect the infant's belief that he has 'lost' the object from A when it goes onto the platform; his anticipation represents an attempt to predict the appearance of the 'other' object which usually turns up at B soon after; it is difficult to think of any other explanation for this very odd behaviour.

On the identity theory, what would we predict would happen when the infant begins to recognise that the object at B is featurally identical to the object at A? In all conditions, the pattern should shift from one of tracking the 'first' object to the entry and increasingly precise prediction of the appearance of the 'new' object to one showing signs of confusion on the appearance of what is recognised to be the same object, an object believed to have been 'lost' on interacting spatially with the occluder. We might also expect this pattern of behaviour to be followed by increasing attention to the occluder itself. This is very much what happens. Attempts to 'relocate' the object while it is perfectly visible on either unoccluded section of the track - a clear indication of identity confusion - soar at 17 weeks and again at 21 weeks (Graph 5.2), the latter peak being accompanied by a jump in attention to the occluder itself. (20)

(20) Mathematical regression analysis confirmed that the two apparent peaks in Graph 5.2 were in fact significant aspects of the data. (Newton-Spurrell coefficients were derived and from these the optimal regression curve was found by graphical means. This turned out to be a quartic curve of the form $c + ax^2 - bx^4$, a curve which could account for 82.6% of the variance in Graph 5.2. This particular form of quartic curve has two maxima - in other words, two clear peaks. I am grateful to Rodney Noble for carrying out this analysis for me).

Graph 5.2 : Identity confusion graph



Rule 1 behaviour : place and movement errors
Rule 2 behaviour : attention to occluder and other side of track

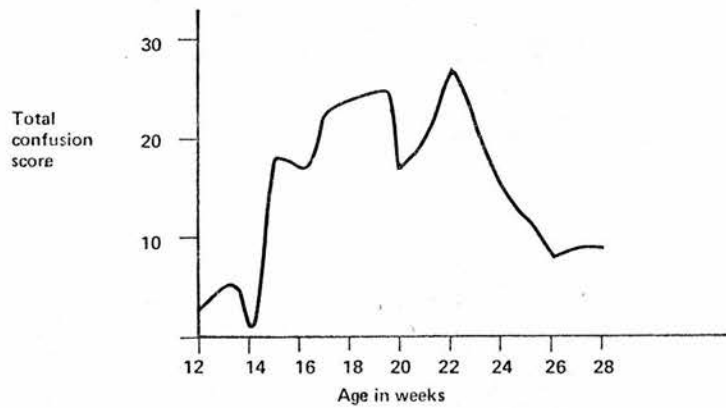
Why two peaks in confusion? It might be hypothesised that each peak represents a crisis in confusion prior to acquisition of a new and better identity rule. The infant starts with Rule 1 : an object is a bounded volume of space in a particular place or on a particular path of movement. The platform display could therefore present him with five (or possibly even seven) 'objects'; the stopped object at A, the object moving on path A, the object-and-

platform, the object moving on path B and the stopped object at B (with the possibility that the transition points are interpreted as yet another two objects). The other two conditions could contain a minimum of four objects. Some time around 17 weeks, Rule 2 might be acquired : an object is a bounded volume of space of a certain size, shape and colour which can move from place to place along trajectories. Features are incorporated into the definition of an object and the infant will now understand that an object can move or stop and yet remain the same object. The infant will now recognise that the two objects at A and B are featurally identical but will still find the spatial interaction of object and occluder totally mysterious. The peak in confusion at 21 weeks could therefore be interpreted as presaging acquisition of Rule 3, the understanding that an object can in fact go into a spatial relationship with another object and yet retain its unique identity.

The supposition that the first peak at 17 weeks may represent acquisition of Rule 2 seems quite feasible since attention to featural information in such situations normally occurs around 20 weeks (Bower, 1974a, Goldberg, 1976, Gardner, 1971, Moore, Borton & Darby, 1978) and we might expect some acceleration to result from repeated exposure to such conceptually 'pure' stimulus information. This incorporation of features into the infant's identity rules should be accompanied by the elimination of place and movement errors (see p 139). Unfortunately for the theory, although it can

be seen that this holds true temporarily (Graph 5.2), these errors increase in frequency again in synchrony with the appearance of the second postulated identity crisis. One possible explanation for this might be that the second crisis throws the infant back onto his earlier solutions in a desperate attempt to find a rule which will cover his newly acquired awareness that the same object is involved on both sides of the occluder and yet seems to go out of existence between these times. Some support for this suggestion comes from examination of the responses to the simple tracking situation (Graph 5.3)

Graph 5.3 : Simple tracking confusion



(Confusion was measured on a 3pt. scale : 1 = slight)
2 = moderate)
3 = extreme)

It is obvious that behaviour in this situation mirrors the confusion so apparent in the tracking situations involving interactions with another object, peaking slightly later at 19 and 22 weeks. Why should infants who by 14 weeks were perfectly competent at tracking in this situation suddenly produce such confused tracking, frequently

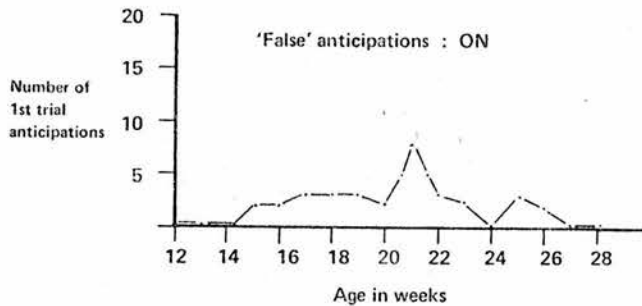
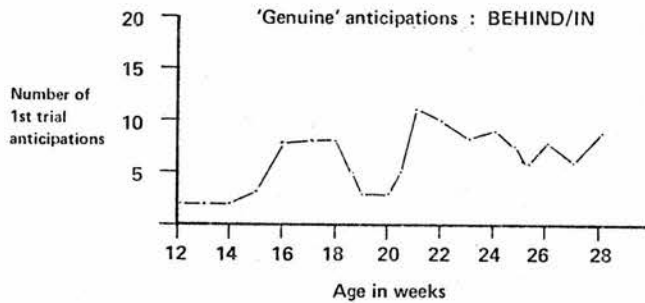
checking back and forth along the track in the absence of either stops or an occluder? I believe this to be clear evidence of hypothesis testing in progress. The infant is in the process of elaborating a higher order identity rule which must be able to cope with any event sequence, however simple; any former lower level rules are double-checked for their inadequacy (a process reflected, for example, in the resurgence of place and movement errors at 17 and 21 weeks in all situations) and a new hypothesis eventually formulated. When this is adopted, the erroneous behaviours produced by the lower level rules will fall away and order will be restored (see Graph 5.2).

What of the second supposition, that the peak at 21 weeks presages acquisition of Rule 3 and understanding that an object can interact spatially with another object and yet retain its unique identity throughout? The infant now knows that the 'two' objects are the same and that an object can move from place to place but is still unable to understand what is happening in the centre section of the track. If this is in fact the case, we might expect a flurry of attention to the occluder itself to be associated with this peak, along with checks across to the other side of the track. This is just what happens (Graph 5.2). It is interesting to note that in the particular case of the platform condition, both general confusion and attention to the occluder set in much earlier. This is hardly surprising - the behaviour in relation to that 'occluder' is visible throughout (if not understood) and must blatantly contradict the identity rules the infant is hypothesised to possess

at this time (two objects cannot be in the same place).

If this second peak is indeed evidence of the imminence of Rule 3, we might also expect a rise in genuine ⁽²¹⁾ anticipations of the reappearance of the object in the screen and tunnel conditions and a fall in false anticipations in the platform conditions. There was in fact a rise in 1st trial anticipations around 20 weeks in both screen and tunnel conditions (Graph 5.4).

Graph 5.4 : 'Genuine' & 'False' anticipations



(21) How is one to define an anticipation as 'genuine'? It is considerably easier to write off an anticipation as false than to prove that it is genuine. In this study, we must settle for a matter of degree; anticipations on the first trial of any presentation are more likely to be 'genuine' indications of object knowledge than any appearing after repeated exposure to the event.

Unfortunately, no sharp drop in platform anticipations accompanied this, the pattern being very similar to that shown in the inside and behind conditions. The following weeks did, however, see a sharp fall in these false anticipations while the other conditions in general maintained their anticipation rate. That there was no further increase (and occasional decreases) in anticipations shown in the two occluder situations should not surprise us.

Anticipations require very exact spatio-temporal coding of the event in order to be counted as successful anticipations; it does not seem unreasonable that the motivation for such precise behaviour, while present around the time the new identity rule is formed, should fall away with increasing confirmation of that rule (see also Table 5.1).

Further evidence that this peak is evidence of the imminence of Rule 3 comes from the analysis of the behaviour on the reaching tasks.

RESULTS : REACHING

Table 5.2 shows the age of first presentation of the Stages III - IV and IV - V tasks and age of first success in these tasks for each subject. An infant was judged to have achieved a stage on that week in which he successfully dealt with one set of trials, with the proviso that:

no error was made if a 2nd set of trials was presented in that session, or

if no 2nd set of trials was presented in that session, no error was made on the next session in which that particular condition was presented.

TABLE 5.2 Age of achievement of Stages IV and V in 3 different conditions of presentation

SUBJECT	CONDITION OF TESTING											
	PLATFORMS				SCREENS				CUPS			
	First tested		Passed		First tested		Passed		First tested		Passed	
	IV	V	IV	V	IV	V	IV	V	IV	V	IV	V
1	19	20	19	20	19	19	19	19	20	21	21	21
2	17	18	18	18	17	20	20	21	16	18	16	18
3	17	18	18	18	18	19	19	19	17	19	19	21
4	19	24	24	24	19	26	26	27	20	24	24	24
5	17	19	17	19	19	20	20	(28)	18	20	20	21
6	18	21	21	21	18	20	20	22	19	21	21	21
7	15	17	15	17	16	21	20	21	19	20	20	20
8	25	25	25	26	25	28	28	28+	25	25	25	25
9	19	22	22	26	20	24	26	28+	19	27	27	28
10	15	18	18	18	15	19	19	19	16	21	21	21
11	18	22	22	22	19	23	23	24	18	21	21	21
12	17	23	23	23	19	22	22	24	18	22	22	23
13	18	21	21	(28)	20	26	26	(28+)	19	27	27	(27)
14	19	19	19	19	20	22	22	22	19	25	25	25
15	15	15	15	15	16	21	21	22	15	19	19	20
16	25	26	25	28+	25	-	28+	-	26	26	26	28+
17	15	17	17	20	18	28	23	(28)	15	21	21	21
18	20	21	20	21	21	21	21	25	20	20	22	22
19	18	21	18	22	20	20	20	25	19	21	21	24
20	17	17	17	17	17	19	19	19	17	17	17	17
21	16	21	21	21	16	21	21	28	17	23	23	23
22	21	21	21	22	21	25	25	25	22	22	24	24
23	19	19	19	19	19	19	19	19	20	24	24	24
24	18	18	18	18	19	21	22	25	18	18	18	18
Mean *			19.70	20.60			22.04	23.10			21.83	22.17
S.D			2.83	3.23			2.94	3.24			2.98	2.85

* Bracketed ages were omitted from calculation of the mean either because subject showed clear preference for the occluder rather than the object or because subject showed no interest whatsoever in that particular hiding task.

As can be seen from Table 5.2, mean age of achievement of Stages IV and V respectively was 19.70 weeks and 20.60 weeks for platforms, 22.04 and 23.10 weeks for screens and 21.83 and 22.17 weeks for cups. This fits well with the analysis of the tracking results forwarded in the preceding section. According to that analysis the transition from level 2 to level 3 identity rules occurred around 21 weeks in this group. Theoretically, this advance would allow these infants to cope with all the later object permanence tests, from IV - VI.

Friedman 2-way analyses of variance on age of achievement of Stages IV and V for the three conditions showed that for both Stage IV and Stage V, age of success differed significantly in the different conditions (IV: $\chi_r^2 = 14.25$; V: $\chi_r^2 = 21.84$ - both significant at .001 level). Table 5.3 shows the results of sign tests carried out on age of achievement of Stages IV and V in all possible pairs of conditions.

TABLE 5.3 Results of sign tests on data in Table 5.2

Condition pair	Sig. level	
	IV	V
PS	.001	.001
SC	NS	.016
PC	.004	.004

(P = platform, S = screen, C = cup)

As predicted, the platform task is clearly easier than both screen and cup tasks at both Stages IV and V. No difference was

found between age of success on screen and cup tasks for Stage IV but a significant difference in favour of cups was found for Stage V, a finding which lends little support to the Bower/Neilson hypothesis that 'behind' holds a privileged position in the infant's understanding of spatial relations (see also Lucas & Uzgiris, 1977).

What of the relationship (if any) between age of achievement of Stages IV and V? Stage V, since it requires 2 successful A trials, cannot of course be tested until the infant has succeeded in the Stage IV task. Inspection of the mean age of achievement of both stages for each condition shows that success on Stage V follows very quickly on Stage IV success in all 3 conditions (Table 5.2). If, in addition, we compare age of achieving Stage IV and Stage V in each baby and make allowance for the fact that the age of these babies often precluded presentation of both tasks in the same session (because of fatigue, irritability etc.), it can be seen that, for platforms and cups, the majority of babies passed Stage V on the very first occasion of presentation (Table 5.4). If we include infants who passed Stage V on the second occasion of presentation, we see that, for screens too, Stage V success follows very rapidly on Stage IV success.

TABLE 5.4 Relationship between age of achievement of Stage V and week of testing

	<u>Platforms</u>	<u>Screens</u>	<u>Cups</u>
No. infants achieving Stage V on first occasion of presentation	17/23	9/21	16/24
No. infants achieving Stage V on second presentation	4/23	6/21	6/24
Total	21/23	15/21	22/24

(any infant in whom the gap between presentation and age of success was very large (e.g infant 13 : platform/7 weeks) but who had consistently shown clear preference for the occluder over the object throughout these weeks was omitted from this analysis).

A trend analysis on performance over sessions confirmed the finding that there was no step-wise progression from Stage IV to Stage V, with 88% of the variance being accounted for by a linear trend and no significant cubic trend being present. This fits well with the 3-stage identity theory of the development of object understanding but poorly with the traditional six-stage interpretation of object concept development.

DISCUSSION

Clearly the most important result to come out of this study is the vast acceleration in age of achievement of Stages IV and V shown by all infants. With hindsight, it is obvious that Stage VI behaviour should also have been tested. This was not unfortunately done. Since the normal age of achievement of Stage VI is 15 - 18 months and these infants were still only 28 weeks old at the end of the study, this is perhaps excusable. First impressions of even the Stage IV and V behaviour were not in any case very favourable. Although fulfilling the criterion adopted, it at first seemed doubtful to me that the behaviour was as object-oriented as a simple numerical analysis of successful recoveries might lead one to believe. It must be borne in mind that these infants were well below the age at which one would normally test for Stage IV - V behaviour, never mind expect to find it. Stage IV errors are commonly found around 8 - 10 months of age; these infants averaged 4 months at onset of testing.

It could be possible, of course, that the Stage IV error is a developmental error, i.e. that it only occurs with development. Gratch & Landers (1971) found no evidence of any such growth error in their longitudinal study of the Stage IV error. 10 out of 13 infants made the AAB error on the first session in which they could successfully locate an object at A. This study did not, however, consider infants under 6 months of age. The infants in our study, regardless of their training, could possibly have been too young

either to show the errors characteristic of Stage IV or to be capable of truly passing it. As no one to my knowledge has ever attempted to investigate the behaviour of such young infants in this situation, the possibility that the Stage IV error is a growth error is one which cannot merely be dismissed.

The early search behaviours can only be described as messy. The infants would frequently become very agitated or excited as they attempted to organise their response. Although there was no time restraint on onset of search, organisation of a response, if successful at all, could take the full two minutes in the early weeks and frustration was very apparent. Attention was almost exclusively directed at the side where the hiding event was occurring, little attention being given to the other side. After the infant had successfully removed the correct occluder, attention to the uncovered object was seldom focused and many infants did not appear to have noticed its reappearance until several seconds after removing the occluder, their attention being absorbed by manipulating or chewing the occluder itself. This type of behaviour provoked the suspicion that the behaviour was not as successful or object-oriented as might seem on an analysis based on recovery of the object alone. Successfully choosing the correct side may have been an artefact of the infant's exclusive orientation to the side where something interesting happened. At best, the correct side was chosen because something interesting involving an object happened with that particular cup in the immediate past; at worst, the interesting event was over but, since the baby was oriented in that direction, he

might as well amuse himself with that particular cup. Neither implies any understanding that the object continues to exist throughout the sequence. In other words, the remarkable 'success' of these babies could be completely false and have little or nothing to do with any acceleration of development of the object concept. Any infant tested at this age would be able to produce 'successful' behaviour.

Two considerations, however, make me certain that these behaviours were, in fact, directed by a developing object concept. Firstly, close analysis of the behaviours reveals incidents which clearly indicate expectations of the reappearance of an object on removal of the occluder and would indeed be hard to explain in any other way. The baby, for example, might happily pull the screen towards him and chew the top of it, apparently not noticing the object which he had revealed. After a few seconds, however, his hand would reach round the screen, accurately locating the object and bringing it to his mouth, all this without any apparent refocusing of attention. Other more straightforward examples of reaching round the screen were also observed. (22) The following

(22) According to Bruner (1968, 1970) the behaviour of reaching round a screen is not found until approximately 9 months, reaching until then being limited to reaches along the line of sight. Although this behaviour is not frequent, it occurs sufficiently often to lead to doubts over the validity of this generalisation. These infants had not, after all, been given any specific practice in reaching.

was also occasionally observed: although happily attempting to demolish the (correct) paper cup and apparently totally ignoring the uncovered object, an infant would suddenly, with his free hand appropriately shaped, reach out in the correct direction of the object and recover it, even although, by now, he may have turned away from the original position of that cup. It is difficult to imagine other than object-related reasons for such behaviours. Further supporting evidence came from the few errors these infants made in the very first weeks of testing. Any error on the catch trial of the Stage IV - V task would be accompanied by clear signs of surprise and on two occasions by a degree of upset which necessitated terminating the session.

There is a second and stronger reason for believing the successes to be genuine. Half of the infants in this study moved into a further tracking/reaching study at 29 weeks (Neilson, 1977). Although the tracking tasks were expanded to include presentations involving two platforms, two screens and two tunnels, the reaching tasks were identical to those given here. Babies were tested from 28 - 42 weeks. During this period only 11 Stage IV errors were found out of a total of 864 test presentations. This makes it extremely unlikely that the early successes were false passes. Had this been the case, the normal Stage IV errors would have appeared in due course.

A third possible proof of the genuineness of the behaviours would have been a correlation between, say, age of elimination of place and movement errors in the tracking tasks and age of success in the

reaching tasks, since we have already established (Experiment 1) that the two tasks reflect a single developing concept. As we have seen, however, it would be very difficult to establish this in this particular study because of the resurgence of these errors at subsequent points in development. If we were to take elimination of all those responses we took as evidence of identity confusion in the tracking tasks, we can see that for the group as a whole, there seems to be a very close link indeed between this and age of success in the search tasks - a finding which lends support to the claim that there is no true décalage between object understanding as expressed in tracking tasks and object understanding as demonstrated in reaching tasks (see p 31).

Taking all this into consideration, it now seems reasonable to conclude that weekly exposure to the tracking situations used in this experiment produces a genuine and substantial effect on age of attainment of the later stages of the object concept. Why should this be? The identity hypothesis answer would be that the tracking situations presented contained all of the information necessary for formation of the sequence of identity rules it believes to underlie the six stages of object permanence behaviour - objects moving and stopping, surviving spatial interactions with other objects and so on. Unlike the real world, the event sequence seen by these infants was stripped down to the fundamentals and presented repeatedly and without variation, thereby allowing ample opportunity for the framing and testing of hypotheses. Obviously it would be easier to

extract some ordering principle from such a conceptually pure display than from the confusion which surrounds normal everyday experience with objects.

The effects of different kinds and amounts of training : an extension of Experiment 5

It could be that in some way the successful object permanence behaviour shown in this experiment is attributable to the fact that the infants were exposed to tracking tasks involving a number of different spatial relations. In order to assess whether this was an important factor in their success or whether exposure to any single spatial relations tracking task would produce equal across-the-board acceleration, two further experimental groups were run.

SUBJECTS AND PROCEDURE

Group E 2 consisted of 12 infants who were exposed fortnightly to 8 trials of one or other of the three spatial tracking tasks seen by the original experimental group. 4 saw the platform tracking task, 4 saw the screen tracking task and 4 saw the tunnel tracking task. Each set of infants was therefore being given the same amount of tracking experience in any one condition as the original group but only one quarter of their total tracking experience.

Half of the subjects in each of the 3 groups started training at 12 weeks of age, the other half at 13 weeks. Stop trials were

inserted in a ratio approximating that for each condition in the original design, i.e in alternate sessions, with week of initial and subsequent stop trials being staggered within each group.

Group E 3 consisted of 12 infants who were exposed weekly to 16 trials of one or other of the three tracking tasks; all were 12 weeks old at onset of training. 4 saw the platform task, 4 saw the screen task and 4 saw the tunnel task. Each set of infants in this group was therefore being given the same total amount of tracking experience as the original group but in only one condition. On this one condition they were receiving four times the amount of training given to the experimental group. Stop trials were inserted on odd weeks for half the group, on even weeks for the remainder.

Both groups were tested on all three manual object permanence tests as soon as they showed themselves able to reach for a dangling object within two minutes of its presentation. Manual object permanence testing was carried out weekly thereafter while tracking continued on its previous schedule, i.e fortnightly for Group E 2, weekly for Group E 3. For each infant, testing terminated when level of manual object permanence competence could be assessed in all three tasks within the one session. Financial restrictions did not, unfortunately, permit testing to continue beyond this point. As a result, all comparisons with E 1 are based on success rates at that particular point in development, a situation which is not ideal but still allows some information to be gathered on the relative efficiency of different kinds and amounts of training.

RESULTS

Table 5.5 compares the number of Stage IV and Stage V successes in groups E 1, E 2 and E 3 on the first week in which all three tasks could be presented together.

TABLE 5.5 Comparison of number of Stage IV and V successes in the 3 experimental groups

<u>GROUP</u>		<u>PLATFORMS</u>	<u>SCREENS</u>	<u>CUPS</u>	<u>% SUCCESS</u>
E 1 (N = 24)					
Mean age: 19.02 wks	IV :	20	11	12	60
(S.D. 2.24)	V :	15	7	9	43
E 2 (N = 12)					
Mean age: 18.08 wks	IV :	6	1	4	31
(S.D. 2.19)	V :	6	1	3	28
E 3 (N = 12)					
Mean age: 18.83 wks	IV :	9	2	4	42
(S.D. 1.12)	V :	5	1	2	22

χ^2 tests on the Stage IV and Stage V success rates revealed that significant differences existed amongst the three groups (IV : $\chi^2 = 9.74$, $p < .01$; V : $\chi^2 = 7.54$, $p < .05$); pairwise comparisons are laid out in Table 5.6.

TABLE 5.6 Results of pairwise χ^2 tests on data from Table 5.5

<u>Groups</u>	<u>IV</u>		<u>V</u>	
	<u>χ^2 value</u>	<u>Probability</u>	<u>χ^2 value</u>	<u>Probability</u>
E 1/E 2	9.24	p < .01	4.08	p < .05
E 1/E 3	3.16	p < .10	6.78	p < .001
E 2/E 3	1.64	NS	0.72	NS

It can be seen that groups E 1 and E 2 differed significantly in terms of both Stage IV and Stage V successes. The performance difference between E 1 and E 3, while large, did not quite reach statistical significance on Stage IV but was significant in Stage V. No real difference existed between the performance of E 2 and of E 3 on either level of task. It is important to note that, although performing more poorly than E 1, both E 2 and E 3 performed better on the manual tasks than would have been expected for their age (18 - 19 weeks). Single condition training does therefore appear to produce some acceleration, but not the massive acceleration produced by mixed training.

It might have seemed reasonable to assume that the single condition training undergone by E 2 and E 3 subgroups would have resulted in specific transfer effects, with training on a particular condition carrying over to the matching reaching task. This would mean, for example, that infants trained on screens would find the screens reaching task easiest and so on. Inspection of the data suggests, however, that this was not the case (Table 5.7).

TABLE 5.7 Relation of training condition to success of E 2 and E 3 on Stage IV and V tasks

Training condition	<u>E 2 SUCCESSES (IV+V)</u>			<u>E 3 SUCCESSES (IV+V)</u>		
	Testing condition			Testing condition		
	Platforms	Screens	Cups	Platforms	Screens	Cups
Platforms	2	0	0	3	0	1
Screens	4	0	1	6	3	4
Tunnels	6	2	6	5	0	1

In the original, mixed training experimental group (E 1) the order of difficulty of the reaching tasks was $P < C \leq S$. This order of difficulty remained the same in all subgroups of E 2 and E 3, despite the fact that these subgroups were being trained exclusively on one particular spatial relation. (One minor exception occurred in E 2: the tunnel training subgroup's performance on the cup tasks equalled (but did not better) their performance on the platform tasks).

In order to test more rigorously for any effects of specific transfer, expected frequencies were computed from Table 5.7 on the basis of subgroup and task differences and t-tests were then used to compare the difference between these expected frequencies and the observed frequencies, with the sign of the difference being assigned in accord with the hypothesis that single condition training would lead to specific transfer. In neither case were significant differences found to exist (E 2: $t = 1.15$, N.S.; E 3: $t = .76$, N.S.) We cannot

therefore reject the null hypothesis that no specific transfer results from single condition training; training in a specific tracking task would not appear to produce specific transfer effects on Stage IV and Stage V reaching tasks.

These results are in accord with the recent abstract specific theory of development put forward by Bower (1976 - see Appendix C). The fact that no specific transfer occurred suggests that the infant's early conceptualisation and understanding of the training tasks could not have been formulated in terms which were specific to the particular spatial relationship that he was watching. The success rate of these infants, almost all of whom were under five months at testing, suggests however that a degree of general transfer did in fact occur in both groups. That this was significantly less than in the case of the mixed training is not surprising. If, as Bower suggests, early conceptualisation of the problem is indeed abstract, it would seem easier to abstract the general principle necessary for successful transfer - that an object can go into a spatial relationship without losing its identity - from a set of interrelated stimulus displays, each of which embodies that principle in a slightly different way, than from a single instance, no matter how frequently that may be presented (see also Neilson, 1977).

DISCUSSION

The main findings of Experiment 5 are outlined below:

1. 'On' poses problems for young infants in both tracking and reaching tasks
2. 'Behind' holds no privileged position in the infant's understanding of spatial relations between objects
3. Weekly exposure to tracking tasks involving a variety of spatial relationships produces quite astonishing acceleration in success on manual object permanence tasks, an acceleration which appears to be genuine
4. Such training seems to produce general rather than specific transfer effects
5. Stages IV and V of the object concept can be achieved virtually simultaneously by infants given such training
6. Both tracking and manual object permanence tasks mirror the same level of object understanding; no true décalage exists between visual and manual competence. Data on anticipatory looking for an object which has gone out of sight should thus be treated with caution and not as all-or-nothing evidence of understanding of the nature of objects.

All of the above results fit well with the identity hypothesis of object concept development but two in particular are perhaps worthy of further discussion. The first, the finding that the spatial relationship 'on' produces tracking confusion in young infants, lends support to the findings of Experiment 4 and to the identity claim that boundaries at all stages are more important to notions of object permanence than visibility/invisibility. The infant's problem is not simply one of understanding that objects continue to exist while unperceived; his problem lies rather in

discovering the details of that existence. According to the identity hypothesis, development of the object concept is development of a set of conceptual rules which will allow the infant to attribute a stable identity to an object throughout any event sequence. These rules go further than merely giving continuing existence to any object. They concern permanence in a more particular way, allowing the infant to identify the object as one and the same object at any point in time.

The second finding of particular importance to the identity theory of object concept development is the finding that Stages IV and V of the object concept can be acquired virtually simultaneously. Normally this segment of development may take 4 - 6 months to unfold. According to the identity hypothesis, however, no true conceptual advance coincides with acquisition of either of these stages; the different search behaviour found in Stages IV and V results rather from the formation of probabilistically-determined search strategies (see p 144). These behavioural search rules take note of the occluding object and its position but do not imply any understanding of the continuing, unchanged existence of the object being searched for. The conceptual key to success in all of the later search problems is knowing that an object can go into a spatial relationship with another object and yet retain its unique identity throughout. If this knowledge is promoted early enough in development, (by, for example, constant exposure to a tracking task stripped of all irrelevant information in which an object continually goes into a

variety of boundary-violating spatial relationships with another object and yet emerges unchanged each time,) there is no reason why all the later object permanence tests should not be passed together; there would of course then be no need for the evolution and continual modification of search rules and the accompanying characteristic 3 step progress through Stages III - VI. Experiments 1 and 5, taken together, suggest that just such a compression of the developmental sequence can in fact occur, strong evidence in favour of the identity interpretation of the infant's problems.

The above results not only fit well with the identity hypothesis but also provide considerable problems for any of the other explanations of object concept development we have looked at thus far (see Chapter 3). Motor skill explanations, for example, suggest that the Stage III - IV task poses behavioural rather than conceptual problems for young infants; infants in Experiment 5 were, however, in Stage V within a couple of weeks of the very earliest signs of the emergence of reaching. Memory and representation theories would likewise have difficulty in explaining the problem caused by the spatial relationship of 'on'; the object is in sight throughout yet the infant clearly has problems in understanding what is happening. The fact that early visual experience produces massive effects on manual competence in very young infants also compromises both the intersensory co-ordination explanation and the action argument of object concept development (depending, of course, on whether we choose to extend

the notion of 'activity' to include perceptual activity or not - see p 98).

Moore's Identity Theory

This is perhaps the point at which reference should be made to Moore's (1975) identity theory. Starting from his early collaborative work with Bower (Bower, Broughton & Moore, 1971), Moore has also arrived at a three stage model of the development of identity rules. The first two stages are fairly similar to those given here and based on very much the same experimental evidence. The third, however, diverges completely from the model offered here, as can be seen in Table 5.8.

TABLE 5.8 Moore's Identity Model

Level	Age (months)	Description of levels	Examples of transformations for which an object's unique identity is maintained
1	0-4	Identity maintained for steady-state transformations of the visual world	Objects in motion Objects at rest
2	5-8	Identity maintained for transformations of visible objects	Objects in motion stopping Objects at rest starting to move
3	9-18	Identity maintained for transformations producing occluded objects	Objects disappearing in motion Object disappearing at rest

(From: Moore & Meltzoff, 1978)

According to Moore, acquisition of the third level of identity rules depends on the criteria of place and movement being extended to cover invisible displacements. On his model, the infant's difficulties in the later object permanence tasks are interpreted as being the result of identifying a hidden object in terms of its place or trajectory of disappearance and reappearance. These final rules for identity are hypothesised to be successively reorganised to cover more and more complex sequences of disappearance, a process stimulated by the infant's acknowledgement of the featural identity of the 'objects' involved in the disappearance and reappearance parts of the sequence (Clark, 1975).

There are several difficulties with this model. Although it can be used to explain some awkward experimental findings quite neatly (e.g. Evans & Gratch's (1972) finding that infants will make the AAB error even when a new, featurally different object is hidden at B), ⁽²³⁾ it has no means of explaining either the problems older infants have in situations where the object is not invisible (Experiments 4 + 5) or the early solution of problems in which the object is invisible (Experiment 3).

A fundamental difference between the two theories concerns the role of permanence in the development of the infant's identity rules. The theory presented here assumes that the infant, from a very early point in development, already has a primitive notion that objects

(23) A recent study by Schubert, Werner & Lipsitt (1978) failed, however, to replicate this finding.

exist at all times, whether or not they are being perceived (Bower, 1967; Experiment 3). This is not to deny that infants have considerable difficulty in understanding the true nature of objects. This misunderstanding, however, is believed to be on a far more subtle level than that of mere existence or non-existence of objects while unperceived. Moore, however, believes that development of the early rules of object identity is necessarily prior to development of any notion of object permanence. Object permanence is considered to be only a special case of the more fundamental problem of object identity. For Moore, a belief in the permanence of unseen objects is not acquired until around 9 months of age, at which time it becomes essential for the further development of the identity rules to cover disappearance sequences.

Like many other theorists, Moore equates permanence only with the belief in the continued existence of an object when out of sight and treats identity and permanence as two initially independent problems. To separate identity and permanence in this way is surely artificial - what of the permanence of identity, a question not as facetious as it might at first seem? We have already seen that an object which remains perfectly visible throughout an event sequence can produce evidence of identity confusion in an otherwise competent infant (Experiment 5). When, for example, an object moves over the top of a platform, the infant may act as if the 'original' object has disappeared - but surely his glances back are evidence that he believes in the continued

existence of that particular object somewhere. His confusion is over the identity or non-identity of the object at various points in the event sequence, whether it goes out of sight or not; although recognising the 'new' object to be featurally identical to the 'original' object, he is unsure that it is the same and the only object involved.

A tracking study by Moore, Borton & Darby (1978) may illustrate the difficulties such a theory will encounter. Moore et al set up three tracking situations in which they sought to separate permanence and identity problems. In the permanence violation condition, an object moved behind one of two screens, failed to reappear from behind that screen but reappeared at the appropriate time from behind the second screen (Figure 5.1)

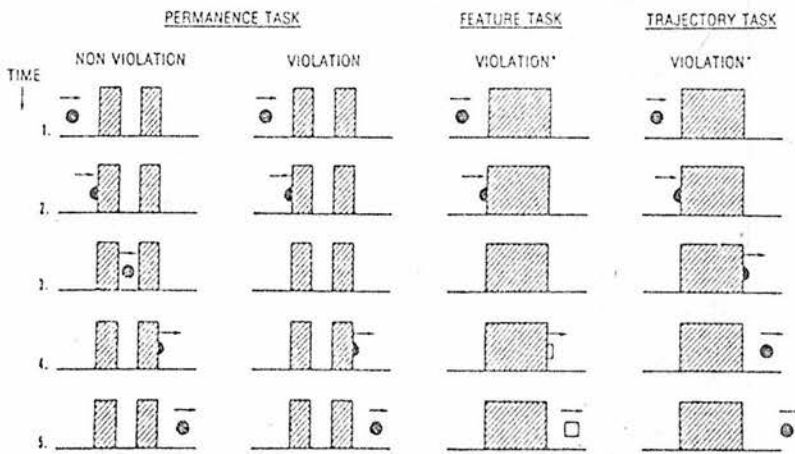


Fig. 5.1

Tracking tasks used by Moore et al (1978)

In the two identity violation conditions, the object moved behind a single long screen, either to reappear prematurely from the other side (trajectory violation) or to reappear at the appropriate time but completely transformed in features (featural violation). All visual responses were coded and three particular patterns of

responses selected as indicators of disrupted tracking: looking away from the task while the object was in sight, looking back along the track when the object reappeared from behind the screen(s) and monitoring the final then initial screen edges while the object was out of sight. Only the two identity violation conditions produced these patterns of looking behaviour in 5 month olds while the tracking of nine month olds was disrupted by all three conditions. From this, Moore et al conclude that nine month olds have permanence and five month olds do not.

This conclusion is not the only one that could be drawn from the data presented. For a start, to expect disruption to be indexed by the same patterns of behaviour at both ages and in all situations (situations which even superficially are quite different) may be theoretically convenient but is somewhat unrealistic. The permanence violation situation involves two short screens and a violation which occurs between these two screens; the feature and trajectory tasks involve one long screen with the violation occurring at the end of that screen. On information processing demands alone, an important developmental variable in itself, these tasks are quite different. Attention and memory capacity could also differentially affect performance on the different conditions at different ages. Even if we were to disregard these possible sources of the differences in behaviour which were found, there are also considerable problems in using the same measures of tracking disruption for all three conditions. Looks back on reappearance of

the object may be appropriate indicator behaviours of identity violation in the feature and trajectory tasks but surely behaviour at the point of non-reappearance is the relevant behaviour in the permanence situation. (Moore et al refer to the object as being 'occluded' at this point. Equating 'out of sight' with 'occlusion' is to ignore an important distinction, as Experiment 3 has shown).

There are other problems. All of the behaviours chosen to index awareness of violation appear in non-violation presentations of the three conditions as well, a fact which surely undermines the conclusions drawn from the data. By concentrating only on the difference in frequency of the selected responses between violation and non-violation conditions, Moore et al ignore what must surely have been a wealth of potentially valuable information about the level and nature of the infants' understanding of the non-violation events they presented. Even if these differences in response frequency were to be as meaningful as Moore et al believed, it should also be noted that very emphatic conclusions are being drawn from differences which only achieved significance levels of .10 at times, significance levels which in several important cases were not attained in a previous study which used a larger number of infants but was identical in all other aspects (Borton & Darby, 1975).

The most important flaw, however, is perhaps the simplest. The study explicitly set out to present tracking conditions in which identity but not permanence was violated and vice versa. This is as impossible as separating place and response seems to be (see p 95).

Even on Moore's own account of the development of identity rules, this was not achieved. Nine month old infants are hypothesised to attribute identity to successive appearances of an object which disappears from view on the basis of its trajectory or place of disappearance (Moore, 1975); five month olds are assumed to be developing this notion (Moore, Borton & Darby, 1978). Surely then on this analysis the infant's supposed identity rules must also have been violated in the permanence violation condition since the object did not continue on its trajectory between the two screens?

Overview: So far then, the identity hypothesis forwarded here seems to be the only theory which can adequately cover the variety of appropriate and inappropriate object-related behaviours found in infancy. Alternative spatial explanations have, however, been advanced for individual stages in the developmental sequence and, before deciding finally on the identity hypothesis, it will be necessary to consider and evaluate these alternative accounts. This will be done in the next and final chapter.

CHAPTER SIX - SPATIAL UNDERSTANDING IN INFANCY

Previous chapters have already considered the most commonly forwarded alternatives to the traditional Piagetian analysis of object concept development. With the possible exception of the most weak form of the action argument, all of these explanations were found to be incapable of accounting for the entire range of object-related behaviours found during this period of development; few were able to explain more than even a small segment of that development. A variety of experimental evidence was both reviewed and presented which, while undermining the other theories, either positively supported or was consistent with the identity account of the development of object understanding. At this point it would perhaps be useful to recap on the evidence so far presented and summarise the main points of the identity theory of object concept development.

The identity theory suggests that the conceptual problem which underlies the six stages of object concept behaviour is one of object identity rather than object permanence. A basic idea of object reality (including some idea of permanence) is assumed to be present from the start. The infant is seen rather as having difficulty in maintaining the identity of an object throughout an event sequence. This difficulty is present regardless of whether the event entails temporary disappearance of the object or not (Experiments 2 and 3) and is particularly acute if the sequence involves close interaction with any other object (Experiments 4 and 5).

On this theory, development is seen as a progressive refinement of the infant's rules for attributing identity to an object over time. The infant moves from the simple recognition that an object is the same object at different times and in different places, through to more elaborate notions which define identity in a much stricter sense, with the object not only being recognised as featurally the same but as identical in the sense of being one and the same object throughout the sequence - i.e the same and only such object involved (Experiment 5).

The identity hypothesis accepts the six behavioural stages observed by Piaget as veridical, with the qualification that the Stage IV - V error is seen as existing on an equiprobable rather than absolute basis (Experiment 1). The identity hypothesis forwards a sequence of five behavioural search rules which could account for the behaviour of each of these six stages. Underlying these 5 search rules, however, is assumed to be a sequence of only 3 conceptual rules, the rules which define identity and in part determine the search rules. From this, it is clear that each change in search strategy does not necessarily reflect a true change in cognitive status. Object concept development is therefore seen as a three rather than six-stage process. The hypothesised sequence of search and identity rules is outlined in Table 6.1.

TABLE 6.1 Hypothetical sequence of development of Search and Identity rules

Stages I and II

Identity Rule (1)	An object is a bounded volume of space in a particular place or on a particular path of movement.
Search Rule (1)	To find a stationary object, search for it in the place where it usually is. To find a moving object, search for it along its path of movement.

Stage III

Identity Rule (2)	An object is a bounded volume of space of a certain size, shape and colour that can move from place to place along trajectories.
Search Rule (2)	To find an object, search for it in its usual place or, if it has moved, along its path of movement. If, however, another object of a different size, shape and colour is now in the same place or on the same path of movement, do nothing (a mysterious disappearance).

Stage IV

Identity Rule (2)	(Same as Stage III)
Search Rule (3)	To find an object that has disappeared mysteriously, remove the object which has replaced it.

Stage V

Identity Rule (2)	(Same as Stage III)
Search Rule (4)	To find an object that has disappeared mysteriously, remove the object which is now in the place where it was last seen.

Stage VI

Identity Rule (3)	Same as Stage III <u>plus</u> : Two or more objects can, however, be in the same place or on the same path of movement simultaneously <u>if</u> they bear a spatial relationship to each other which involves a sharing of common boundaries.
Search Rule (5)	To find an object that has disappeared, remove the object which is now in the place where it was last seen, taking into account any subsequent movement of that object.

(after Bower, 1974a)

The first and second identity rules cover Stages I - V and are applied with differing degrees of success to events involving single objects. They determine when two appearances of an object will be linked to the same object, with Rule 2 growing out of and representing a considerable advance on the earlier definition. Boundaries still, however, play a very large - and as yet, unqualified - part in object identification up to this time. As a result, any sequence involving close spatial interaction between two objects will lead an infant restricted to these lower level rules into difficulties. While recognising the object as being featurally the same before and after any spatial interaction, the infant working with Level 2 rules will find the spatial interaction itself totally mysterious and will fail to understand that one and only one object is involved throughout. According to the identity hypothesis then, Stages III, IV and V, while they may differ in terms of search strategies, do not in fact reflect any real change in conceptual competence. Given this, there is no reason why the later stages of object concept behaviour should not all be achieved simultaneously, provided the type of information necessary to produce Rule 3 is introduced at the appropriate time, i.e subsequent but close to acquisition of the Level 2 rule (Experiments 1 and 5).

Each change in level means that the infant can maintain the identity of an object over increasingly complex event sequences. Each new identity rule reduces the population of 'objects' with which the infant must deal and therefore represents a considerable cognitive

achievement. (24) In many ways, the evolution of the conceptual rules which the identity hypothesis forwards could be seen as paralleling the growth in the baby's own ability to interact directly with his world. There is evidence, for example, that young infants, even when able to reach for and manipulate objects, at first have great difficulty in dealing with two objects simultaneously (Bruner, 1973). Experience of spatial interactions between objects will often therefore depend on the intervention of some third party. This, coupled with the fact that objects which do not move or interact in any case far outnumber animate objects in any baby's environment, means that rules which focus only on the usual place of an object and ignore spatial interactions will be eminently well adapted to both the infant's circumstances and to his capabilities. With development, the infant will obviously become more able to investigate the rules of spatial interaction for himself and from such self-initiated activity, it is suggested, the final and most successful identity rule will eventually emerge.

The identity hypothesis is basically then a hypothesis about development of the understanding of spatial relations. At some level or another, spatial relations are assumed to pose problems to the young infant throughout the first two years of life. In terms of

(24) The development of the identity rules proposed by the identity hypothesis fits well with the organisational principles assumed by computer modellers to be central to any valid model of cognitive development:

1. the principle of redundancy elimination
2. the principle of local search for regularities (Klahr, 1976).

We are at present ourselves investigating the possibility of modelling this segment of development, using a production systems approach.

the standard object permanence tasks, the spatial problem seems to be one of understanding the spatial relations which may exist between any two objects without doing violence to the unique identity of either. Achievement of this understanding does not, however, mark the end of development of spatial understanding. The infant may still have problems in understanding spatial relations in the wider sense in which that term is used, in the sense, that is, of the interrelations between positions in space. This is a problem which will obviously become particularly acute when the infant begins to crawl or walk since almost any locomotor activity will change the spatial relationship between the infant and the objects around him.

Spatial localisation theories of object concept errors

There have recently been a number of attempts to explain object concept errors themselves in terms of problems of spatial localisation, a possibility which Piaget himself considered some 30 years ago (see p 88). Such theorists would deny that the infant's problem in object permanence tasks is one of understanding object identity or of understanding that two or more objects can share the same space. According to their analyses, the infant's problem is one of co-ordinating or coding the spatial position of objects, particularly of objects which change position, a viewpoint which has led to most of the research being concentrated on the Stage IV error. Experiment 1 would suggest that any adequate theory must be capable of extension to the entire sequence of development and it is difficult to

imagine how this type of explanation could possibly account for earlier or later object permanence errors. Nonetheless, the onus is still on the identity theory to prove that it has a better and more valid explanation of all stages of object concept development. These theories are in any case attracting a great deal of attention and should therefore be considered at this point. Three main investigations will be discussed: those of Butterworth, Bremner & Bryant and Lucas & Uzgiris.

Butterworth (1975, 1976) concentrated his attention on the Stage IV - V error, taking it as given that this error must stem from a misunderstanding of space but suggesting that this need not imply that permanence or identity problems accompany this misunderstanding. He performed a series of experiments which led him to the conclusion that the AAB error results from a lack of co-ordination between two simultaneously present ways of coding space, one egocentric, the other allocentric. Both of these codes were assumed to operate in an equiprobable fashion in the 8 - 11 month old and could therefore account for the characteristic pattern of divided search found during this period.

This hypothesis has already been discussed (see p150). Butterworth elaborated his position in a later paper (Butterworth, 1977). There he suggested that the problem of co-ordinating spatial frameworks could be reduced to one of acquiring skill, skill to both locate an object and direct action (i.e remove the occluder) within a single and stable perceived frame of reference. Prior to this it is assumed that object and occluder are coded separately and

differently, i.e one egocentrically and one allocentrically. In an AAB situation, the two codes would of course coincide on A trials and so there will be no difficulty. On the B trials, however, these two codes will no longer coincide and the egocentric coding of the object⁽²⁵⁾ will need updating, a process which Butterworth believes to require accessing a representation of space, a facility not presumed to be present at this stage. On the basis of work by Lee & Aronson (1974), and his own experiments with Hicks (1977), Butterworth suggested that postural development would lead the child increasingly to rely on external frames of reference, giving up his egocentric coding of space for one that would remain invariant with movement. The AAB error would thus drop out, 'the first step in the transition to a represented space'.

Interesting though such a theory may be, it nonetheless is highly speculative. While most of Butterworth's data is not inconsistent with such a theory, none of his experiments could claim to provide any real proof for it. In many ways, in fact, the theory seems an overexplanation of behaviours which could equally well be explained in far simpler ways, requiring far fewer assumptions. There is in addition some experimental evidence - some of it Butterworth's own - which would be very difficult to reconcile with such an analysis. Take, for example, evidence of the presence of qualitatively and quantitatively similar errors in AAB situations

(25) On Butterworth's theory, it seems essential to assume that the object rather than the occluder will be coded egocentrically, an assumption which seems difficult to justify.

which use transparent cups (Neilson, 1977, Butterworth, 1977). Such findings surely undermine any updating theory of the AAB error, particularly one which denies that there is any identity confusion in such a situation. If the object is perfectly visible throughout the sequence and the cups are only 8" apart, it seems somewhat implausible to maintain that the infant is being led into error by an out-of-date egocentric coding of object position - some more basic miscomprehension must be present. Runs of errors on repeated B trials further undermine any updating theory - as does Butterworth's own finding that errors still appeared when no occluding object was involved, in a task in which the object was visible and uncovered on all trials (see also Experiment 5). In the latter case no detour behaviour was required since there were no occluders; surely then there is little reason to assume that two coding systems would be put into operation. The identity hypothesis would of course predict that visible uncovered objects could well present the infant with problems - if they were in a spatial relationship which resulted in violation of their boundaries, as they were in Butterworth's study. Before considering the identity analysis further however, we should also look at the work of Bremner & Bryant who hold a very similar theoretical position to Butterworth and who also have focused on the AAB error as a means of exploring spatial understanding in infancy.

One experiment has already been considered (p 93). In that study an attempt was made to distinguish between place and response perseveration in the AAB task by using the strategy of moving the

baby to the opposite side of the table between A and B trials (Bremner & Bryant, 1977). It has already been suggested that any attempt to make an absolute distinction between place and response behaviour requires making the assumption that the infant understands and codes space in the way adults do, by reference to some stable visual framework, one which will remain constant in the face of movements by objects or observer. This does not seem to be a legitimate assumption. Acredelo (1978), in a very elegant experiment, demonstrated that infants under 11 months of age make absolutely no use whatsoever of visual information as to position. This finding was confirmed by Bremner & Bryant's own experiment; although one side of the table was white and the other black, nine month old infants still tended to respond to the side which was the same in egocentric terms, ignoring both movement and the highly distinctive visual clues to the correct location of the object. Bremner & Bryant, however, believed their results to be 'a striking vindication of Piaget's suggestion that ... perseveration is of responses rather than to places'.

Later papers by Bremner (1978a, 1978b) are more guarded in their interpretation of the results from that experiment and see the strategy of moving baby or table only as a means of separating allocentric and egocentric coding of space. In a study which was otherwise identical to the original study, Bremner found that the introduction of heightened visual clues to object position could eliminate egocentric errors after movement. If, instead of using different colours for each side of the table, the two hiding

positions were identified by different coloured cloths, infants seemed able to overcome their egocentric tendencies and succeeded in relocating the object, whichever side it was hidden on (Bremner, 1978a).

In Bremner's second study, certain important - and I believe necessary - alterations were made to the procedure used in the earlier experiments (Bremner, 1978b). It was, for example, acknowledged that it would be more informative to hide the object and then move the baby than to do a series of A trials after which the baby was moved and the object then hidden in either the same or a new position (allocentrically defined), a procedure which must surely encourage inattention and automatic responding. Bremner himself confirmed this suspicion. He found that infants who were given 5 A trials before movement were more than twice as likely to err on the movement trial than infants who had no prior experience of finding the object. Bremner also made basic apparatus improvements in this study, changes which were also, I feel, essential if it was hoped to interpret the infants' responses in terms of spatial understanding. In the first two studies, the baby was lifted out of a chair, bodily carried around the table and deposited in another chair. The object was then hidden and, after a delay, the baby and chair were moved into position for search. 18 seconds elapsed between trials. The number of things other than spatial understanding or the lack of it which could have influenced responses in such a situation is surely large; an AAB situation with movement is a complex enough experimental paradigm without disruptions between trials adding to the confusion. With these modifications to procedure,

Bremner confirmed that use of different covers improved performance and also found that changes in position due to movement of the infant were easier than those arising from object movement.

On the basis of these experiments, Bremner & Bryant put forward a theory of the development of spatial understanding which is very similar to that of Butterworth in certain respects. According to their theory, early coding of spatial locations is typically egocentric, although, in exceptional circumstances, it is believed that this may be overridden and replaced by truly allocentric responding. With development, the infant is seen as relying more and more on external frames of reference and a true understanding of space and spatial interrelations emerges.

Such a theory of the development of spatial understanding is attractively simple and seems to have commonsense merit. None of the Bremner & Bryant studies, however, produce any actual evidence to support it. All of their studies used only one age group of infants, nine month olds. There is therefore absolutely no evidence for any developmental theory - although the particular theory they put forward is not in fact one which I would in general dispute. Nor, it could be added, is there any real evidence for their other claim - the coexistence of two spatial coding systems in nine month olds. Only one condition produced allocentric responding, the condition in which the infant moved and object position was identified by use of distinctively coloured cloths. No baby performed in more than one condition in any of the experiments while in the first two

studies, each baby was given only one set of trials. Again, their results, like Butterworth's, are not inconsistent with their claims but there is no actual evidence to support them.

What would the identity hypothesis have to say about the behaviours found by Bremner & Bryant and Butterworth? The identity hypothesis can also be reduced to a hypothesis about spatial understanding and certainly would not deny that the nine month old has considerable problems in understanding space. It would not maintain, however, that the AAB error stems from an inability to co-ordinate spatial information as to position of an object which has moved, as would Bremner & Bryant and Butterworth. The spatial problem of the nine month old is seen as being at a far more basic level. Objects are defined in very basic spatial terms, terms which give especial emphasis to the integrity of boundaries. As a result, the infant fails to understand that an object can still retain its identity while sharing space in common with another object, an identity confusion which leads to errors in object permanence tasks. On this analysis, success on the AAB task, focus of so much experimental interest, is in fact directed by exactly the same level of conceptual understanding underlying success on the Stage III - IV task (see Table 6.1). Improvement in performance between Stages III and V is due only to an improvement in the rules of search the infant applies; experience has modified his earlier rules to take into account the last seen position of the object, thereby producing 'success'. No truly significant conceptual advance has been made, however, nor will be until solution of the Stage V - VI task.

It could be argued that the Stage IV infant's rule of search does in fact include some reference to position: 'to find an object which has mysteriously disappeared, remove the object which has replaced it'. I would like to suggest, however, that this part of the rule would normally be very secondary in importance. It will only be needed (and used) when the main rule is ambiguous, as, for example, when two identical occluding objects are in the visual field. Then, any definition of identity might fall back on position, with position being defined in rather imprecise egocentric terms (e.g 'to find an object which has mysteriously disappeared, remove the object which has replaced it, the one on my left' - a rule which would of course lead to error in an AAB situation). The point is that the infant's problem is still at this stage very much one of object-object relations and not one of interrelating positions in space. During this period the infant undoubtedly has a very restricted understanding of such interrelations. It is suggested, however, that in the standard object permanence situations this is not what produces the characteristic errors.

Bearing the above in mind, virtually all of Bremner's results can easily be fitted into the identity framework. As mentioned, Bremner found evidence which he believed showed that the nine month old's definition of the position of a hidden object need not be egocentric. If visual clues were made more salient (by using different covers rather than different colours for each side of table top), infants were significantly more successful in recovering the object even when after movement it was in a new egocentric position.

Bremner assumes from this that the infant is using the cover cue to identify a position in space. What would be the alternative identity explanation? The identity hypothesis would not deny that use can be made of visual referents. The Stage IV rule of search specifically mention such referents. These referents are, however, primarily concerned with the occluding object and only secondarily, if at all, with its position in space. Obviously then, differences in the occluding objects would aid solution to the AAB task, just as Bremner found. Using different covers does not necessarily mean that allocentric clues are being heightened, as Bremner seems to assume (an assumption apparently also made by Harris, 1977); the infant may code this information simply as, for example, 'under the grey cover', a coding which says nothing about absolute position in space and yet will lead to success. Support for this interpretation comes from Bremner's finding that switching the covers between A and B trials in an otherwise standard situation (i.e without movement) improved performance (Bremner, 1978a). Such a result confirms the importance of the cover itself in determining response and surely detracts from any spatial localisation hypothesis.

One finding of Bremner's does embarrass the identity hypothesis, his finding that the use of different covers made no difference to errors in a standard AAB task. The identity hypothesis would be forced to predict that such a modification would improve performance. Butterworth, fortunately, has found exactly the opposite (Butterworth, 1978). Such diametrically opposed results point to the difficulties of investigating spatial coding in AAB-type situations. The Stage

IV - V task is best reserved for investigation of object understanding and even then may provide misleading information as to underlying competence.

Further supporting evidence that the spatial problem in the Stage IV - V task is indeed primitive in nature comes from work by Lucas & Uzgiris (1977). They discovered that the presence of a marker screen at the original position of an object which had been invisibly displaced led to an increase in errors in 8 - 9 month old infants. (The object stood in front of a marker screen, another screen moved over, picking up the object and invisibly displacing it to a new location, leaving the marker screen sitting in its original position). They found, however, that if the object was placed slightly to the side of the marker screen (such that 'the boundaries of the object and the marker screen were clearly distinguishable and the relation of separation between them was pronounced'), these difficulties disappeared.

Lucas & Uzgiris interpreted this as evidence of a lack of precision in spatial localisation: in the first case, they assume that the infant locates the object in the region of the marker screen and, not appreciating the invisible displacement, looks for the object in the last place it was seen. Separation of the object from the screen removes this topological association and enhances the chances of looking behind the correct screen (since the original position of the object - no longer defined in relation to the marker - is obviously empty). Such a result could equally well, however, point to the importance of the integrity of boundaries to success in

any search task. If the infant does not initially identify the object as a separate and obtainable object (since it has no clearly defined boundaries), he is hardly likely to search for it when it is invisibly displaced (see Experiment 4). To move to explanations in terms of spatial codings of position seems unnecessarily complicated, the exact same criticism as was levelled at the theories of Butterworth and Bremner & Bryant. The simpler identity explanation seems able to cover all of the above findings and unlike its competitors does not require any elaborate (and therefore potentially ambiguous) task to produce evidence of the supposed difficulty - placing an object on a platform will suffice.

Understanding spatial relations between self and object

Denying that the AAB task reveals anything about the infant's ability or inability to understand the interrelations of positions in space does not of course add anything to our understanding of that particular aspect of development. On the basis of the experiments reported in previous chapters, it would not seem unreasonable, however, to suggest that any such understanding could not possibly emerge in search tasks such as those used by Bremner until some point after acquisition of understanding of the spatial relations which are possible between any two objects which do not move. Not until the infant has some reasonable grasp of the relationship between object and occluder will he be able to begin to fathom the complexities of the spatial relations arising between himself and other objects in any search task involving movement.

The theorists discussed above would obviously disagree with this suggestion. Butterworth in particular would seem to suggest that egocentric responding is a defining characteristic of Stage IV; thereafter the position of all hidden objects is presumably coded allocentrically. At this point in time there is no empirical evidence to support or refute such a claim. Although Bremner's final experiment avoided the pitfalls of examining spatial understanding within the AAB paradigm, neither his nor the other studies investigated the problem developmentally. There is therefore at present no data on the developmental course of spatial understanding in infancy. Experiment 6 was designed to fill this gap.

EXPERIMENT 6

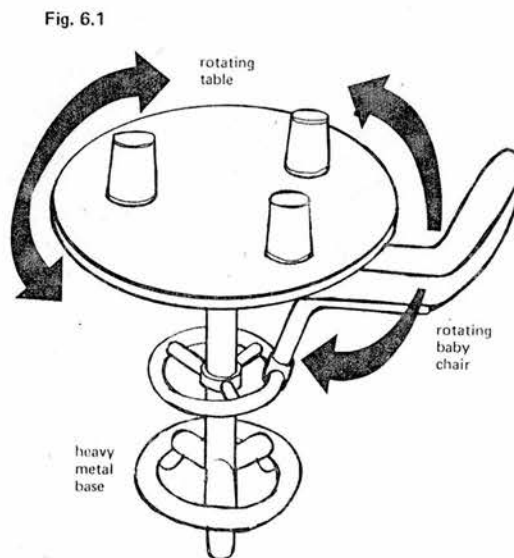
SUBJECTS

Two main groups of subjects were run, one cross-sectional, one longitudinal. The cross-sectional group consisted of 85 infants between 12 and 24 months of age. The longitudinal group consisted of 24 infants seen fortnightly from 12 months of age. Testing of this group reverted to monthly after two consecutive sessions in which the

infant was successful on all given trials and terminated at 24 months. A third group consisting of 14 infants from Experiment 5 (the longitudinal tracking and reaching study) was also run. This group were brought into the laboratory at monthly intervals from 8 - 12 months and fortnightly thereafter until criterion performance was achieved. Testing of this group was terminated at 20 months.

APPARATUS

The apparatus consisted of a circular table-top, 28" in diameter, painted matt white and mounted on a heavy revolving base. A standard baby chair was attached to this in such a way that it could be independently rotated around the outside of the table (Figure 6.1).



Apparatus used in Expt. 6

Standard blue paper cups were used to hide the object. The cups were placed 12" apart and 6" in from the edge of the table. Various objects were used, according to the preference shown by the particular baby. Where possible, one object was used throughout the entire testing sequence. All objects were of similar size and all were brightly coloured.

PROCEDURE

The baby was securely strapped into the chair and familiarised with the fact that both he and the table could be made to move. The procedure was explained to the mother who was asked to avoid giving the infant any clues to the location of the object. The baby's attention was drawn to the object which was then hidden under one of the cups. Table, baby or both were then moved. Table movements were performed as inconspicuously as possible by E, who remained in the same position throughout. Movements of the baby were performed by the mother who also restrained the baby from reaching for any of the cups prior to completion of any movement sequence. The infant was then allowed to search for the toy. In the event of an incorrect response, the infant was given time (and encouragement) to correct his mistake. If he did not, E drew his attention to the appropriate cup and uncovered the hidden object.

Two series of presentations were given, the first involving two cups, the second three. Order of presentation in the 2 cup series was fixed except for these few babies who found movement

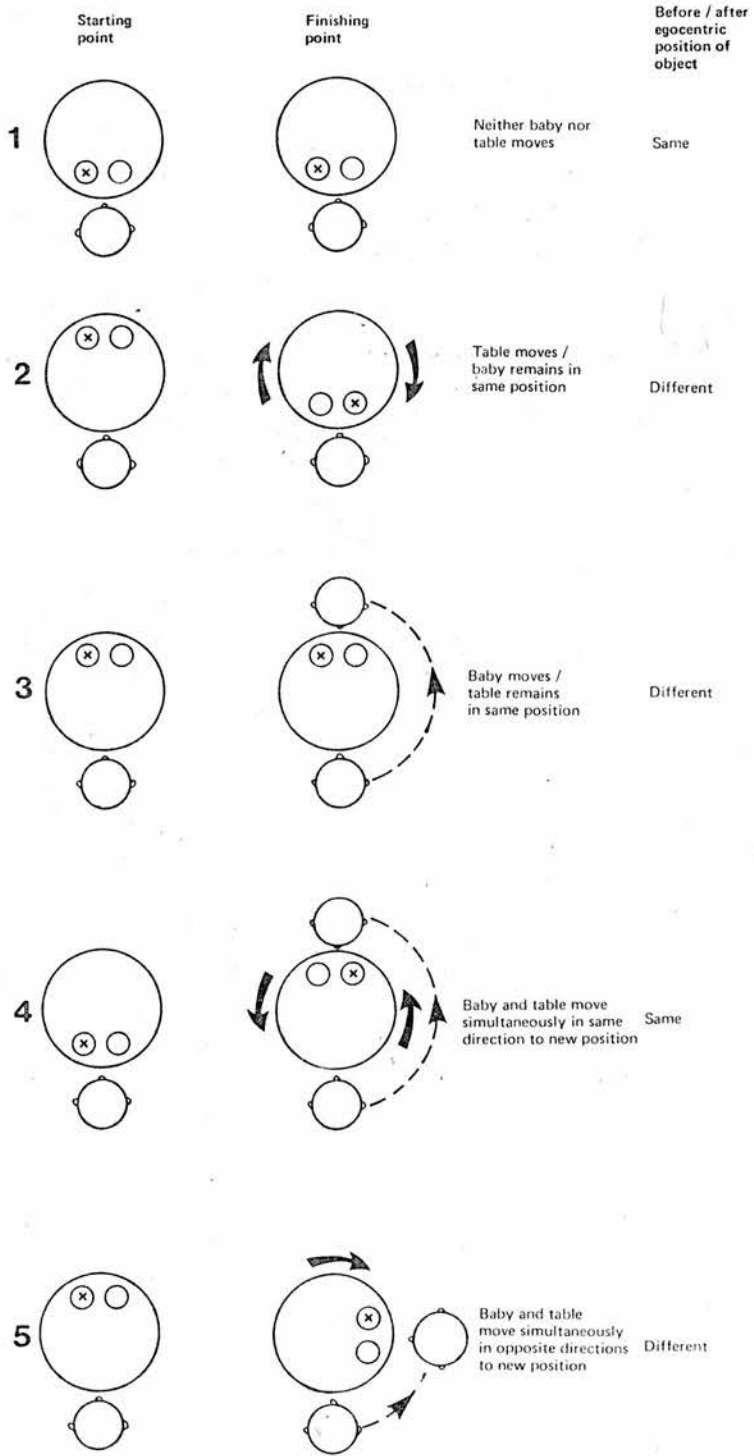
round the table at first disturbing. Two trials of each presentation were given, one on the left and one on the right. Order of side of hiding was randomised within each presentation, as was the direction in which the table or infant turned. In the 3 cup series the 12 trials were presented in random order.

In the case of younger babies, it was sometimes impossible to get through both series in one session. Cross-sectional babies were brought back within the same week to complete the presentations; longitudinal babies were not brought back unless they had failed to complete all of the first series. On completion or termination of the movement trials, infants in the third experimental group (Experiment 5 infants) were also presented with six trials of the Stage V - VI object concept task at the end of each session.

2 cup series

The 2 cup series of presentations is shown in Figure 6.2.

Fig. 6.2



2 CUP SERIES

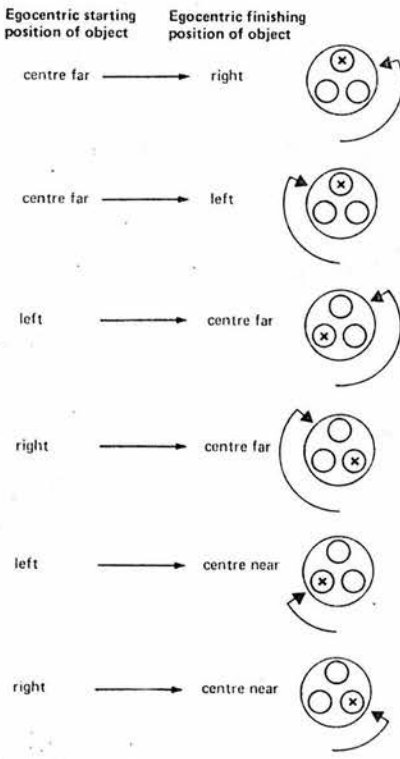
Presentations 2, 3 and 5 involve changes in the egocentric position of the object between time of hiding and time of search; if, for example, the object was initially on the baby's left, it would be on his right after movement. If the young infant codes space absolutely (i.e with reference only to himself), relocating the object should prove to be more difficult on these trials than in presentations 1 and 4.

3 cup series

The 3 cup series consisted of 12 presentations, given in random order. In 6 trials the infant was moved round the table; in the other six, the infant remained in the same position and the table was turned (Figure 6.3).

Fig. 6.3

BABY MOVES / OBJECT STATIONARY



OBJECT MOVES / BABY STATIONARY

Egocentric starting position of object	Egocentric finishing position of object
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As opposite but table rather than infant turns through 60° or 120°

From Figure 6.3 it can be seen that all 12 trials in the 3 cup series involve a change in egocentric position of the object after movement.

RESULTS

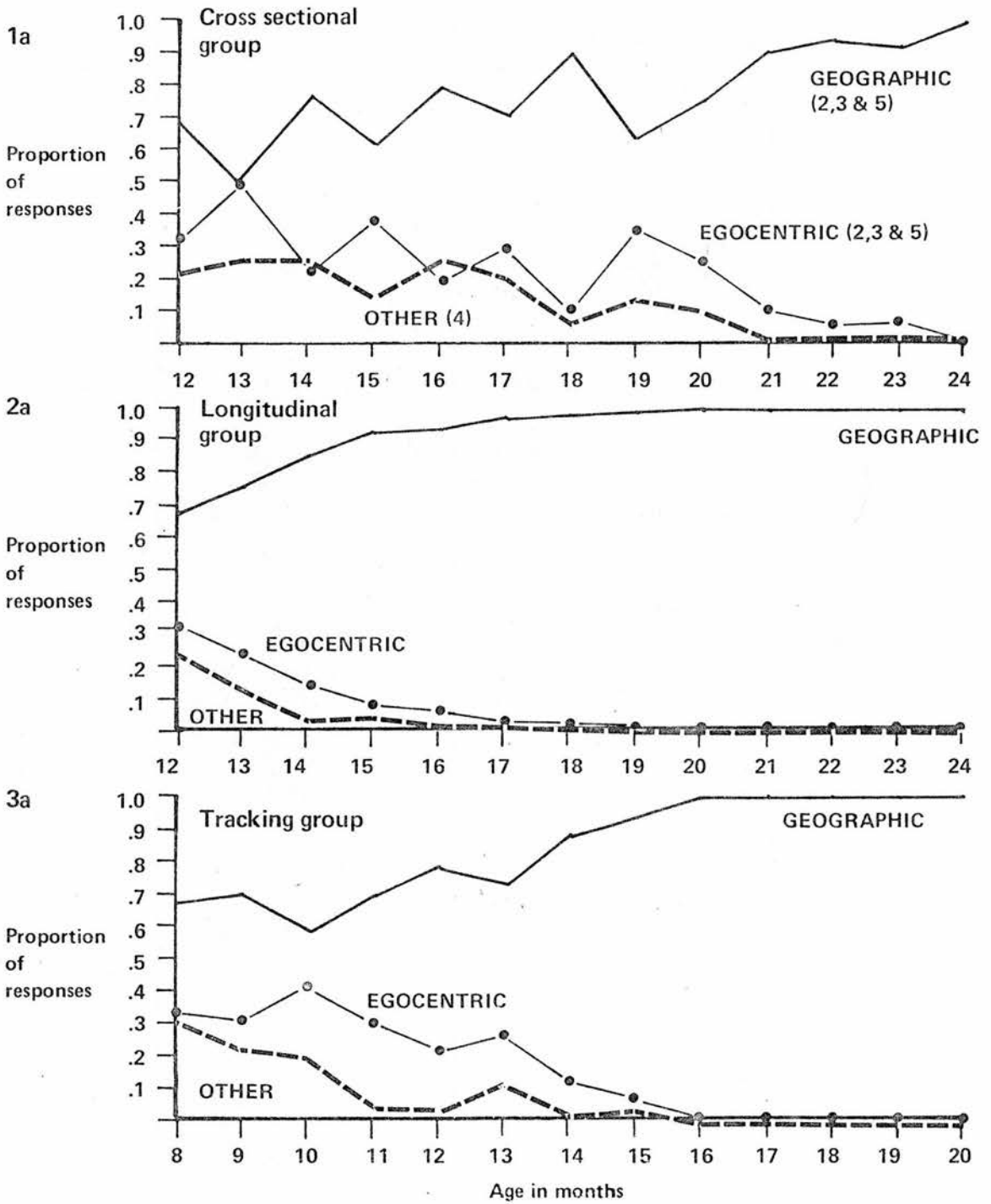
2 cup series

Presentation 1 was used to assess whether the infants were still making Stage IV errors. Not surprisingly, since the tracking group were already known to be in Stage V (see Experiment 5) and the other groups were 12 months of age at onset of testing, no infant made any errors on this presentation in any session.

Responses to presentations 2, 3 and 5 were scored as being either geographic or egocentric. In all three presentations, a geographic response represented successful relocation of the object after movement; looking for the object in its original egocentric position after movement would lead the infant into making an error. In the case of presentation 4, both a geographic and an egocentric coding of object position would lead to a successful response; incorrect responses in this situation were therefore classified as 'other'.

Graphs 6.1a - 6.3a (see over) show the proportion of geographic, egocentric and 'other' responses found at monthly intervals in all three groups. Incorrect 'other' responses in presentation 4 suggest that the baby believes that something changes when he or the object

Graphs 6.1a - 6.3a Geographic v. Egocentric responding in the 2 cup series (uncorrected)



moves. They also suggest, however, that his correct responses in presentations 2, 3 and 5 need not necessarily imply use of geographic information as to position; any rule of thumb for changing response after movement could lead to the same response, thereby artificially inflating the number of 'correct' responses in these presentations (which do not after all allow for any clear 'other' response). Since a fair number of 'other' responses did in fact occur, it was felt that these should therefore be applied as a correction factor to the proportion of successful responses found in the other three presentations.

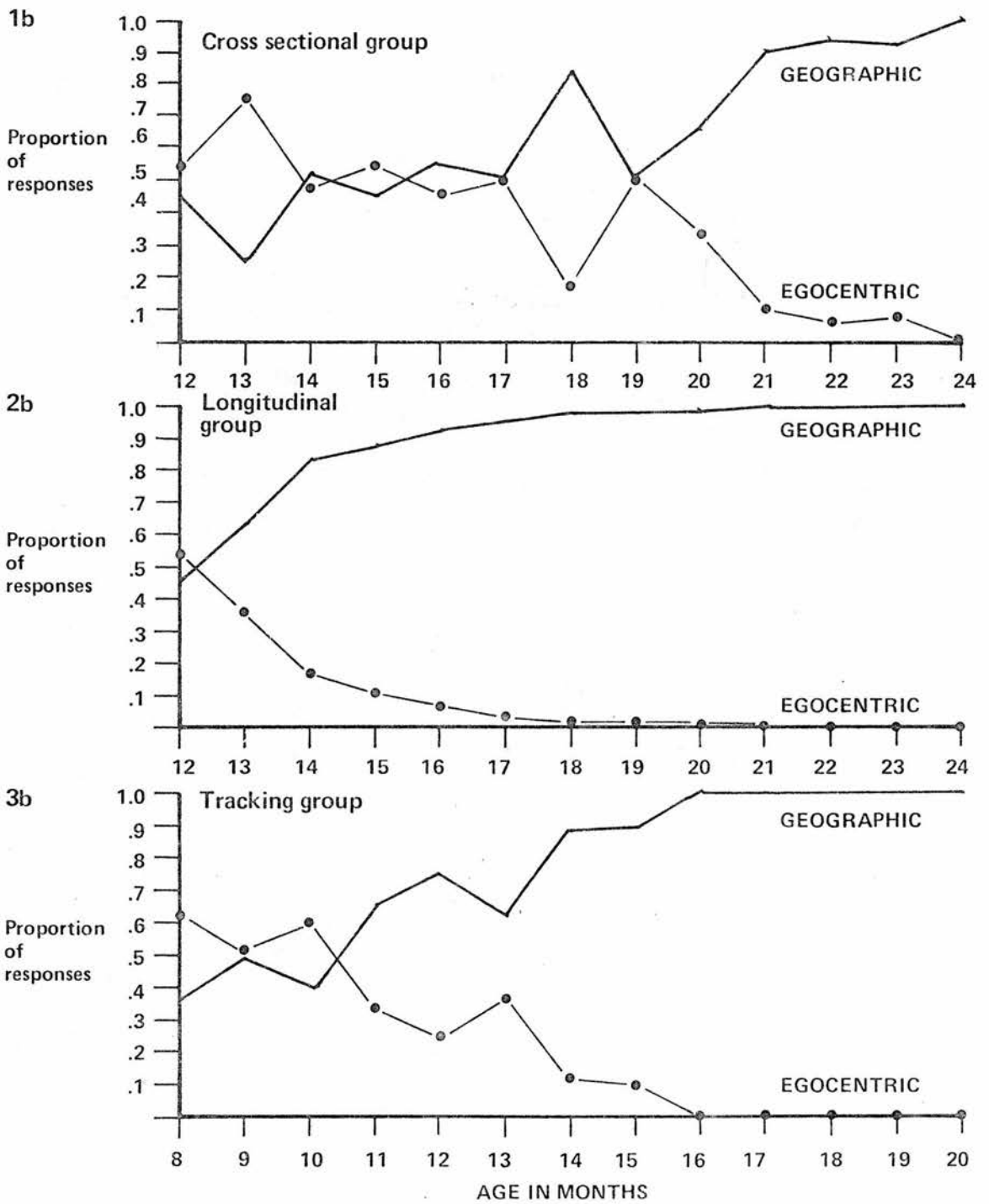
Graphs 6.1b - 6.3b (see over) show the proportion of geographic and egocentric responses for the three groups when corrected for this factor. In addition, the range and mean age of success (2 weeks all correct) in the 2 cup series in each group is set out in Table 6.1.

TABLE 6.1 Range and mean age of success in 2 cup series in the 3 experimental groups

	<u>Range</u> <u>(in months)</u>	<u>Mean</u>	<u>S.D.</u>
Cross-sectional	$15\frac{1}{2}$ - 23	n/a	n/a
Longitudinal	$12\frac{1}{2}$ - 21	15.27	2.08
Tracking	11 - 16	13.98	1.61

From the corrected graphs, it can be seen that in the beginning egocentric responding is higher than geographic responding in all three groups. It is also clear that some infants were still making

Graphs 6.1b - 6.3b Geographic v. Egocentric responding in the 2 cup series (corrected)



egocentric errors by late into the second half of the second year. All of these infants were, however, in at least Stage V of the object concept and should not, according to Butterworth, still have been making such errors.

The fairly steep decline in egocentric errors in the longitudinal group suggests that experience in this sort of task can accelerate development considerably, with the mean age of success in this group equalling the age of the youngest successful baby in the cross-sectional group. That experience accelerates development is confirmed by the results of the tracking group. Mean age of success was even younger in this group, a fact which may or may not be related to the fact that this group were already vastly accelerated in object concept development, a phase of development which I would like to argue must be virtually complete before any headway can be made in understanding the wider world of spatial relations. At 12 months, the rate of egocentric responding in this group was only half that of the longitudinal group. This could merely be the result of experience in this particular task; the error rate of the longitudinal group also fell dramatically within 4 presentations of the onset of testing. It is interesting to note, however, that when first sessions are compared, the tracking group in fact performed better than the longitudinal group, despite being 4 months younger.

3 cup series

The three cup series has a built-in advantage over the 2 cup series. Each trial allows for geographic, egocentric and 'other'

responding; there is therefore no need to introduce any correction factor.

Graphs 6.4a - 6.4c (see over) show the proportion of geographic, egocentric and 'other' responses in the 3 cup presentations for all three groups. With the exception of the tracking group, it can be seen that egocentric and 'other' responses, taken together, virtually equal geographic responding at 12 months. Thereafter the picture is one of a general decline in both egocentric and 'other' responses and a rise in geographic responding.

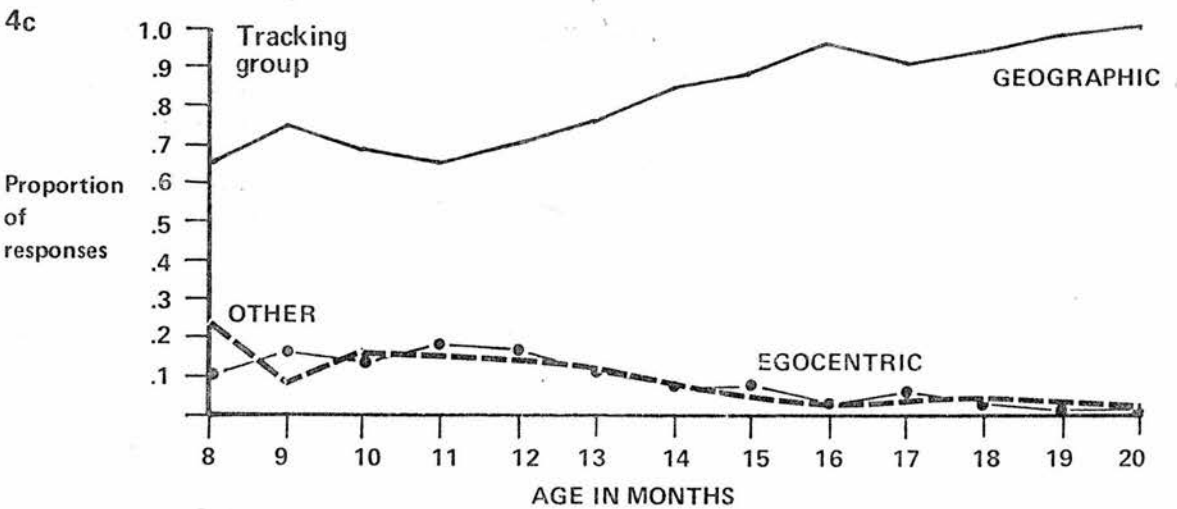
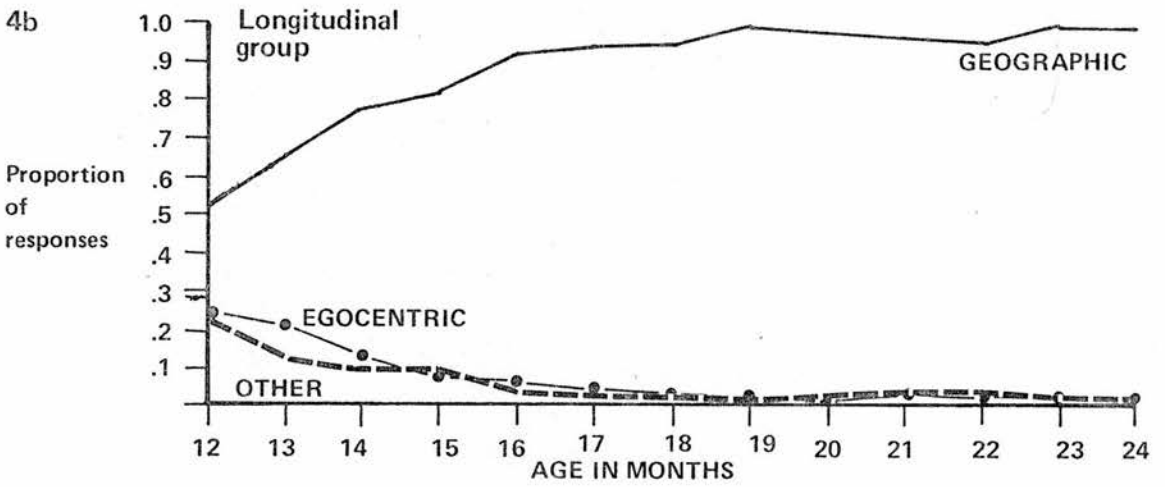
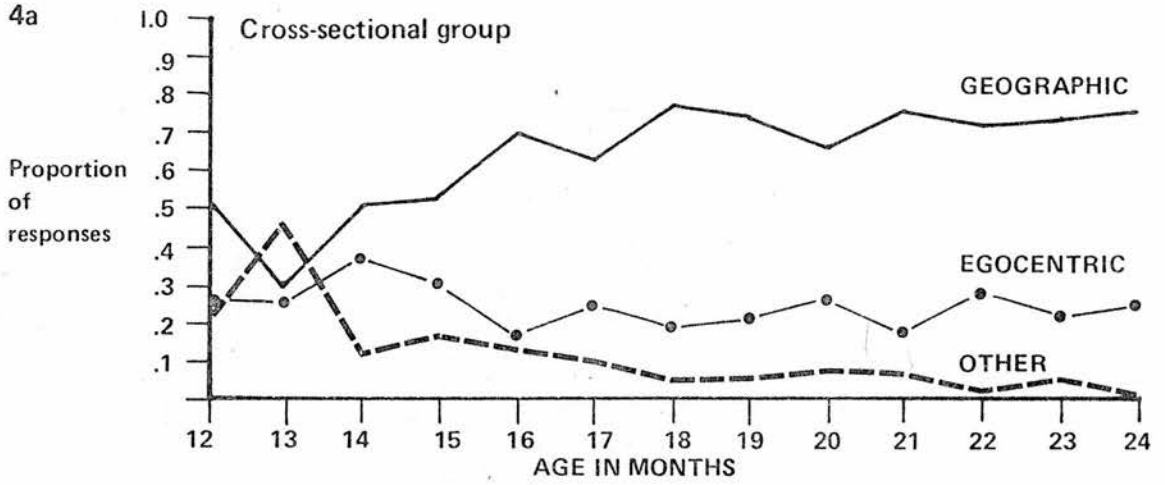
The tracking group again seemed to have a distinct advantage in the early months of testing. Their performance at 8 months was quite noticeably superior to the performance of the longitudinal group at 12 months. Since this represents the first session of testing on these tasks, it is hard to avoid the conclusion that acceleration through the sequence of object concept development facilitates spatial understanding in the wider sense.

Table 6.2 shows the range and mean age of success in the 3 cup series in all three groups.

TABLE 6.2 Range and mean age of success in 3 cup series in the 3 experimental groups

	<u>Range</u> <u>(in months)</u>	<u>Mean</u>	<u>S.D.</u>
Cross-sectional	17 - 24+	n/a	n/a
Longitudinal	$14\frac{1}{4}$ - 19	16.48	1.45
Tracking	$12\frac{3}{4}$ - $19\frac{1}{4}$	15.30	1.77

Graphs 6.4a - 6.4c Geographic v. Egocentric responding in 3 cup series



The three cup series was obviously more difficult than the 2 cup series. In the cross-sectional group, some infants were still making a substantial number of errors at 24 months of age. In the longitudinal group, only 3 out of 18 infants could pass the 3 cup series before success in the 2 cup series. In the tracking group, only one infant did so. Success in the 3 cup series does, however, appear to follow rapidly on success in the 2 cup series; 14 out of 18 infants in the longitudinal group, for example, passed the 3 cup series within one month of success in the 2 cup series. Since the principle underlying success in the two tasks is the same, this is not perhaps surprising.

It is, of course, always possible that the claim that successful infants must have understood the spatial relations involved in these search tasks is invalid. It could be argued that the successful infant merely kept his eye on the correct cup throughout the period of movement. Observation during testing suggested that this was not the case. Few infants kept track of the object throughout its movement and frequently those infants who actually did follow it to the point at which it came to rest would still go on to choose the wrong cup. In order to ensure, however, that this was not the reason for the infants' success, 4 20-month old infants of varying levels of competence in the 3 cup series were brought back to the laboratory. After the object had been hidden, a screen was positioned between the 3 cups in such a way that it prevented the infants from being able to keep their eyes on the

correct cup. All 4 infants still produced exactly the same pattern of responses; none seemed perturbed by the introduction of the screen. From this, it seems that success in these tasks is truly a cognitive rather than a perceptual achievement.

DISCUSSION

It would seem from the results of Experiment 6 that the spatial relations which arise between infants and objects provide them with considerable problems of understanding throughout the second year of life. This should not surprise us. Previous chapters have laboured the point that infants have enormous difficulty in understanding the spatial relations between objects. Since the self is, after all, only one object in a space common to many other objects and holds no special spatial privileges, it seems obvious that even very simple self-object relations would present difficulties to the young infant.

We have already mentioned some evidence that would lead us to suspect this to be true, the fact that young infants are quite unable to make use of tactual clues to object location in a Stage III - IV task (p 103). Amazingly, even if the infant's own hand is the sole occluder used in the hiding task, he still seems unable to understand the spatial relations involved. Take, for example, the situation in which an object is placed in the infant's hand and his hand then closed over it. The 5 - 6 month old infant will act as if the object no longer exists, looking surprised if it later falls from his hand

into view again (Brown, 1973). Spatial relations between self and object are obviously as mysterious as object-object relations at this stage. It is hardly surprising then that search tasks involving changes in the spatial relations between self and object are even more difficult.

Acceptance of evidence of such difficulties does not, however, necessitate accepting the Piagetian viewpoint that there is no knowledge of the self in early infancy (see p 26). As we have already seen, a variety of behaviours suggest that the self-world dichotomy is present very early on, as early in fact as present-day research techniques have allowed us to look for it. Reaching, defensive responses to approaching objects, imitation - all of these behaviours testify to a very early knowledge of the spatially distinct existence of self from objects. There seems no need, as Piagetians would maintain, for any lengthy period of construction of this knowledge. It could perhaps even be directly given. At a simple biochemical level, it is certainly true that from the outset a distinction is made between self and non-self. There also seems no reason to disbelieve that this distinction, as in adults, is made at the level of sensation and perception, with exteroception and interoception being clearly separated in experience, a separation which after all seems to have structural parallels in the organisation of the brain (Rosar, 1978). Maintaining the opposite is surely more difficult. It may indeed well be the case that knowledge of the self goes even further than mere knowledge of its separate and independent

spatial existence. A fairly large body of evidence on visual-motor co-ordinations in early infancy suggests in addition the presence of a highly co-ordinated body image (see e.g Meltzoff & Moore, 1977). Knowledge of the differentiated and co-ordinated existence of the self by no means implies knowledge or understanding of the spatial relations which continually arise between self and objects, however, and it is here that the infant's problem seems to arise.

Although Piaget believed there to be no knowledge of the self in early infancy, he did not neglect the problem of spatial understanding in infancy. He believed that construction of an understanding of space was intimately related to the development of understanding of the separate existence of self from objects. Since all organisation of understanding is in terms of personal action schemas, egocentrism is inevitable on Piaget's account of the development of spatial understanding.

"A very young infant has little or no conception of space or movements. When he does begin to form a concept of space, it is at first centred on his own body and on the location of successful actions".
(Piaget, 1957)

According to Piaget's model, however, egocentrism should be over on completion of the development of the object concept. The results of Experiment 6 suggest that this is not the case. The tracking group continued to make egocentric errors in later testing sessions, despite the fact that they were no longer making any errors in the Stage V - VI transition test (see Appendix C). This finding obviously does not embarrass the identity hypothesis. It would

maintain that little headway in reducing egocentric errors could in fact be hoped to be made until some point after the infant can appreciate the nature of object-object relations, a process which is not complete until Stage VI.

One last point is perhaps worth discussing very briefly, the finding that the young infant tends to make spatial judgements on the basis of absolute (egocentric) referents. Evidence of such absolutism fits well with what we know of his behaviour in other areas. Between 12 - 24 months, for example, an infant will also find it difficult to form a seriated tower of cups (Greenfield, Nelson & Salzman, 1972). To do so, he would have to assess the size of the cups in relation to each other, not himself. To do the latter is well within his capabilities; he can after all adjust his hand accurately to pick up any of the cups. Until, however, he stops using his own body as the absolute referent for size, he will be unable to form a tower, succeeding only in forming inappropriate pairs of cups. This absolutism of the infant's early perception and understanding of the world around him has also been demonstrated in studies of drinking behaviour and response to objects of varying weights (Bruner, 1968, Bower & Wishart, 1976, Mounoud & Bower, 1974).

IN CONCLUSION

This thesis has examined the development in infancy of the object concept. A series of six interlinked experiments were presented. These attempted to demonstrate that the problem for the infant in standard object concept tasks lies in maintaining the identity of the object over the spatio-temporal transformations it undergoes in such tasks and not, as traditionally viewed, in understanding the permanence of that object when no longer in view. According to the identity hypothesis, the problem for the infant at all stages of development of the object concept is one of spatial understanding; this is a problem for the infant regardless of whether the object in question goes out of sight or not.

While other theorists have argued that problems of spatial understanding are linked to performance in object concept tasks, most have assumed at least some understanding of the spatial relations involved in the hiding task to be presented; none, for example, would predict that an 'on' relationship between two objects would pose problems or that 'inside' should prove difficult if the object is in fact visible. It would seem from the experiments presented above, however, that all but the most basic facts about objects and space must be learned. In addition, it would seem that achievement of Stage VI does not mark the culmination of the development of spatial understanding in infancy, as other theories would seem obliged to maintain. Even when in Stage VI, the infant still appears to have considerable problems in understanding the

complex spatial relations which arise in any situation in which he or the objects around him move. He must realise that he himself holds no privileged position as a spatial referent before he can hope to develop some flexible yet stable spatial referencing system; only then will he be able to succeed in the most complex of object search tasks.

All of the above represents a fairly radical departure from the traditional Piagetian analysis of this segment of development. It is also incompatible with the intersensory co-ordination, memory, motor and action theories of object concept development which were considered in previous chapters. It is to be hoped that the evidence presented in this thesis makes such disagreement seem reasonable. In conclusion, however, it should be pointed out that this thesis agrees wholeheartedly with Piaget on two important points: firstly, that there is indeed throughout infancy a problem in understanding the nature of objects and secondly, that this understanding is of great significance to later intellectual development. (Some evidence in support of this second point is presented in Appendix C). The latter point makes it especially important that we establish beyond doubt the causes and nature of the development of the object concept in the normal infant. Only then might we reasonably hope to intervene effectively in situations where that development might not otherwise be expected to take its normal course. This surely should be one of the major aims of this type of research.

(i)

APPENDIX A : DESIGN OF TRACKING STUDY (Experiment 5)

CONDITION

1:Simple tracking 2:Platform 3:Screen 4:Tunnel

SUBJECT/ SEX		12	34	42	31	14	23	43	21	13	24	32	41	→			
E1a	1 F	█		█		█		█		█		█		12	34	42	etc
	2 M		█		█		█		█		█		█	34	42	31	etc
	3 M	█		█		█		█		█		█		42	31	etc	█
	4 M		█		█		█		█		█		█	█			█
	5 F	█		█		█		█		█		█		█			█
	6 M		█		█		█		█		█		█		█		█
	7 F	█		█		█		█		█		█		█			█
	8 M		█		█		█		█		█		█		█		█
	9 M	█		█		█		█		█		█		█			█
	10 F		█		█		█		█		█		█		█		█
	11 M	█		█		█		█		█		█		█			█
	12 F		█		█		█		█		█		█		█		█
E1b	13 F	█		█		█		█		█		█		█		█	
	14 M		█		█		█		█		█		█		█		█
	15 M	█		█		█		█		█		█		█		█	
	16 F		█		█		█		█		█		█		█		█
	17 F	█		█		█		█		█		█		█		█	
	18 M		█		█		█		█		█		█		█		█
	19 M	█		█		█		█		█		█		█		█	
	20 M		█		█		█		█		█		█		█		█
	21 M	█		█		█		█		█		█		█		█	
	22 F		█		█		█		█		█		█		█		█
	23 F	█		█		█		█		█		█		█		█	
	24 F		█		█		█		█		█		█		█		█

2nd 28-week session: remaining two conditions

← 18-23 weeks → ← 24-28 weeks →

L = starting week (age 12 weeks)
█ = stop in eight weeks

return to complete first section

APPENDIX C : THE RELATIONSHIP BETWEEN OBJECT CONCEPT DEVELOPMENT
AND LATER INTELLIGENCE

Infants from Experiment 5 - the longitudinal tracking and reaching study - were brought back to the laboratory at age three and administered the L-M scale of the Stanford-Binet intelligence test. The Stanford-Binet test was chosen for various reasons: its high reliability, its good mix of performance and verbal items and the fact that it is generally easy to interest children of this age in its test material. It should be noted, however, that previous studies have generally failed to find any significant correlation between performance on infant tests and later intelligence (see e.g. review by Goodenough, 1954). This is most probably due to the high motor content of the infant development scales typically used in such studies. Evidence is gathering, however, that Piagetian-based infant tests may have better predictive value than the more traditional tests, with object permanence tests in particular being shown to correlate significantly with later levels of development (Birns & Golden, 1970, Wachs, 1975).

It would have been interesting to have been able to test the intelligence of these children on a Piagetian-based intelligence test. Unfortunately, no easily administered or well-validated Piagetian-based intelligence test currently exists, a rather surprising fact in view of the attention Piagetian theory has attracted. Pinard & Laurendeau have for some time been working on the construction of just such a test but the present version takes, I believe, a total of

around ten hours to administer and, because of the clinical nature of the testing procedure, requires a very sophisticated tester if the results are to have any reliability and meaning. Although the new British Intelligence Scale includes Piagetian items, these are for supplementary use only and are not used in calculating I.Q.

SUBJECTS

Experimental group: 18 out of the original 24 infants who participated in Experiment 5 were relocated. Nine of these had also participated in the follow-on study of Neilson (1977 - see p 216). None of the subjects had, however, been to the laboratory in the preceding 18 months. It was therefore unlikely that there would have been any effect of familiarity with either experimenter or surroundings in favour of the experimental group. Mean age of the experimental group on testing was 3 years 0.9 months.

Control group: The control group consisted of 18 children out of our subject pool, matched with the experimental group for age, sex, birth order and number in family. Performance of the experimental group could have been evaluated simply by direct reference to test norms. Performance on the Stanford-Binet has, however, significantly improved in recent years and norms at younger age levels in particular are now suspect (Garfinkel & Thorndike, 1976); direct comparison with test norms might therefore have resulted in an inflated estimate of the experimental group's performance. Use of a control group served a

second purpose. As has already been pointed out, our mothers are all volunteers; they are therefore self-selected and tend towards the middle class and better educated end of the population. It would not be surprising to find that the average I.Q. of any group of subjects drawn from such a pool was above the population norm, irrespective of experimental treatment. Use of a control group from within this pool therefore avoids the possibility of mistaking the effects of the socio-economic bias of the sample for true experimental effects.

PROCEDURE

All but one of the **children** were tested with the mother present. Testing procedure was strictly adhered to although order of presentation of some items was occasionally altered, a variation considered by the test designers to be permissible in this age group and one indeed which proved to be essential if interest and good motivation were to be maintained in certain subjects. Testing was sometimes spread over two sessions. This was partly due to the unexpectedly wide age range of items which had to be presented before a fail point was reached (from 2.6 to 9 years in one case) and partly due to the fact that higher age Stanford-Binet items are predominantly verbal; many children were considerably less tolerant of such items and quickly lost interest.

RESULTS

Stanford-Binet scores for the experimental and control groups are laid out in Table A. A Wilcoxon matched pairs signed ranks test revealed significant differences to exist between the performances of the two groups ($T = 33$, $p < .01$).

Table A - see over

TABLE A : Stanford-Binet performance of experimental and control groups at age 3

<u>SUBJECT</u>	<u>EXPERIMENTAL</u>	<u>CONTROL</u>
1	145	141
2	145	131
3	136	123
4	143	138
5	147	143
6	141	136
7	171 (+)	113
8	130	132
9	138	123
	Mean	
	144.00 (S.D. 11.43)	131.11 (S.D. 11.82)
10	132	106
11	118	127
12	138	130
13	153	132
14	118	134
15	134	139
16	142	145
17	134	122
18	132	120
	Mean	
	133.44 (S.D. 10.94)	128.33 (S.D. 11.46)
	Overall mean	
	138.72 (S.D. 12.14)	129.72 (S.D. 10.44)
1	127	
2	136	
3	145	
4	145	
5	138	
6	111	
7	138	
8	149	
9	121	
	Mean	
	134.44 (S.D. 12.49)	

The experimental group, it will be remembered, consisted of two groups of infants, one of whom ($N = 9$) had continued in the experiment of Neilson (1977) while the other was seen only once a month and given no further training in tracking. Examination of Table A suggested that there were differences between the two halves of the experimental group in favour, surprisingly, of those who had been trained for the shorter period of time (12 - 28 weeks versus 12 - 42 weeks). A Mann-Whitney U test on performance scores of these two groups confirmed this difference ($U = 18.5$, $p < .05$) while a further test confirmed that this was not due to differences in the two halves of the control group ($U = 34.5$, NS). Separate experimental-control comparisons were made for the Wishart-only and Wishart-Neilson groups; while differences significant at the .005 level were found for the former ($T = -1$),^{Wilcoxon} no significant difference in performance was found between the Wishart-Neilson group and their control group ($T = 14$, NS). That is, if the experimental group was broken into the two treatment groups, it could be seen that the superior performance of the experimental group as a whole was due to the performance of the Wishart-only group. The Wishart-Neilson group performed no differently from a control group who had received no training whatsoever.

Before launching into possible explanations of these results it would be wise to sound a cautionary note. Significant differences were found between the experimental group as a whole and the control group. These differences were, however, found to be wholly due to the superior performance of those subjects who had received medium as

opposed to extensive amounts of training. For this experimental group, I.Q. performance was indeed significantly superior ($p < .005$). We should be most wary, however, of drawing any strong conclusions on the basis of such a reduced sample, no matter how significant the differences found. In addition, if we want to conclude that a certain amount of training on object permanence tasks at an early point in development enhances later intelligence, we might have expected there to be some relationship between, say, age of achieving Stage VI and I.Q. in the Wishart-only group. Although both Experiment 1 and Experiment 5 show that early training accelerates appearance of the later stages of object permanence behaviour and the above results demonstrate to some extent that infants given medium amounts of early training perform better on I.Q. tests than control infants, no direct correlation between the age of achieving Stage VI and I.Q. performance was in fact found (r_s (VI.SB) = .21; NS). There are possible statistical reasons, however, for this. Stage VI tasks were only being presented monthly to the Wishart-only group. In comparison to the exactness of measurement of Stanford-Binet performance, age of achievement of Stage VI was only very grossly measured; many tied ages entered the computation, thereby reducing the possibility of uncovering any correlation between age of achieving Stage VI and I.Q.

In spite of the lack of correlation between object permanence performance and I.Q., certain facts still need explaining. Mean age of achievement of Stage VI in the Wishart-only group was, for example, very low - 10.9 months as compared to 12.45 months in the Wishart-

Neilson group, 13.9 months in the control group of Experiment 1 and Piaget's estimates of 18 - 24 months. Mean I.Q. of the experimental group as a whole was 138.72 while that of the control group was only 129.72, a difference of 9 points. In the case of the Wishart-only group, this difference widened to nearly 13 points. Even in the Wishart-Neilson group a difference of 5 points was found which, although insignificant, was still a positive difference.

How then are we to explain this pattern of results? Why should the group with less training in tasks which seem to bear some relation to later intelligence perform better than those with more training? Although it is beyond the scope of this thesis to consider this question in any great depth, it should be pointed out that these results fit well with the recent theory of development put forward by Bower (1976). Bower, in contrast to most accounts of development, has proposed that development goes from abstract to specific; that is, that the infant's understanding of the world around him proceeds from conceptions which are initially abstract to descriptions which are highly specific - and not vice-versa. Any such abstract → specific progression has important consequences when we consider any situation in which it is hoped that training on one task will promote transfer to another conceptually-related task. If an infant is overtrained on the first task, his descriptions of that task will move away from abstract descriptions to highly specific descriptions, descriptions which specify precisely both stimulus and response. The conceptual relationship between transfer and training task will therefore become obscured and 'spontaneous' transfer will be

less easy to achieve. In the case of the Wishart-Neilson group, this would mean less rapid acceleration of the later stages of object concept development. If we maintain that object concept development is intimately related to later intellectual development, it would then be possible that just such a process could explain the I.Q. differences found between the Wishart-only and the Wishart-Neilson groups.

Any attempt to evaluate Bower's theory in the context of this thesis suffers certain limitations, however. Take, for example, object concept performance in the two groups. All the infants, although only 28 weeks of age, were already in Stage V when transferred to the Neilson study. This leaves only the Stage V - VI task for comparison. Perhaps on the Bower theory we might expect the continued training provided by Neilson to have an inhibitory effect on acquisition of Stage VI. A comparison was made between age of achievement of Stage VI in the Wishart-only group and Wishart-Neilson group. Mean age for the Wishart-only group was 10.9 months while mean age of success in the Wishart-Neilson group was 12.4 months, a fairly large difference but one which was significant at only the .10 level (Randomisation test $t = 1.55$). Such a comparison is in any case suspect for two reasons. Firstly, testing was performed by different experimenters. Although objective criteria for success were identical (6/6 correct on consecutive sessions), personal criteria for what can or cannot legitimately be considered a trial can vary greatly between experimenters. More importantly, the Wishart-Neilson group were not

tested on Stage V - VI tasks until they had shown conclusive evidence of passing the Stage IV - V task (2 consecutive sessions all correct). This seems to have been an unnecessary precaution since all infants had already proved themselves to be in Stage V on entering the Neilson study. Attentional problems (hardly surprising in a group who had been presented with the same problems for many weeks) made criterion performance on the Stage IV - V task difficult to obtain, with the result that age of achievement of Stage VI was likely to have been inflated in this group, a fact confirmed by Neilson's finding that many infants passed Stage VI within the first few weeks of its presentation.

Neilson also trained a group of naive infants from 28 - 42 weeks. Comparison of object permanence behaviour found little or no difference between the groups by the end of the experiment, the naive group, if anything, being slightly superior on object concept tasks. I brought back nine of these infants for Stanford-Binet testing (see Table A). There was no significant difference in intelligence between this group and the Wishart-Neilson group ($U = 46$, NS) who, it will be remembered, had shown no advantage over a completely untrained control group. This constellation of results suggests very much that training, to be effectual both in the short and long term, must be of a certain amount and will only be efficient if given at the appropriate time. Both amount and timing of training require to be more extensively studied if we are to understand this interaction.

One further note of caution should be sounded. The long term effects of object permanence training on later intelligence could have nothing to do with any relationship between object understanding and

the development of intelligence. It could equally well be possible that weekly attendance at the laboratory heightens a mother's perception of her baby's abilities and increases her motivation to promote his development, a process with long term returns. Allowing that our group of mothers is in all probability highly motivated (and skilled) in the first place, it is still a possibility which cannot be ignored.

In order to examine this possibility, a group of infants who had taken part in another longitudinal study (infants from Experiment 6) were brought in for Stanford-Binet testing. These infants ($N = 9$) averaged 4 years 4 months on testing. Difference in mean age between this and the original Wishart-only group was not considered to be important since I.Q. scores by their very nature take this into account. These infants had been involved in approximately the same number of visits to the laboratory, spread over the same amount of time as the group from Experiment 5; none had been to the laboratory in the preceding 18 months. A Mann Whitney U test on both sets of scores (see Table B) proved to be insignificant ($U = 41.5$). Such a finding may indeed weaken the implications of the earlier results although it should be pointed out that this thesis argues that the skills promoted in Experiment 6 are in themselves intimately related to object concept development. Additionally, it should be mentioned that any argument that the differences found stem from the effects of visiting the laboratory on the mother rather than the baby cannot

explain the differences found between the Wishart-only and Wishart-Neilson group; on that hypothesis, the performance of the latter group should at least have equalled that of the Wishart group and might even have been expected to exceed it. This was not the case.

TABLE B : Stanford-Binet performance of Wishart-only group and 2nd Wishart control group

<u>SUBJECT</u>	<u>WISHART-ONLY GROUP</u>	<u>2nd WISHART CONTROL GROUP</u>
1	145	136
2	145	159
3	136	148
4	143	124
5	147	138
6	141	146
7	171 (+)	144
8	130	118
9	138	171 (+)
Mean	144.00 (S.D. 11.43)	142.66 (S.D. 16.33)

Obviously, further studies are required to separate out these alternative explanations more satisfactorily.

APPENDIX D : PUBLISHED PAPERS

- BOWER, T.G.R. & PATERSON, J.G.
1972 Stages in the development of the object concept.
 Cognition, 1, 47-55
- BOWER, T.G.R. & WISHART, J.G.
1973 The effects of motor skill on object permanence.
 Cognition, 1, 165-171

Stages in the development of the object concept

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Abstract

There are problems in discussing a topic such as the development of the object concept, since the measures used to assess the status of the object concept change drastically during the alleged period of development, and the concept itself does not seem to develop in any continuous fashion. An acceleration experiment is performed to discover whether or not intervention at one point of the hypothetical process effects development at later points. The results are positive, suggesting that there is, indeed, an object concept that develops over an 18-month period. An unexpected result of the study was the finding that development is discontinuous and stage-like, rather than continuous.

The development of the mature object concept is generally reckoned to be one of the most significant steps in intellectual development in infancy. (Piaget and Inhelder, 1969). The main outlines of this segment of development were initially described by Piaget over thirty years ago (Piaget, 1954). Subsequent work has merely amplified and extended his description without materially changing it (Bower, Broughton and Moore, 1971; Bower, 1971; Escallona and Corman, 1969). In all of that time the validity of the problem has never been questioned. No one has ever asked for evidence that there is an object concept that bedevils all of developmental psychology. The development of the object concept spans the period from birth to about 18 months. The responses used to index the level of the concept change drastically in this period; eye movements, heartrate, operant responses, overt grasping, locomotor movements, have all been used to gauge the stage of concept attainment. The stimulus presentations used to elicit these indicator behaviors also change markedly, from simple movement of an object to fairly elaborate versions of 'find the lady'. What justification do we have for saying that these various S-R situations are all markers for a unitary concept? To take a

specific example, how can we say that the stage of development that ends around five months with the ability to track a visible object following it when it moves, wherever it moves, regardless of where it has moved in the past, stopping when it stops, (Bower *et al.*, (1971); Bower and Paterson, in press), is the ancestor of the stage of development that ends nearly a year later with the infant able to find an object hidden in any location, regardless of where it has previously been hidden? The problem is particularly acute here since the older infant apparently repeats, at a formal level, many of the mistakes made and overcome by the younger infants.

The techniques used by embryologists are of interest in this connection, although they are obviously not directly applicable. We cannot stain a behavior as we can stain a cell, using the presence of the stain to make manifest the descendants of the original cell. Nor can we destroy a behavior as we might destroy a cell to identify its descendants by their absence in the developed organism. However, we can seek to accelerate the appearance of a behavior. If the acceleration succeeds in speeding the appearance of one behavior, and also — without further intervention — the appearance of a later behavior, we might with some justice conclude that behavior *one* is causally connected with behavior *two*, subject of course to many obvious qualifications. The first experiment to be reported here was directed only at establishing the presence or absence of a long-term causal connection between three substages in the development of the object concept, with long term acceleration effects as criteria for causation.

Two of the three phases of behavior under investigation were briefly alluded to above. The first phase concerns the development of accurate visual tracking of objects, and terminates between four and five months of age. The second phase concerns the development of accurate, visually guided search for hidden objects, and terminates between nine and twelve months of age. The characteristics of the development of visual tracking in early infancy have been described elsewhere (Bower, 1971). Briefly, the infants of 12–20 weeks of age display two characteristic errors in tracking tasks. When tracking a moving object that suddenly stops, these infants will continue to track along the path on which the object was moving, ignoring the visible, stationary object. This error may be described as the result of an inability to identify a moving object with itself when stationary. The complementary error resulting from an inability to identify a stationary object with itself when in motion, has also been demonstrated, although with a somewhat more complex experiment. If infants of 12–14 weeks are presented with an object that moves from place 1 to place 2 and back again cyclically, stopping in both places, they can learn to track the object back and forth between the two places. The error described above occurs initially but drops out, so that the infants simply track the object from place to place. If, however, the object moves to a new place going from place 1 to place 3, the infants will look for the object in place 2, the place where they have usually seen the object, ignoring the fully visible

object at place 3. The infants will then look for an object in a familiar place, ignoring it as it moves to a new place. Both of these errors decline to zero frequency of occurrence by the age of 23 weeks in cross-sectional samples.

The second phase of development studied here was the transition from stage 4 to stage 5 of the object concept. When a child is in stage 4 he can retrieve an object that has been hidden under a cloth or in a container. However, if allowed to retrieve the object from one place, A, more than once, the child will search for the object at A after seeing it hidden at B, a different place. In stage 5 the child does not commit this error, and can find an object that he has seen hidden, regardless of his and its past history of hidings and findings. It is noteworthy that the error characteristic of stage 4 is persistence of search for an object at a place where the object has been found before, ignoring the new place where the object has just been seen to be hidden. At one level of description at least, this error seems identical to the error described above as characteristic of the tracking behavior of young infants; they look for an object where they have seen it before, ignoring the place where the object has just been seen to move to. The formal similarity between these behaviors would seem to argue against a causal connection between them, since it seems improbable that the same error should have to be overcome twice at different times in the development of the same concept, while there is adequate precedent for the same problems having to be overcome twice in the development of different behaviors (Bernstein, 1967).

The third phase of the behavior investigated was the transition from stage 5 to stage 6 of the object concept. In stage 5 the infant makes errors that can be explained as an inability to track invisible displacements of an object. The way we assess this inability was devised independently by Aronson and McGonigle.* The child is presented with two cups or cloths under one of which a toy is placed so that it is out of sight. The stage-5 child has no problem in finding the object under such circumstances, no matter what the sequence of hidings is. If, however, the two cups or cloths are transposed so that the cup or cloth containing the object is in the place that was occupied by the other cup and vice versa, the stage-5 child will pick up the wrong cup. The transposition is done in full view of the child who nonetheless fails to take the transposition into account in choosing which cup to pick up.

1. Subjects

Sixty-six infants served as subjects. They were divided into an experimental and a control group, matched for birth order, sex, and parental occupation.

* Pers. comm.

2. Procedure

The tracking task (Bower and Paterson, *op. cit.*) was as follows. The object to be tracked was a 10 cm. diameter bulls-eye, painted in day-glo pink, white and orange. It was mounted at the end of an arm 30 cm. in length, driven by a sweep generator at .24 cycles per sec, through an arc of 180°. The infant sat one meter from the display. Object position was monitored by a T. V. camera mounted behind the infant. Head and eye movements were monitored by a T. V. camera mounted behind the display. The output of the two cameras was combined and fed into a VTR, providing a simultaneous record for subsequent analysis of object position and head and eye position.

The object was set in motion before the infant was brought in. The presentation 'began' when the infant first looked at the display. From this point, twenty movement cycles were presented. The last cycle and a random three others incorporated a stop in which the object stopped moving for ten seconds. Stops were always made in the central 90° of the arc. Records were scored for frequency of tracking on all trials. Behavior on the stop trials was scored for the following features.

1. Did the infant stop and fixate the stopped object?
2. If yes, for how long?
3. If no, did the infant continue to track the trajectory of the object?
4. If no to both 1 and 3, did the infant (a) return to starting point of movement, or (b) look away?
5. If yes to 1, did the infant then after the time given in 2, (a) continue to track the trajectory of the object, or (b) look back to starting point or (c) look away?

Records were scored by two observers.

The experimental group was given weekly exposure to the tracking task from 12 weeks until 16 weeks. The control group was given an equivalent number of laboratory visits that did not involve tracking and then tested on tracking at 16 weeks.

After this test no further tracking experiments were carried out. However, all of the infants were brought in ten times to participate in experiments on reaching before the object-permanence testing was begun and repeated weekly. It was originally intended to continue the object-permanence testing until all of the infants had reached stage 6. However financial considerations forced us to stop before this point was reached.

The object-permanence testing was always begun with a simple stage 4 test. An object was covered by a cloth in view of the infant. If the infant succeeded in obtaining the object, the stage 4-5 transition testing was begun. Two cloths were placed on the table, and the object hidden under one of them, A. After retrieval and recovery from the infant, it was again hidden under the same cloth, A. After retrieval and recovery from the infant, it was hidden under the other cloth, B. After this, new cloths and a new toy were introduced, and the procedure repeated. After each AAB sequence toys and

cloths were changed. The side chosen as the A side varied randomly from trial block to trial block. Six AAB sequences were run through. When the child reached the criterion of six errorless B trials, the stage 5-6 testing sequence was begun. On each week thereafter the infant was given one AAB trial, as described above, before the testing proper began. The testing procedure was as follows. Two cloths were placed on the table. An object was placed under one cloth, with the baby watching. The positions of the two cloths were then transposed. Six trials were given. Testing was discontinued after two sessions without errors.

3. Results

The results are summarized in Table 1. As can be seen there, the accelerated group maintained and even increased its lead over the whole experiment. It will be seen there that the results as presented are a hybrid of measures, with number of errors at a particular age used in one place, and age of attainment of zero errors used elsewhere.

Table 1. *Development of Stages of the Object Concept in Experimental and Control Groups of Infants*

	Accelerated	Control
Probability of errors in tracking at 16 weeks	0	.51
Mean age of attainment in weeks of Stage 5	39.3	48.6
Number reaching Stage 6	.8	.6
Mean age of attainment in weeks of Stage 6	43.7	59.5

We had originally intended to treat our results in terms of errors at a particular age only. However, the developmental changes in errors were such that a measure of that sort would be necessarily misleading. The use of such a summary depends on the assumption that performance improves continuously from zero correct responding to zero errors. In the course of the experiment it became obvious that such an assumption would be entirely erroneous in this context. Fig. 1 shows the performance of one infant in the weeks up to and including the last error in the stage 5-6 transition test. This profile was not uncharacteristic of all of the infants and certainly does not suggest any continuous decline in errors. The distribution of errors for all of the infants on the last day on which they made an error in the stage 4-5 transition test is shown in Table 2, which also gives the expected distribution on the assumption of random responding.

Figure 1

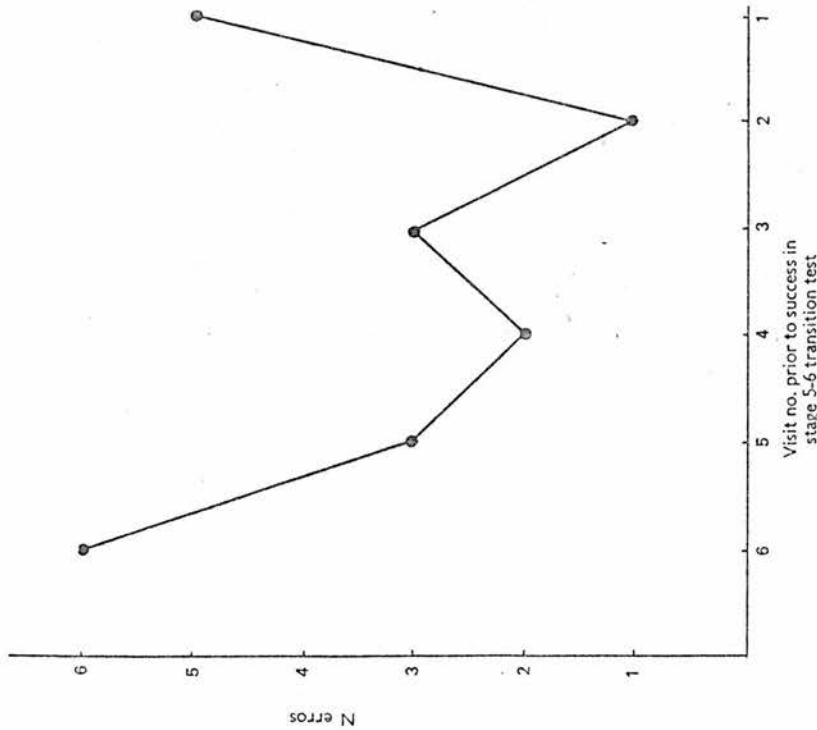


Table 2. *Expected and Obtained Distributions of Errors on last error trial of Stage 4-5 transition test*

N errors	f expected	f obtained
6	0	1
5	5	6
4	13	14
3	18	14
2	13	12
1	5	7

chi-square = 2.09, .90 > p > .75

As can be seen there the difference between the two distributions is not significant. Table 3 shows expected and observed distributions of errors on the last error trial of

Table 3. *Expected and Obtained Distributions of Errors on last error trial of Stage V-VI transition test*

N errors	f expected	f obtained
6	1	3
5	3	1
4	7	6
3	9	12
2	7	6
1	3	2

chi-square = 6.9, .25 > p > .10

the stage 5-6 transition test, for those infants that reached stage 6. The difference is again not significant.

4. Discussion

The results described above support the hypothesis that there is an object concept developing from birth onwards and that facilitatory intervention at one point will speed development at later points. However, results like this tell us nothing unless we can devise a plausible theory to link the various stages. That is beyond the capacities of the present writers. However, we will outline some of the questions such a theory would have to answer, and some of the answers the theory might come up with.

The theory would have to be able to describe the infant's concept of an object at each stage of development. This is not such an easy task as one might suppose, since there are apparent circularities and reversals in the course of development. For example, there is evidence that a 12-week-old infant expects that a stationary object will remain in place after it has been covered by a screen (Bower, 1971). There is evidence that a 12-week-old infant expects an object that moves behind a screen to reemerge from behind the screen. By around 20 weeks these two bits of information are coordinated. Why then does the 24-week-old infant, presented with an object covered by a cloth or a cup, act as if the object was no longer obtainable? The hypothesis that this results from lack of motor skill (Bower, 1967) has been disproved (Yonas, pers. comm). Bower (1967) suggested covering objects with transparent covers; if motor skill hindered success with opaque covers, it should equally well hinder success with transparent

covers. Yonas found that this was not so; infants who were successful with transparent covers were not successful with opaque covers. Perhaps the answer lies in the object concept, or perhaps it lies in the concept of a cover. Certainly the covers used at 24 weeks to elicit manual search are different as stimuli from the screens used at 12 weeks to elicit visual anticipation.

A similar problem arises with the latter stages of looking behavior and manual search. By around 20 weeks the average infant will look for an object where he has seen it move, ignoring the place where he has been accustomed to see it. Why then does the infant some months later search for an object where he has been accustomed to find it, ignoring the place where he has just seen the object hidden. Is this error a result of conceptual development or does it represent lack of transfer of information from the eye-movement control system to the hand-movement control system? There is some evidence favoring the latter interpretation in an unpublished study by Heinowski (pers. comm.) who found that infants who were in stage 5 as far as their hand movements were concerned were still in stage 4 when required to crawl to a hidden object. That is to say, they would crawl to the place where they had been accustomed to find the object, rather than the place they had seen it hidden. If what we are observing here is lack of transfer of information between motor control systems, then it is not a problem for a theory of development of the object concept. This explanation, however, runs into difficulties with the experiment described here, since it is hard to see how motor skill could transfer between motor systems as diverse as those of the eye and the hand.

These then are some of the descriptive problems that must be solved before a theory of the development of the object concept can even begin to consider the processes that produce the development.

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Résumé

Certains problèmes surgissent lorsqu'on discute du développement du concept de l'objet. En effet les moyens utilisés pour établir le statut de ce concept changent radicalement au cours de la période du développement. Cependant le concept lui-même ne semble pas se développer d'une façon continue. Une expérience d'accélération a été faite pour voir si une intervention effectuée à un moment donné au cours du

processus hypothétique peut avoir une influence sur le développement postérieur. Les résultats sont positifs et suggèrent qu'il y a effectivement une conception de l'objet qui se développe au cours d'une période de 18 mois. Cependant, cette expérience a également montré, et cela d'une façon inattendue, que ce développement est discontinu et se ferait par paliers.

The effects of motor skill on object permanence

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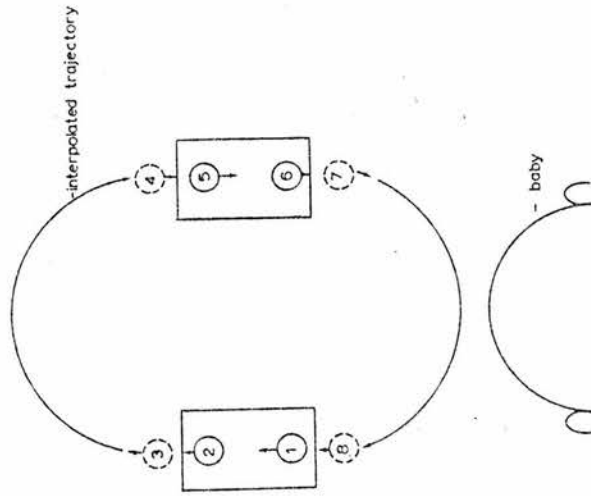
Abstract

Piaget found that infants in the first year of life will not remove a cloth or a cup that they have seen cover a toy. Part of the difficulty is a motor skill problem. However, deficits in motor skill are not sufficient to account for the failure in the situation. We cannot assume that out of sight is out of mind for such infants for they will reach out to obtain an object that has been made to go out of sight by switching off the room lights, leaving the baby in total darkness.

Piaget (1954) found that if one presents a six-eight month old infant with an attractive toy that is then covered with a cloth or a cup before the infant can grasp it, the infant will make no attempt to remove the obstacle to get at the toy. This observation has been interpreted as showing that such infants think that an object that is no longer visible no longer exists; out of sight is, allegedly, out of mind at this stage of development. Other investigators, by contrast, have found that infants of twenty weeks or less do seem to believe that objects that are out of sight still exist in a localizable place. Thus, Bower, Broughton and Moore (1971) found that infants of twenty weeks were able to anticipate the reappearance of an object that had moved out of sight behind a screen. Mundy-Castle and Anglin (1970) found that even younger infants were able to do this and in addition to follow the invisible path of the object while it was out of sight, even when that path was complex (Fig. 1). These experiments would thus seem to show that out of sight is not out of mind for infants of twenty weeks or more.

The standard interpretation of Piaget's classic observations is in contradiction with the more recent observations described above. Bower (1967) argued that the contradiction was more apparent than real. Bower *et al.* (1971) and Mundy-Castle and Anglin (1970) used eye movements as indicator behaviors to make manifest

Figure 1. Mundy-Costle and Anglin used the apparatus shown here. They found that, after the object disappears in one window, prior to its reappearance in the other, infants of 16 weeks will interpolate an eye-movement trajectory corresponding to the invisible path of the object.



the infants' knowledge about objects. Piaget, by contrast, used hand movements, manual search behavior, as an indicator. Manual search behavior is a far more complex task for an infant than is visual search behavior. Control of the hand develops much later than control of the eyes. Bower (1967) thus argued that the apparent contradiction between Piaget and the other authors cited was simply a matter of experimental method: The infants in the Piagetian manual search situation knew that the toy was under the cup but they did not know how to remove the cup to get at the object.

Bower presented data in support of this hypothesis gathered in an informal experiment in which 5-6 month old infants were presented with a toy that was covered, before they could reach it, with a transparent cup. Since an object under a transparent cup is fully visible all the time, a failure with it could not be put down to out of sight meaning out of mind. Failure with a transparent cup could only result from lack of manual skill, and the same lack of manual skill could explain failure with an opaque cup, without thereby suggesting that the infants did not know that an object they had seen hidden under a cup was under the cup.

The results gathered from what was an extremely unsystematic experiment favored the hypothesis that 5-6 month old infants fail the standard Piagetian test because they lack the motor skill to pick up a cup; the infants failed with both transparent and opaque cups. The data was gathered very unsystematically and, indeed, was not reported as an experiment. Yonas (pers. comm.) and Graich (pers. comm.) have performed more systematic replications, finding the opposite result, that infants who failed with opaque cups could remove transparent cups. Since the result is important for theories of the development of the object concept, it seemed worthwhile performing the experiment with more control of conditions than had been employed before in any of these studies. The first experiment was thus a systematic replication of the observations reported by Bower (1967).

Although at first sight there would seem to be few methodological problems involved in testing whether or not an infant knows there is an object under a cup, this first impression would be very misleading. Object permanence experiments are done under somewhat relaxed conditions with a heavy emphasis on rapport between subject and experimenter. Given the need for rapport, it is essential to have very precise definitions of what constitutes a passing response or a failing response. The mere fact that a child finishes up with the object that was hidden in his hands is not a scorable piece of information. The following considerations must be borne in mind in devising criteria for a pass or fail response in an object permanence situation. First of all it must be certain that the subject can pick up an object from a foreplane surface. If the baby cannot pick up any object at all, there is little point in checking whether or not the subject can pick up an occluder to get at another object. If the subject can pick up an object, then it follows that he can pick up an occluding object, provided the occluder is not too large. However picking up an occluding object is not the same thing as picking up an occluding object in order to get at an object that had been hidden underneath the occluder, and it is the latter action that we wish to consider criterial in this situation. Piaget has certainly never denied that infants who do not have object permanence can nevertheless pick up objects. The special characteristic of picking up an occluder in the object permanence situation is that the occluder is not picked up for its own sake but is removed to allow the infant to get at the object that has been occluded. It is this ability to conjoin actions rather than the mere ability to pick up an occluder that Bower (1967) thought was lacking in the infants who failed the standard object permanence test. The problem is thus to decide whether an infant who picks up an occluder is picking it up for its own sake or in order to get at the object inside the occluder. The criterion was as follows. Prior to the beginning of object permanence testing the infants were presented with a toy placed on the table top before which they sat. The time from presentation up to successful capture of the object

was recorded; this time interval will be referred to as free capture time. It was determined that if an infant removed an occluder and then picked up the object that had been under the occluder, with the time from removal of the occluder to picking up the object less than that infant's free capture time, the infant would be recorded as having picked up the occluder to get the object, a successful response. Picking up an occluder without getting the object that had been occluded or only getting it after an interval longer than free capture time was scored as a failure.

Subjects

16 twenty-one week old infants served as subjects, 8 male, 8 female.

Procedure

Subjects sat at a plain brown wooden table, facing the experimenter. A stylized manikin 4.0 cm high, painted day-glo pink, by 1.5 cm in diameter was used as a toy. Previous work had found this to be a desirable enough toy. The transparent occluder was a plastic cup 6 cm high by 3 cm in diameter, with a transmission ratio of .7, so that an object within it could be clearly seen while the cup itself was clearly visible. The opaque occluder was a white plastic cup 6 cm high by 3 cm in diameter, that was perfectly opaque.

The infants were presented with the toy, placed within reach, and their free capture time recorded. After 15 seconds the toy was taken away from the baby. In its original location was placed one of the occluders, the opaque to 8 babies, the transparent to the remainder. Free capture time was recorded. The occluder was then taken away and the toy replaced in its original location. Before the baby could take the toy again the opaque occluder was placed over the toy. The baby was then given three minutes to remove the occluder before the trial was terminated. At the end of the trial the occluder was removed revealing the object which the infant was allowed to pick up and retain for 15 seconds. At the end of this time the toy was removed and replaced in its original location, this time being covered by the transparent occluder. Trial duration was again three minutes, save that if an infant had a hand on the occluder at the end of three minutes he was given a further two minutes to complete his response. At the end of this period, if the infant had the toy, it was taken away, replaced and recovered by the opaque occluder, with a trial duration equal to that given with the transparent occluder. If the infant did not have the toy at the end of the transparent occluder trial, the occluder was removed, and the infant allowed to take and retain the toy for 15 seconds before the second opaque occluder trial was begun.

Results

The results are summarized in Table 1. As can be seen there, the hypothesis that there is no difference between an opaque and a transparent occluder as obstacles in a manual search task can be clearly rejected. The opaque occluder was far more difficult than the transparent occluder. On the other hand, it cannot be concluded that the transparent occluder offered no difficulties at all. Only eight infants were clearly able to pick up the occluder to get at the toy. The latency of picking up the transparent occluder when there was a toy inside it was far greater than the latency to pick up the occluder alone, indicating that the conjoined response was more difficult.

Condition	N. picked up occluder	Mean time to pick up occluder	N. picked up toy	Mean time to pick up toy	N. within free capture time
Opaque 1	0	—	0	—	—
Transparent	14	115 secs	10	40	8
Opaque 2	2	125 secs	2	35	2
		Mean free capture time for object	45 secs		
		Mean free capture time for occluder	55 secs		

Discussion

The result of this experiment reopens the issue of the apparent contradiction between the eye movement results cited above and the classic Piagetian manual search task. The transparent occluder did pose problems but not enough to account for the difficulties shown with the opaque occluder. Part of the problem in the classic situation is behavior sequencing but it is obvious that the opaque occluder, with the toy out of sight, produced yet more serious problems, seemingly implying that out of sight is out of mind in the manual search situation. Since out of sight is definitely not out of mind in eye tracking situations, this raises the theoretically interesting possibility that there is a process of decalage operating between the eye movement control system and the hand movement control system; with, at this stage of development, the eye movement control system knowing that out of sight objects still exist while the hand movement control system has not yet incorporated this information. As Piaget normally uses the term decalage it is applied to extension of information from one situation to another that resembles the initial one formally if not in detail. One can thus speak of decalage between conservation of volume and conservation of weight since the situations are formally similar and developmentally asynchronous. It would not be doing violence to the concept to use it in the context

of an asynchrony between an ability to find objects that have gone out of sight by eye and the ability to do this with the hand. However, the statement 'out of sight is out of mind' is a very broad one. The data of the experiment described above do not unambiguously support such a statement. The transparent occluder did produce difficulties, so that the resulting non behavior might have resulted from a summation of occluder effects with effects of the out of sight condition, without the latter being so severe that the infant thought that the occluded toy no longer existed. To test this hypothesis it is necessary to have an out of sight condition that imposes no behavioral problems or only very minimal ones. If out of sight is out of mind for the hand the absence of behavioral problems will not help the infant. If, on the other hand, out of sight is simply a problem, then the absence of the additional behavioral problems posed by the classic situation might allow the babies to succeed. The next experiment was designed to test this hypothesis.

Subjects

12 twenty-week old infants, 6 male, 6 female, served as subjects.

Procedure

The subjects were given a standard Piagetian object permanence test as described in experiment 1. All of them failed to do anything with the occluder. They were then given a different out of sight condition. The table used before was removed. The manikin was presented on the end of a string, dangling in front of the baby. Before the baby could reach out for the toy, the room lights were extinguished. Since the room was light tight, this left the baby in total darkness. The toy was thus out of sight, as was everything else in the environment. The babies' behavior was observed and recorded with an infra-red T.V. system, the vidicon of which was sensitive to light between 850 and 875 millimicrons. Illumination in this spectral band, which is totally invisible to the human eye, was provided by a specially constructed light source. The babies were left alone in darkness for three minutes. At the end of this time the standard object permanence test was repeated.

Results

None of the infants passed the standard object permanence test on either presentation. All of them were able to reach out to obtain the object out of sight in darkness. The reaching in the dark was accurate. The hands went straight to the object locus - see Fig. 2 - even after initial periods of distress lasting as long as 90 seconds.

Discussion

It thus seems that out of sight is not necessarily out of mind, not even that part of the mind that controls hand movements, provided the transition to out of sight is accomplished by plunging the room into darkness. One could infer from this that out of sight is not out of mind in the standard test situation either, the difficulties of the motor task simply summing with difficulties created by the fact that the object is no longer visible. On the other hand, one should beware of equating all the changes in stimulation that result in disappearance of an object. The psychophysics of disappearance has been studied (Michotte, 1962; Bower, 1967; Gibson *et al.*, 1969) and it is clear that some disappearance sequences result in perception of the continued existence of the object that has disappeared while others have just the opposite result, the vanished object seeming to no longer exist anywhere. It is possible that disappearance under a cup or a cloth is a disappearance transformation of the latter sort, for infants of 5-9 months. More careful psychophysical work will be required to decide the issue.

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