LEARNING HOW TO LEARN: THE DEVELOPMENT OF MEMORY IN 3-6 YEAR-OLDS

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Dissertation submitted for the
Degree of Ph.D. to the
University of St. Andrews.

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October 1982
PREFACE

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration.

ACKNOWLEDGEMENTS

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ABSTRACT

The aim of the present study was to investigate the development of children's ability to make use of external sources of information when they are studying or remembering different types of information. More specifically, the research was directed at two recurring problems for theories of memory development: the production deficit; and the problem of change.

The production deficit describes children's failure to spontaneously use a strategy which is 'in' their behavioural repertoire. Use of the strategy can be induced with minimal training. The study contains a set of experiments which suggest a number of reasons why children may fail to use available strategies.

Another major problem with theories of memory development lies in explaining changes in strategy use. Three experiments address the issue, and suggest two mechanisms which produce such changes. The experiments indicate that feedback may provide one means by which routines already in the cognitive system are generalised to serve memory goals. Monitoring of one's own performance may also produce such changes. These mechanisms are incorporated into a model of how early strategies might develop.

Other theories of memory development have stressed young
children's lack of knowledge about their own memory processes. This has been invoked to explain both the production deficit and developmental change. Apart from the demonstrations that monitoring may influence strategy generalisation, the study found little evidence that knowledge about memory is related to either of these phenomena. Current theories of the development of knowledge about memory are reviewed, and it is suggested that there are major problems with explanations of memory which appeal to such knowledge. One weakness of such theories is that they fail to explain the origins of this knowledge. The present study provides an account of the early development of knowledge about memory.

The results of the experiments are also considered in the light of recent speculations about developmental theories and also memory processes in adults. It is suggested that the mechanisms of change demonstrated in this study may well apply to other areas of development. It is also argued that recent theories may have misrepresented the nature of adult memory processes.
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INTRODUCTION COGNITIVE THEORIES AND MEMORY DEVELOPMENT

0.1 The issues

This chapter provides the background both for the review of literature in Chapters 1, 2 and 3 and the experiments conducted in Chapters 4, 5 and 6. It begins by discussing what attributes an adequate developmental theory should possess and then focuses on particular issues which have been controversial in recent developmental psychology. These issues are also discussed in the light of theories of memory development. Thereafter, the concern is with psychological accounts of memory and the importance of the environment in everyday remembering.

0.2 Criteria for a developmental theory

Despite the enormous amount of research effort which has been dedicated to the study of particular theories of development, there has been little speculation about what criteria theories of development in general have to satisfy. There are of course, some exceptions to this, (e.g. Atkinson, 1982; Brainerd, 1978a; Flavell, 1972; Flavell and Wohlwill, 1970; Wohlwill, 1973). Simon (1962) characterises the construction of developmental theories in the following way:

We select certain instants in the course of .... dynamic change, take 'snapshots' of the system at
these instants, and use these snapshots as descriptions of the system at a particular stage of development. (p. 130).

Though this account will explain some aspects of behaviour at different points in development, it is not truly developmental because it fails to provide a mechanism which will explain the transformation of the system from one 'instant' to the next. The account is misleading in a second respect; there are many different approaches to a given psychological field (e.g. in the field of language we have theories of pragmatics, syntax and semantics), and it is clear that no single theory will account for all the phenomena within one of these fields. A developmental theory should therefore have a limited domain of application within its field.

Atkinson (1982) offers a detailed set of five criteria for judging the adequacy of theories of language development. Following Newell (1962), he proposes that a developmental account requires the construction of a series of explanations of behaviour at different points in development. He labels each of these explanations as a theory \( T, \ldots, T_1, \ldots, T_n \) which applies at a given point of development \( t_1, \ldots, t_i, \ldots, t_n \) in a domain \( D \).

Atkinson's first two conditions concern the relationship of the developmental theories to general psychological accounts. He argues that each development theory \( T_1, \ldots, T_1, \ldots, T_n \) should constitute an adequate psychological explanation and that all the theories \( T_1, \ldots, T_i, \ldots, T_n \)
should be constructed in accordance with a particular general theory. While the first condition seems acceptable, the second may be problematic because there are acceptable developmental accounts which appeal to different general theories. Atkinson is aware of this possibility "if the \( T_i \) \((1<i<n)\) are not so constructed, then additional argument may restore the explanatory status of \( T \)." (p. 26), but in adding this qualification, the original condition has been weakened.

Atkinson borrows from Flavell's (1972) analysis of developmental sequences in the construction of his next two conditions. It is important to note that Flavell's analysis was intended to operate at the level of individual cognitive 'items', and not at the level of theory construction discussed by Atkinson. His third condition is that if theories admit of additive complexity, then they are explanatory only if \( T_{i+1} \) is additively more complex than \( T_i \). The latter part of the statement seems to capture an important intuition we have about development: that the organism becomes more complex (see Harris, 1957 and Brown, 1973, for these arguments). As Atkinson and Flavell note, however, it is possible that some sorts of developments may lead to the simplification of the theories explaining behaviour. One such mechanism by which this may be achieved is generalisation, by which a single cognitive item takes over the functions which had been served by a number of different items, thus simplifying the theory we offer to explain behaviour. Atkinson recognises this by introducing
an alternative third condition, that if the theory operates within a domain of constraints, then $T_{i+1}$ should be less complex than $T_i$. This explains the qualification in the first version of the third condition, that the theories must "admit of additive complexity". However, there are sequences in theories which admit of additive complexity which may not result in more complex theories. Flavell (1972) notes that the substitution of one item for another may have this result.

Atkinson's two final conditions concern the explanation of theoretical sequences. The fourth condition states that a developmental theory has explanatory status only if the sequence of theories ($T_1, \ldots, T_n$) admits of a teleological, a reductive or an environmental explanation. A teleological sequence occurs when an early theory is included in a later one. To give an example at the level of individual cognitive items: the ability to name objects quickly is a prerequisite for verbal rehearsal, and it would be impossible to imagine an account in which rehearsal emerged before this ability. A reductive sequence involves appeal to some other level of explanation in attempting to account for the sequence. To give another example: it has been argued (e.g. Denney and Ziobrowski, 1972) that children change from clustering items in recall according to functional criteria, to recall according to taxonomic criteria. Denney (1972) argues this is due to a change in underlying cognitive structures, and a corresponding shift from the classification of objects according to functional
criteria, to their taxonomic classification. Other types of reductions are possible e.g. to the level of physiology, but the basic principle remains that certain items at one level of our theory can be related to items at a different level of explanation, that the sequence of the items of the reducing theory is repeated at the level of the theory to be reduced, and that the items emerge in the reducing theory before they do in the theory to be reduced. The environmental reduction argument is that items could not emerge before time \( t_1 \), because they were simply not available in the environment before this time. One such sequence may relate to arguments about Motherese (e.g. Snow and Ferguson, 1977). The argument is that children base their early utterances on the speech of caretakers, which is carefully tailored to match the linguistic and cognitive demands of the child. Caretakers thus exclude complex syntax or complex concepts from their speech to children. Thus the environment could not be said to make such information available to the children.

The final condition concerns the proposal of the mechanism of change discussed earlier. Atkinson states that theoretical adequacy is only achieved when a mechanism is provided to explain the sequence of theories described above.

It seems that overall, despite the problems with Atkinson's second and third conditions, his account is well supported by other research that has failed to find such a change, but this does not affect the argument.
motivated. While his criteria will not be explicitly applied to the theories of memory and metamemory development discussed in Chapters 1, 2 and 3, the arguments he offers are important, especially concerning explanation and the mechanism of change, and some attention will be paid to the problems he raises.

0.3 The Piagetian legacy and recent issues in developmental psychology

Leaving aside these normative statements about developmental theories, there are a number of particular issues which have generated controversy in recent developmental psychology. The dominant theory in this field has been that of Piaget, and the controversies have mainly arisen from demonstrations that his predictions are not fulfilled.

0.3.1 Generality

The first concerns the generality of cognitive structures. Piaget's structuralist approach led him to propose that children's logical skills could be explained by a limited number of highly general logico-mathematical structures. According to Piaget, all tasks which tap the same structures should be performed with equal facility. However a large number of experimental studies have shown this assumption to be false. In particular, it has been shown that subjects do not perform at the same level on tasks which are logically isomorphic. (Donaldson, 1978;
Johnson-Laird and Wason, 1977). While these studies have shown a lack of generalisation, and recent theories of development (e.g. Fischer, 1980; Keil, 1981) recognise this fact, there have been no real attempts to specify the factors which constrain generalisation.

In principle, the above studies do not demonstrate that thought processes are necessarily context-specific, all they show is that generalisation does not occur for the logically isomorphic tasks which Piaget studied. It may be that generalities can be found if a different level of analysis is employed.

A first step towards such an analysis may be provided by recent studies which have offered explanations for the context-specificity of thought. Two sorts of arguments have been made to explain young children's failure to generalise a skill which is 'in' their cognitive repertoire. The first (e.g. Brainerd, 1973; Bryant, 1974), suggests that our criteria for inferring the presence of a skill require abilities in addition to those under study. Simplify the task, and the skill will be manifested. The context-specificity here is explained by the fact that the 'simple' and 'complex' tasks may be logically isomorphic, but they place different information-processing demands upon the children. Other writers, (e.g. Bruner, 1966; Donaldson, 1978) suggest that children have problems in accessing the appropriate cognitive skill in certain tasks. Both suggest however that within certain domains,
cognitive skills will generalise.

The problem of context-specificity is not limited to the study of purely cognitive skills, however, for as Chapter 1 will illustrate a major feature of young children's memory behaviour in certain task situations, is that they fail to use strategies which are clearly 'in' their behavioural repertoire. A major aim of Chapter 4 is to examine what underlies preschool children's failure to employ a memory strategy in various situations.

0.3.2 Competence in preschoolers

Another problems for Piagetian theory was the finding that the cognitive structures which were supposed to emerge late in development could sometimes be found in very young children. Piaget's theory can explain away the late emergence of cognitive structures in terms of "environmental factors", but early emergence clearly cannot be incorporated into the theory.

Aside from the implications for Piagetian theory, the research into preschoolers' capabilities is important in the consideration of other developmental problems, such as change. If the demonstrations of preschool competence are correct; we have clearly simplified the problem of explaining change. If the thought processes of adults and children are "similar", then the mechanism we propose to explain change will have to be considerably less
powerful, than if adult and child thought are radically different. Of course, it still remains to be specified exactly what is meant by arguing for the 'similarity' or 'difference' of thought processes through development, and this is a major problem with recent accounts (e.g. Keil, 1981) which adopt this position.

Whatever we might find out about memory skills in preschoolers therefore has implications for such theories, but there is also some internal debate within the memory development literature about the extent of the preschooler's memory skills. Early studies (e.g. Appel, Cooper, McCarrell, Sims-Knight, Yussen and Flavell; Yendovitskaya, 1971) suggested that young children were incapable of using deliberate cognitive strategies in order to remember. This led to a further set of studies (Wellman, Ritter and Flavell, 1975; Yussen, 1974) which indicated that this was false. These in turn generated other studies which showed that apparently intentional strategy use may have a stimulus-response type characteristics (e.g. Gordon and Flavell, 1977; Ritter, 1978).

One aim of the experiments conducted in Chapters 4, 5 and 6 is to assess exactly the nature of strategy use in very young children. In addition to resolving an empirical dispute, the memory capabilities of preschoolers will clearly influence the nature of the developmental change we have to explain.
0.3.3 Change

A final issue concerns the mechanism proposed to account for change. Piaget explains this process in terms of a homostatic mechanism of assimilation and accommodation. Fodor (1972) points out one major problem with this explanation. According to Piaget, development takes the form of long periods of 'preparation' in which minor changes in structures occur. These are followed by 'achievement phases' in which structures undergo radical and general change. Fodor argues that one mechanism cannot explain these two radically different types of change. We might wish to argue, as Flavell and Wohlwill (1969) have done, that Piaget's preparation-achievement description is incorrect, and that all development consists of steady quantitative type change. If there is only one type of change, then Fodor's argument does not apply. There is, however, a much more serious problem with Piaget's account: it is circular, because the processes of assimilation and accommodation proposed to explain change, cannot be inferred independently of the changes they are proposed to explain.

Other developmental research has not suggested much to replace such an account. There have been a set of more piecemeal attempts to investigate possible mechanisms in particular the role of conflict in inducing change (e.g. Bower, 1974; Bryant, 1974; Doise, Mugny and Perret-Clermont, 1975; Russell, 1982) but these could not
be said to represent a coherent alternative. Evidence from training studies could be utilised in the search for change-inducing mechanisms, but for the most part such studies have concentrated on demonstrating that a behaviour which is not spontaneously manifested may be induced with suitable training. A further problem with training studies are that they show sufficient but not necessary conditions for change.

The approaches described above also tend to assume a single change-inducing mechanism. There are two pieces of evidence suggesting this may not be entirely justified. Firstly, the earlier discussion of context-specificity might lead one to propose that a single mechanism cannot explain change in a widely fragmented system. If thought is context-specific, then the mechanisms which lead it to change may be also context-specific. Secondly, cross-cultural research (e.g. Greenfield, 1969) has indicated that there may be separate routes to the same cognitive acquisition, which would again imply the need for multiple mechanisms.

In contrast to cognitive theories, the problem of explaining change has been considered in some detail by theories of memory development. In particular, Flavell (1971) and Brown (1978) have argued that changes in cognitive strategy use are the result of children's increased knowledge of their own memory processes. The adequacy of this explanation is subjected to theoretical analysis.
Chapters 2 and 3, and to experimental test in Chapters 4, 5 and 6. A further reason for conducting these studies is that there has been little investigation of preschool children's knowledge of their own memory processes, and none of it has been attempted to establish how this knowledge influences memory.

0.4 Memory

0.4.1 Defining memory

It is important that any developmental account of something must include an analysis of what that thing is. One problem with undertaking such an analysis lies in the diversity of the phenomena which are describable by the term memory. A core meaning to the term would seem to involve the reproduction of autobiographical events, but it is clear that such a definition is too restrictive, because it is possible to remember things one has not experienced (e.g. the date of Queen Victoria's coronation), and there are certain things which are not event-like which are remembered (e.g. the colour of a friend's eyes or how to drive a car).

In addition to the different types of information which can be remembered, we must provide some account of how such information is initially acquired and also appropriately accessed. We must also explain the phenomenon of being unable to access information once known, i.e.
forgetting. Now given the diversity of types of information to be remembered, it is likely that there will be different explanations for the processes involved in acquisition and access of these different types. Thus, remembering the plot of a book or story may occur as a byproduct of comprehension and interest, whereas remembering facts for examinations may require detailed intentional strategies such as imposing organisation on the materials or note-taking. Accessing information will clearly depend not only on the type of information, but also on the requirements of the situation. Thus, for example, remembering in the absence of environmental support may be considerably different from remembering when the environment provides support such as diaries, reference books or other people as external information sources. A related point is that the criteria we use in applying the term memory, may vary with the type of material and situation. Thus, verbatim recall is unnecessary if we are to attribute someone with remembering an incident or story, whereas absolute accuracy of reproduction is necessary if we are to claim to have remembered a telephone number.

0.4.2 Domains and theories

As we noted earlier for the case of language development there are a number of different approaches to the same field within psychology. This is also reflected in the different focusses of theories of memory. Thus, early
approaches to memory investigated only the processes involved in learning and forgetting of arbitrary stimuli, whereas later ones proposed that the organism transforms the information it receives, and the focus became the internal organisational structure of the organism which enabled such transformations. More recently there has been some stress on how memory is used in other cognitive tasks (e.g. Baddeley and Hitch, 1974).

The present thesis will be constrained to the study of constructive and reconstructive processes in memory, i.e. children's preparation for retrieval, and retrieval, when external sources of information such as cues are present. Such processes were chosen for study because they reflect the types of processes involved in everyday remembering and also those required in schools. In particular, I shall be interested in the use of intentional strategies in memory, because knowing when something has to be done in order to remember is again important in education.

One problem is choosing such a domain is that there is no obvious theory of adult memory to account for these phenomena. An obvious strategy in constructing developmental theories is to take the adult account and to investigate how it relates to developmentally prior phenomena. Although Reitman (1970), Norman (1973) and Collins, Warnock Aiello and Miller (1975) do have some useful suggestions about these memory processes, the major attempts to
deal with this problem have been developmental, and it is these which are reviewed in Chapters 1-3.
1.1 Historical background and mediational theories

It has often been suggested that a qualitative change takes place in the nature of thought processes sometime between infancy and school-age, and this has sometimes been attributed to the increased role of language in controlling thought. (e.g. Vygotsky, 1962; Luria, 1961; Kendler and Kendler, 1961; 1962). These theories claim that the infant is largely stimulus-bound and incapable of reflection - but that the development of language and the symbolic function enable the older child to generate mediators between stimuli and responses, allowing him to exercise increasing control over his own behaviour. Although there are differences of detail among the theories, two reasons are generally given to explain the younger child's failure to mediate. The early theories (e.g. Kuenne, 1946; Kendler, Kendler and Wells, 1960; Reese, 1962) suggested some form of mediation deficit, i.e. the child generated a verbal response but for some unspecified reason it failed to mediate performance. The second reason, was advanced by Kendler (1964) and Maccoby (1964), who drew attention to the fact that children may not mediate because they fail to produce a mediator. These were combined in Kendler's (1964) model where the development of discrimination learning is represented as a three stage process. In the first stage, the child does not generate
the mediator spontaneously, nor does it improve performance when generated: this Kendler attributes to some unspecified 'structural deficit'. As children mature, the mediator does begin to influence performance, but they do not generate the mediator spontaneously. In the final stage, the mediator is generated in all appropriate situations and it does improve performance.

It is worth noting several problems with these theories. There is a failure to make explicit the processes by which mediation facilitates recall, and the related problem of explaining the mediation deficit (why a potential mediator sometimes fails to mediate) is not dealt with. In addition, no reason is given for the change from mediation to production deficit: why should a word suddenly begin to mediate performance? Finally, there is the problem of why children fail to utilise a mediator which is 'in' their behavioural repertoire, and which does improve performance. These problems are not unique to the above theories of discrimination learning; they also appear in the mediational theories of memory, which were derived from such theories.

1.2 The early experiments

In the late 1960's Flavell began a series of experiments on memory development utilising notions derived from the framework of mediational theories. Although he originally operates with concepts similar to the classical mediational
theorists, Flavell's experiments led him to suggest that the discriminative learning model of Kendler must be changed in important ways if it is to account for memory development. In the following account we see how theoretical concepts like mediation are extended to a range of non-verbal behaviours, and terms like production deficit are shown to have less precise meaning than was originally foreseen.

In 1966, Flavell, Beach and Chinsky conducted an experiment to investigate the role of verbal mediation in a simple task of memory for an array of objects. Children were shown a set of objects, which were named, and then the experimenter indicated a subset of the objects. The child had to remember this subset during a delay period, during which the objects were removed from view and point to the correct subset on a recall instruction. In contrast to the earlier discrimination learning experiments (Kuenne, 1946; Kendler et al, 1960) observation of mediation was carried out directly; one of the experimenters simply lip-read the instances of verbalisation. Rehearsal increased with age; about 10% of 5-year-old children were observed to name the objects, compared with 100% of 10-year-olds.

As recall data were not available in this experiment, it was impossible to directly test the relationship between verbalisation and recall. Flavell's next experiment investigated this issue, in the form of four different
hypotheses:

1. Does rehearsal increase performance? Spontaneous producers of the rehearsal strategy should outperform non-rehearsers. If they do not, this is evidence of a mediation deficit.

2. Can non-rehearsers be induced to rehearse? If they can, this indicates a production deficit.

3. Is induced rehearsal as effective a mediator as spontaneous strategy use?

4. Do children who are trained to rehearse maintain this strategy when they are not explicitly requested to use it?

The experimental task was the same as in the Flavell et al (1966) study: children were first classified as spontaneous producers if they rehearsed on 9 out of 10 pre-trials, or non-producers if they failed to rehearse on more than one pre-trial. Children who did not fall into either of these groups were dropped from the experiment. The producers were further sub-divided into a group who were given instructions on how to rehearse, and a group who were not given training. All non-producers were instructed in the rehearsal strategy, and all the three groups were given a retest on the original task, with both training groups being given instructions to rehearse before the retest began. Following this, more trials were administered, before which the experimenter explained to the children that they could say the names if they wished but it was no longer required of them to do so.
The results of the study gave clear answers to each of the questions. Children who spontaneously rehearse remember more items than non-rehearsers, and the rehearsal strategy can be trained in children who do not spontaneously produce it; these children now rehearsed on 75% of the trials. When trained producers use the strategy their recall is improved to the level of spontaneous producers. All this indicates that rehearsal does mediate recall, and that failure to rehearse is the only reason why non-producers do not perform well.

In theoretical terms we have clear evidence for a production deficit; the non-producers can be easily induced to produce a behaviour which mediates recall. Whenever rehearsal is used, recall increases, so there is nothing to indicate a mediation deficit. In answer to the final question, it was found that children who rehearsed only under instructions, quickly abandoned this strategy when they were no longer directly requested to use it. Ten of the 17 non-producers failed to use the strategy when given the choice whether to do so.\(^2\)

Flavell had therefore demonstrated a clear relationship between mediation by simple verbal rehearsal and recall. He had found strong evidence for a production deficit, but little to indicate problems of mediation.

\(^2\) But see the later discussion of the effect of instructions and priming on strategy selection.
In his next study (Moely, Olson, Holmes, and Flavell, 1969), Flavell attempted to investigate whether his results generalised to mediators of a more complex cognitive form than simple verbal rehearsal. It has often been demonstrated in the adult literature (G. Mandler, 1967) that sorting conceptually related items during study will considerably improve recall of lists of items. The question of interest was whether and when this would mediate performance in the young child. The study differed from early mediational research in another way: Flavell suggested that the change from production deficiency to spontaneous production may not occur as a sudden qualitative shift, as the mediation theories imply by the dichotomy they propose between elicited production under conditions of explicit instruction, and spontaneous production where no cues are given. Flavell argued that every situation includes some clues to the strategy required and that strategies first emerge when they are explicitly requested and gradually generalise to situations which provide weaker clues for strategy selection. To test this, Moely et al introduced an intermediate instruction condition in which the children were given a hint as to the strategy they should employ.

In the experiment, the children (aged from 5 to 11 years) were shown a set of pictures, which could be categorized into sets of animals, furniture, vehicles and articles of clothing. They were told they should study the pictures, so that later they could say them back to the
experimenter. It was suggested to the children in the control group that they could move the pictures or do anything they liked to help them remember. A second group (Naming) received more explicit cues for strategy selection - the experimenter named all the categories (e.g. "Things to ride in") and then pointed out each category member. In the explicit cue condition (Teaching) the children were told to sort the items manually, then label them, and then count the number of items in each category.

Strategy use was again directly observed by filming the subject's activity through a one way mirror. Following the test trials, the subjects were asked to sort the items. This is important, because it must be established whether failure to sort was due to an inability to categorise, or whether this is another example of a performance deficit, i.e. the subjects can category-sort but they just do not do so in order to remember.

The results of the sorting task indicated that even the youngest children were capable of some category-sorting, although the absolute level of performance increased with age. The interesting comparison, however, is between children's sorting behaviour under instructions to remember, with that under instructions to sort, that is how good are children at employing their sorting skills as a strategy to mediate recall? Moely et al compared sorting performance under the two sets of instructions
within subjects to control for differences in absolute sorting ability. They found that the ratio of clustering produced category sorting/under instructions to remember, to category sorting made under instructions to sort, increased from 0.07 in 5-year-olds to 0.60 in children aged ten, indicating that the older children were much more likely to employ their sorting skills to mediate memory. These results indicate that young children have a production deficit as regards this particular mediator, but even the oldest group failed to make maximum use of their categorisation skills. Moely et al's observations suggest one reason for this may be the use of other strategies such as rehearsal or self-testing (looking away from the pictures and trying to reproduce them from memory).

Another difference between the age-groups was in the explicitness of the instructions required to elicit clustering as a memory strategy. While only the 10-year-olds sorted spontaneously, to remember, both this group and the 8-year-olds showed sorting behaviour in the Naming condition. For the 5-year-olds and 6-year-olds only the strong prompts of the Teaching condition induced appreciable clustering. These results are important because they suggest that mediational strategies do not enter the child's repertoire, and immediately generalise to all situations. Younger children may need highly explicit prompts to engage in a mediational strategy, which older children will produce under mild prompting.
In neither case could the strategy be said to be fully productive however.

In addition to these differences in production 'threshold' the data suggest that even when a strategy is elicited, it may be executed more or less efficiently. For example, the youngest group in the Teaching condition showed evidence of category sorting, but often only applied this to a few of the list items. So, the ability to execute a given strategy like the ability to evoke it is not an all-or-none phenomenon, as the older mediational theories would seem to suggest. The Moely et al study showed that many different behaviours in addition to speech may serve to mediate memory. This was supported by Corsini, Pick and Flavell (1969), who demonstrated that the modified mediational framework could be applied to a task which involved specifically non-verbal cueing. Children were required to remember a pattern and provided with materials which made it possible to construct a replica of this pattern. The replica could then be used to remember the pattern. Again there was no evidence of a mediational deficit; children who correctly constructed recall cues recalled equally well, independent of age (as in the other studies, there was strong evidence for the production deficit). The Moely et al finding that production threshold for a given strategy decreased with age was also replicated.

The final experiment in this series, conducted by Daehler,
Horowitz, Wynns and Flavell (1969), attempted to look at the effect of different recall demands on strategy selection. Subjects were shown the same stimulus array, a set of coloured lights flashing in sequence, but were variously required to remember the colours which flashed, the order they flashed, or both. Daehler et al predicted that a verbal rehearsal strategy would mediate recall of the colours, whereas gestural rehearsal (pointing) would improve recall for the sequence. It was also expected that older subjects would be better able to select the appropriate strategy for each task.

The results for the colour-naming and colour-and-sequence tests essentially replicated Keeney et al (1966). Most subjects at some time used verbal rehearsal, this increased with age, and was positively correlated with performance.

In contrast, the sequence and gestural rehearsal data were completely at variance with this. The incidence of rehearsal was equal in both older and younger children, in addition it was unrelated to memory performance. Overt, gestural rehearsal does not seem to mediate recall of position sequences.

There were also some interesting asymmetries in strategy transfer for the two strategies. Half the subjects had received colour-only and then sequence-only tests with the other half being tested in the opposite order. Few
subjects who received colour-only trials first and used verbal rehearsal on these trials, then used it as a strategy to remember sequence. In contrast, gestural rehearsal seemed to generalise from early sequence trials to later trials for colour. This result is important because it shows that strategy selection is not only influenced by the instructions before a given trial, but depends on what has previously occurred in the experiment - certain strategies may be 'primed' by what has happened earlier.

1.3 The mediational model

On the basis of these experiments Flavell produced an mediational account of memory development. Before attempting a detailed explication of the model, I shall make a few preliminary remarks about the nature of the developmental theory he was proposing.

Firstly, the basic emphasis was on the similarity of memory processes throughout development and the same mechanism, mediation, was proposed to explain memory. This is in contrast with the then predominant Piagetian account of the development of cognitive processes which stresses qualitative differences between the processes in operation at different stages of development.

In addition to proposing the basic mechanism of mediation, Flavell argues that development is the result of changes
in the mediational strategies available to the young child, in the number of strategies available, and in the child's increasing efficiency in using an appropriate mediational strategy, often as a result of having a larger mediational repertoire to choose from.

The model also provides a description of various mediators, a set of theoretical concepts for analysing changes in mediational activity within and among tasks (e.g. production and mediation deficits, production threshold), a descriptive account of various developmental sequences which obtain among mediators, and some speculations about what might explain these developmental sequences.

1.3.1 Memory is mediation

Flavell argues that memory occurs as a result of mediational strategies. When subjects are induced to, or spontaneously employ, a behaviour such as rehearsal, category clustering or cue construction, these mediational activities result in increased recall. Evidence for this is provided by the finding that spontaneous strategy producers recall more than those who do not produce, but the argument is made much more powerfully by the demonstration that when non-producers are induced to employ a strategy they improve their recall.

Flavell's account of the mediation process is much richer than that of his predecessors; the notion of mediator is
extended from a simple verbal response interposed between stimulus and response (as in Kendler and Kendler's (1962) S-(s)R account of mediation) to encompass a whole variety of cognitive activities from rehearsal to self-testing or constructing images. He does not only focus on the differences among strategies, he points to the variations in what seems to be essentially 'the same' strategy. For example, the young child's 'rehearsal' activity may stretch only as far as the simple naming of objects which are physically present, while the older child might rehearse in the absence of the objects, re-order them to construct links amongst items and self-test to see whether the items are well-encoded. Although it is not explicitly stated, the account suggests that the sophisticated memoriser may resort to the use of more than one strategy in a given task.

Flavell regards all these activities as the result of deliberate problem-solving activity by the child:

"a memory task can be profitably regarded as a type of problem-solving situation in which efforts at mnemonic mediation constitute the means or problem-solving strategy and recall the goal or problem solution. (1970, p.195.)"

It is important to note that Flavell characterises such problem-solving as a deliberate conscious activity, a fact which will assume greater significance in our later discussions.

There are, however, several problems with the memory as mediated activity model, some of which are raised by
Flavell's own data. The first concerns the mediation deficit. There are two separate issues involved here. The first concerns the traditional mediation deficit, and the question of why behaviours which mediate memory in adults, do not do so in younger populations. Secondly there is the problem of explaining why some behaviours mediate, whereas others do not. I shall deal first with the general problem of certain behaviours failing to mediate. While this was much emphasised by the early mediational theorists, it seems to play almost no role in Flavell's account. It is of crucial significance to the theory to establish whether such deficits do exist, because if they do, it means that not all activity results in improved memory. While it is possible to generate trivial examples of activities not having memory pay-offs (e.g. going to the pub does not help exam revision) there is an important counterexample to the principle in the Daehler et al experiment. Gestural rehearsal, which on prima facie grounds appears to be adequate strategy for remembering sequences, does not result in improved memory for any age group. This suggests that for every memory task there are a limited range of activities which will benefit recall, and the research has identified some of these by the study of adult processing (as in rehearsal and category clustering) or on intuitive grounds (cue construction). An adequate theory must specify the constraints on those activities which will facilitate memory for a given task and explain why certain activities (e.g. gestural rehearsal) show no effects on performance in those
tasks. The questions of why behaviours may not mediate at one age level, but do so later in development is also not tackled. In one sense Flavell is justified in ignoring this problem because he found little evidence for it.

Flavell's data also show the opposite effect; memory occurs in the apparent absence of mediation. For example, children who show no signs of rehearsing or category clustering nevertheless retain several items when tested. (Keeney et al, Moely et al). How can we account for this? Flavell's solution is to retain the 'memory is the result of mediational activity' axiom but to suggest that some mediation may occur in an involuntary manner.

One must assume that some mnemonic processes - no less "mediational" in the literal sense - are not ordinarily subject to voluntary control. (1970, p.193).

If this is so, then the model must both specify what processes underlie involuntary mediation, and criteria for distinguishing it from deliberate mediation if it is to remain more than an ad hoc means of explaining away awkward data. Suggestions as to how involuntary mediation might occur, are the most important way in which Flavell's (1970) model has been modified. The notion of involuntary mediation is discussed in the next chapter.

A second solution to the problem of "recall without strategies" is to propose that the youngest groups are in fact employing deliberate strategies but we do not know what they are, because they are covert and because the children are unable to describe them to us. This form of
explanation is both implausible and inadequate; implausible, because adults typically remember some items when they are prevented from rehearsing (e.g. Baddeley and Hitch, 1974), and yet cannot and do not report the use of any strategy; and inadequate, because it does not specify the processes involved in these 'unobservable' strategies. (see later discussion of methodology).

The notion that memory occurs as a result of deliberate problem-solving activities is further weakened by Flavell's suggestion that under certain circumstances task materials may 'elicit' various behaviours, which do mediate behaviour but are not the result of intentional activity. In his discussion of a study in which children had to set up pictures as cues to locate various animals (Ryan, Hegion and Flavell, 1970), Flavell appeals to this notion (1970, P.206)

.....another(child)might idly bring the pictures up next to their animal referents, on one or more trials (a prepotent high-probability response to these particular task materials for young children, we think, even without a recall set).

Again Flavell appeals to the notion of mediation following on involuntary behaviour, though this account better explains recall than in the rehearsal case, because on this occasion the effective mediating process is specified. There seem therefore, to be three problems with the mediational model proposed by Flavell. The first concerns his failure to answer the question of which activities can serve as mediators for different stimuli in different situations. Secondly, he weakens the mediation principle
by allowing that memory may occur in the absence of mediation, without saying when this might occur, or what principles determine memory under these conditions. Finally he suggests that mediation may not always involve the intentional access of cognitive routines. This notion is derived from his demonstration that mediations can be generated without intention to remember (Ryan et al, 1970). The theory must therefore include some account of the child's other activities which will allow the explanation of why a certain stimulus array "elicits" particular behaviours. All these problems have led to modifications of the model which will be discussed in Chapter 2.

1.3.2 Changes in mediational activity

In addition to the axiom that memory occurs as a result of mediational activity, Flavell argued that the development of memory followed changes in the number and type of mediators available. Older children have a broader range of strategies from which to choose, and are therefore more likely to possess one which is task appropriate. In addition, they have more powerful strategies in their repertoire, as well as being more flexible in their control and use of strategies.

The theoretical constructs inherited from the mediational theorists, mediation and production deficits, and spontaneous production suggested neat distinctions and qualitative
stage-like shifts between them, and one of Flavell's major contributions to this field is his emphasis on the continuity of development in mediational skills, and the complexity of factors involved in the selection and use of a particular strategy.

The original conception of mediation (leaving aside the mediational deficit which has already been discussed in detail) represented development as the smooth execution of an invariant behaviour, first only in those situations in which it was elicited by the experimenter and then its sudden generalisation to all situations where it would facilitate memory.

Flavell's experiments suggested that this account was wrong on two counts. The mediational behaviour itself undergoes changes in efficiency over the entire course of its development, although the changes themselves may be gradual, over long periods there may be radical changes in form. In addition, the process of a strategy becoming productive involves slow generalisation from those situations where the behaviour is strongly elicited by experimenter instructions and the materials employed, to situations where few such cues are present. Flavell's account differs from Piaget's general cognitive model, firstly because behaviours undergo discrete changes with development, and also because of the lack of generality of a given mediator across different tasks.

Flavell describes two types of changes in the form of a
given strategy. The first he calls changes in efficiency; the young child may correctly elect to employ a certain strategy, but fail to execute it correctly or completely. Examples of such behaviour occur on the Moely et al task where young children only partially category sort, or in the Corsini et al experiment where they decide upon a cue construction strategy, but sometimes construct the cues in an inaccurate way.

The second type of change is more radical; in the same task children show behaviours which are so dissimilar that we do not regard them as variants or increases in efficiency of the same strategy, but as different strategies. For example, in the Moely et al experiment, young children labelled stimulus items when the items were physically present, a lower order verbal strategy which appeared in a more sophisticated form in the older groups who averted their gaze and attempted to name all the stimulus ideas in a self-testing strategy. In the Keeney et al experiment subjects demonstrated an intermediate form of this strategy - they used verbal rehearsal as a simple means of retaining ideas in memory while the stimuli were physically absent.

While it is possible to dispute that the above behaviours are all variants of the 'same' strategy, it is obvious that a simple production deficit a spontaneous production model will not satisfactorily account for the data, because it ignores changes in the mediating behaviour.
The acceptance that mediational behaviour may increase in efficiency or exist in different forms creates a whole series of new explanatory problems. We now have to give an account of these changes in strategies and allow for the possibility that a subject may use more than one strategy in a given task, and possibly build in some form of executive decision maker to determine which strategy variant is accessed.

According to Flavell, the original conceptualisation of the production deficit was wrong in a second sense; a mediational behaviour does not suddenly change from being highly situation-specific and elicited only under conditions of explicit instruction to adecontextualised general strategy. This view is to some extent derived from studies which contrast training with no-instruction conditions. The experiments of Møely et al and Corsini et al demonstrate however that the discontinuous notion of production deficit ought to be replaced by something like a production threshold, with less and less explicit situational ones being required to evoke a given strategy as it develops. This suggests that a mediational behaviour should show a pattern of slow generalisation across different situations.

This has two implications for the model; firstly it means that the actual task context is a crucial determinant of memory performance as to whether it elicits a particular strategy. We must therefore attempt a detailed analysis of tasks to determine the factors which are critical in
this process. In Flavell's experiments, control over these eliciting factors is operationally defined; subjects are given no instructions, a hint or explicit strategy model to cue a desired behaviour. While it is clear that instructions will have a powerful effect in determining behaviour, it is not obvious how an analysis of task might proceed in the absence of such obvious manipulations of instructions. Flavell does suggest that recall demands may have an effect of strategy selection, more subjects labelled items when they were told to remember their names, (Mølly et al) than when they merely had to point to them (Keeney et al), and a similar effect was noted in the Daehler et al study. Other relevant variables appear to be the presence or absence of the items: more naming was observed in the Mølly et al study when stimuli were present, than the Keeney et al study when they were not. Another way of conceptualising the effects of task or stimulus variables is to investigate the child's normal activities with such materials, for example, Ryan et al suggest that picture-object matching is a high probability response even when no memory goal is set, consequently such behaviours may need little experimental inducement to be evoked. While much of this account is plausible, it must be noted that we lack a theory of task analysis; and explanations of eliciting factors are either obvious (e.g. explicit instruction is more likely to evoke strategies than implicit) or ad hoc (remembering sequences is more likely to elicit gestural rehearsal than is remembering colour names. Another problem is that the weighting of
the various factors, i.e. materials, task demands and instructions, may change with age, for example, Donaldson (1978) has suggested that pre-school children pay little attention to verbal instruction on certain tasks, and worse still, the various factors probably interact with each other.

The problem of eliciting factors is further complicated by the fact that evocation of a given strategy is not independent of the child's proficiency with that strategy. For example, a child may preferentially select a strategy which he can smoothly execute, rather than one which at first sight better fits the problem, but may be difficult to actually use.

1.3.3 Predicting sequences of strategies

One task of any developmental theory is to predict the order of emergence of various behaviours (Flavell, 1972, Fischer, 1980). This is made all the more difficult in the case of memory strategies because of the constellation of processes subsumed under the general category of strategies, and also because of the effects of the various eliciting factors.

If we consider the case of a single strategy, prediction of 'the age' at which it 'emerges' is complicated by the various task and instruction factors. A strategy will emerge much earlier if it is elicited by close training or
clever manipulation of materials. In addition, different strategies may well have had different amounts of practice, which we have just argued may be a powerful determinant of strategy selection. For example a behaviour like object naming may be overlearnt and hence more elicitable than, say, category clustering.

Leaving aside the problems of task factors and practice, and assuming we have adequate criteria for assessing the contribution they make to strategy selection, if we hold these factors constant is there anything else we can say about the sequences in which memory strategies emerge? Flavell immediately rejects any notion of general structural change, because of the widely different sets of skills which make up each strategy. What he attempts to do is to explain the sequence obtained in his experiments where he discovered that labelling/naming developed before rehearsal which itself preceded category-clustering in terms of a sort of measurement sequence, in which the set of skills required for an early developing strategy are included in and thus a pre-requisite for, the development of later strategies. So for example, simple labelling, the ability to name an object is necessary for rehearsal, that is, naming it when it is no longer present.

The problem with the inclusion account is that it can only be systematically applied to closely related skill sets. How, for example, would we be able to predict
whether tying a knot in a handkerchief emerges before the self-testing strategy of the Moely et al study?

The theory implies that there exists some hierarchy for explaining the order of emergence of strategies and although some of the sequences (e.g. rehearsal develops before category clustering because one involves temporal ordering and sequencing without reference to meaning and the other involves the construction of relations at a conceptual level), do have intuitive plausibility, a theoretical explanation is nowhere given.

In conclusion, although Flavell is correct to stress the complexity of factors which determine the evocation of strategies, his failure to provide a detailed account of task factors and the strategy hierarchy means that prediction of ages of emergence of various strategies, and of the sequences and relations which hold between different strategies means that the theory makes very few specific predictions about development. Because of this, it is extremely difficult to refute.

**Explaining strategy development**

In addition, Flavell provided an explanation for the development of memory by reference to specific and general factors. The specific factors apply to the particular cognitive activities which underlie the use of particular mnemonic mediators. A strategy such as rehearsal, for
example is made up of a whole set of underlying skills, such as item-naming, sequencing, re-ordering and recycling, and it is clear that a factor such as speed of stimulus naming may constrain rehearsal efficiency, if for example naming is to show, then the user may only be able to rehearse items in sets of two.\footnote{Chi (1978) has suggested that there are age differences in the skills which make up rehearsal. For example, children are slower to name a familiar stimulus (see Chapter 2).} Development of such underlying skills may well make the strategy more efficient, and hence more likely to be elicited in a wide range of situations. A similar argument which Flavell doesn't make, could extend across strategies; general cognitive development should leave the subject with a wider range of activities which can be subsumed to a memory goal. He is therefore more likely to have a strategy which better fits the task demands.

The general factor Flavell calls planfulness. Consistent with his arguments that memory is a matter of generating mediators to achieve memory goals, he suggests that careful planning of activities to do now (encoding), which will have pay-offs later (recall), is not part of the general cognitive outlook of the young child. This increased awareness of the means-ends structure of certain problems is not linked to any specific strategy, but it may account for the fact that older children are much less dependent on eliciting factors in selecting strategies, than are younger children. This is the
Introduction of the concept of 'metamemory' or knowledge about memory which was later refined and invoked as a major explanatory factor in the emergence of strategies (Flavell, 1971). Metamemory will be discussed and evaluated in Chapters 2 and 3.
CHAPTER 2 MODIFICATIONS TO FLAVELL'S MODEL

2.1 Introduction

The modifications which have been made to Flavell's (1970) model are not the result of it being falsified, but follow from its failure to provide an adequate account of several important phenomena including the development of involuntary memory, the production deficit and memory for meaning. The changes also represent attempts to integrate the field with other areas of research, in particular, information processing in adult cognition, Russian research and Piagetian cognitive development. Both research findings and explanatory notions have been imported from all these fields.

This chapter will focus on two ways in which the model has been modified, the first following the integration of the notion of mediation with the literature on Levels of Processing (henceforth referred to as LOP) and attempts to explain changes in mediation. The second followed the inadequacy of mediational theory in explaining memory for text, recognition memory and relative recency. This second difficulty led to the introduction of structural explanations of memory imported from theories of information processing. Both modifications resulted in reconsiderations of developmental issues. A number
of theorists speculated about changes in the child's use of different mediational strategies (Brown, 1975; Flavell, 1971; Meacham, 1972; Paris, 1978a; 1978b) and Piaget and Inhelder (1973) present a case for structural change.

2.2 Changes in mediational models

2.2.1 Mediational models and levels of processing

Meacham (1972) drew attention to the similarities between the mediational model of Flavell and the levels of processing literature (Craik and Lockhart, 1972; Hyde and Jenkins, 1969). The research in both areas shared three basic assumptions: (a) memory is dependent upon the particular cognitive operations the subject applies to the stimulus materials; (b) operations differ in their implications for memory and these operations may be arranged in some sort of hierarchy; and (c) it is not important whether such operations are the result of intentional selection. The first of these propositions that memory is dependent on the particular operations the subject uses, is illustrated in a typical LOP experiment in which subjects may be instructed to carry out operations focusing on the structure of words (e.g. cross out all the letter e's), while others are induced to focus on the meaning of the stimulus (e.g. rate the meaning of the words along the dimension pleasant-unpleasant). Jenkins and his colleagues (e.g. Hyde and
Jenkins, 1969; Jenkins, 1971; Johnston and Jenkins, 1971) have conducted a number of such studies. The generalisation which emerged from this research was that the activity in which subjects engaged substantially affected their memory performance. In 1972, Craik and Lockhart suggested that such activities may be ordered in a hierarchy from the 'perceptual' to the 'semantic'. Thus, a subject required to assess whether a word contains a letter 'e' will remember less than the subject making semantic decisions. Finally as the experiments of Mandler (1967) had shown for organisation, it is the activity itself which determines memory, it does not matter whether such activity was selected by subject or experimenter. Meacham pointed to the parallels between these propositions and the suggestions of Flavell (1970). The notion of activities having different implications for memory performance and the concept of a strategy hierarchy has already been discussed in Chapter 1. The research on incidental memory also closely relates to the performance deficit, for what Flavell's experiments demonstrated was that experimenter-induced strategies were as effective as spontaneous strategies in mediating memory.

This led to a series of experiments based on the paradigms of adult research Murphy and Brown (1975) and Geis and Hall (1976), replicated the standard LOP result that instructions which lead to processing of meaning ("deeper" levels) lead to better free recall than instructions
to process more superficial features such as colour or shape.

However there have been a number of recent criticisms of the LOP approach and some of these have important implications for mediational models. It is important that these criticisms are examined not only because of the general insights they offer into mediational models but because a number of reviews have suggested that LOP theory be used as a framework for interpreting memory development (Brown, 1979; Naus, Ornstein and Hoving, 1978). Firstly, there have been criticisms of the notion of a hierarchy of levels. For example Craik and Tulving (1975) demonstrated large differences in recall for subjects processing to the same semantic level. This suggests that there are differences in processing within levels. Craik and Tulving, recognising that the notion of "levels" had relied on intuitive definition, attempted to find an independent measure of depth of processing. They suggested that processing time may well offer such a measure, but their data indicated that this was not so. Subjects required to make complex judgements about the formal features of words took much longer to carry out such tasks than subjects making semantic rating decisions. If time is an adequate measure of processing depth than the group engaged in the formal orienting activity should perform better than the group making semantic ratings. Craik and Tulving found that this was not the case. A further problem for
the LOP approach was the finding that semantic ("deep") processing may not always lead to better recall than perceptual ("shallow") processing. Morris, Bransford and Franks (1977) demonstrated that memory performance was not determined by encoding activity alone, but by the compatibility of encoding activity with retrieval demands. Subjects who were required to remember perceptual features of the stimulus performed better when they had engaged in the perceptual rather than the semantic orienting activity. Thus depth of processing alone does not determine performance, rather it is the appropriateness of the encoding activity for the demands of the retrieval task.

In addition to these problems, which are internal to the LOP framework, there are a number of difficulties associated with using the model in the interpretation of developmental data. Firstly, there is the problem of mapping the sorts of encoding strategies studied by Flavell onto the levels described in the model. Thus, while it is obvious that labelling involves shallower processing than categorisation, what is the depth of coding of a strategy such as self-test (i.e. looking away from stimuli and attempting to name them all). This brings us back to the previously mentioned problems with the model: that levels of processing were defined in an ostensive and intuitive way. The account does not really explain the cognitive processes involved with each type of processing, i.e. why it is that semantic
processing is more efficient than perceptual processing. A second problem with applying the framework to developmental data is that it ignores the crucial problem of the production deficit. The LOP experiments typically involve the experimenter instructing subjects to engage in various orienting activities: they do not explain the relationships between these activities and the strategies subjects normally employ. In addition, the account cannot explain the fact that children become increasingly able to select strategies appropriate to the task demands.

Given the problems associated with the framework itself and also with its application to developmental issues, it does not appear that the LOP framework in a developmental context offers any great advances on the theory put forward by Flavell. However, it does illustrate some of the problems associated with the mediational account. In particular, there is the problem of explaining why it is that mediators differ in their efficiency for inducing memory. What is absent from the mediational account is any discussion of internal mechanisms, because of the focus on external activity. A model which includes such state variables may go some way towards accounting for the differential effectivness of different mediators. In addition the findings of Morris et al (1977) imply that any such account must include some reference to the retrieval environment.
2.2.2 Explanations of mediational change

It has already been suggested (Chapter 1) that a major problem with the mediational account is explaining how mediation changes, and becomes increasingly effective with age. A number of different accounts have been offered attempting to explain this change.

Flavell's metamemory account

In 1971 Flavell published an article in which he reaffirmed that memory is an intentional problem-solving activity, and then attempted to apply what is known about the development of problem solving in order to understand the development of memory. Although acknowledging that an increase in the mediational behaviours in the child's repertoire may contribute to this development, he argues that the major reason for the increased efficiency of mediated memory is that it comes under increased intentional control. This he attributes to children's increased knowledge of when and how to remember. Thus, if young children do not realise that they forget, they may make no special effort to try and remember. Alternatively, children may realise that they should do something to remember, but they don't know enough about the cognitive routines they have available to assess the correct one. Flavell attributes this to a general change in the child's cognitive abilities.

As children grow older, we know that they
become more aware of the mental processes of other people (role-taking) and also more aware of their own mental processes (introspection). We think that they also become more aware of the what and the how of their own memory, simply as a special case of their increasing introspective ability. (1971, p. 277).

A more detailed exposition and analysis of the position advanced by Flavell will be attempted in Chapter 3, the section was included here merely to contrast the theory with others which have been suggested.

The involuntary account

The set of suggestions discussed in this section has been advanced piecemeal by a number of writers as a modél for the development of memory. The most detailed discussion of this position is by Paris (1978a), but he does not offer any empirical support for it. Apart from this, both Brown and De Loache (1978), Meacham (1972) and Yendovitskaya (1971) offer some speculations which are consistent with the account offered here. According to Yendovitskaya (1971), Meacham (1972), Paris (1978a) and Brown and De Loache (1978), one very important means by which memory becomes more efficient is by involuntary routines coming under the increased control of deliberate memory. This is distinct from the account offered by Flavell (1971) in two respects. In Flavell's account it is suggested that memory strategies are problem-solving routines specifically generated to meet the goal of remembering. According to Yendovitskaya (1971) and Brown and De Loache (1978)
strategies are the modification of routines already in the cognitive repertoire. The second difference lies in the generality of the mechanism proposed to explain how routines come under the control of deliberate mechanism. Whereas Flavell (1971) argues that the growth of deliberate memory is the result of a general increase in reflectivity, they seem to suggest that reflectivity acts at the level of the specific routine itself. Meacham (1972) speculates that practice of the routine may lead to reflection into its structure, but no really detailed explanation is offered to account for reflectivity. A number of experiments and two major reviews (Lange, 1978, Ornstein and Corsale, 1979) offer some support for this position, although the data are suggestive rather than conclusive in many cases. If the account is to be supported, it seems that it is necessary to establish (a) that routines are originally involuntary, i.e. they are produced independently of memory goals; (b) that routines are later under the control of deliberate memory; and (c) that some knowledge of the structure of the routine emerges during this time. Condition (a) could be satisfied by giving the children a variety of non-memory instructions and establishing that the behaviour is produced in the absence of memory goals. Evidence that a routine is under deliberate control (condition (b)) might be supplied by the child modifying the earlier 'automatic' behaviour to meet the memory demands of the particular situation. Condition (c) may be satisfied by some metamemory measure.
Two major reviews of organisation in children's memory, by Lange (1978) and Ornstein and Corsale (1979) suggest that initially organisational factors are involuntary and only gradually come under the control of voluntary memory.

...the subject is "struck" by the organisation he perceives, and he encodes and stores organisation unites as a direct and automatic function of their perceived structure...it is reasonable to posit further that the recall organisation we sometimes see in pre-school and elementary school children has an exogenous basis and occurs through a series of involuntary actions that can operate at both the perceptual-encoding and retrieval phases of processing. (Lange, 1978, p. 107).

It is clear that both these reviews would argue that organisational factors in the memory of older children are under deliberate control, although neither seems to argue strongly for 'reflection on structure' being responsible for this change.

Lange advances two arguments to support his contention that early clustering is involuntary. The first is that such clustering only occurs with high-associate items (Haynes and Kulhavy, 1976). It could be argued that with low-associate items young children fail to detect the categories, but as Lange points out, this failure should be avoided when the experimenter labels items and categories. However, even when labels are provided no such clustering occurs. (Cole, Frankel and Sharp, 1971a, Moely et al, 1969). In contrast, clustering does occur when items from the same category are presented in sequence (blocked presentation), because in this case
the experimenters is imposing an organisation rather than suggesting one to the children (Bjorklund and Ornstein, 1976).

In contrast, older children and adults appear to impose structure on lists, regardless of item-relatedness or item-order. They will even do so when there are no category relations between items (Tulving, 1962). In addition subjects will modify the positions of the stimuli or their order, so that the stimuli correspond to their own category organisation (Moely et al, 1969; Ornstein, Moes and Liberty, 1975).

There is thus evidence which satisfies Conditions (a) and (b) above, that routines are initially involuntary and only later come under deliberate control. What is the evidence for Condition (c), that this change is due to reflecting on the structure of organisation? Three studies have found that knowledge of the advantages of categorised stimuli emerges around the time of the first deliberate use of organisational strategies. (Monroe and Lange, 1977; Moynahan, 1973; Salatas and Flavell, 1976a). However two of the studies found only weak evidence that knowledge of category structure was predictive of strategy use, and Monroe and Lange (1977) report no relationship.

Brown and Smiley (1977) advance the argument that story recall is initially mediated by involuntary processes.
which come under intentional control and can thus be employed as study strategies. They point out that all subjects in the age range they tested (3 - 17-year-olds) "extract the main theme and ignore the trivia" (Brown, 1979, p. 239). Brown and De Loache (1978) argue that this occurred "with or without conscious intent to do so" (p. 19), although they give no empirical evidence in support of this statement. While it is implausible that the youngest group were employing a deliberate strategy of ignoring trivia, this has not been demonstrated. Brown, Smiley, Day, Townsend and Dawton (1977a) do demonstrate that other processes of text memory, initially are mediated in an involuntary manner but they report no relevant study of the extraction of central themes.

The evidence that the routine is later under intentional control is much stronger. Brown and Smiley report two findings which support this contention. Firstly they found that children of 14 years or older, if given a period of extra study time (equal to three times their normal reading rate) would considerably improve their recall for the important elements of the text. Recall of less important details did not improve. Younger children shared no such improvement. In addition, older children were observed to make attempts to render important information more salient, either by underlining it, or by taking notes during study time. These actions do not much resemble automatic or over-learnt activities. Condition (b) is therefore met:
there seems to be clear evidence of intentional use of the study strategy, although there are slight problems with satisfying Condition (a) as the crucial experiment has not been conducted. There is also some difficulty with Condition (c); Brown and Smiley do report that subjects' knowledge of the structure of text increases with age, but there is no obvious relation between this knowledge and the emergence of the study strategy.

The remaining evidence for this position is rather more anecdotal in nature. In a study of the development of cue use, Ryan, Hegion and Flavell (1970) observed that not all their subjects seemed to be employing cues in an intentional manner. Rather, it seemed that putting pictures at the locations of identical animals, was the result of some low-level matching behaviour. "Another (child) might idly bring the picture up next to their animal referents on one or more trials (a prepotent, high-probability response to these particular task materials for young children ... even without a recall set)" (Flavell, 1970, p. 206).

Other studies of cues also report similar behaviours: Ritter (1978) found that young children would search under a marked cup even when they had observed an animal being hidden under a different (unmarked) cup. It is almost as though the children believe the cued object moves with the cue. Gordon and Flavell (1977)
also suggest that early cuing has stimulus-response characteristics. Young children had no awareness that the usefulness of a cue might depend on the knowledge of the searcher, or that low-associate objects may serve as useful cues. Although these studies are consistent with the general argument advanced here, in that apparently involuntary early behaviours come to have increasingly deliberate characteristics, there is no attempt to explain these changes in terms of changes in knowledge about cuing. Ritter (1978) does include a number of questions which are designed to assess the extent of children's knowledge about cues, so it is possible to test the hypothesis. Ritter's data would seem to weakly support the hypothesis: knowledge about the cueing strategy appeared to increase during the pre-school and early school years, and this was followed by more systematic use of the strategy by older children. However the expected relationship did not emerge at the level of individual subjects. It is not possible to conduct a similar analysis on the Gordon and Flavell data.

In conclusion, there is a body of experimental findings which support the contention that involuntary routines are later used in a deliberate, intentional manner in the service of memory. However there is little evidence to support the argument that this is the result of reflection on the structure of such routines. There is more to support the account than Flavell's (1971)
arguments. The fact that knowledge of the structure of different routines emerges at different ages depending on the nature of the routine, suggests that a general change in introspective ability cannot be responsible for the increased intentionality of memory. There is, however, one major problem with which the account leaves unexplained, and that involves the origins of 'insight'. The account offers no explanation as to how children might become aware of the structure of their routines. The problems of trying to explain the origins of knowledge about memory, and the relationship of this knowledge to the use of deliberate strategies will be discussed in the next chapter.

Paris (1978a) suggests that reflectivity may not be the only means by which involuntary routines enter the repertoire of strategies:

> Considerable practice and feedback may be necessary before the child understands the functional utility of the skill as a memory operation" (p. 269)

Paris also suggests that another means by which routines may enter the repertoire is by instruction, i.e. under suggestion from the experimenter, an adult or a teacher. This is important, because it suggests an important means by which novel routines may enter the repertoire. Unfortunately Paris' comments are largely speculative and he offers no data to support these arguments.

If we consider first the influence of practice on the development of intentional strategy use, there seems only
to be one relevant experiment, conducted by Butterfield and Belmont (1977). The experimenters compared a group who had extensive training in a particular strategy, with a naive control group on a series of memory tasks. They found that the trained group showed much more efficient use of the strategy. In particular, unlike the controls, they did not blindly apply the strategy to lists they had already overlearnt. In addition, Butterfield and Belmont found that the experimental group showed a greater tendency to generalise the strategy to new lists. While the results of this study are not inconsistent with the reflectivity account it seems that the data are more consistent with Paris' (1978a) focus on instructional settings.

The second mechanism suggested by Paris, to explain how routines become intentional strategies is feedback. Here we run into the problem of defining when a routine has become such a strategy. We may determine whether a routine already in the repertoire is initially involuntary, by the criteria offered above. Similarly, it is clear that a routine directly induced by the experimenter is involuntary, because it has not been intentionally accessed. After feedback, routines already in the repertoire must satisfy the criteria set out above, but what conditions must a trained behaviour meet, in order to be accorded intentionality? This problem has been raised by Kuhn (1974) in the context of inducing change cognitive development and Brown (1978) when training
memory skills. They both conclude that the criterion of generalisation is too strict because naturally developing skills do not generalise in this way (witness the whole debate on context-specificity, e.g. Donaldson, 1978). Brown has suggested that the criterion for inferring that change has occurred is that the routine follows the normal pattern of development. Though well-intentioned, this criterion is of little use, because we do not know the natural course of most developmental acquisitions, and secondly the amount which a given routine generalises during natural acquisition may depend on its state of development (Flavell, 1970).

Given these problems in defining change in cognition, and the unacceptability of the criterion of generalisation, it would seem that use of the strategy when the experimenter no longer prompts is sufficient criterion for inferring the behaviour is under voluntary control.

What then, is the evidence to suggest that induced behaviours will be maintained without prompting, if feedback is given? Kennedy and Miller (1976) demonstrated that feedback will lead to maintenance of a rehearsal strategy. The initial part of their experiment was a replication of Keeney et al (1967), in that they diagnose 6-7-year-old children as producers or non-producers and then trained the non-producers in the rehearsal strategy. As in the Keeney et al study they found that training elevated the performance of these children
to the level of spontaneous strategy users. Kennedy and Miller then randomly assigned non-producers to two groups and gave half the trained producers feedback about the influence of strategy use. These children were told that they were remembering much better and that this must be due to the fact that they were whispering the names of the stimuli to themselves. The spontaneous producers and the two groups of trained producers were then given a transfer test. They were told that they could whisper the names of the stimuli to themselves if they wished, but they need not do so. Both the spontaneous producers and the trained producers who were given feedback continued to use the strategy. The trained producers who did not receive feedback failed to maintain the strategy. Feedback information would therefore seem to be crucial in determining the maintenance of induced strategies. It is possible that a similar mechanism could operate in natural learning settings. Other studies have also shown that feedback can influence strategy maintenance. (Borkowski, Levers and Gruenenfelder, 1976; Cavanaugh and Borkowski, 1980; Moely and Jeffrey, 1974).

Although feedback seems to influence the maintenance of evoked strategies, it does not seem to be an absolutely necessary condition. A number of studies report maintenance in the absence of feedback. (Bjorklund, Ornstein, Naus and Stone, 1977). and the position is further complicated by the fact that others find that
feedback is sometimes, but not always required. (Heisel and Ritter, 1981; Ringel and Springer, 1980).

A study by Brown, Campione and Barclay (1979) suggests a possible resolution of these anomalies. In the initial part of the experiment they trained a group of educable retarded children on a supraspan list. The children were taught both a strategy for dealing with the task, and a checking strategy to monitor the effectiveness of the strategy use. When these children were given a different task - the recall of prose passages - it was found that they retained the original strategy. Another group of children who did not receive training in the monitoring strategy did not show transfer (Brown and Barclay, 1976). The findings here are exactly analogous to the Kennedy and Miller (1976) study except that feedback information is not provided by the experimenter, but is detected by the children themselves, in monitoring their performance. If children can detect the effectiveness of the strategies they have been induced to use, and if they realise that performance improvements are due to the use of strategies, then this should lead them to use the strategies in the service of memory. In the absence of such training in monitoring, transfer or maintenance will depend on the child's spontaneous monitoring skills. Three studies have been conducted which show that even 5-year-olds are accurate at judging their performance after they have carried out a memory task (Berch and Evans, 1973; Bisanz, Versander and Voss, 1978; Masuk, McIntyre and Flavell,
1973). However these suggestions of early competence in monitoring memory tasks are contradicted by findings in other cognitive domains suggesting that children's moment-to-moment monitoring of their performance is poor (Flavell, Speer, Green and August, 1981; Harris, Kruithof, Meerum-Terwogt and Visser, 1981; Markman, 1977; 1979). Possible reasons for these differences are suggested in Chapter 3, in the review of metamemory. However, if we assume that the ability to monitor strategy effectiveness does increase with age, then the data on strategy transfer may be explained.

If we consider first the Ornstein et al (1977) study, we find that maintenance of a rehearsal strategy seems to be a function of strategy effectiveness. The experimenters trained 7- and 11-year-olds to produce one of a number of different rehearsal strategies. Children were taught to rehearse in sets of one, two or many items. It was found that for the 7-year-olds, only those subjects who rehearsed many items were observed to maintain the strategy when not directly instructed to use it. Now, in general, the subjects using the many item strategy were much more effective in remembering the list, for one and two item rehearsal produces little elevation of performance. It is possible that the one and two item rehearsers did not monitor the strategy because (a) their inability to monitor accurately left them unable to detect the improvements resulting from the use of the strategy; or (b) they could detect
the effects of the strategy but decided that the advantages of strategy use were so slight that there was little point in employing the strategy; or (c) they detected a small change in performance but attributed this to other factors likely to produce such a change, e.g. practice and not the strategy itself. Whichever of these explanations is applicable it is clear that transfer crucially depends on the detectability of the changes in performance following strategy use. This would seem to depend among other things upon the absolute size of these changes, and the ability of the child to detect them.

The other experiments in which maintenance occurs without feedback also suggest that such factors are important. Thus Bjorklund et al. (1977) found strategy maintenance in 10- but not 8-year-olds. Closer analysis reveals that the strategy did not improve performance in the 8-year-olds, there is therefore no real reason why this group should maintain it. The Heisel and Ritter (1981) and Ringel and Springer (1980) studies provide evidence for explanations (b) or (c) offered above. Both studies found three different sets of conditions under which maintenance could occur: (1) when information was provided about changes in performance and the relationship of these changes to strategy use; (2) when information was provided only about the effectiveness of strategy use; and (3) when no information was provided. It was found that the amount of feedback information and
explanation necessary to induce maintenance decreased with age, although the ages differed in the two studies because different strategies were involved.

It seems therefore that feedback is not the only means by which trained routines may come to serve as memory strategies. If children are able to detect the results of their activities this may produce maintenance when no feedback is given. This sort of mechanism may only operate, however, if strategy is detectable, i.e. if its effects are large and children are able to monitor them.

Paris' (1978a) offered a number of speculations as to how routines may enter the memory repertoire. Although he reviewed no evidence for these suggestions, it appears that there is some validity in what he proposed. Both practice at a strategy and feedback about its effectiveness seem to influence whether strategies are maintained. Change may also be brought about by a mechanism he did not specify: self-monitoring may well explain maintenance in the absence of feedback. All of the evidence reviewed here concerns induced strategies, it remains to be seen when feedback or self-monitoring influence voluntary routines in the way Paris suggests. Despite this, there is rather more evidence to support Paris' speculations than there is for the account which attributes developments in deliberate memory to reflections on the structure of involuntary actions.
The motivational account

Another set of speculations about how mediated memory develops is offered by Russian theorists (e.g. Istomina, 1975; Leont'ev, 1975; Yendovitskaya, 1971) and endorsed by statements from Brown (1975), Meacham (1972) and Paris (1978a). Although allowing that practice, feedback and instruction can and do influence memory development, these theorists suggest that major changes in the ecology of the young child may be the determinants of developmental change. In particular, they suggest that the goals which are motivating to the older child or adult are not motivating for the pre-schooler. They argue that deliberate memory (remembering for its own sake) is much less motivating for the younger child. The first emergence of skills occurs in those situations in which memory is subordinated to some other activity which is meaningful for the child.

4 These speculations parallel recent suggestions made by Donaldson (1978) about general cognitive development. She suggests that young children do not perform well on tasks which are "abstract" or do not make "human sense".

the development of retention and recall as internal, purposeful acts takes place initially as part of a broader, articulated and meaningful activity (since it is only within the context of such activity that the specific acts of remembering and recall have any meaning for a child). (Istomina, 1975, p.8-9).

The theory therefore suggests that memory skills (presumably equivalent to mature adult abilities) emerge first in a restricted set of situations, and only later generalise to...
the set of situations corresponding to adult usage. The restricted situations can be characterised by the fact that they are "embedded in a meaningful (to the child) activity" (Brown, 1979, p. 249), and they later occur in other situations in which memory itself is the goal of activity. However, if this account is to have explanatory value, it becomes necessary to appeal to some independent criteria by which we can determine which context will be "meaningful" to the young child. We require a theory of the child's goals and activities in order to provide this. The nearest that the account comes to specifying what might be meaningful contexts, is to suggest that young children perform well in "game-like" situations. Clearly the manipulation of embedding a memory task in a game-like setting does improve memory (Istomina, 1975), but it seems to be motivated by an intuitive rather than a theoretical analysis of what is "meaningful" for the young child. Another problem lies in the claim that in deliberate memory tasks, remembering itself is the only goal. It is clear that any activity takes place in some context with its attendant motivations, such as a desire to please the experimenter or instructor. Memory is therefore not the only goal involved. This relates to the problem of defining meaningful contexts because a principled analysis of context would have indicated that deliberate memory tasks are different but not context-free situations.

The theory also seems to contravene a commonly held
assumption of developmental theories. Memory strategies first emerge when memory itself is subordinated to some higher-level activity, and are only later in evidence in the service of memory alone. Subordinating a strategy to achieve a memory goal in order to carry out some meaningful activity would appear to a more complex activity than simply subordinating that strategy to memory. If this is the case, then memory becomes simpler with age, which would appear to contradict most theoretical statements about development (e.g. Atkinson, 1982; R. Brown, 1973; Harris, 1957). Of course, the account could be rescued by arguing that deliberate memory tasks are part of some wider activity, but this would seem to contradict the fundamental tenets of the argument.

Finally, an account such as this must specify how children become increasingly able to apply strategies in the absence of supportive contexts. Some theorists are clearly aware of this problem, and Kussman (1976) and Elkonin (1972) advance a set of "leading activities" which children at each age level find most motivating. In generating this description, the authors make some appeal to the conditions and ecology of the child at each of these ages. But such speculations in no way amount to an explanation of why leading activities change, nor how they are related to the everyday environment of the child.

Literacy

Another factor invoked to explain changes in mediated
memory has been formal education or literacy. (e.g. Brown, 1977; Meacham, 1972; Paris, 1978a) Cole and Scribner (1977) review a number of experiments which indicate that non-literate peoples behave rather as do young children when confronted with a deliberate memory task. They characteristically show production deficits for categorisation and rehearsal strategies (Scribner, 1974; Wagner, 1974). In addition, Scribner and Cole (1973) suggest that unschooled populations do not transfer strategies.

There are two problems with this approach. Firstly, in some of the studies it is not clear that the onset of literacy or formal education is the only explanation for the results obtained, because in some of the studies the effect of schooling may be confounded by other variables such as conversion to a cash economy (Cole and Scribner, 1977) or collective farming (Luria, 1971). Additionally, one may have found differences between the two populations and the relationship of these differences to a particular factor, but it is still not clear precisely how schooling or literacy influence memory mediation. It may well be that schooling and formal education include more of the sorts of instruction and feedback type activities which have been shown to influence memory. If this were the case, (and it is an empirical question whether schooling includes these processes) then this argument is reducible to the mechanisms suggested earlier in the chapter.

In the initial sections of this chapter I have discussed
attempts to apply the LOP framework to mediational models of memory and also attempts to explain how mediational processes develop. I concluded that there are a number of important deficits in the LOP model when applied to adult memory. The model is even more problematic when applied to developmental data, in particular because there has been no detailed analysis of encoding activities, and consequently it is difficult to see how the results of Flavell's (1970) experiments could be interpreted within the model. Additionally, the model avoids the key question of how subjects access encoding activities which is of crucial importance in exploring production deficits. Because of these difficulties, it was concluded that the LOP framework was of little use in developmental theorising.

I then examined a number of reformulations of Flavell's (1970) model which attempt to explain the production deficit, and also the question of how memory mediation becomes more efficient. A number of alternatives were suggested one of which (Flavell, 1971) will be assessed in the next chapter. A number of theorists have suggested that memory is initially involuntary in nature and only gradually comes under the control of intentional processes. The evidence would seem to support this view, but not the mechanism suggested by some accounts to explain the change. Of the studies so far conducted, none show that knowledge of the structure of routines induces intentional strategy use. In addition such accounts do
not explain how such knowledge originates. Evidence for Paris' (1978a) speculations about the influence of feedback in modifying involuntary routines into deliberate ones was also reviewed. It was suggested that feedback may well induce such a change, but that evidence suggests other factors (such as self-monitoring) may also be responsible. Soviet theories of memory development were also reviewed and found to be problematic in a number of ways. In addition it was argued that cultural factors influence the development of mediated memory, but that such factors may well be integrated with the earlier studies on feedback, self-monitoring and instruction.

2.3 Memory without mediation

Attempts to integrate the mediational model with the LOP framework, and the speculations about how mediation may change with age (Brown, 1975; Flavell, 1971; Istomina, 1975; Meacham, 1972, Paris, 1978a) were all modifications to the basic model, and all accepted the principle that memory is mediated by various strategies. A number of experimental results which emerged in the early 70's suggested, however, that mediation may not be a sufficient explanation of memory, i.e. certain phenomena were detected which could not be explained within the mediational framework. These led to a modification of the basic model by Brown (1974, 1975) to include the structural features of information
processing models. Brown (1974, 1975) and Hagen, Jongeward and Kail (1975) review evidence for such structural effects, and Brown (1975) provides a taxonomy of tasks and processes in an attempt to unify structural and mediational explanations.

2.3.1 Problems for the mediational model

One finding which suggests problems for the mediational model has already been noted. In Flavell's (1970) review he points out that in most studies non-producers remember some (but often not many) items. This would suggest that mediation is sometimes not necessary for memory. To give an example, non-rehearsing 4- and 5-year-olds typically manage 23% correct responses, while rehearsing 10-year-olds obtain 45% correct (Hagen and Kingsley, 1968).

Chi (1978) reviews other data which suggest the inadequacy of the mediational account. In all these experiments, attempts have been made to control for strategy use in adults and children, and yet age differences still remain. Thus: if an adult strategy is taught to children, recall is still generally better in adults (Butterfield, Wambold, and Belmont; 1973); if an adult strategy is taught to both children and adults, the initial difference in performance between age groups is generally maintained (Huttenlocher and Burke, 1976); and if adults are prevented from using certain strategies, their performance remains superior to that of children (Chi, 1977).

In the above experiments, it is clear that mediational
accounts cannot explain all of what is remembered. It could be argued, however, that the account is still adequate, because the "non-strategic" component is relatively small, and could be written into an explanation as a sort of "error term". Brown (1974) argues that this ad hoc modification to the theory will not suffice, because there are phenomena in which memory performance occurs in the total absence of mediation. She claims that recognition memory and memory for relative recency are two such phenomena, and that strategies cannot explain any part of what is remembered in these cases.

In addition there are a number of tasks in which memory occurs, where it is not clear what mediational factors may be acting, although a mediational explanation looks possible in principle. Thus, adults recall lists of taxonomically related items by category, without any overt evidence of item sorting (Tulving and Pearlstone, 1966). Such findings can be explained by extending the notion of mediated activity to something internal, and claiming that the recall observed in adults is the result of the internalisation of the externally mediated activities observed in children (e.g. Moely et al, 1969). What, however, are the internalised activities which mediate the recall of text (Mandler and Johnson, 1977; Stein and Glenn, 1979) or sequences of story-like events (Brown and Murphy, 1975)? Again the explanation in terms of internalised mediational processes looks possible in principle, but it is not clear what the form of these
processes might be.

Brown's (1974; 1975) and Hagen et al's (1975) solution to these problems was to propose that mediation was not the only explanation of memory. They argued that the above anomalies could be explained if we invoked the structural factors included in information processing models (e.g. Atkinson and Shiffrin, 1968) and also theories of cognitive development (e.g. Piaget and Inhelder, 1973).

2.3.2 Structural effects in memory

Two types of structural models have been invoked in attempts to explain the various anomalies with the mediational model: these are the modal model (e.g. Atkinson and Shiffrin, 1968; Waugh and Norman, 1965); and the semantic and structural models, (e.g. Collins and Quillian, 1972; Piaget and Inhelder, 1973; Rummelhart and Ortony, 1977; Schank and Abelson, 1977a, 1977b).

The modal model argues that information entering the memory system is held in three separate stores, it being transferred from a low-level sensory store, to an intermediate short-term store of limited capacity, and then to a long-term, permanent store. Each store was primarily defined in terms of three characteristics: capacity, coding type, and the length of time the information could be retained in the store. Information
in the sensory store was said to be a "copy" of the sensory input (hence the terms iconic or echoic store), and could be held in this store for short periods. The duration of the sensory store ranged from half a second to several seconds, depending on the particular store studied, and the method of measurement. Its capacity was large, but there were problems in accessing information from the store, so the capacity could not be directly estimated. The information from the sensory stores was transferred to a short-term store (STS) of limited capacity (7 ± 2 "chunks" of information according to Miller, 1956), in which it was stored in the form of a speech based code. The amount of time information could be retained in STS depended on control processes such as rehearsal, by which this information can be refreshed. It was then transferred to a long-term store (LTS) of large capacity in which information is held for long periods (in the order of years) in a semantic code.

The model came under attack by Craik and Lockhart (1972) in their initial LOP paper. They point out that there are problems with capacity, coding and duration in each of the stores. For example, there are large disparities in the estimates of duration for the sensory stores mentioned above. Similarly there are problems with the notion of coding in STS and LTS. In particular, semantic effects have been found in STS, and speech based coding in LTS, both of which are obviously contradictions of the
basic model. Craik and Lockhart also pointed to anomalies between different estimates of capacity for STS which vary, once again, with the method of measurement used. The solution that Craik and Lockhart proposed to all these problems was an attempt to explain many of the invariant structural features in terms of control processes such as rehearsal or chunking. This approach has also been advocated in the working memory theory of Baddeley and Hitch (1974).

If Craik and Lockhart are correct, then it would appear that there is little use in appealing to the modal model, because many of the features which were thought to be explicable in terms of structures now seem to be the results of processes similar to mediational activities.

This contention is supported by the recent work of Chi (1976, 1977) and Huttenlocher and Burke (1976) who have investigated developmental changes in memory span. The consensus is that the explanation for such changes lies mainly in adults' and older children's use of control processes such as rehearsal or re-ordering items. There was little evidence to suggest any changes in the underlying capacity of memory. This conclusion is important because it challenges the contention of a number of recent Neo-Piagetian theories, that changes in cognitive skills follow directly from increases in the capacity of memory (Case, 1974; Pascual-Leone, 1970). At the very least, it suggests that "capacity" is a
Chi (1978) *does* report some underlying differences between adults and children which are not readily explicable by control processes. In a carefully controlled set of experiments, she attempted to prevent adults from using strategies in a face recognition test. She used faces which were equally familiar to child and adult groups, and prevented adults from modifying their order of recall. Additionally, the use of face stimuli should prevent organisational strategies, because groups of faces do not readily form units. Despite all these precautions, Chi still reports differences between adults and children. These differences were removed, however, by reduction of the time the stimuli were exposed to the adult subjects. By reducing the presentation time for adults to half their speed at naming the stimuli, Chi managed to equalise performance in the two groups. Thus, there are underlying processes such as speed of naming, encoding time, which are not themselves control processes, but which change with age, and influence the use of such processes. As Chi (1978) puts it:

> One could speculate... that the inaccessibility of the (stimulus) names prevents the children from actively using any mnemonic strategies that required name manipulation. (p. 80)

Such changes go some way towards explaining some of the anomalies which first led us to question the utility of the mediational model. It may well be that they will explain why children do not perform as well as adults
when trained to use adult strategies (Butterfield et al, 1973) or why adults are better than children when trained on a new strategy (Huttenlocher and Burke, 1976). They will not, however, explain all the anomalies. The results of Chi suggest that there are limitations in the component skills which make up control processes. They do not explain memory in the absence of such control processes (e.g. Flavell, 1970) or when the use of strategies is blocked (Chi, 1978).

In conclusion, structural models of memory such as the modal model seen problematic in their application to adult memory (Craik and Lockhart, 1972). Many of the properties associated with structural features seem to be the result of control processes such as those described in the mediational model. If indeed the structural model is reducible to such processes, it will not serve to explain the anomalies in the mediational model, because some these problems are common to any mediational account. Research on the modal model, and in particular the notion of capacity, has, however led to the discovery that the components of control processes (such as naming or encoding) may well vary with age, and hence explain the differences in performance between adults and children when strategy use is apparently matched.

The second set of structural models which influenced developmental theorists, were those that included some component of meaning. Among these were the semantic
memory models (Anderson and Bower, 1973; Collins and Quillian, 1972), schema models (Piaget and Inhelder, 1973; Rumelhart and Ortony, 1977), and story grammars (Mandler and Johnson, 1977; Rumelhart, 1977; Stein and Glenn, 1979; Thorndyke, 1977). All these models are cognitive, i.e. they make the assumption that there are certain state variables (in most cases, these take the form of structures) to which incoming stimuli are assimilated. This results in some modification of the input (and in most models, a reciprocal change in state) and then some output. The output is not a replica of the input because of the influence of the modifying state variables, and it is possible to make inferences about the putative cognitive structures from the process of distortion which results. These distortions are not the result of deliberately invoked strategies, because in most cases the effects seem to be involuntary. If we consider that the modifications to the input often result in reduced performance, because the criterion used for memory is verbatim reproduction, this strongly suggests the effects cannot be prevented.

A large number of studies have investigated semantic effects at the level of individual words. Thus Esrov, Hall and LaFaver (1974), and Kail (1976) demonstrated the presence of category information in 3-5-year olds. Similarly, habituation (Faulkender, Wright and Waldron, 1974), choice reaction time (Morin, Having and Konick, 1970), and the Stroop effect (Rosinski, Golinkoff, and Kukish, 1975) have all been employed to demonstrate the presence of
taxonomic encoding. A review by Kail and Siegel (1976) concludes that children are much better at encoding the denotative than connotative features of stimulus words.

A series of studies on adults by Bransford and his colleagues (Bransford, Barclay and Franks, 1972; Bransford and Franks, 1970; and Bransford and Johnson, 1973) suggested that the knowledge system may influence what is remembered at higher levels than the level of individual words. These experiments suggested that under certain conditions, adult subjects did not remember individual sentences (Bransford and Franks, 1970), they also modified their memory for sentences in accord with their knowledge of spatial relationships (Bransford et al, 1972) or setting information such as a picture or story (Bransford and Johnson, 1973).

Corresponding studies have been conducted on children. Thus Paris and Carter (1973) and Paris and Mahoney (1974) have found that young children also integrate information across sentences or pictures to make spatial inferences. Harris, Mandias, Meerum-Terwogt and Tjintjelaar (1980) showed that children use the information provided by a title to disambiguate a prose passage. Paris and Upton (1976) also suggested that children may use information in their knowledge system to go beyond the information presented in the text.
There are, however, a number of problems with these studies. The results of Paris and Carter (1973) and Paris and Mahoney (1974) were obtained using a false recognition paradigm, which Paris (1975) and Trabasso and Nicholas (1980) point out may be subject to response bias. Additionally Liben and Posnansky (1977) show that part of the effect attributed to semantic inferences in the Paris studies, can in fact be explained in terms of a syntactic matching strategy. The presence of this strategy demonstrated that subjects did not abstract only the meaning of the stimuli, but did retain information about the surface structure of text.

There are also problems with the results obtained by Paris and Upton (1976). They asked subjects questions which probed verbatim information and two types of inferences which could be drawn from the passage. These were **lexical inferences** and **contextual inferences**: the first assessed children's knowledge of word meanings; the second, their ability to infer the motivations of the characters, and the consequences of their actions. Paris and Upton found that the ability to make inferences increased with age, and also that contextual inferences correlated with free recall scores. From this, Paris and Upton inferred that recall depends on the extent to which children integrate the story with their knowledge of the world. Older children are better able to make such inferences, and hence better able to remember.
In a similar study, Omansen, Warren and Trabasso (1978) showed, however, that inferential skill as assessed by a questionnaire (as in Paris and Upton) was not related to recall. Three groups were respectively given positive, negative or no contextual information about a story. The two groups given such information were better able to answer the questions about the characters' motives or intentions, and the consequences of their actions. These two groups did not, however, outperform the no-context group in the recall test. A second problem for structural theories of memory is that such inferences may be the result of deliberate strategies (Paris, 1978a; Harris et al., 1980). If this is the case, they may tell us little about the structure of children's knowledge bases, but more about how children operate them.

The major problem with the research of Bransford and Paris and their colleagues is that their research demonstrates that high level semantic factors do influence recall, but does not suggest what factors may constrain the nature and context of semantic inferences. Although some attempts have been made to provide a taxonomy of inferences (Nicholas and Trabasso, 1980; Paris, 1978b), this could in no way be said to represent a theory of how knowledge factors interact with material to be remembered.

Attempts have been made elsewhere in cognitive psychology to suggest structures which constrain the nature of
inferencing, or constructive processes. Minsky (1977) and Schank and Abelson (1977a), proposed the existence of internal structures corresponding to prototypical spatial arrangements (i.e. a room frame) or event sequences (a script). It is the involuntary operation of these structures which lead to the types of constructive or 'normalising' errors described by Bartlett (1932) and possibly contribute to the effects reported by Bransford and Paris. As Schank and Abelson put it:

> In understanding a story that calls up a script, the script becomes part of the story even when it is not spelled out. The answer to the question, 'Who served John the hamburger?' seems obvious, because our world knowledge, as embodied in (restaurant) scripts answers it. (1977b, p. 425).

The occurrence of such script-relevant intrusions has been reported for adults by Bower, Black and Turner (1979) who asked adult subjects to recall short stories based on incidents such as visiting the doctor or eating in a restaurant. Mandler and Parker (1976) showed similar effects of 'normalisation' when adult subjects were presented with pictures containing objects normally found in rooms, but with the spatial positions of the objects randomised. Brown and Murphy (1975) also report 'normalisation' effects when pre-school children attempt to remember event sequences.

Nelson (1978) set out to address the question of the child's representational structures in more direct manner. She wished to establish how young children represented familiar
event sequences such as playgroup routine or eating at home or at McDonalds. The procedure she employed was to ask children to describe or enact such sequences. She found that certain events (one of which was eating) seemed to be central and appeared in all accounts, whereas other events were of less importance as judged by their frequency of mention. More importantly there were few instances of sequencing errors. A second study showed that knowledge of playgroup routines depends on familiarity or experience with the routines. In all cases, however, children seemed to show sophisticated knowledge of activities, actions, roles, instruments and their sequencing. In both studies probing methods were used. It was found that older children required fewer probes, and what probes they did require were less specific.

There are a number of theoretical and methodological problems with this study. First of all, it had a large linguistic component, and young children are always going to be disadvantaged in both the comprehension and production of language. One of the indices of scriptal knowledge was the ability to produce long unprompted "chunks" of the script. This may well be a poor measure to use given young children's well documented inability to output prose (e.g. Brown and Murphy, 1975). Some of the developmental trends may be explained by this factor alone. Nelson also makes some capital of the fact that children's answers became more specific with age. In adults the specificity of the answer depends greatly upon a number
of factors, such as context, and the inferred knowledge state of the questioner. The pragmatic skills of giving relevant answers may well develop with age. Changes in response specificity may therefore have resulted from a developing awareness of what the questioner requires. The study requires another skill which young children seem to lack: the ability to introspect on the structure of their cognitive routines. Again developmental differences in this ability may have contributed to Nelson's results. Finally, the finding that output follows temporal sequence is no guarantee that information is represented in this way. As Linde and Labov (1975) have shown, spatial organisations may well be described in a particular sequence, because that happens to correspond to a convenient retrieval strategy.

A second "prediction" of these structural models is that stimuli which are "well formed" with respect to the internal structures will be better remembered than poorly formed stimuli. This effect occurs over and above the sorts of normalisation effects reported above. Thus, Carey and Diamond (1977) showed that children's recognition of upright faces was superior to this recognition of inverted faces at the ages of 8 and 10 years. This difference was not present in 6-year-olds. Similarly, Mandler and Robinson (1978) report a superiority in recognition memory for organised over unorganised scenes, which increases with age. Both sets of authors explain their results in terms of the development of schemata for faces or scenes. This explanation seems a little
problematic for faces, because one might have expected a schema for such an important stimulus as a face to have developed before the age of 8 years.

The concept of stereotypical sequences of incidents being represented internally led several researchers to propose that stories could be organised in this way. These researchers proposed hierarchical 'story grammars' from which they hoped it was possible to analyse the well-formedness of particular stories, and to predict where intrusions or modifications to story order might occur. (Mandler and Johnson, 1977; Rumelhart, 1977; Stein and Glenn, 1979; Thorndyke, 1977). At first sight, story grammars do seem to provide an adequate structural account of story memory. Mandler (1978) and Stein and Glenn (1979) both report the sorts of 'normalisation' errors described above, where intrusions were attempts to fill known, but missing story categories. Mandler and De Forest (1979) presented subjects with well-formed and poorly-formed stories. The well-formed stories consisted of two episodes presented in canonical fashion. In the poorly-formed stories incidents from the two episodes were intermixed. The not unsurprising finding was that subjects at all age levels recalled more of the well-formed stories, and additionally they modified what they could remember of the poorly-formed stories to follow canonical study order. One interesting developmental trend was that although 7- and 9-year-olds were unable to prevent normalisation, 15-year-olds did show some modest abilities to follow the original
intermixed story order.

By far the most systematic study of structural theories of memory development has been conducted by Piaget and Inhelder (1973) and other experiments which followed their research. The argument they advanced was that the same set of internal structures are responsible for both memory and cognition. Piaget and Inhelder investigated a number of different effects and attempted to explain them in terms of the structural systems they had proposed to explain related cognitive phenomena. These systems include those responsible for seriation, conservation, horizontality and verticality concepts.  

It is possible to generate a number of predictions from the theory: (a) the assimilative properties of structures will lead to the normalisation phenomena reported for other theories, i.e. intrusions or modifications of the stimulus will occur which bring it in line with these structures; (b) well-formed stimuli will be better remembered than poorly-formed stimuli, with this being partly the result of normalisation. These predictions are common to the structural theories described earlier. However, because Piaget and Inhelder's is a developmental theory,

5 Although there is much dispute about the status of these structural systems (Brainerd, 1978a, 1978b; Brown and Desforges, 1979; Siegler, 1979) this research has an advantage over the other structural theories of memory, because there is at least some evidence for the independent existence of the proposed structures in domains other than memory.
they also include predictions which take structural change into account: (c) if a stimulus taps certain cognitive structures, then it will be better remembered by subjects in possession of those structures; and (d) if a stimulus taps certain cognitive structures and the subjects' level of operativity increases (i.e. structures are acquired) during test and retest, then subjects' memory for the stimuli will improve. In her review of the Genevan literature Liben (1977a, 1977b) refers to predictions (c) and (d) as the cross-sectional and longitudinal hypotheses respectively.

Predictions (a) and (b) are supported by data from experiments conducted by Altemeyer, Fulton and Berney (1969) and Liben (1974). Altemeyer et al presented 5-year-old subjects either with arrays of sticks which were seriated or in a random sequence. They found that after post-presentation intervals of one week and 6 months, the children tended to normalise the random array, so that their reproductions were more like the original seriated array. This resulted in higher memory performance for the group who received seriated arrays initially. The data also provide some support for prediction (c) because/increasingly seriated between test and retest. According to Piaget's theory, it is at this age that seriation skills first emerge. Liben (1974) found essentially the same results, but for a different cognitive structure—horizontality.

Furth, Ross, and Youniss (1974) conducted a study to
investigate hypothesis (c) above, that memory for stimuli should be influenced by subjects' operative level. The cognitive skills tapped were horizontality, spatial transformation, number sequencing and verticality. The respective stimuli were pictures depicting: a glass tipped at an angle of 45°; a stick falling off a table, a sequence of 1, 2, 3, 5, and 6 dots arranged as on the side of a die; and a house with a chimney with the smoke coming out of the chimney at the wrong angle. Children aged 6, 7, 8 and 10 years were tested on these stimuli at intervals of 2 hours, 2 weeks, 6 months and one year after presentation. In addition, half the subjects were asked to copy the stimuli while they were still visible, and the other half asked to reproduce the stimuli immediately after presentation.

Collapsed over all sessions, the data support the Genevan position. Older children produced more correct and fewer irrelevant reproductions for the glass, stick and dot stimuli. For the house stimulus, there was an increase in the number of drawings which corrected the error in the original drawing by making the smoke come out of the chimney vertically. These findings substantiate Piaget's claim about the relationship of memory to operative level: according to his theory drawings should increasingly conform to high level operative concepts. Thus, there was an increase with age in correct drawings for the operatively correct stimuli (stick, glass and dots), and when the stimulus was not correct,
there was an increased tendency to modify it in the
direction of correctness. Liben (1975a; 1975b) also
investigated the cross-sectional hypothesis over a
range of stimuli and with subjects greatly differing
in operative level. She presented 5- and 9-year-old
subjects with six pictures which were related to three
operative concepts: seriation, horizontality, and vertic­
ality. After one week and five months the subjects were
asked to complete pictures from which the operative
components were omitted.

The predictions for the seriation stimuli were that
these would initially be poorly reproduced by the 5-year­
olds, but their reproduction would improve on retest
because of developments in seriation skills. In contrast,
the 9-year-olds should be adept at seriation and thus
perform well at test and retest. The predictions for
horizontality and verticality are rather different: 9-
year-olds are transitional with respect to both of these
concepts, and so initially reproductions should be mixed,
with an increase in operative skills resulting in higher
level reproductions at retest. Five-year-olds should
perform poorly throughout because of their lack of knowl­
edge about these concepts.

In general the predictions were fulfilled. Reproductions
of the seriation stimulus were mixed for the 5-year-olds,
and at ceiling for the older group. For the horizontality
and verticality stimuli, the only perfect reproductions
were generated by the older children. Additionally, long term improvements were found on the seriation stimuli for the younger group, and on the horizontality and verticality stimuli for the older group.

In conclusion, both studies which have tested a wide operativity range over a variety of stimuli would seem to support the Piagetian position. However, most of the studies conducted within the framework have focussed on prediction (d): that changes in operative level should result in memory improvement for individual children. It must be noted that the above two studies provide evidence at the group level.

Piaget and Inhelder's original (1973) experiments investigated long term memory for a variety of stimuli requiring seriation and Euclidean spatial concepts. The seriation data offer strongest support for the hypothesis: Piaget and Inhelder report 74% of 5-year-old children improved their reproduction of a seriated stimulus between an initial test after 1 week and retest after 8 months. The remaining children's performance was stable over this interval. Most other studies do not report such high levels of improvement, 30% is closer to the norm.

There have been at least ten attempts to replicate the finding of long-term improvement. Altemeyer et al (1969) in the study cited earlier, investigate this effect for seriated and unseriated arrays. The subjects
were 5-year-old children and test and retest were one week and six months after presentation. Children predominantly showed improvements in reproduction of both sets of stimuli. More importantly, most children showing improvements had produced very poor performance after one week, and so their reproductions had little to do with the original stimulus. This suggests that Altemeyer et al may not have tested memory, but some strategy for drawing sticks elicited by the command to remember. An additional problem was the presence of regressions, which were about half as frequent as improvements. Dahlem (1968) also tested 5-year-olds' memory for seriated arrays. She found 50% improvement and 10% regression between one week and six months.

Other studies report a rather larger proportion of children showing regressions. Dahlem (1969) attempted a replication of her earlier experiment and found equal numbers of improvements and regressions. Liben (1974, 1975a) investigated Euclidean concepts, as well as seriation. She found evidence for some long-term improvements, but these were not significantly more frequent than long-term regressions.

A number of other studies report a large number of regressions. Thus Crowley (1975) found 50% regressions for seriated arrays, and Furth et al (1974) report

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6 In this case, improvement is defined as increased operatively, thus subjects who saw unseriated arrays produced drawings which were more seriated, and hence less like what they originally saw.
'massive regressions' for the seriation and spatial concepts reported earlier. Murray and Bausell (1970, 1971) also investigated long-term memory for seriation of liquid, length and number. They found very little evidence for long-term improvements, and these are far exceeded in number by regressions. However, as Liben (1977b) points out, the criteria for improvement were unusually stringent: children had not only to reproduce those points of the drawing that were relevant to the operation under study, they were also required to reproduce irrelevant parts of the stimuli in order to achieve a 'correct' response.

A further set of problems for the hypothesis were raised by the findings of Fink elsewhere (1973). They investigated whether long-term improvement depended on the initial stimulus, and also whether test-retest effects could account for part of the improvement. They presented subjects with arrays of seriated, or partially seriated arrays. Test-retest effects were assessed by omitting some subjects from the early test sessions. Overall, Fink and Crowley (1973) found approximately equal numbers of improvements and regressions. In addition, improvements were dependent on the structure of the original stimulus, with poorly-seriated arrays showing much more improvement than well-formed ones. In addition, they report effects due to repeated testing, for example subjects improved performance between the first test after one day to the second test after a week.
Clearly operativity is unlikely to have altered during this interval.

Following these studies, a number of criticisms have been levelled against the hypothesis of long-term memory improvement. The first concerns the significance of the improvement. Piaget and Inhelder argued: (1) that no other theory of memory makes predictions of improvement with time; and (2) that improvements should be tested against a null hypothesis of no improvements. If improvements are found, these are evidence for the operative account. However as Liben (1977b) notes, there are other theories which predict memory improvement under certain conditions, such as the encoding specificity model of Tulving (Tulving and Thomson, 1973). Improvement may not therefore offer support only for the operative account. The second problem concerns the methodological justification for the null hypothesis. Changes in performance may be the result of factors other than operativity, such as measurement error. Measurement error cannot be neglected because it has been invoked to account for regressions.

If we accept that measurement errors occur, then the hypothesis under test becomes whether there are more improvements than regressions. According to Maurer, Siegel, Lewis, Kristofferson, Barnes and Levy (1979), who have re-analysed the existing data, if we accept the new hypothesis, none of the studies so far conducted
supports the improvement hypothesis. Even if this were not the case, the very existence of regressions represents a major problem for the theory. An appeal to measurement error cannot be justified on theoretical grounds because of their magnitude and pervasiveness and also for the reasons described above, i.e. that such an appeal would explain away improvements also. One solution to the problem of regressions proposed by Furth et al (1974) and Crowley (1975) is that these are the results of the figurative memory function, which does not rely on operations, but is a 'copy' of the stimulus which decays with time. Figurative memory produces the high initial levels of performance, which are not sustained in the long-term. Not only is this solution post hoc, in that any and every regression could be explained in this way, but it is also contrary to the principles of Piaget and Inhelder's whole model.

Memory does not conform to the perceptual configuration of the model but rather to the manner in which the model was assimilated to the ... schemes of the subject. (Inhelder, 1969, p. 347)

It is clear, however, that memory must contain some of the figural aspects of the stimulus otherwise it would not be a memory of that particular stimulus. In a sense, therefore, the appeal to figurative memory is justified in that such a notion must be incorporated into the account, but as formulated by Furth et al and Crowley it cannot be independently specified and hence remains an ad hoc and theory-saving modification.
The final attack on the notion of long-term memory improvement has been the suggestion that there may be other, non-operative explanations for improvement. I have already cited the results of Finkel and Crowley (1973) who report "improvements" as a result of retesting. The argument here is that increased familiarity with the test situation and stimuli, (if a recognition measure is used, subjects actually see the correct stimulus during test) may lead to an improvement in memory which does not result from changes in operativity. Dahlem (1969) did not report any such effects for repeated testing, but Crowley (1975) did find that repeated testing influenced recall. As already reported, Finkel and Crowley (1973) found repeated testing effects, but as they included a recognition measure in their tests, this may well have influenced memory.

An alternative non-operative explanation has been offered by Adams (1973) who suggested that "improvements" result from children's increased understanding of the demands of the experimenter. In order to test this, Adams gave subjects pretraining on either a seriation or geometric discrimination task. If repeated testing succeeds by making the children more aware of the relevant aspects of the stimulus, we might expect the group pretrained on seriation to show greater memory improvement over the test-retest period. Adams found no evidence for this hypothesis. Altmeyer et al (1969) attempted a similar manipulation by making explicit
reference to the size of the sticks for one of their groups. They found that this manipulation did not influence patterns of memory change. Another suggestion is that improvements result from increased drawing skills. A number of studies (e.g. Altemeyer et al, 1969; Liben, 1975b) have shown, however, that children older than 5 years can accurately copy a visible stimulus. In addition, long-term memory effects still occur when recognition measures are used.

In conclusion, attempts to explain improvement in terms of non-operative factors have not generally been successful. Two studies showed that repeated testing influences recall, but as one of them contained a recognition measure, this may well have produced the effect. In view of this, it is important to establish whether recognition does influence memory in repeated testing paradigms, because if it does, this would invalidate the results of several other studies, including those of Murray and Bausell (1970) and several of Piaget and Inhelder's own experiments. While the hypotheses of Adams (1973) and Altemeyer et al (1969) have not been supported, this does not mean that non-operative factors do not influence memory change. It remains to be conclusively demonstrated, however, that such factors are important.

A final prediction derivable from Piaget and Inhelder's position is that changes in memory should be directly related to changes in underlying operative skills. To
test this, it is necessary to independently assess both memory and operativity within subjects.

Piaget and Inhelder's own research did not consistently include measures of operativity. In some cases operational level was inferred by age, and in others by diagnostic questioning which was often not consistent across subjects. In one case, where the expected correspondence was not found, Piaget and Inhelder explain it away by post hoc appeal to the specific experience of the particular group under study.

Dahlen (1969) measured children's seriation skills after the six-month memory test, using a set of stimuli (triangles) which were visually quite different from the memory stimuli. The results suggested moderate support for the operativity theory, most of the children showed correspondence between memory and operativity although there were examples of operativity without memory, and memory without operativity. Murray and Bausell (1970) also measured operativity but made their assessments before the memory test. The particular stimuli they employed tested conservation, seriation and Euclidean spatial concepts. Two of the three conservation tasks showed no relationship, and for the seriation stimuli correspondence only emerged for one of the memory measures. No clear evidence could be obtained for the spatial concepts, because few children had any success on the
operative assessment of seriation.

A better test of the hypothesis would be to employ two measures of operativity conducted before and after the memory test, to discover whether changes in operativity predict memory changes. Liben (1974) used this procedure for stimuli tapping knowledge of horizontality. She found weak correlations between operative levels and memory performance at the beginning and end of the study, but little evidence to suggest changes in operativity are paralleled by memory changes. A second study/Liben (1975b) found substantially the same results for the operations of horizontality, verticality and seriation. Crowley (1975) reports similar conclusions for seriated, and randomly ordered stick stimuli.

The studies which have attempted to demonstrate a close relationship between operative levels and memory have largely found weak but significant correlations, although there have been some disconfirmations (Murray and Bausell, 1970). The hypothesis that memory changes parallel changes in operative level is not supported by any evidence. These results are not surprising when taken in the context of other developmental research. Experiments on the context-specificity of both child (Donaldson, 1978; Fischer, 1980) and adult cognition (Johnson-Laird, Legrenzi and Legrenzi, 1972) indicate that varying the materials used in psychological tests, produces vast differences in performance, even though the tasks possess
the same logical structure. A number of attempts to investigate relations between different instances of concrete- and formal-operational structures have largely discovered weak but significant correlations (Hamel, 1974) and longitudinal studies have found little evidence for concurrence in the emergence of related operations (McShane and Morrison, 1981). Another problem they with such studies is that / may compound two measurement errors.

What then is the status of the operative theory of memory proposed by Piaget and Inhelder? Overall, there does seem to be qualified support for the hypothesis from the cross-sectional data. The within-subject studies offer less convincing evidence of weak, but significant correlations. The hypothesis of long-term memory improvement is much more questionable, however. Piaget and Inhelder (1973) appear to have employed the wrong null hypothesis because they fail to take account of measurement error. When the data are re-analysed to allow for this, the effects of improvement are no longer significant (Maurer et al, 1979). In addition the theory has problems in explaining the presence of long-term regressions, and the modification proposed to explain these results severely reduces the predictive power of the theory. A number of alternative explanations for improvement have been suggested, but so far evidence for only one of these has been obtained, that of repeated testing effects. However, even this effect does not seem to be reliable. In conclusion, the operative theory seems to have some
explanatory value at the level of group explanations, but the within-subject designs do not offer the same support.

2.4 General problems with structural theories

The evidence reviewed in the latter half of this chapter suggests that there are a number of problems with the structural models discussed here. The first of these concerns the predictive power of structural explanations. The central problem here is that structural accounts suggest that memory is the result of stimuli being assimilated to, and hence distorted by, cognitive structures. This does not always occur, however, for sometimes memory output seems to be an unmodified version of input. There are two issues here: how is this "unmodified" memory possible; and can we derive any model which will enable us to predict when memory will be "unmodified" and when it will be the result of assimilation?

If we examine each of the models discussed above, we find instances of the same problem. Thus, in the research on the phenomenon of semantic integration Paris and his colleagues found that subjects did not always integrate individual sentences into higher-order units of meaning. As Liben and Posnansky (1977) and Hayes-Roth and Hayes-Roth (1977) have shown, subjects seem to have available large amounts of information about the surface structure of the text. This clearly indicates that subjects do
not process solely for meaning and discard syntactic information. A developmental study by Moeser (1976) suggests that semantic integration is not a necessary feature of encoding but depends on the particular conditions of the experiment. Factors such as the provision of additional contextual information, the sequencing of premises, the instructions, and the number of premises all influence the amount of integration.

The same difficulty of predicting the influence of structural factors seems to occur also with the research on scripts, frames and story grammars. Although these studies report normalisation 'errors', or intrusions which are consistent with the assimilative explanation, the instances of such 'errors' seems to be highly context-dependent and in many cases relatively infrequent (e.g. Brown et al, 1977). The influence of structural factors can be clearly demonstrated if we destroy structural organisation (e.g. Mandler and De Forest, 1979; Thorndyke, 1977) but is it possible to predict when memory will be veridical and when normalisation errors occur? The problem of veridical memory is also highlighted when stimuli contain material anomalous to the proposed assimilating structure. In some accounts (e.g. Bransford and Johnson, 1973) anomaly is ignored or overridden, in contrast, in the schema model of Mandler (1979) and script theory (Schank and Abelson, 1977a) anomaly receives special processing:
any event that occurred within them that was not predicted by them will be placed on a 'weird list' to be specially remembered. (Schank and Abelson, 1977b, p. 431)

This seems to be another example of material which resists the process of assimilation.

We have already seen the occurrence of the same phenomenon in the operative account of Piaget and Inhelder. Again it can be demonstrated that putative structures influence memory, but there still remains the problem of explaining figurative effects in memory. Some attempts have been made to provide constraints for the operation of structural effects. Thus, it is possible to predict with reasonable certainty that structures will not influence memory when they are absent from cognition. A 5-year-old is unlikely, for example, to show operative improvement on a stimulus requiring knowledge of Euclidean spatial concepts. If children do possess the requisite operations, however, the theory cannot predict the precise extent to which they will modify the stimulus. One solution to this problem is to argue that veridical memory is itself the result of accessing cognitive structures. While this may be plausible for certain 'well-formed' stimuli such as a routine meal in a restaurant, it leads to massive proliferation of internal structures and one which completely weakens the explanatory power of the theory.
Perhaps the solution to this problem is not to regard structural effects as a unitary phenomenon, but to look as Moeser (1976) has done, at the conditions under which such effects operate. As Clark and Clark (1977) argue for text, what we remember may very well depend on how we wish to utilise the information.

This leads to a second problem with some of the data. Whereas/semantic memory data reviewed by Hagen et al (1975) and Brown (1975) are clearly the results of involuntary coding processes the same cannot be said for all the data. Thus, Moeser (1976), Trabasso and Nicholas (1979) and Paris (1978b) suggest that semantic integration may in some cases be a strategy evoked to deal with certain situational demands. Mandler and De Forest (1979) and Brown and Smiley (1977) also discuss the deliberate exploitation of story structure as a retrieval strategy. While the cross-cultural evidence (Mandler, Scribner, Cole and De Forest, 1980) does suggest that story grammars are not always strategic, some of the data on older children may reflect strategy use. It has been shown that deliberate strategy use can influence the structure of recall (Brown and Smiley, 1977). Now if we have not controlled for the presence of strategies in our investigations of structure, we may well have inaccurate structural models. This suggests that structural theories which rely on structures inferred from experiments outside the domain of memory may be more accurate, because they avoid contamination by strategy factors.
A much more serious problem concerns the status of the structural entities proposed to explain the effects described above. In some cases it is not clear what, if any entities are posited to explain these effects. Are the encoding effects reviewed earlier the result of the operation of a semantic memory system (e.g. Collins and Quillian, 1972)? If this is the case, then such explanations are problematic, because of the recent attacks which question the validity of the model. At present there seem to be three competing accounts of the structure of semantic memory. (Collins and Loftus, 1975; Smith, Shobin and Rips, 1974; Glass and Holyoak, 1975).

No such problem arises with the semantic integration and inferencing phenomena investigated by Paris and his colleagues. I have already argued that one major weakness of this research is its failure to propose any underlying structural entities to constrain the types of inferences made.

This is clearly not the case for the research of Nelson (1978) or any of the studies of story grammar. There are some problems with the structures proposed here also. The concept of a script has recently come under attack on a number of theoretical accounts (Dresher and Hornstein, 1976), but its major weakness seems to lie in its lack of generality. Thus, while it does seem very likely that certain events such as visiting the doctor or going to a restaurant, or certain spatial organisations
such as rooms do have a stereotypical structure which can specified, it is clear that most events or spatial organisations are not so rigidly constrained. Schank and Abelson (1977a) pay this problem some attention, they build in to their system the notion of plans, which make it possible to process irregularities, and also lower level scripts which they call tracks which handle context specificity within scripts. As G. Bower (1978) argues, such structures may well be in operation, but until they can be incorporated into a principled account, they seem very much to explain away rather than explain the data.

The theoretical validity of the story grammar has also recently been called into question. Not only are there debates about whether story comprehension and memory can be explained by a single 'grammar' (Anderson and Pichert, 1978; Baker, 1978; Thorndyke, 1979), there are also internal debates between those who do accept this proposition. Firstly, it is apparent that there are a number of alternative grammars suggested (Mandler and Johnson, 1977; Rumelhart, 1975, 1977; Stein and Glenn, 1979; Thorndyke, 1977). In particular there are disputes about the relationship between episodes (Johnson and Mandler, 1980), and the relationship between position in the story hierarchy and likelihood of recall (Mandler and Johnson, 1977; Thorndyke, 1977). Additionally, Kintsch (Kintsch, 1977; Kintsch and Green, 1978) claims that the rules for characterising the structure of the
predominantly European folktales which have mainly been analysed are inadequate to characterise American Indian stories. These disputes would seem to suggest there are major difficulties associated with the concept of a story grammar, and in consequence appeals to such structures in attempts to explain story memory may well be suspect.

The final set of cognitive structures to which appeals have been made are the structures of pre-operations, concrete-operations and formal-operations in the Genevan approach to memory. In recent years, Piaget's whole theory has come under increasing attack (Brainerd, 1978b; Bryant, 1974; Flavell, 1977; Gelman, 1978). These attacks have concerned the generality of cognitive structures (Brainerd, 1978; Flavell, 1977.), the age of emergence of specific behaviours (Bryant, 1974; Gelman, 1978) and the problem of change (Brainerd, 1978b). If we consider the more specific structures studied by Piaget and Inhelder, alternative explanations have been offered for seriation (Young, 1978), and conservation (Kuhn, 1974). However, as the exact status of such explanations remains in doubt, we must reserve our criticism of Piaget's own speculations.

In summary, there are a number of problems with cognitive structures proposed to underlie structural effects in memory. In all cases, there are problems with these entities. There are disputes about the psychological
status of semantic: memory models, scripts, frames, story grammars and operational structures. The Piagetian account seems to be slightly less problematic than the others, however, for cognitive operations do seem to have some validity outside the sphere of memory, and unlike some of the other constructs they were not invoked purely to explain memory phenomena.

Finally we come to a problem which most of the theories make no attempt to tackle - the problem of change. It is clear that as children grow older they encode words differently, or remember events or stories in different ways, or remember Piagetian stimuli differently. It is clear that any purely structural theory must explain such changes in terms of structural reorganisation. Kail and Siegel (1977) discuss the problem of change in encoding, and speculate that a number of factors may be responsible. One of these, the trend towards selectivity is so vague as to be useless. The suggestion that there are changes in the rate of encoding information has experimental support (e.g. Chi, 1978) but won't explain structural change. One factor they do suggest which could lead to change is the addition of 'features' to the nodes in the child's semantic network, and appeal to Clark's (1973) semantic feature theory for support. Unfortunately on theoretical (see Atkinson, 1982) or empirical grounds (see Richards, 1979) this is hopelessly inadequate as a theory of semantic development.
The structural models derived from artificial intelligence also run up against major problems in explaining change. The source of these problems lies in the fact that such theories are fundamentally assimilative. The process of memory, comprehension or perception is generally represented as the construction of a set of inferences or interpretations upon poor quality, possibly ambiguous, information. The environment has so little role to play in the behaviour of the organism, that the existence of change is something of a mystery, because there seems to be no reason why potentially anomalous information should not be assimilated to fit into the organism's structures (cf Abelson, 1973). Most of these models do pay some attention to the problem of change, but the mechanisms of accommodation suggested are vague. Piaget's theory does claim to offer a mechanism of change in the form of the assimilation-accommodation model. However the account is circular: we can only infer the presence of accommodation when we find that change has occurred! A more promising approach would seem to be the study of the conditions in which change occurs. Thus Bower (1974) and Bryant (1974) suggest that conflict may be a condition to induce structural change and Doise et al (1975) make similar claims for the influence of social interaction.

Although Piaget and Inhelder may provide an inadequate account of how change comes about, their theory at least attempts to describe changes in cognition structures
and relate these to changes or differences in memory. Thus, the superior recall of older children with stimuli requiring Euclidean spatial concepts, can be related to their different underlying cognitive structures. Most of the other theories make little attempt to describe differences in structures, much less attempt to provide evidence for the existence of such structures from elsewhere in cognition. Although there is little evidence that cognitive change is paralleled by memory change, the Piagetian studies do find weak correlations between cognitive level and memory.

In conclusion, the studies reviewed here have conclusively demonstrated the influence of structural factors and knowledge on memory. Encoding studies have indicated that children have extremely sophisticated semantic knowledge. Additionally research on stories and scripts has shown it is possible to make a number of predictions about a limited range of stimuli, e.g. subjects 'normalise' towards good forms, and they remember good forms better than bad forms. Such accounts only allow us to weakly predict the actual structure of the output. The Piagetian account of memory fares rather better in this respect, because it suggests some constraints on the structures operating at different ages. In addition to the normalisation and well-formedness, predictions, this account attempts to relate memory to cognitive change. There is supportive evidence for these predictions from group data, but the predictions about long-term memory
I suggested earlier a number of reasons why mediational theories are inadequate to explain memory development, but can the structural theories reviewed above provide answers to these problems? Some of the problems raised by Chi (1978) can be solved by the model she proposes. The failure of children to perform at adult levels after training in adult strategies and the superiority of adults on novel strategies can be explained in terms of differences in encoding or naming speed. Clearly, structure, in the sense of these basic processes, does influence memory.

The major problem for the mediational account was, however, memory in the absence of mediation, for example, non-rehearsers (Flavell, 1970), adults who are prevented from using strategies (Chi, 1978), and adults and children on recognition and relative recency tasks, all remember without the use of strategies. It is not clear that appeal to structural theories provides us with any better explanation, for none of the theories reviewed above touches on these phenomena.

Research on structural factors in memory, with the possible exception of the work on Genevan theory does not seem to have enriched an understanding of memory. In addition to their failure to adequately explain phenomena within their domain of application, structural theories do not solve
the problems they were originally invoked to explain.
CHAPTER 3  METAMEMORY

3.1  Introduction

In his review, Flavell (1970) documents several examples of a paradoxical feature of young children's memory behaviour: the production deficit. He demonstrated that young children fail to use spontaneously, cognitive routines which are in their repertoire and which benefit memory. The routines can be elicited with minimal training, indicating they are 'in' the repertoire, but will not be used in the absence of strong prompting from the experimenter. (Keeney et al, 1967). Flavell then goes on to provide a tentative explanation for this phenomenon, and suggests what changes may lead to the deficit being overcome:

The general change might consist of an increasing propensity, both in recall tasks and in many others which have a similar means-to-ends structure, to search the repertoire for activities to perform now, the performance of which has no immediate relevance but will facilitate some other activity subsequently (in this case recall). (1970, p. 205)

Flavell goes on to refine this explanation. He suggests that memory be regarded as a problem-solving task, requiring the representation of some memory goal, the generation of a plan to meet the goal, and the efficient execution of that plan. He argues that young children may not only lack the means-ends problem-solving approach
to memory problems, but they may not know what or how to remember.

the human mind knows more and thinks better as it grows older, and these changes in what it knows and how it thinks have powerful effects on what it learns and remembers, how it learns and remembers, and even perhaps when it learns and remembers. (p. 273).

He then goes on to suggest the ways in which young children's lack of knowledge about memory could influence their memory performance. They may not be sensitive to situations which require deliberate efforts to remember (e.g. Appel et al, 1972). This may be the result of overestimating their memory ability (e.g. Flavell et al, 1970). They may also not accurately monitor the extent to which items are remembered and hence fail to execute strategies efficiently (Flavell, Friedrichs, and Hoyt, 1970). Finally they may not understand the implications of stimulus structure for memory (Moynahan, 1973) and hence not study critical parts of the stimulus (Masur et al, 1973). Flavell also speculates about the origins of this knowledge. As noted in Chapter 2, he regards it as part of the child's growing introspective ability.

In summary, Flavell (1970, 1971) offers a characterisation of memory as a mediated activity. The accessing of strategies is the result of intentional problem-solving behaviour. This is limited in the young child by a lack of strategies potentially servicable for memory, but more importantly by the absence of knowledge about
situations, variables and strategies influencing memory. This knowledge is acquired as a result of general changes in the child's cognitive system, and the emergence of the ability to reflect on the nature of one's own thoughts. In addition, Flavell (1971) suggests a series of techniques by which we might assess this developing knowledge of memory.

This chapter will review three aspects of the theory. I shall firstly examine the techniques used to assess metamemory, and suggest there are problems in that different measures yield different results. There may also be inaccuracies in Flavell's characterisation of young children's metamemory, and an alternative explanation for some of the phenomena which have been attributed to metamemory development. Secondly, I shall review a number of experiments which have examined the relationship between memory and metamemory. It emerges that such experiments provide little support for the contention that metamemory determines memory abilities. The studies investigating how metamemory might develop, suggest that the opposite may well be the case: that metamemory depends crucially on strategic skills. These experiments combined with the context-specificity of metamemory already mentioned, argue strongly against Flavell's explanation of metamemory development. Far from being the result of general developments in introspective skill, metamemory seems to be the outcome of the piecemeal acquisition of different memory strategies.
3.2 Assessments of metamemory

A number of different techniques have been utilised in the assessment of metamemory, and these are broadly categorisable into two types: questionnaire studies, and studies which make inferences about metamemory by directly observing performance. I shall refer to these as declarative and procedural measures respectively. A third type of assessment technique involves the child making verbal assessments while carrying out a particular task. This will be discussed along with the procedural measures.

3.2.1 Declarative measures

Most of the major studies of metamemory have relied on declarative measures of memory (Brown, 1978; Cavanaugh and Borkowski, 1980; Kreutzer, Leonard and Flavell, 1975) and several reviews of this literature have been published (Brown, 1978; Flavell, 1978; Flavell and Wellman, 1977). The technique involves asking children questions about memory situations: sometimes with the relevant memory material present: 'Which set of cards will be easier to remember, this set or this set?'; on other occasions children are required to answer probe questions about hypothetical situations, e.g. 'If you were told a friend's 'phone number, would you prefer to 'phone right away, or get a drink of water first?'. Alternatively, children may be asked more open-ended questions, such as
how they might ensure they remembered an invitation
to a birthday party. The majority of the research has
focussed on the early school years although there
have been limited investigations of metamemory in pre-
schoolers (Gordon and Flavell, 1977; Wellman, 1977b.
1978) and adolescents (Brown and Smiley, 1977). The
major developmental differences reported in the studies
occur between the ages of 5 and 8 years. Five-year-olds
are a little less sensitive to situations which require
deliberate memory strategies, but seem to know much
less than 8-year-olds about the variables influencing
memory performance, and the memory capabilities of
others. In addition, they have much less knowledge about
potential memory strategies, and what strategies they
do have rely on external storage rather than internal,
in-the-head memorising (Kreutzer et al, 1975; Yussen

A number of other studies have assessed children's knowl-
edge of text structure (Brown and Smiley, 1977; Danner,
1976; Yussen, Levin, Berman and Palm, 1979). These
studies indicate that this knowledge does not emerge
until early adolescence, and in some cases may never
fully develop. These results are important when compared
with other research into children's knowledge of the
structure of memory stimuli. Kreutzer et al found that
5-year-old children know that the number and familiarity
of stimuli influenced memory. In contrast, children
may not be aware of the effects of relations among stimuli
(e.g. categorisable lists) until the age of 9 years (Moynahan, 1973). Similarly, it is not until this age that they realise that a story is easier to remember than a list (Kreutzer et al, 1975). Taken together, the results suggest that there is no 'one age' at which children are able to judge the influence of stimulus structure on memory. The emergence of such knowledge depends crucially on the type of stimulus material provided, so that the ability to make accurate judgements will not emerge at the same age when the stimulus is text as when it is categorised lists. Indeed, Brown (1978) argues that even for the same materials (e.g. text) the ability to make accurate judgements about structure may depend on the content of the text itself.

The results of two other studies relying on verbal criteria have important implications for issues discussed later in this chapter. Markman (1973) found that 5-year-olds believe that older children recall more than younger ones. Kreutzer et al (1975) report that not until the age of 9 or 11 years do children realise that this is the result of older children's different study behaviour. These studies suggest that young children may not clearly understand the relationship between strategies and memory. Further evidence for young children's impoverished concept of memory is provided by two studies of the comprehension of the verbs 'remember' and 'forget' (Johnson and Wellman, 1980; Wellman and Johnson, 1979). Wellman and Johnson asked children to make judgements about a
model attempting to locate a hidden object. The 3- and 4-year-old subjects in the study tended to employ a behavioural theory of memory in making their judgements. The model was judged to have 'remembered' if he gave the correct response to the problem, regardless of whether he had previous knowledge of the location (i.e. he had seen the object being hidden). He was judged to have 'forgotten' whenever he gave an incorrect response, even if he had not seen the object being hidden. At the very least, these studies suggest young children have much to learn about memory. It seems that young children focus on the act of recall itself, rather than upon the study behaviour or cognitive activity which makes memory possible.

There are, however, a number of problems with the studies which have employed verbal means to assess children's knowledge of their own memory processes. One criticism made by Wellman (1978) is that such studies underestimate the complexity of memory processes. A study will often investigate the child's knowledge of only one variable influencing performance on the memory task. Wellman argues that decisions about strategy selection and execution are made on the basis of subjects' knowledge of the interaction of a number of variables. Thus, the particular strategy evoked may depend on the structure of the materials used, the familiarity of those materials and the memoriser's own facility with the strategy. When metamemory questions were designed to assess such interactive
effects, Wellman found that children's abilities to make principled judgements was considerably reduced. It may well be that the majority of the questionnaire studies have overestimated metamemory skills.

The above criticism could be answered by modifying the questions used in metamemory tasks. There are however a more serious set of objections which can be raised against the use of verbal measures to assess cognitions. This problem has been a matter of some controversy in developmental psychology for a number of years. (Brainerd, 1973, Kuhn, 1974; Miller, 1976). The major issue concerns the young child's poor verbal skills and the implication that in such subjects, verbal measures may very well underestimate the child's knowledge. If we are to avoid such false negative errors by simplifying response requirements, we run the risk of overestimating the young child's abilities. 7

In addition, recent reviews of adult cognitive research employing introspective and verbal protocols has suggested that certain cognitive processes may very well not be introspectible or that information about such processes may not be veridical (G. Bower, 1978; Nisbett and Wilson, 1980).

7 A number of recent studies (e.g. Wellman, 1978, Yussen and Bird, 1979) suggest that these problems may be overcome if sufficient care is taken with the design of non-verbal measures. Both these studies showed children pictures of children in different learning situations and required them to indicate the easiest or most difficult memory task.
The studies cited by Bower suggest that the processes subjects report during decision-making tasks, may be unrelated to the criteria they actually use in making such decisions, and unrelated to their reasons for acting as they do.

There are more specific problems involved in the use of metamemory measures concurrently with memory activity. One difficulty concerns the timing of the verbal measure i.e. whether to probe knowledge before, after or during the memory task. For example, Moynahan (1973) and Salatas and Flavell (1976a) found that children's knowledge about categorisation was influenced by task experience. Moynahan tested 7-, 9- and 10-year-old child's knowledge of the benefits of categorical organisation on memory. She found that metamemory scores were superior for the group tested after memory attempts compared with the group tested before memory. Salatas and Flavell (1976a) also found effects of task experience on subject's knowledge of stimuli and their categorisability. It is not only subjects' knowledge of 'facts' about memory (e.g. that category-structure aids recall) that may be influenced by the exact time of test. Wason and Evans (1978) report that subject's accounts of the decision processes they executed in reasoning tasks were dependent on the solutions they gave to the probe. Subjects often gave incorrect solution procedures when the experimenters arranged for their solution to be correct. Protocols in this task appeared to be rationalisations of whatever solution had been
arrived at. We should not conclude that subjects never have access to cognitive processes, but it is clear that protocols taken after solution are not trustworthy under certain test conditions. It might be the case that such rationalisation only occurs for particular tasks especially those which demand reasoning, where the protocol is really a form of justification.

One alternative to the problem of post-hoc rationalisation is to take protocols during the task. There are two difficulties with this approach: (a) attempts to verbalise may actually reduce performance efficiency or even change the processes evaluated; and (b) the actual protocols may be less accurate because of the difficulties involved in engaging in concurrent problem solution.

A final problem with some of the items in the questionnaire studies concerns the cognitive demands they place upon young children. Such items often require the children to imagine themselves in a particular situation, a demand which may well be beyond the abstractive skills of the younger group. In this respect at least, procedural measures may be more reliable than declarative ones.

In summary, the results of studies using questionnaire type are made problematic by a number of factors. Firstly, knowledge about memory is apparently highly context-specific: five-year-olds can make judgements about stimulus structure on the basis of item number or familiarity,
but knowledge of the structure of text may not appear until adolescence. This would seem to argue against the emergence of a 'general introspective ability' which Flavell (1971) suggested. A number of other criticisms have been levelled at the use of verbal measures as a means of assessing cognitive processes. Such measures may seriously underestimate metamemory in very young children, because linguistic comprehension and production are not proficient in this age group. In addition, a number of objections have been raised to the use of verbal measures in adult cognition experiments, both as to when and what subjects should be asked to verbalise. Finally Wellman (1978) has argued that questionnaire studies may present oversimplified and hence unrepresentative problems for children's judgements. Strategy selection seldom involves assessment of one memory-relevant factor, it is usually the result of a complex judgement about the interaction of a number of factors.

3.2.2 Procedural measures

Two features of memory behaviour in adults which are often attributed to the development of metamemory are the ability of older subjects to spontaneously make appropriate strategies and to modify such strategies to meet the demands of the particular task.

The evocation data have already been reviewed in Chapter 1. Flavell (1970) argued that a number of factors such as
stimulus structure, experimenter prompts and initial instructions do serve to influence strategy evocation. A generalisation which emerges from these and other experiments which manipulate such factors, is that older children require less environmental support (i.e. prompts, stimulus structure or instruction) in order to produce strategies. One explanation for this increased independence from environmental elicitation is that developments in metamemory allow children to select appropriate strategies in the absence of explicit elicitation.

A number of other experiments have investigated changes in children's abilities to modify the stimulus or their own strategies in order to achieve memory goals. Thus, Rogoff, Newcombe and Kagan (1974) investigated how 4-, 6- and 8-year-old children modified their study strategy in response to differing response demands. Children were given explicit experience of recall over a time interval of either a few minutes, a day or a week. After this the children were given a series of pictures and told they could study them for as long as they wished, but to make sure they would recognise them after a time interval of the same duration as the first part of the study. Only the oldest group studied the pictures for longer when they had to remember them for greater time intervals. Younger children did not alter their study strategy in response to different memory demands. Another demonstration of the ability to modify a strategy to meet particular situational demands has been demonstrated by
Salatas and Flavell (1976b). They found increasing flexibility in strategy use with age. Thus 21-year-olds were able to use a retrieval strategy as an indirect means to solving another memory problem. Although all subjects overlearnt a strategy of retrieval by taxonomic category only the oldest groups were able to utilise this strategy to answer different memory questions.

Another feature of mature memory behaviour which is taken to be the result of metamemory development, is the skill of selective study. A number of experiments have investigated this particular skill (e.g. Brown and Smiley, 1977; Cuvo, 1974; Hagen and Hale, 1973; Masuret al, 1973). In these experiments, it is of interest whether children study the elements of the stimulus which are crucial for recall. Thus, Brown and Smiley report that older children show strategies such as underlining key parts of a story they are required to remember. If given additional study time, older children also seem to improve their memory for the important elements of text, whereas younger ones show no such discrimination in study. In the Masur et al (1973) study, children were required to remember all of a list of words. After each recall test, they were allowed to select half the original items for study. An optimal strategy under such conditions, would seem to be to select those items which were not remembered. Masur et al report that 9-year-olds and college students did largely use this strategy, but that it was not employed by 6-year-olds.

In other experiments (Cuvo, 1974; Hagen and Hale, 1973)
the experimenter arbitrarily decides which information is to be remembered and which is incidental to the memory task. Despite the arbitrariness of such selection, the results largely support the other experiments. Older children are better able to study 'central' parts of the stimulus and ignore 'incidental' components.

A final piece of evidence for the flexibility of older children's strategies, is the ability to modify the stimulus in order to employ overlearnt strategies. Ornstein, Naus, and Liberty (1975) presented 8- and 13-year-old subjects with lists of items which were taxonomically related. In one condition, items from the same category were presented together, and in the other condition presentation order was random. Both age groups utilised category information in recall in the blocked presentation condition, but in the random condition only the older group did so. They achieved this by re-ordering the original stimulus material, and rehearsing related items together.

There is therefore considerable evidence for the increased flexibility of strategy use with age. Older children require less prompting to produce a strategy, they modify it in accordance with task demands, and in addition they can apply study strategies selectively to important parts of the stimulus. There are, however, a number of problems with some of these studies, in particular those investigating selective study. In addition, such developments
may be attributable to factors other than the development of metamemory.

The selective study experiments of Brown and Smiley (1977), Masur et al (1973) all found an increased tendency to study crucial parts of the text. In the Brown and Smiley study, however, one reason why subjects may not study these crucial parts is because they cannot distinguish the importance of different parts of text. In a later part of the same study, Brown and Smiley found that this indeed was the case: younger children knew nothing about the structure of text. In the light of this, it is not surprising that their study behaviour was unsystematic. A rather different problem arises with the Masur et al study. The experimenters did establish that children could distinguish between items they had remembered and those they had forgotten. Hence, it cannot be argued that children do not select items they have forgotten, because they cannot identify those items. Brown (1978) suggests, however, that one reason why young children continue to select remembered items for study is because they would forget them otherwise. This can be tested by giving the children the items they have forgotten. If Brown is correct, younger children should perform no better with the 'optimal' strategy because they will forget items when they are not able to 'keep them alive' by continuous study. In a study with educable retarded children, Brown and Campione (1977) found support for this prediction. Young children may therefore select remembered items for
further study, because they will forget them otherwise. The studies of Cuvo (1974) and Hagen and Hale (1973) rely on the assumption that what the experimenter selects as important in the stimulus is treated as such by the child.

A more crucial problem for the metamemory hypothesis is that such increases in evocation or strategy flexibility may be explained without appeal to changes in knowledge about memory. The standard explanation of flexibility or evocation is that developments in the cognitive executive system allow the child to modify a limited range of strategies in order to meet specific memory demands. An alternative explanation which has been proposed by Baron (1978) is that we regard such developments as the result of changes in the strategies themselves. As the child's cognitive system develops, the number of routines available as potential memory strategies increases, and hence children are better able to generate some appropriate strategy simply because they have more strategies available. While it is unlikely that all changes in strategy efficiency and flexibility can be explained in terms of the development of the strategies themselves, it is important to note that some of those changes may be explained without recourse to the concept of metamemory.

The research on the differentiation hypothesis (Appel et al, 1973) also illustrates the dangers of inferring knowledge about memory from strategy use, without taking into account the development of strategies. This hypothesis
was first advanced in the Russian literature (e.g. Yendovitskaya, 1971), and the claim is that memory is entirely involuntary in young children. i.e. they realise that certain situations require them to remember, but they never produce strategic behaviour to achieve this end. They should therefore never use deliberate memory strategies, and hence behave no differently in situations which require deliberate memory than in situations where strategies are not required. Appel et al tested this hypothesis by presenting 4-, 7- and 11-year-old subjects with two sets of pictures. Each set of pictures was accompanied by a different instruction. In one condition children were told they would have to remember the pictures at some later time. In the other condition they were told to look at the pictures on the pretext that this would help them on the subsequent task. The results suggested support for the differentiation hypothesis: the oldest group clearly modified their behaviour to meet memory demands, while the 4-year-olds responded in essentially the same way following both sets of instructions. The behaviour of the 7-year-olds seemed to be transitional: although they showed considerably different behaviours in the two situations these differences were not reflected in their recall.

There are, however, a number of reasons why the youngest children may not behave differently in the two situations. They may realise that the two sets of instructions demand different behaviours, but be unable either to decide
which behaviours will aid memory, or to execute the necessary behaviours. Thus, rehearsal is a strategy which clearly benefits memory, but young children may not realise this and may be unable to produce the strategy.

A series of later studies suggest that strategy complexity may well prevent this group from demonstrating that they can distinguish the two sets of demands. Yussen (1974) examined children's behaviour when they were shown a film of an adult model and told (a) they would play a game with the model, or (b) they would have to remember what items the model indicated. Yussen found differences in looking behaviour and subsequent recall in the two conditions. Thus, the strategy children are required to produce in order to indicate differentiation seems to crucially influence whether such differentiation is observed. Studies by Wellman, Ritter and Flavell (1975) and Yussen, Gagné, Gargiolo and Kunen (1974) support these conclusions.

As Flavell (1978) and Wellman (1977) note, all that research on the differentiation hypothesis demonstrates is that strategies develop:- a fact we already know. Indeed, it may be impossible to establish that there is a stage at which children realise they will have to remember, but are unaware that this has any implications for present behaviour. This is because very young children lack the strategies to indicate differentiation, and also because they may not understand the demands of the
situation and that they will be required to remember. The hypothesis may therefore be untestable in the crucial age range, because we cannot establish that the children have actually set themselves a goal of remembering. Indeed, Istomina (1975) provides some anecdotal evidence that pre-schoolers have some difficulty in recognising that a particular task has a goal of memory. It is clear, however, that the ability to recognise memory demands will be highly situation specific. Children as young as 2 or 3 years will respond to certain retrieval demands (e.g. 'Where's your coat?') which clearly require some form of search strategy.

In conclusion, there are several problems with the studies which have employed strategy use and flexibility as criteria for inferring metamemory. Many such studies have not taken into account the fact that changes in strategy flexibility and use may be partially attributable to the development of the strategies themselves.

3.2.3 Monitoring studies

A different type of procedural measure assesses children's abilities to monitor and interpret their immediate mnemonic experiences. Such judgements can take the form of predicting performance or of assessing the accuracy of performance after recall.

Studies of prediction have used two different methods
of assessment: span estimation and recall readiness. In the span estimation procedure (Flavell et al, 1970; Yussen and Levy, 1975) children are shown a single item such as a picture and asked whether they will be able to recall the name of the picture, if it is removed from view. Items are added one at a time, until the children no longer claim they will be able to recall all the items on immediate test. The results of the above studies consistently demonstrate that children below the age of 9 years overestimate their ability in such a task. Fifty per cent of 5- and 6-year-old children claim they can remember 10 items (the maximum number presented in the above studies). Such unrealistic estimates are offered by only 5% of 9-year-olds. Replication attempts by Markman (1973) and Brown, Campione, and Murphy (1977) suggest that the procedures used above may even have overestimated young children's monitoring skills. Both studies report that minor procedural modifications such as asking for several assessments indicate that judgements are less accurate than Flavell et al and Yussen and Levy claim.

The recall readiness procedure is similar to the span estimation task. Children are given a set of items equal to their short-term span to learn and told they may study the items for as long as they wish. The children are told to inform the experimenter when they are sure they can recall all of the items. Flavell et al (1970) and Markman (1973) both report that 5-year-olds
are insensitive to their readiness to recall. In contrast, when older children claimed they were ready to recall, they usually remembered all the items correctly.

A different procedure has been used by Wellman (1977c). He investigated the development of children's feeling-of-knowing judgements. Children are shown a set of objects and asked to name them. For those they cannot name, they are required to judge whether they would recognise the objects' name if it were presented. Wellman found that children's ability to make such judgements showed large increases between the ages of 5 and 8 years. In a second experiment, he investigated possible reasons for this and concluded that younger children do not utilise other available information, such as whether they have seen the object before, in order to help make such judgements.

There are, however, a number of problems with the prediction experiments. Kelly, Scholnick, Travers and Johnson (1976) attempted to replicate the span estimation results using a spatial memory task with subjects aged between 3 and 10 years. In addition to asking the children whether they could recall all the items, Kelly et al requested them to point to those items they believed they would recall. There were no developmental differences for either of these estimates. Kelly et al suggest that a crucial difference between their study and those cited above may be the nature of the material to be
remembered, and the response criteria used. The other span estimation experiments required children to judge the likelihood of recall of picture names, whereas in the Kelly et al study the judgement concerned the ability to place cue cards in their appropriate spatial locations. It may be that monitoring skills crucially depend on experience in similar task situations, and as Wellman (1977a) has noted, preschool children generally perform better on spatial tasks. This argument gains further plausibility if we consider the results of Chi (1978). She found that prediction skill for the task of remembering chess positions generally depended on chess knowledge not on age. In addition, predictive skill depended on the nature of the stimulus. Chess experts were not always superior at monitoring to novices, because experts often overestimate their ability to remember highly structural stimuli. A similar finding is reported by Monroe and Lange (1976) for list learning. These studies of monitoring suggest that prediction skill may well depend upon subjects' knowledge of the task used and upon the exact configuration of the stimuli employed. Under certain conditions, monitoring skill may not increase with age.

The Kelly et al study did replicate the findings of Flavell et al and Markman for recall-readiness. One problem with this measure of monitoring ability is that it is confounded by motivational and strategic factors. Thus younger children might be uninterested in correct
recall, or unable to maintain their attention on study until a state of readiness is achieved. The problem of strategy development is that older children have more efficient strategies for rectifying matters if learning is not complete.

Finally, research on adults suggests that feeling-of-knowing judgements may not be assessing moment-to-moment monitoring of memory states. Gruneberg, Morris and Sykes (1977) suggest that subjects respond to the demand characteristics of the experiment in making such judgements. They present evidence that subjects' assessments are based on what the subjects think they ought to know, and not on direct monitoring.

A number of studies have also investigated children's abilities to make judgements about their performance after retrieval has been carried out. In contrast to the findings of Flavell et al and Yussen and Levy, for prediction, young children seem fairly accurate at assessing their performance after retrieval. Studies by Berch and Evans (1973) for recognition, Moynahan (1976) for free recall, and Bisanz, Versander, and Voss (1978) for paired-associate learning all report that "post-diction" judgements are accurate in 5-year-olds. Although all these studies report developments in this ability, performance does not change as much as in the above studies of prediction. Young children may also be competent at other sorts of judgements about retrieval.
They seem aware that they have or have not completed recall of all items (Neimark, Slotnick and Ulrich, 1971; Geis and Lange, 1976) and can distinguish between the items they have recalled and items they have not recalled (Masur et al, 1973).

These results would seem to contradict a number of studies of strategy maintenance which were reviewed in Chapter 2 (Börkowksi et al, 1976; Kennedy and Miller, 1976). Such studies indicate that children will only maintain strategies when they are given direct feedback as to the effectiveness of strategy use. From this it could be argued that such feedback is necessary because children either cannot, or do not monitor the influence of strategies on their performance. However, the arguments advanced in Chapter 2 suggest that failure to monitor may be the result of deficits in processes other than monitoring. In addition, a number of studies have shown that maintenance can occur in the absence of feedback (Bjorklund et al, 1977; Heisel and Ritter, 1981; Ornstein et al, 1977; Ringel and Springer, 1980). The failure to maintain a trained strategy cannot therefore be advanced as evidence of deficits in monitoring skill.

A large number of studies have been conducted to investigate the development of children's abilities to assess the state of items in memory before retrieval, and to make judgements about retrieval completeness and accuracy. It was argued that the ability to make post-diction
judgements is present in children as 5 years. The interpretation of the data on prediction is much more problematic; evidence from other studies suggests that monitoring skills depend on the task and stimulus configuration employed. Under certain conditions young children may be as accurate as adults in their predictions. Criticisms were also made of the use of the feeling-of-knowing judgement as a means of assessing direct monitoring.

3.2.4 Conclusions about assessments of metamemory

The research reviewed above suggests that there are large changes in children's knowledge of facts about memory, in the case of evocation and flexibility of the strategies they employ, and in their ability to make judgements about their performance before or after retrieval. However, as the earlier sections have argued there are a number of problems associated with the assessment of metamemory. In the case of questionnaire studies there is the general problem of using verbal methods with younger children. The procedural measures did not avoid such problems either. It is possible to explain accessibility and flexibility of strategies without appeal to metamemory. In addition there are problems with several of the studies of monitoring reviewed above.

A second major difficulty in assessing metamemory
concerns differences between measures purportedly assessing 'the same' knowledge. Measures of prediction ability appear to depend greatly upon the task (Chi, 1978; Kelly et al, 1976), and Brown (1978) argues that even within a task domain, metamemory ability may depend upon the content and complexity of the stimulus under study. As I have already noted, these results seem to argue against the general development of a metamemory function as described by Flavell (1971).

3.3 Metamemory as an explanation of memory performance

The previous sections provided some discussion of the different criteria which have been employed in the assessment of metamemory. In the accounts of Flavell (1971), Brown (1978) and Cavanaugh and Perlmutter (1982) metamemory is intended to be more than an object of study, it is meant to serve an explanatory function in theories of memory. Thus, Flavell (1971) suggests that young children's failure to realise that certain memory situations require strategies, their inability to monitor the state of items in memory, and their lack of knowledge about what variables affect memory all contribute to inefficient performance. The present section examines the evidence for these different hypotheses in the light of recent experiments. Before embarking on a detailed examination of this evidence, however, it is worth returning to the conclusions of the previous section. The above review of techniques for metamemory
assessment, and recent publications (e.g. Cavanaugh and Perlmutter, 1982), suggest that there are a number of problems with the measurement of metamemory. If this is the case, then it may be difficult to draw reliable conclusions about the explanatory value of metamemory when the methods used for its assessment are problematic. For this reason, it is important that each test of the metamemory-memory relationship takes into account the reliability of the metamemory measures employed.

One technique of metamemory assessment can give us no adequate explanation of memory development. This technique involves the use of procedural measures such as ease of evocation and flexibility of strategy use. Since our measure of metamemory is directly derived from strategy use in this case, any appeal to metamemory involves a viciously circular argument. Metamemory is inferred in this case from strategy deployment and cannot therefore be called upon to explain deployment.

The differentiation hypothesis also runs into similar difficulties. Flavell (1971) and Appel et al (1972) argued that one reason why preschool children may fail to prepare for retrieval is because their memory is entirely involuntary, i.e. they do not realise that certain memory goals can only be achieved if action is taken now to prepare for later retrieval. As the previous section argues, a number of false inferences were made about preschoolers' inability to identify such situations.
This was because experiments did not allow that strategies are poorly developed in this age group, and it was from preschoolers' lack of strategies that they could not identify deliberate memory situations. However when tasks were employed which required simple strategies (e.g. touching or looking at stimuli), it became clear that young children are capable of preparation for retrieval. There is no conclusive evidence that young children ever perceive that a certain task requires them to recall at some later time and yet they fail to realise they should engage in some appropriate mnemonic preparation for this eventuality. The differentiation hypothesis cannot therefore explain any of the deficits observed in young children's strategic behaviours.

Flavell (1978) and Flavell and Wellman (1977) have argued that one source of difficulty for young children may lie in identifying situations which possess implicit demands for memory. In support of this Flavell (1978) cites a number of experiments showing that older children are more likely to keep physical records of previous solution attempts (Siegler and Liebert, 1975) and also of the need to study further items they have just forgotten in a memory test (Masur et al, 1973). However, this interpretation of the evidence may be problematic. The Siegler and Liebert study requires children to take notes of previous solution attempts, a strategy which may be more practiced in older children. As I have already argued children may well not select forgotten
items for study in the Masur et al study, because they are unable to keep remembered items 'alive' in memory if they do so. In addition a study by Istomina (1975) suggests that under certain conditions, 5-year-olds may well respond to implicit demands to prepare-for-retrieval. Despite this, the hypothesis remains plausible, it is just that the present experimental evidence is insufficient to evaluate it.

A different type of argument has been advanced by Flavell (1971) and Brown (1977, 1978) to explain the relationship between monitoring skills and strategy use. The Flavell et al (1970) and Yussen and Levy (1975) studies both seemed to show that young children vastly overestimate their ability for immediate recall. In addition, the Flavell et al and Kelly et al (1976) studies indicated that they are also unable to assess when they have fully mastered the material to be remembered. This may well explain their failure to employ strategies, if children do indeed overestimate their ability for correct recall, it is not surprising that they fail to employ strategies when these are necessary. The argument is suspect, however, because it assumes that children spontaneously make assessments of their likely performance and on the basis of these, decide upon whether or not to use a strategy. Two studies have subjected this hypothesis to experimental test (Flavell et al, 1970; Kelly et al, 1976), and neither has found any evidence for a relationship between monitoring assessments and
subsequent recall.

A number of studies have investigated the relationship between post-test assessment and the level of memory performance (Bisanz et al, 1978; Kelly et al, 1976). It is argued that those subjects who most accurately post-dict will be those who maintain their performance during test most closely and hence determine when material has been mastered sufficiently for recall. This argument is also suspect, because the ability to make post-diction judgements may not be related to children's spontaneous self-assessment. In any case, the Kelly et al study reports no relation between post-diction and recall, and the Bisanz et al experiment found evidence for the relation only in their oldest group who were college students.

Experiments which offer feedback as to the level of performance are sometimes cited in the context of monitoring influencing strategy maintenance. The argument is made that feedback provides children with information about their level of performance when they use trained strategies and this leads them to maintain such strategies. However, feedback typically involves much more than information about performance levels. In the Borkowski et al (1976) and Kennedy and Miller (1976) experiments (see Chapter 2) subjects were not given information about the absolute level of their performance using the 'trained' strategy. Instead they were provided with information about the level of their performance when they used the
strategy and this is compared with performance without the strategy. The superiority in the instructed condition is then attributed to strategy use. We cannot therefore use such experiments to make inferences about the relationships between maintenance and monitoring, because other metamemory information is supplied by feedback in addition to monitoring. Other studies (Heisel and Ritter, 1981; Ringel and Springer, 1980) have separated the different processes of monitoring, comparing strategy and no-strategy performances, and interpreting this difference as being attributable to the use of strategies. These studies showed that deficits in each of these processes do influence children's strategy selections.

Thus of the research on the relationship between monitoring and strategy maintenance, only the feedback experiments suggest any real evidence for the hypothesised relationship. Experiments on the relationship between prediction and post-diction have not found evidence for a clear influence of metamemory or memory behaviour. It seems that feedback experiments provide information in addition to monitoring and that such information also influences strategy maintenance.

The above experiments have evaluated evidence for two ways in which metamemory can influence memory performance. The differentiation hypothesis suggests that children's different conceptualisation of memory is responsible for their generalised production deficit, and later studies
argue that direct monitoring skills may influence strategy deployment. Flavell (1971) suggests a further means by which knowledge influences memory processes. He argues that young children may not know certain facts about the variables which influence memory and strategy use. Thus, children who do not know that certain parts of a story are more important for memory than others will not structure their study behaviour accordingly.

Several studies have demonstrated that such lack of knowledge does influence memory (Brown and Smiley, 1978; Ritter, 1978; Wellman, Drozdal, Flavell, Salatas, and Ritter, 1975; Yussen et al, 1979). Brown and Smiley (1978) established that recall of prose at all ages characteristically shows the omission of information irrelevant to the theme of the story, and highlighting of this central information. Recall of the different parts of the story is therefore determined by their level of importance. Older school children and adults typically exploited this by using strategies such as underlining crucial portions of text, or using periods of extra study time to focus on these portions. Younger children, in contrast, did not do this. Brown and Smiley therefore asked subjects of all ages to rate the importance of the different parts of the text. They found that younger children were unable to make such judgements. More importantly, the study strategies described above did not emerge until several years after the ability to rate the importance of text units. Thus knowledge about the structure of text recall
would appear to be a prerequisite for systematic study strategies. Similar results have been reported by Yussen et al (1979) and Danner (1976), for text, and by Wellman et al (1975) and Wimmer and Tornquist (1980), for different sorts of knowledge about memory.

One problem with these sorts of demonstrations lies in the precise criteria employed to establish that subjects possess certain knowledge about memory. As Brown (1978) points out, if we modify our criteria we may not find evidence of knowledge about certain aspects of text until late adolescence. Despite the apparent support for the hypothesis, there are a number of problems with the conclusions which have been drawn. The major difficulty concerns the failure to adequately specify what 'facts' about memory are necessary for strategy use. This has led to disputes in the literature about exactly what knowledge is necessary for particular tasks. Thus Cavanaugh and Perlmutter (1982) claim that Tornquist and Wimmer (1980) have used too stringent criteria for assessing metamemory. If the criteria are relaxed, the sequence of metamemory appearing before strategies is not always found. In the experiments on text study there is a similar failure to specify what exactly must be known about text structure before strategies can be employed. Thus, the studies find different time intervals between the ability to make such judgements and the onset of systematic strategies.
The vagueness of the hypothesis is further illustrated by the inconsistencies in the classification of various metamemory acquisitions. Thus, Brown (1978) interprets experiments on short-term span estimation as indications of children's knowledge of the fact that they have limited short-term memory capacity. In contrast, Flavell (1978) and Flavell and Wellman (1977), suggest the results reveal children's ability to monitor their memory state. The degree of disagreement between the Brown and Flavell classification systems is illustrated by the fact that other metamemory items are categorised in the opposite manner, with Brown classifying as process what Flavell classifies as factual knowledge.

These disagreements about the classifications of different metamemory items, and also the problems of determining what knowledge is required for a given task suggest severe problems for the use of metamemory in explaining memory behaviour. A far more serious problem arises when children's knowledge about memory does not relate to their strategy choice. Thus, Kreutzer et al (1975) report that children who predicted that increased study time benefits recall, did not necessarily study longer than other children. Brown, Campione, Barclay, Lawton and Jones (cited in Brown, 1978) also found that predictions about the relative effectiveness of various strategies bore no relation to strategy choice in educable retarded children (MA 6 and 8). Thus, children who possess greater knowledge about memory may not always utilise this knowledge
in remembering.

Studies by Salatas and Flavell (1976a) and Moynahan (1973) support this conclusion but additionally they suggest that metamemory is itself highly dependent on memory experience. Both experiments investigated the relationship between knowledge about categorisation and recall and its relation to category-sorting strategies with taxonomically organised lists. Moynahan tested 7-, 9- and 10-year-olds knowledge about categorisation either before or after experience with taxonomic lists. She found that children with superior metamemory did not necessarily make more use of category-sorting strategies. In addition, experience with the memory task influenced metamemory judgements. The group who were tested after the memory test recorded higher metamemory scores. Salatas and Flavell (1976a) employed two experimental conditions: in the first, children were given instructions to remember the items in a list, and in the second, they were told simply to look at the stimuli. Following this, their knowledge of category effects on memory was probed. As in the Moynahan study, metamemory was significantly affected by memory experience. The group given memory instructions performed better than the incidental instructing groups. Both groups were given a further test some weeks later, and it was found that metamemory scores did not predict strategy use on retest. However Salatas and Flavell did identify a group of subjects who demonstrated an interesting set of responses. These subjects showed
no evidence for strategy use on early trials, but demonstrated high levels of clustering in recall. They showed high metamemory scores, and later used category-sorting strategies in the retest. Salatas and Flavell argue that these subjects monitor their initial recall patterns, perceive the influence of categories in recall and introduce the behaviour of clustering at encoding as a deliberate strategy. These speculations are consistent with the theories (reviewed in Chapter 2) which suggest that the origins of strategies may lie in involuntary behaviour. There still remain however, a number of problems of explanation for metamemory theories. Despite the predictive value of the metamemory measure for the group described by Salatas and Flavell, metamemory is not a strong determinant of strategic behaviour for the remainder of the subjects in that study, or the other studies mentioned above (Brown et al, 1978; Kreutzer et al, 1975; Moynahan, 1973). In addition, the knowledge hypothesis suggests that knowledge about memory is a prerequisite for various strategies. The Moynahan and Salatas and Flavell studies suggest the opposite is the case: metamemory seems to be strongly influenced by specific experience of the memory task. This conclusion is consistent with the earlier review of prediction skills, which suggested that such skills depend on memory experience. (Chi, 1978; Kelly et al, 1976).

A different approach to the evaluation of the knowledge hypothesis has been taken by Cavanaugh and Borkowski
(1980). They employed a questionnaire to assess a wide variety of different types of metamemory, and investigated how these measures related to strategy use on three related tasks. These tasks were: (a) a free sort task in which children could sort a categorisable list in any manner they wished; (b) a cueing task in which the experimenter provided pictures which could be used as encoding and retrieval cues; and (c) an alphabet search task in which children were given an unanticipated recall test for a set of alphabet letters which had just been presented. Cavanaugh and Berkowski predicted that metamemory measures relating to the skills required by the three tasks should correlate more highly with strategy use than unrelated metamemory items. This prediction was not supported: metamemory items which seemed to be peripheral to the tasks seemed to correlate as highly with strategy use as did apparently more relevant items. Although 76% of metamemory-memory correlations were significant when the data was collapsed over age groups, this figure dropped drastically when the data were examined for developmental differences, and only 18% were significant. Neither were there any developmental trends in the number of significant correlations. Cavanaugh and Berkowski also conducted contingency analyses on an item-by-item basis to establish whether high metamemory subjects were more likely to use strategies. They found no evidence for this hypothesis on any of the metamemory measures. They then tested whether subjects who showed higher overall metamemory scores performed better than low-metamemory
subjects. This was found not to be the case. Finally they attempted to isolate a set of 'core' metamemory items which would predict memory performance. No such factors could be found. Cavanaugh and Borkowski therefore conclude:

No reliable evidence for the contention that verbalizable metamemory is necessary for successful memory was found. A causal hypothesis linking metamemory to memory is not supported by the present data. (p. 451)

This conclusion seems to apply to most other studies which have tested the knowledge hypothesis.

Evidence has been evaluated for a number of different hypotheses about the relationship between metamemory and memory. Very little support was found for any of these hypotheses. The evidence for the differentiation hypothesis first advanced by Appel et al (1972) is extremely problematic; when sufficient care is taken to ensure that young children have the strategic means available, there is every indication that they can distinguish situations which require deliberate encoding strategies. The reliance on strategic competence can be avoided by using monitoring measures. However, no evidence was found to support the contention that prediction or post-diction assessments bear any relation to strategy selection and recall. Most research has focussed on the knowledge hypothesis i.e. that certain facts about memory are prerequisites for the use of certain strategies. Some text studies support this contention, but problems about the criteria used for metamemory assessment should lead us to
reserve judgement about their conclusions. A number of other studies have failed to find such a relationship. The results of several of these studies also suggest that metamemory may not determine strategy selection, rather that experience in particular memory tasks influences metamemory. While it may be argued (e.g. Salatas and Flavell, 1976a) that this explains the origins of metamemory, there is little to suggest that even when metamemory does emerge, that it can significantly influence performance. Some accounts attribute the failure to find the predicted relationship to inadequacies in our methods of strategy assessment. (e.g. Cavanaugh and Perlmutter, 1982). However, such arguments cannot be employed to save metamemory theory: unless more sensitive means of assessment can be devised, metamemory can serve no function as an explanatory concept.

In contrast to the above, a number of studies conducted within the framework of metamemory have succeeded in showing some influence of information about memory. The studies in which children are given feedback of various forms (e.g. Kennedy and Miller, 1976; Borkowski et al, 1976) do show that such information affects strategy maintenance. Some accounts e.g. Flavell (1978) suggest that these experiments provide children with metamemory information which they do not possess, (e.g. Rehearsal improves recall). Other experiments (e.g. Heisel and Ritter, 1981; Ringel and Springer, 1980) indicate however that strategy maintenance may be the result of a complex
set of decision making processes. It may well be that if we can model such processes we may understand how strategies are selected. Such a model may include processes already mentioned such as monitoring, but they would form part of a more complex multifactor explanation than has been advanced by metamemory theorists.

3.4 Explanations of metamemory

Regardless of the status of metamemory as a construct which explains changes in memory strategies, it still remains that metamemory itself develops, and any adequate theory must provide some account of how this occurs. In the previous chapter I discussed a number of accounts of memory development which also included speculations about the origins of changes in metamemory. The majority of theories of metamemory change suggest it results from particular experiences in memory tasks (e.g. Brown and De Loache, 1978; Meacham, 1972; Paris, 1978a). These accounts stress that metamemory evolves in a highly context-specific manner, in contrast to the speculations of Flavell (1971) who argued that metamemory was the result of a generally emerging introspective ability.

The experimental evidence would seem to weigh heavily in favour of the piecemeal acquisition account. The data reviewed in the previous sections indicates that monitoring skills are highly domain-specific (Chi, 1978; Kelly et al, 1976), that knowledge about text depends on
the content and structure of text (Brown, 1978) and that knowledge about the structure of materials in memory tasks depends crucially on the nature of those materials (Brown and Smiley, 1978; Moynahan, 1973). A number of experiments have attempted to train metamemory skills (Brown, 1978; Brown, Campione and Barclay, 1979; Brown, Campione, 1977b). All of these studies established the maintenance of trained strategies, but only the Brown et al (1979) study showed any evidence of metamemory generalisation. Although we cannot directly infer the structure of natural acquisition processes from training studies, these studies do support the view that metamemory is acquired in a domain-specific rather than a generalised manner.

Having established that metamemory is a context-specific acquisition, precisely what mechanisms are responsible for its emergence? One position (advocated by Brown and De Loaché, 1978) is that metamemory follows from some form of reflection on the structure of a previously overlearnt behaviour. Meacham (1972) and the Russian theorists (e.g. Leont'ev, 1975) explain this slightly differently. They argue that it is only when a behaviour has been highly practised that it becomes servicable as a routine capable of being subordinated to memory goals. These accounts are problematic in three respects. They do not state precisely how much an involuntary behaviour must be exercised before it becomes a potential strategy. The account of knowledge of the structure of involuntary behaviours somehow emerging
through use begs the very question it is meant to explain: how is this sudden insight made possible? Even if we accept the above, the account is inadequate in another respect: it can only explain a limited range of the phenomena of metamemory. It might therefore explain the acquisition of strategy knowledge, but not for example, the process of monitoring.

Neither of the above accounts makes appeal to the studies which have attempted to train metamemory. The studies do not show that the procedures employed in training are the mechanisms which necessarily operate in the natural acquisition of the cognitive skill in question; they may, however, suggest the possible mechanisms of change. The evidence from the studies suggests that feedback is one such mechanism which leads to changes in metamemory, but that changes may occur when feedback is not provided. One possible explanation for metamemory change in the absence of feedback may be that children are able to monitor their metamemory judgements and modify them. Monitoring may therefore influence both strategy and metamemory change.

The previous sections have described experiments suggesting that strategy maintenance can be influenced by feedback, but a number of other experiments show that feedback may also influence metamemory acquisition. These studies have attempted to train children to accurately predict their performance in an immediate memory test (Brown et
al, 1977b; Markman, 1973; Yussen and Levy, 1975). The results are consistent for older children: all three studies showed that feedback induced children older than 5 years to estimate their performance accurately. Feedback may not modify predictions at all ages, however, for the Yussen and Levy experiment included a group of preschool children who seemed to be impervious to such information. Finally Cavanaugh and Borkowski (1979) showed that feedback can influence children's knowledge of what variables influence memory performance. Thus feedback seems to be a possible mechanism by which we can modify metamemory as evidenced by these induced changes in maintenance, prediction and knowledge about memory.

As was noted above, feedback is not always necessary to induce changes in metamemory, and a number of experiments show that changes may occur in its absence. If we employ strategy maintenance as a criterion for metamemory then several studies reviewed elsewhere in this thesis indicate metamemory change without feedback (Bjorklund et al, 1976; Heisel and Ritter, 1981; Ornstein et al, 1977; Ringel and Springer, 1980). These studies suggest that feedback may not be necessary in older children (Heisel and Ritter, 1981; Ringel and Springer, 1980), or if strategies are highly effective (Ornstein et al, 1977). Brown et al (1977b) found that age may also influence whether feedback is necessary to modify metamemory. They employed a different measure of metamemory, that of
span estimation, in educable retarded children (MA 6 and 8 years). Both groups were given 10 trials in which they had to predict recall performance, and then actually recall. Half the subjects at each age level were given feedback. The older subjects became more accurate at prediction whether or not feedback was provided, whereas feedback was necessary to induce more accurate monitoring in the younger group. The studies of Moynahan (1973) and Salatas and Flavell (1976a) also show that verbal knowledge about memory can be modified by task experience, without feedback. Moynahan found that subjects who made their metamemory judgements after performing the task were substantially more accurate than those making them before the memory test. Salatas and Flavell (1976a) found that metamemory judgements were better in subjects who had been instructed to remember than in subjects asked to look at the same stimulus materials. Experience in the particular memory task, it seems, can influence metamemory, even in the absence of feedback. This is consistent with the results of Chi (1976) and Kreutzer et al (1975) who all found that metamemory was superior in task settings in which the child is familiar. This still does not provide a mechanism for metamemory change in the absence of feedback, but the above results are consistent with the view that spontaneous monitoring leads to changes in metamemory. Thus, older children, with their superior monitoring

8 This analysis only includes children who were initially inaccurate in their predictions.
skill are more likely to modify judgements in the absence of external feedback. If we return to the speculations of Brown and De Loache (1978) and Meacham (1972), it is possible to square their account with the one offered above. Monitoring and feedback may provide the mechanisms by which metamemory evolves from strategy use.

In conclusion, there has been little theorising or research conducted into the origins of metamemory, and the mechanisms responsible for its change. The available data do, however, suggest that Flavell's (1971) speculations about there being a general increase in introspection ability are incorrect. Brown and De Loache (1978) and Meacham (1972) offer an account in which metamemory is dependent on developments in particular strategies. While their account is little more than a redescription of the data on strategy change, evidence from a number of training experiments suggests that feedback and monitoring may be mechanisms which induce change.

3.5 General Conclusions

The present chapter discussed a number of issues relating to metamemory, including methods of assessment, its relationship to memory and explanations of change in metamemory. In the section on methods of assessment I suggested there were a number of difficulties with the procedures used in assessing the construct. In the case
of questionnaire methods, this was related to the poor verbal skills of very young children, and the consequent problem of them understanding questions and producing answers about memory. Other methods which rely on strategy changes as indicators of metamemory development, fail to take into account developments in the strategies themselves, which may contribute to the observed increases in evocation and efficiency. A special case of procedural measurement, is the differentiation paradigm, and this is subject to the objections voiced above. Leaving aside the problems of measurement, as Brown (1978) and Cavanaugh and Perlmutter (1982) point out, research on metamemory has generated little more than a mass of data showing that aspects of knowledge about memory increase with age. No explanation is offered as to the relations between the different aspects nor is there any attempt to suggest why certain elements emerge before others.

The second problem with metamemory is that it does not explain memory phenomena as early accounts (e.g. Flavell, 1971; Hagen, 1971) argued it would. Explanations of memory development which rely on metamemory measures derived from strategy use, cannot be accepted, as they are circular. This is not the case with the overestimation and post-diction hypotheses about monitoring. In these experiments it is possible to generate independent measures of metamemory, and it is clear how these measures should influence behaviour. The limited available
evidence does not, however, provide support for the hypothesis. A third major hypothesis advanced by Flavell (1971) was that young children's lack of knowledge about certain metamemory variables may be responsible for their failure to use strategies. Some of these experiments have found experimental support for the hypothesis. (Brown and Smiley, 1978; Danner, 1976; Yussen et al, 1979). However, several other experiments have arrived at the opposite conclusion, i.e. that knowledge has no effect on strategy choice (Brown et al, 1978; Mandler and De Forest, 1979; Møynahan, 1973; Salatas and Flavell, 1976a). Furthermore, a large-scale correlational study by Cavanaugh and Borkowski (1980) tested variants of the knowledge hypothesis and found little evidence for any of them. The available evidence suggests that rather than metamemory providing an explanation for the development of memory, metamemory itself depends on experience in particular memory tasks (cf. the suggestions of Salatas and Flavell, 1976a). Modifications have been made to the original theory (e.g. Flavell, 1978 Flavell and Wellman, 1977), arguing that metamemory and memory may only be closely linked in older children and adults. These suggestions are problematic in two respects: firstly they are motivated by research findings contradicting the theory; and secondly, no attempt is made to specify when close metamemory-memory links might emerge. Analogous arguments have been made by Cavanaugh and Perlmutter (1982) who claim that metamemory knowledge may not be used in all appropriate
situations. A clear difficulty here is that Cavanaugh and Perlmutter are silent on what might determine the use or non-use of metamemory 'facts'.

Finally, the different accounts of metamemory development were individually examined. The available data suggest that Flavell's (1971) characterisation of the process as general in scope is incorrect, and the explanations in terms of a Vygotskyan model (e.g. Brown and De Loache, 1978; Meacham, 1972) were found to be little more than a description of the available data. A number of studies have looked into the conditions in which metamemory changes occur. It is possible that mechanisms such as monitoring and feedback may be responsible for the changes which Brown and De Loache and Meacham describe.

The overall evidence seems to favour the interpretation that in the early stages of development at least, metamemory development is largely dependent on specific memory experiences. Although this is contrary to the position advocated by Flavell (1971) and Brown (1978), it may offer some clues as to which 'bits' of metamemory may develop first. Flavell (1978) may be correct in asserting that metamemory may only be influential in determining memory behaviour in older children and adults, but this has yet to be demonstrated.
CHAPTER 4 USE OF INFERENCING STRATEGIES AND THE ROLE OF SELF-ASSESSMENT IN CUE USE

4.1 Introduction

As we noted in Chapters 1 and 2, a large amount of experimental evidence has been accumulated to demonstrate that young children have a production deficit for many memory strategies. The finding that children fail to employ a routine which is in their repertoire bears some relation to the recent demonstrations of context-specific thought in preschoolers. The latter have largely shown that cognitive skills which are not demonstrated in Piagetian tasks can be elicited under other conditions (Donaldson, 1978; Gelman, 1978, Siegler, 1978). A major difference between this cognitive research and recent research on the production deficit has been the emphasis in cognitive research, on finding the reasons underlying this context-specificity, and numerous factors have been suggested to explain why children may fail to manifest particular skills. The picture is somewhat different for memory developmental research. Although there has been some theoretical speculation (e.g. Meacham, 1972; Wellman, 1977a) and some research on differentiation (Appel et al, 1972), there has been little attempt to provide explanations for very young children's strategic deficiencies. One aim of this chapter is therefore to investigate the reasons
underlying these deficiencies.

A second, and related point, concerns the young child's ability to use cognitive routines in an intentional manner to benefit memory. Early research into this issue suggested that preschoolers did not use intentional strategies (Appel et al, 1972), but there is now a considerable body of evidence showing that this is not the case (Acredolo et al, 1975; Wellman et al, 1975; Yussen, 1974; Yussen et al, 1975). These experiments undoubtedly indicate that intentional strategies are sometimes used by preschoolers, but they do not demonstrate that such strategies are always used. In fact, evidence from other studies suggests that memory may sometimes be the incidental byproduct of the child's activities when they are directed towards a goal other than remembering (Ryan et al, 1970). In addition, preschoolers may not always fully understand the implications that their activities have on remembering (Gordon and Flavell, 1977; Ritter, 1978; Ritter et al, 1973). A second focus of this chapter will therefore be on the intentional nature of the young child's memory behaviours.

The present chapter describes a series of experiments which investigate the development of a particular retrieval strategy: inferencing. There are a number of reasons for the choice of this particular strategy: firstly, there is a long tradition in developmental psychology of studying inferences, originating with Piaget,
Inhelder, and Szeminska (1960); secondly, the development of the ability to 'go beyond the information given' is claimed to be of crucial importance in education; and thirdly, adult models of memory have stressed that remembering often involves generating information from an incomplete knowledge base and that inferencing is the mechanism by which this is achieved (Collins, Warnock, Aiello, and Miller, 1975; Lindsay and Norman, 1972).

4.2 Experiment I: Do children make inferences in spatial location tasks?

Introduction

This experiment investigated preschool children's ability to use an inferential strategy to supplement what they could directly remember in a spatial location task. The task required subjects to remember the identity of four toy animals hidden at four different locations.

Previous research on indirect retrieval strategies (e.g. Salatas and Flavell, 1976b; Keniston and Flavell, 1979) suggests that the skill of accessing one memory in order to cue another does not emerge until adolescence. Similarly, experiments investigating the role of inferential skills in spatial memory tasks also suggest these are acquired during the school years (Drozdal and Flavell, 1975; Wellman, Somerville, and Haake, 1979).

If an inferential strategy is used, however, it may operate
in the following way: if the subjects cannot directly remember all the necessary information, they may use what they can remember to infer likely solutions to the memory problem. Thus, subjects who can recall which of the animals are at three of the locations can infer the identity of the fourth by elimination, provided they can remember the identity of the four animals originally hidden. Other variants of the same strategy are possible; children remembering the locations of two of the animals may guess the locations of the final two animals, with a 50% chance of getting both correct. A complete analysis of the expected distributions is presented in Footnote 1. The analysis leads to a specific prediction: if children are using an inferential strategy more children should score four than three items correct. This prediction is independent of what the children directly remember.

Pilot studies of older children and adults suggested that this strategy may well be employed. The present study was designed to investigate whether such processes occurred in preschool children.

Method

Subjects: The subjects were 51 children from a number of different playgroups in the St. Andrews area, who ranged in age from 3;0-5;2. The children were divided into three age groups: 3;0-3;9 (n=14, mean age=3;5); 3;10-4;6 (n=22, mean age=4;3); and 4;7-5;2 (n=15, mean age=4;10). Approximately equal numbers of boys and girls were present in each age sample. Two children in the youngest group failed to complete the experiment and are excluded from the above description and the analysis.
Procedure: The children were tested individually and were shown four toy farm animals, a toy policeman and four plastic cups. The animals, a pig, a sheep, a dog, and a duck, ranged in height from 0.5 cm to 2.5 cm and could all be hidden under the cups. The children were first asked to name the animals, which they were all able to do, although some of the names were idiosyncratic. They were then told that the animals were going to play hide-and-seek with the policeman. The children were told: 'The policeman's going to close his eyes while the animals hide in these houses (gestures to four cups). I want you to keep your eyes open and watch where the animals all hide so you can help the policeman to find them all.' At this point the policeman doll was moved away from the array, so he "couldn't see" where the animals were hiding. On one of the two trials the child hid the animals, and on the other they were hidden by the experimenter. Once the animals were hidden, one under each cup, the policeman declared that he was coming to look for them. The policeman approached the first cup and knocked on the top of it, saying "Who's hiding in this little house?". After two such attempts without getting any response, the policeman asked the children if they knew who was hiding in the "house". When the children had given a response or said they did not know which animal was under the cup, the experimenter "opened the door of the house" by lifting the cup and briefly exposing the hidden animal. The policeman continued.

*The cues were arranged in a semicircle in front of the child, and care was taken to ensure that obvious spatial cues such as one cup being nearer, were avoided. The apparatus is shown in Appendix V, Fig. 1.
his search until each house had been probed. The houses were probed in a random order, and all the children received two trials with four animals hiding. These were counterbalanced as to whether the child or the experimenter hid the animals on the first trial.

Results

Preliminary analyses indicated that there were no differences due to sex, and so the data were collapsed across sex. The distribution of scores for the three groups is shown in Table 1 and Table 2. It is clear that a large percentage of children did obtain scores of three correct (20% on the first and 16% on the second trial). A 3 (Age) X 2 (Identity of hider) analysis of variance was conducted on the data. The effect of age was significant (F(2, 48) = 3.84, p < 0.03), but the identity of the hider made no difference to recall (F(1, 48) = 2.86, p > 0.05).

Discussion

The distribution analysis generated a prediction about the probability of various scores if the children were using the strategy. This prediction was not supported by the data. Many children obtained scores of three correct (21%, 14% and 20% of the respective age groups). Also the prediction that there should be more scores of four than three items correct was only verified for one of the three groups on one trial only. Although these results are suggestive, they do not conclusively demonstrate that inferential strategies are not employed. It is just
possible that many of the children who obtained scores of 0, 1 or 2 items do employ the strategy. This speculation cannot be verified without a measure of direct memory, which is not possible using this procedure.

Evidence from a different source suggest that some of the children were using such a strategy. They either requested information from the experimenter which would enable them to make the inference e.g. 'Which ones haven't I said yet?'. Alternatively they directed such enquiries to themselves e.g. 'I've said X, Y, and Z, now let me see, what does that leave me?' (without appeal to the experimenter).

The second experiment attempted to establish whether inferencing would take place, when the information processing load was reduced, by giving children cues about which animals are at previously probed locations, and which animals made up the original array.

4.3 Experiment II: Do cues facilitate inferencing?

The first experiment offered weak evidence that preschool children are unable to use an elimination-based inferential strategy to increase what they directly remember on a spatial location task. There are a number of possible reasons why this may be the case: (1) they may be unable to remember the animals which constitute the original array; (2) they may be unable to keep track of the animals
at previous locations and hence eliminate them as possible solutions; and (3) they may be in possession of all this memory information, but be unable to make the elimination inference.

Other research in cognitive development suggest independent evidence that all these factors may be responsible for the absence of strategy use. There is some controversy in the literature on transitive inferences as to whether memory for premise information, or an inability to combine this information, is responsible for developmental trends in such tasks (Breslow, 1981; Bryant and Trabasso, 1971; Trabasso, 1977). Alternatively, experiments on problem solving (e.g. Eimas, 1970), suggest difficulties in keeping track of previous solution attempts, and Flavell et al. (1981) and Markman (1977, 1979) document children's inability to monitor their own performance.

The present experiment allowed the children to avoid the necessity of remembering the original array and monitoring previous solutions, by providing two types of cues: (1) Array cues, which consisted of a set of four animals identical to the animals of the original array: These cues remained visible throughout the experiment; and (2) Monitoring cues, which avoided the necessity of remembering previous solutions by leaving each animal outside the cup after that location has been probed.

Thus, children who utilise the cues should possess
sufficient information to make the inference by the time the fourth location is probed. The array cues give information about which animals constituted the original set. The children should also be able to eliminate as possible solutions those animals which are visible at the previously probed locations.

The experiment addressed a number of questions concerning the development of cuing and inferential skills:-

(1) Do preschool children spontaneously make use of indirect retrieval cues? A number of recent studies have shown that whereas young children may be proficient at employing high associative cues (Gordon and Flavell, 1977; Ritter et al, 1973, Expt. I; Ryan et al, 1970), they are poor when the associative relationship is less direct (Gordon and Flavell, 1977; Kobasigawa, 1974). Measures of cue use were obtained by direct observation of children's eye-movements. The array cues were arranged slightly out of the children's line of vision, and monitoring cues were placed just behind their cups so they were partially obscured (see Fig. V). In both cases it was apparent when either set of cues was used.

(2) If children do look at array and monitoring cues are they able to use this information to make inferences? Again the available data on indirect cue use (Gordon and Flavell, 1977; Kobasigawa, 1974) and the research on transitive inferences (Breslow, 1981) suggests this may not be the case. It should be possible to detect use of the inferential strategy by the distribution of memory
scores. Use of the strategy should lead to enhanced recall at the fourth location to be probed, because at this location, children should have sufficient information to make the inference.

(3) Are children who do not spontaneously utilise the cues able to employ the strategy, if their attention is drawn to the cues by the experimenter? It should therefore be possible to detect whether poor performance is due to a failure to utilise information relevant to the task, or to an inability to make inferences. The experiment also investigates the development of indirect cuing skills.

Method
Subjects: The subjects were 128 children who ranged in age from 3;0-5;3. They were divided into the same age groups as in Experiment I. They were further divided into an experimental and a control group consisting of 67 and 61 subjects respectively. For the experimental group there were 16, 24 and 27 children in each age group, and the mean ages were 3;5, 4;1, 4;9 respectively. There were 18, 23 and 20 children in the control group with mean ages 3;6, 4;2, 4;9 respectively. None of these children had participated in the previous experiment.

Procedure: The control group of subjects received four trials, and the procedure was identical to that employed in Experiment I.

* Two subjects in the youngest experimental, and one in the youngest control group, failed to complete the procedure, and are excluded from this description.
The experimental group had two pretrials with the same procedure, but were given the monitoring and array cues on both the third and fourth trials. The array cues were introduced by the experimenter who claimed that the four cues were "friends" of the animals who were hiding under the cups, and that the friends wanted to watch the game. The four original animals were placed alongside their "friends" and the experimenter asked the children whether they noticed anything about the animals and their friends. A series of hints was given, until the children agreed that the two sets were the same. The hiding animals were then put alongside the cups and the game commenced and no further reference was made to the array cues. After probing each location the experimenter simply did not replace the cup over the exposed animal, but alongside it, so that the animal was partially obscured in the manner already described. No mention was made of the fact that this procedure differed from that employed in the first two trials. If a child failed to respond at the fourth position to be probed the experimenter silently pointed to both array and monitoring cues. This was to ensure that inferencing was not due to a lack of information. The experimental-set-up is shown in Figure 1 (Appendix V).

Results

The results of the experiments will be reported as three separate sections. The first concerns the direct observations of cue use, the second the analysis of the memory scores, and the final section will examine children's
failures and errors at the fourth location to be probed. This final section also includes analysis of the effect of the experimenter's prompts.

Cue use

Cue use was scored in a categorical manner, either children used a particular type of cue, or they did not. The criterion for use of the monitoring cues was that the child scrutinised all the exposed animals after any one of the four probes. Array cue use was inferred when the children shifted their gaze to the array following the probe question. The number of children using the monitoring cues on neither, one or both of the trials is shown in Table 3. Overall cue use was high, 81% of children made use of monitoring cues. Only two of the youngest group did not use the cues at all, although there was an increase in cue use with age. A $\chi^2$ analysis comparing the number of children employing cues reveals that the two older groups are more likely to use cues than the youngest group ($\chi^2(1) = 6.05$, $p<0.015$). Table 4 shows array cue use for three age groups. Fewer children made use of the array cues than monitoring cues (McNemar's $\chi^2 = 8.93$, $p<0.01$) and there were no developmental differences in array cue use when the youngest group was compared with the two older groups ($\chi^2(1) = 1.81$, $p>0.05$).
Distribution of memory scores

The influence of cues on memory performance was investigated by a 2(cue v. no-cue) x 3(age) x 4(serial position) analysis of variance for unequal numbers of subjects.*

Children were taken as "remembering" the item, if they generated a correct response without prompting by the experimenter.

The data are shown in Table 5. There were a number of significant main effects: age $F(2,122) = 9.44, p<0.001$; in addition, cues significantly influenced performance $F(1, 122) = 28.05, p<0.001$; and there was a serial position effect $F(3, 366) = 16.76, p<0.001$. In addition, the data suggest that the advantage of cues is limited to the last two locations to be probed. This is manifested by an interaction between the presence or absence of cues and serial position $F(3, 366) = 21.18, p<0.001$. Planned comparisons using the Tukey statistic showed significant differences between cue and no-cue groups at third and fourth locations to be probed.**

These results are consistent with the hypothesis that children are using the information afforded by the cues to make eliminative inferences.

There was no age x cue/no cue or age x serial position effect $F(2,122) = 1.02, p<0.05$, $F(6, 366) = 1.33, p<0.05$. Both of these results might have been expected if older children make more use of cues, but as Table 5

*/* See over (p. 172) for FNs.
The analysis was conducted on a computer using the unequal cell numbers analysis of variance (UNEN) from the ALICE statistical package. This programme computes within group means and then pools these for the between groups analysis. (Grubin, Baner & Walker, 1976).

The middle and older groups both outperformed the youngest group (Neuman-Keuls = 9.47, 13.48; both significant at the 0.01 level). The planned Tukey test showed that groups with cues performed significantly better at the third and fourth locations ($CR_T = 29.82, p<0.01$; $CR_T = 69.88, p<0.01$).
indicates, there is a ceiling effect for the older
groups at the final two locations.

**Failures at the fourth location**

Despite the presence of array and monitoring cues, a
number of children made errors or failed to respond
when the fourth location was probed. Such failures
accounted for 13% of the responses in the experimental
group. The number of children who always responded
correctly at this location did show a developmental
increase. A $\chi^2$ analysis comparing the youngest group with
the older children demonstrated this. ($\chi^2 (1) = 10.14,
p<0.0015$). This change is not necessarily the result
of increased inferencing ability, however, as the measure
confounds this with changes in cue use and direct mem-
ory. There were a number of reasons why children failed
to respond correctly at the final location. There were
seven incorrect responses, four of these followed the
failure to use the cues, which is likely to be an error
in direct memory. The other three which followed the
use of cues, may have resulted from some error in
inferencing, or may have been a direct memory response.
If children did not respond, or they made an error,
the experimenter indicated the cues and repeated the
question. It is clear that failure to use cues is not
sufficient to explain inference failure; seven of the
responses came when children had spontaneously looked
at the cues. So, although the children possessed
sufficient information to make the inference, they did not do so. On ten occasions children failed to respond correctly, without using cues, and on five of these occasions they did not make the inference even when given assistance by the experimenter. It was not possible to subject these different response patterns to statistical analysis, as the number of responses in each category were small.

Conclusions

This experiment was designed to investigate children's ability to use indirect retrieval cues in order to employ an inferential strategy in spatial memory. The results indicated that preschool children do show an increasing ability to make use of externally provided information. This information enables them to bypass the problems of internally storing the information necessary for the inferential strategy. It is clear from the serial position data that such a strategy is being employed by the experimental group. The failure of the control group to show the same serial position effect suggests that deficits in monitoring and memory skills are two reasons why the strategy is not always employed. In this respect, the results are consistent with the work of Trabasso and his colleagues who argue that one reason for young children's failure on Piagetian transitive inference problems results from an inability to retain premise information.
Other data from this experiment suggest there may be a number of additional reasons why young children fail to use the strategy. Some children were in possession of sufficient information to make the inference and yet did not do so. This immediately suggests an inability to make the inference. However, an alternative possibility exists: very young children may well interpret the task instructions to remember, as an indication that their responses should be generated by direct memory alone, and not by other means such as inferencing. This could also explain error responses at the final location. Young children may attempt direct memory solutions even when simpler, more certain, means are available. While this experiment indicates that premise information alone is not sufficient for the inference, it does not differentiate between an inability to inference and a failure to evoke the inference in appropriate situations. Experiment IV tests these alternative explanations.

A number of conclusions may be drawn about why young children fail to manifest this particular strategy. The advantage of the cued over the experimental group suggests that deficits in auxiliary skills such as memory for the original array, or monitoring previous solutions, may leave the child with insufficient information to employ the strategy. Interestingly, the data on cue use indicate that older children are better able to bypass such monitoring and memory deficits by their more active use of external cueing aids. Other reasons for
failure may be more directly related to the inferencing skill itself. The failure to respond correctly when given sufficient information may be due to an inability to make inferences or result from the failure to access the relevant skill. This failure to evoke the appropriate strategy could be due to a belief that only direct memory solutions are appropriate to the task.

4.4 Experiment III: What type of cues facilitate inferencing?

The previous experiment suggested that preschool children failed to employ inferential strategies because of deficits in memory for the original array and monitoring of previous solutions. However, as the experiment provided both forms of information in the cued condition, it was not clear which deficit was the more crucial. The present experiment employed the same procedure, and provided either array or monitoring cues, but not both. It should therefore be possible to determine which is the more important for the inferencing strategy.

Method

Subjects: The subjects were 68 children in the age range 3;2 - 5;1. They were divided into the same age groups as in the previous experiments. Thirty-five children received only monitoring cues. There were 9, 14 and 12 children in each age group respectively, and
their mean ages were 3;5, 4;2 and 4;8 respectively. The remaining 33 children were given only array cues. There were 9, 9 and 15 in each age group respectively and their mean ages were 3;5, 4;2 and 4;9 respectively. None of these children had participated in any previous experiment.

Procedure: The procedure was similar to that used in the previous experiments. The children were given two trials without cues and then received two more trials with either array or monitoring cues. The instructions varied slightly for the two groups, as the set of instructions used to draw attention to the array cues was, of course, omitted in the monitoring condition. The experimental set up is identical to Fig. 1 except that each group only received one cue type.

Results

The results are reported in the same format as the last experiment, i.e. cue use, memory scores and failures at the fourth location are analysed separately.

Cue use

Cue use was measured exactly as in Experiment II, and the results largely replicate that experiment. Tables 6 and 7 show the number of children who employed monitoring and array cues on the two trials. As Table 6 indicates, use of monitoring cues was again frequent with 80% of subjects using the cues on both trials. There were more children using monitoring cues in the two

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* One child in the middle age group failed to complete the procedure and was excluded from the analysis.

** See Appendix V.
older groups than in the younger group $X^2(1) = 4.52$, p<0.03.

As in Experiment II, more children made use of monitoring than array cues ($X^2(2)=17.31$, p<0.001). The overall percentage of children using array cues on both trials was 30%, and there were no age differences for cue use $X^2(1)=0.03$, p>0.05.

Cue use was also directly compared with that in Experiment II. There was no difference between the experiments for monitoring cues, $X^2(2)=0.0001$, p>0.05. However a difference was found for array cues: $X^2(2)=8.00$, p<0.01. This was due largely to the oldest groups showing a reduced tendency to use cues in Experiment III.

Distribution of memory scores

The percentage of correct responses at each location is shown in Table 8. As can be seen, monitoring and array cues seem to have very different effects. Elevation of recall occurred at the third and fourth locations to be probed only with monitoring cues.

The data were subjected to a 3 (age) x 2 (cue type) x 4 (serial position) analysis of variance.* Although changes in performance with age did not reach significance there was the distinct suggestion of a developmental trend. ($F(2, 62)=2.72$, p=0.07). There were also

* Again the UNEN programme from the ALICE package was used.
significant main effects of cue type ($F(1, 62) = 12.77$, $p < 0.001$) and serial position ($F(3, 186) = 5.71$, $p < 0.001$) and a cue type x serial position interaction ($F(3, 186) = 3.24$, $p = 0.02$), which were due to the superiority of monitoring cues, and their effect in elevating recall at the third and fourth serial positions. Planned Tukey tests showed both these locations were significantly better recalled with monitoring cues ($CR_T = 14.79$, $p < 0.05$, $CR_T = 27.03$, $p < 0.01$). The results of the present experiment were also compared with those of Experiment II. Performance on these trials is illustrated in Table 9. This table shows a clear differentiation in the usefulness of the different cue types. Performance is comparable for the no-cue and array-cue conditions, which show no elevation at the fourth location. In contrast, performance is elevated at these locations for the other two cue conditions, when monitoring cues are present. The data were analysed in a 3 (age groups) x 4 (cue types) x 4 (serial position) unequal cell numbers ANOVA and the results are shown in Table 10. As can be seen from this table, the two groups who received monitoring and array and monitoring cues, performed better than the array and control groups. The effect of cue type was significant ($F(3, 184) = 12.37$, $p < 0.0001$). More importantly cue type interacted with serial position ($F(9, 552) = 6.31$, $p < 0.0001$) which resulted from enhanced recall at the third and fourth locations. Planned comparisons using Tukey's test indicated that both groups who received monitoring cues showed significant elevation of recall at the third and fourth location. This was not true of the group who were

* The respective Tukey values for the third location were 27.75 and 22.83, and for the fourth location 46.06 and 53.51 for the monitoring and monitoring and array cue groups. All these are significant ($p < 0.01$)
provided with array cues only, due to the use of the inferential strategy. Strategy use in the two monitoring conditions was sufficient to produce an overall serial position effect ($F(3, 552)=18.74, p<0.0001$). Overall performance did increase with age ($F(2, 184)=4.42$, $p<0.02$). There was a suggestion that older children may make more active use of cues, although this effect was not significant $F(6, 552)=1.80, p=0.09$.

**Failures at the fourth location**

Of the children who received monitoring cues, 23% made errors. Half the errors followed a failure to use the cues. Following spontaneous or experimenter-induced cue use 75% of the children were able to give correct responses. Comparison with monitoring and array group in the previous experiment suggests that although the error rate is slightly higher due to the absence of array cues in the monitoring condition, there is no significant difference in the types of errors made (Fisher Exact $p=0.30$.) Error rates were much higher in the array only group, and few children (6%) benefitted from the experimenter drawing attention to the cues. Chi squared analysis demonstrated that there were more children making errors in the array than monitoring condition, both before the experimenter indicated the cues ($\chi^2(1)=40.00, p<0.001$). The data suggest that experimenter assistance may well benefit subjects when monitoring cues are available but be of little use for the array cues.

*A post-hoc Neuman-Keuls test showed the two older groups outperforming the youngest ($CR_{N-K} = 23.16, p<0.05$, $CR_{N-K} = 25.30 p<0.05$).*
Discussion

The results of the present experiment replicate and extend the findings of the previous study. The memory data strongly suggest that array and monitoring cues differ in their usefulness for the inferential strategy. Both the higher performance, and the presence of enhanced recall at the later locations only, with the monitoring cues, indicates that monitoring cues are mainly responsible for the strategy use detected in the previous experiment. Providing array cues alone does not elevate performance above the control, or give serial position effects, which suggests that array cues alone are of little benefit. In addition, there is weak evidence from the memory data that older children may make more efficient use of monitoring cues. A more extended discussion of this finding will be presented later.

These conclusions are supported by the analysis of errors. Errors occurred much more frequently with array cues, and the experimenter drawing attention to the array cues did not seem to assist inferencing as it did with the monitoring group. It is interesting that only 6% of the array only group improved performance when the cues were indicated, when a random guess at one member of the array would have improved it by 25%. This would seem to suggest the problem for young children lies in realising how the array cues might be used. The opposite holds for monitoring cues. An animal cannot be in two places at
once - if it has already been exposed it clearly cannot be under the remaining cups. The use of monitoring cues is therefore much more obvious. The error data are consistent with Experiment II, in that all the same types of errors are detected. Thus, some children fail to make the inference, but when provided with monitoring information are able to do so. A small proportion of the subjects were unable to give the correct solution even when such information was provided. Other children responded incorrectly, but gave a correct solution when the monitoring cues were indicated, suggesting they may have attempted to solve the problem by memory. The differential usefulness of the two cue types is also reflected in the direct measurements of cue use. The monitoring cue data are almost identical to the previous experiment, with the majority of subjects making use of them. In addition, fewer children use array than monitoring cues in this experiment. One result does differ from the previous experiment. Array cue use is less frequent than in that experiment. It is the oldest group who are responsible for the reduced use of array cues in Experiment III, which seems to indicate that some children at this age level are sensitive to the fact that array cues do not aid memory. It cannot be argued, however, that this reduction in array cue use is responsible for the absence of array cues effects on memory, because over 60% of subjects were using array cues in this experiment, and also because array cues do not assist performance when they are presented along with
monitoring cues.

The major finding of this study is that the presence of monitoring rather than array cues assist memory. This suggests that young children have distinct difficulties in monitoring previous solutions in memory problems. This monitoring deficit may, however, be more general; for the younger children's persistence in using array cues which do not benefit memory, indicates they are not evaluating the effects of their memory activities.

4.5 Experiment IV: Are there deficits in underlying inferential skills?

The previous set of experiments suggest a number of reasons for the failure to employ an inferential strategy in memory. Children may lack auxiliary skills such as monitoring which means they have insufficient information to make the inference. Even when such information is provided in the form of cues, children may sometimes fail to utilise it. Further, even when cue use is spontaneous or when it is experimenter induced, a number of children fail to make the inference despite the fact that they have sufficient information to do so. In the previous experiments I have argued there are two possible explanations for this failure. Children may simply be unable to execute the necessary operations, i.e. they are unable to inference. Alternatively, they may be influenced by the perceived demand characteristics of
the task. They may obey the instruction to remember too literally, and rely on direct memory, to the exclusion of inferential strategies.

The present experiment attempted to establish whether children failed to make inferences when there were no memory instructions, but the children were all in possession of sufficient information to make the inference. Failure under such circumstances cannot be due to attempts to solve the problem by means of direct memory, and would seem to result from an inability to inference.

If it were discovered that children in possession of sufficient information failed to make inferences, this would have interesting implications for the debate on transitive inferences. While Bryant (1974) and Trabasso (1977) argue that being in possession of premise information is necessary and sufficient for inferencing, this position has been opposed by Breslow (1981), who argues for changes in ability to inference.

The task employed in the present experiment was a modification of that used in earlier experiments. It differed from those experiments because the children did not observe the animals being hidden, and were given no instructions to remember. All children had previously overlearnt the set of animals in the array, and were given monitoring information explicitly by the experimenter.
They were thus in possession of information sufficient to make the inference, and were simply asked if they knew the identity of the animal at the final location. No direct memory solution was possible, because the children had not observed the animal being hidden, and so inferencing was the only means available for solution. None of the children had taken part in any of the previous studies.

**Method**

**Subjects:** The subjects were 59 children in the age range 3;0 - 5;3. They were divided into the same age groups as the previous experiments. There were 11, 26 and 22 children in each group and the mean ages were 3;6, 4;3 and 4;11 respectively.

**Procedure:** The procedure was a modified version of that employed in the previous experiments. Before the start of the experiment itself, the children were given a series of pretrials until they could correctly name all the animals in the array on two consecutive trials. They were then told to close their eyes while the animals were hiding. Each location was probed, and at the final location the experimenter supplied monitoring information by pointing to the exposed animals and saying, 'There's the (named the three animals), now who's hiding under here? (indicating to the final location)'. If children gave a response, the experimenter expressed
his amazement and asked them how they knew the identity of the concealed animal although they had not seen it being hidden. It was possible by this means to elicit justifications of inferencing from the children. All children received one trial.

Results

The percentage of children at each age level who made the inference is shown in Table 11. There was a significant increase in performance with age, with the two older groups performing significantly better than the younger (Fisher exact p = 0.037). The figure also shows what percentage of children giving correct responses to the inference question were also able to give justifications. The ability to give justifications also increased with age ($\chi^2(2) = 5.97$, $p<0.05$) with the older groups outperforming the youngest group ($\chi^2(1) = 5.21$, $p<0.03$).

Discussion

The present experiment eliminated the possibility that strategy failure resulted from lack of information or from the misunderstanding that the task required direct memory solutions only. The results therefore suggest that one reason why some children fail to demonstrate the inferential strategy is because they cannot make inferences. Children who are unable to
demonstrate the strategy in the simplified procedure of this experiment are unlikely to exhibit inferencing on the memory task. We cannot conclude from this, however, that an inability to access the correct strategy plays no role in the memory task. Failures of this type may well occur; what the present experiment demonstrates is that failure to access is not the only explanation of strategy failure when the child has sufficient information to make the inference. The results would also seem to support the position of Breslow (1981) on transitive inferences. He mentions that premise information is necessary but not sufficient for inferencing - a claim which is consistent with the findings of this experiment, for a different type of inference.

None of the 59 children made errors in inferencing. This suggests that the errors made on the memory task were the result of erroneous direct memory solutions. If this is the case, then the errors on the memory task are themselves evidence for the use of memory when inferential strategies are possible.

The finding that the ability to give justifications of strategy use increases with age has important theoretical and methodological implications. The theoretical implication is that there may be a number of different ways in which a cognitive skill can be in the repertoire. In this case, younger children may be able to use a
strategy some time before they are able to describe it. The methodological point is that verbal protocols are not suitable as a means to tapping strategy use, particularly in this age group. Young children may well be employing a strategy but be unable to describe their activity.

4.6 Inferences as memory strategies and the failure to employ strategies

The group of experiments just described had three main aims:
(1) To investigate when inferences are employed to supplement direct memory, and to provide explanations as to why young children do not employ such a strategy;
(2) To assess whether young children are able to make use of indirect cues to aid recall;
(3) To assess the intentional character of the young child's memory behaviours.

Inferences

The exact level of inferencing is impossible to assess directly in these experiments, because of the possibility of direct memory solutions. The fact still remains, however, that the groups with monitoring cues generally performed twice as well as control groups, despite the presence of ceiling effects. These results are interesting because they apparently contradict two
generalisations often made about preschoolers, that they do not often make use of memory strategies (Brown, 1975; Flavell, 1970) and that they lack logical abilities (Piaget, 1946).

If we deal first with the use of strategies, a number of recent studies have convincingly demonstrated the use of simple strategies by this age group (e.g. Wellman et al, 1975; Yussen, 1974; Yussen et al, 1975). The eliminative inference may in reality be simpler than its complexity in logical terms would have us believe. This is especially true if the environment provides cues which avoid the necessity of monitoring previous solutions, as in the case of these experiments. The formal logical account might describe the process as the internal search of the original array, eliminating previous solutions. However, the process may be more accurately described in the present experiments as a realisation that the animals exposed at previously searched locations cannot possibly also be concealed at the final location. This suggests that the findings of the present experiment may not in reality contradict the research of Piaget, because in the present experiment the presence of external cues simplifies the making of the inferences in two ways: (a) it reduces the information processing demands on the child by avoiding the necessity for internal storage of premise information; (b) the presence of the cues suggests the use of the inferential routine to the child.
The experiments also suggest a number of reasons why children may not employ the strategy.

(a) **Auxiliary skills** Experiment II indicated that the inferencing was vastly increased when problems of monitoring and memory for the original array were bypassed. Experiment III established that deficits in monitoring of previous solutions was the more crucial of these deficits in explaining strategy failure. These results are consistent with the literature on transitive inferences, in which performance is massively improved by pretraining on premise information (e.g. Trabasso, 1977). The research of Eimas (1970) also shows that 7-year-old children have difficulty in keeping track of previously rejected incorrect hypotheses in problem solving tasks. Thus, deficits in skills other than those directly under test may explain why inferences are not employed.

(b) **Failure to seek out relevant information** Experiments II and III suggest that a small number of children may fail to demonstrate inferencing even when cues are provided, not because they cannot make inferences, but because they fail to make use of the information provided. We might expect this type of deficit to have decreased with age, given that older children made more use of the monitoring cues. However, the number of children showing this type of deficit was small, and so it was impossible to test the hypothesis directly.
In general, the likelihood of this type of failure will depend very much on the way in which cue information is provided. It has already been argued that the way in which monitoring cue information is to be used is almost self-evident. Array cues offer a less obvious source of information. In addition it seems that the information afforded by array cues is not useful to children of this age. More will be said about this type of failure in the discussion of cue use.

(c) **Failure to select the appropriate routine** Another reason why inferencing may not be employed is that an alternative means of solution is available. It is highly likely, given the task instructions, that some children selected a direct memory solution. Experiment IV found that no children who made inferences produced errors. Children do make errors, however, in Experiments II and III. This may well be because they are attempting such/solutions. One problem with the error based measure is that it ignores those children who rely on the direct memory solution, but who are correct, and are thus indistinguishable from children who use the inferential solution. Again, selection errors may well be highly task-dependent. The monitoring cues in these experiments make the strategy obvious, but the memory development literature is full of demonstrations of production deficits, when children fail to spontaneously manifest a strategy and yet can be induced to use it with minimal training.

(d) **Inability to use the strategy** It has just been argued
that children may fail to use the strategy because they attempt alternative means of solution, e.g. direct memory. Experiment IV eliminated this possibility, and also pretrained children to give them the information necessary for the inference. Despite this, some children still failed the task, which suggests that they may be unable to make inferences. If this is the case, it is hardly surprising that they fail to manifest the strategy.  

Cues

In many ways, the conclusions concerning cue use converge on those made about inferencing. Firstly, there is an apparent anomaly with related research; other studies have suggested that young children's cue use is highly limited in nature. Preschoolers may be capable of utilising identical or highly-associated objects as cues at encoding (Geis and Lange, 1976; Gordon and Flavell, 1977; Ryan et al., 1970) but their performance is massively reduced when cues are indirect or esoteric (Gordon and Flavell, 1977; Ritter, 1978) or if cued retrieval must be exhaustive (Kobasigawa, 1974, 1977).

It is possible that the inability to produce a strategy is not as distinct from the failure to access it, as this analysis suggests. It may be that the children who failed to inference in Experiment IV could be induced to do so if explicit enough instructions were provided. The distinction between inability and access may not therefore be as sharp as has been argued.
At first glance, the results obtained with the monitoring cues would appear to contradict these findings. Very young children are apparently bypassing deficits in their monitoring ability by utilising information about previous solutions provided by the experimenter. A priori, both monitoring and array cues must be characterised as indirect, because both require combination with some other information for solution. However, as I have argued in the section on inference failures, the nature of the task makes it extremely obvious to see how monitoring cues might be used. This may explain why even very young children have little difficulty in seeing how the monitoring cues are to be used, and in actually using them.

The data on array cue use support the claim that preschoolers' cue use is limited in nature. In the array condition children at all ages made use of the cues, despite the fact that array cue use had no effect on memory. It is as though the children realise that in some way the cues ought to be useful, but cannot quite see how they might be used. Cue use may very well be induced by the fact that the experimenter has directly referred to the array cues and stressed their relation to the concealed animals! Similar results were found in the monitoring and array condition where again there is a high level of array cue use, without memory pay-

* An additional factor may be the direction of the experimenter's eye gaze. It may be that the children look at the cues because the experimenter does so. This could be examined by conducting the experiment with the experimenter behind a screen.
Interestingly the use of array cues seemed to be context-dependent. Array cue use was significantly increased by the presence of monitoring cues. In contrast, monitoring cue use was independent of the presence of array cues. We may therefore conclude that although preschool children may make increasing use of indirect cuing strategies, such as using the monitoring cues, the exact nature of the cues used means that the results are not inconsistent with other recent research. The data on array cue use suggests that young children have difficulty in making use of more indirect forms of cues. Even at this age, children do show some sensitivity to cue usefulness, with the two older groups looking substantially more at monitoring than array cues.

The finding that young children may engage in "strategic" behaviour without memory pay-offs may suggest an important mechanism in the development of strategies. Particular situations may elicit certain behaviours in children. Some of these behaviours may well be inappropriate (e.g. array cue use), but it is only by engaging in a number of such behaviours that a child can discover or be instructed which of these have memory pay-offs and should be avoided.

A similar argument has been advanced by Ryan et al (1970) in their study of preschoolers' use of pictures to cue hidden animals. They suggested that young children may place pictures of animals outside their hiding places because such matching behaviour is a "high-frequency behavioural response". The difference between the Ryan et al study and the present ones, is that in their study the elicited behaviour always had memory payoffs.
4.7 Experiment V: Does self-assessment relate to cue use?

The experiments on cue use suggested a number of interesting results:
(a) Some children make very little use of cues;
(b) There is an increase with age in the use of the monitoring cues which do benefit memory;
(c) Some children make use of the array cues, which apparently do not aid memory.

One possible explanation for some of these deficits may lie in children's inability to assess the accuracy of their own performance. A number of studies have found massive overestimations in 7-year-old children's ability to assess their own performance on memory tasks (Brown, 1978; Flavell et al, 1970; Kelly et al, 1976; Yussen and Levy, 1975). If children genuinely believe their performance will be excellent, it is not surprising that they fail to employ strategies, because there seems little need to do so. Unfortunately, the two studies which have attempted to find the predicted relationship between prediction and strategy use (Flavell et al, 1970; Kelly et al, 1976) have failed to do so.

Pilot studies attempting to obtain predictions from preschoolers encountered severe difficulties, so children
were asked to assess performance after rather than before completing the task. The same argument holds for postdiction and prediction, for if children believe they have performed well without using strategies, there is no necessity for employing them. Other studies have not investigated this possible relationship, because they have studied older children, who are usually remarkably good at postdiction (Berch and Evans, 1973; Masur et al, 1973). The lack of postdiction data available for this age group also offered a further reason for conducting the study.

The first study therefore had a number of aims:

(1) To assess preschool children's ability to assess their own memory performance (postdiction);
(2) To investigate whether self-assessment was related to cue use, in particular, whether young children's failure to employ strategies can be traced to overestimation of their own performance;
(3) To assess whether postdiction was related to the type of strategy used. In particular we might expect children who are better at self-assessment to use only monitoring cues, because they detect that array cues do not influence memory.

**Method**

Subjects: The subjects were 67 children in the age range 3;0-5;3. They were divided into the usual age groups with 16, 24, and 27 children in each age group
respectively. The mean ages were 3;5, 4;1, and 4;9 respectively. All children had participated in Experiments II or III some two or three months previously.

Procedure: The experimental procedure was essentially the same as Experiments II and III. The children were given a number of pre-trials in which the experimenter demonstrated what was required, by giving post-diction responses himself. The children were then given two memory trials in which no cues were presented. After recall was completed on each trial, the experimenter exposed all the hidden animals and asked the children to make post-diction judgements ("Show me which ones you remembered in the right places"). There then followed two trials with both monitoring and array cues as in Experiment II. No post-diction judgements were requested for these trials: The experimental set-up is depicted in Fig. 1, Appendix V.

Results
Table 12 indicates the extent to which young children overestimate their own performance. On average children overestimated what they had remembered correctly by 70%. Errors were almost exclusively over-estimations, and on 51 out of a possible 134 occasions the children incorrectly claimed to have remembered all the items on a trial correctly (an 'all right' response). Only one child underestimated his memory, although five other children failed to correctly identify individual items they had correctly remembered.

* One child in the youngest group failed to complete the experiment and is not included in the above statement or the analysis.
Children were scored by item according to whether they correctly stated whether they had remembered the item or not. The scores were subjected to a 3 (Age) x 2 unequal cells (Trial)/ANOVA.* There was a main effect of age (F(2, 64) = 4.01, p=0.02) and no other effects were significant.**

In order to investigate whether children who overestimate the efficiency of their memories fail to employ strategies, children were classified as cue users if they utilised cues on both possible trials. The children were also classified for their monitoring ability: if they gave two incorrect 'all right' responses, they were deemed overestimators; if they gave no incorrect 'all right' responses they were classified as realistic estimators.* Children who did not fall into either of these categories were discarded for the purpose of this analysis. The relationship between monitoring ability and cue use is indicated in Table 13. A Fisher Exact analysis was conducted to see whether post-diction skill was related to tendency to use cues. The cue use data were dichotomised as to whether cues were or were not used. Children who were bad at post-dicting were significantly less likely to make use of cues (Fisher exact p=0.03). It was also predicted that children who were better at post-dicting should also be more likely to use only monitoring cues. A $\chi^2$ analysis was conducted on all those children who used cues, but post-diction skill was not predictive of efficiency of cue selection $\chi^2(1)=1.08$, p>0.05. However, it is possible that by

* Again the ALICE UNEN statistical package was used.

** Post-hoc comparisons by Neuman-Keuls showed the oldest group performed better than the youngest (CR$_{W-K}$=51.14, p<0.05)
dichotomising children into good or bad post-dictors we lose some of the data. One initial prediction was that children who made use of monitoring cues alone, should be better at post-diction than those who used array cues. It was found that children who used monitoring cues on two trials formed 84% of the sample, and these were divided according to whether they used array cues on 0, 1, or 2 trials. The mean post-diction scores (compiled as for the ANOVA described above) for the three groups were 5.82, 6.09, and 5.20. "T" tests did not support the prediction that children who use monitoring and array cues should be better at post-dicting than children who use monitoring and array cues on both trials ($t(33) = 0.73$, $p=0.47$). In fact, children using array cues on one trial were actually superior at assessing their own performance although this difference was not significant ($t(36) = 0.41$, $p=0.68$).

Conclusions

One major result of this experiment is to document young children's inability to assess the accuracy of their performance on this type of task. Their errors consisted almost exclusively of overestimations, which averaged 70% above their actual level of performance. Although other studies such as those of Berch and Evans (1973) and Masur et al (1973) report that self-assessment is almost at ceiling, they in fact tested children 2-3 years older than those in the present sample. Indeed it is not
difficult to see why performance should be so poor. In order to respond to the experimenter's request to "tell me how many you remembered in the right places" the children must retain their own pattern of responses throughout the trial, and then compare them with the 'correct solutions' on questioning. Alternatively they may remember each location and tag it with information as to whether their response was correct. In either case, it is clear that information processing demands are high, because of the demands on memory and comparative skills. It was also proposed that the ability to assess one's own performance might be related to cuing strategies. There was weak support for the prediction that children who vastly overestimate their own memory (as many of this sample did) should see no need to employ cuing strategies. However the strong version of the hypothesis does not hold, because almost all the children who claimed to have perfect memories did make some use of cues. This should not be the case if they are influenced by their estimates. The results of the study are thus consistent with those of Flavell et al (1970) and Kelly et al (1976) who found little or no relation between prediction measures and strategy use.

There was also little evidence that self-assessment skills related in any way to the type of cue selected. Children who showed optimal cue use, i.e. they used monitoring cues only, did not perform better on the self-assessment tests, than other groups. Before rejecting any type
of relationship between cue selection and self-assessment, it is important to consider two other possibilities. Children may well realise that performance is improved when using monitoring and array cues but be unable to isolate which cue type is responsible. They may therefore persist with both types. Alternatively, we may argue that insufficient measures of self-assessment have been taken because there is no reason why assessment scores on the previous two memory trials should directly relate to performance on the trials with cues. Any relationship between cue use and self-assessment may critically depend on judgements made on cued trials, because any decision about strategy efficiency is going to require a comparison of performance on memory trials with performance on cued trials.

4.8 Experiment VI: Does self-assessment relate to the type of cues used?

The present experiment attempts to eliminate the confounding of monitoring and array cues, by presenting the cue types separately. It was argued that cue selection may depend critically on comparisons on trials with and without cues, and so four self-assessment measures were taken i.e. one on each of the trials.

If self-assessment does affect strategy selection we should expect a number of relationships to hold: first, children who vastly overestimate their own performance
should see no need for strategies, and consequently not use them. Also we might expect cue use to relate to self-assessment. Thus, children who accurately check their own performance should realise the usefulness of monitoring cues and hence make maximum use of them. Conversely, they should detect that array cues do not increase performance and therefore not use them. We should consequently predict that children making use of monitoring cues should be accurate at self-assessment, whereas the opposite should be the case for those using array cues. Finally, cue selection should be related to perceived changes in performance when cues are used. Thus, we might expect children who use cues and accurately check their performance to realise that the improvement is due to cue use. They should therefore retain the strategy. If, of course, perceived performance drops when cues are used then we should expect use of the strategy to be discontinued.

There are thus three separate hypotheses concerning the relationship between post-diction and cue use:

(a) Children who overestimate memory on the two initial trials when no cues are present should not use cues when they are provided.

(b) Children who are good at monitoring should use monitoring cues and not use array cues. No such differentiation should occur for the group who are poor at monitoring.

(c) Changes in performance should be related to monitoring.
If children perceive that their performance is improved they should persist with their current strategy. If performance is not improved by cue use, they should not maintain that strategy.

It is important that hypothesis (a) is subjected to test, because the results of the last experiment suggest some evidence for this claim. In contrast, other experiments have found no such relationship (Flavell et al, 1970; Kelly et al, 1970). The rationale for hypothesis (c) is derived from experiments which suggest that information about performance change can influence strategy maintenance (e.g. Borkowski et al, 1976; Kennedy and Miller, 1976). In those experiments such information was provided by the experimenter: the present study investigates whether children use information they themselves have generated.

**Method**

**Subjects:** The subjects were 68 children divided into the usual age groups. Thirty five children received monitoring cues and 33 received array cues. There were 9, 14, and 12 children in the monitoring group (mean ages 3;5, 4;2, and 4;8) and 9, 9, and 15 children in the array group (mean ages 3;5, 4;2, 4;9). All children had participated in Experiments II or III some 6 months previously.

**Procedure:** The procedure was identical to that employed in Experiment V except that after every trial the children were asked to assess the accuracy of their
performance, and children were given either array or monitoring cues, not both.

Results

The self-assessment data for the three age groups under the different cueing conditions are illustrated in Table 14. The results for the no cue condition replicate the data reported in the previous experiment, and for all three conditions children overestimate their actual memory scores by 71%. Again a large proportion of the overestimations are contributed by those children who claimed erroneously to have remembered every item correctly on all of the trials. Altogether 24/68 children incorrectly claimed to be completely correct on all completely trials, and a further 8 claimed to be/correct on three of the trials. Again, there were few failures to identify items correctly remembered, and only two children underestimated their memory aggregates. It is interesting to note that despite the inaccuracy of children's absolute estimates of memory performance, they were to some extent sensitive to the changes in performance resulting from monitoring cue use. Thus in all three age groups, performance assessments were higher in the monitoring cue condition.

The data were analysed separately for the groups who received monitoring and array cues, and analysis took the form of two (Cue/No-Cue) x / (Age) ANOVA's. The data

* Again UNEN from the ALICE package was used.
were scored in the manner described in the previous experiment, with one point being given for a correct response as to whether or not the item had been remembered. Both analyses found main effects of age, but there were no other effects. Thus, there were developmental trends for the group who received monitoring cues \((F(2, 64)=3.97, p<0.02)\)* but there was no difference in assessment accuracy between the cue and no cue conditions. A developmental trend was also evident in the array cue analyses \((F(2, 62)=3.32, p<0.05)\)* but again there was no effect of cueing Thus, although children's assessments of memory increase in accuracy with age, they are not influenced by whether or not they are employing cues.

The data are again amenable to the investigation of the overestimation hypothesis (see Experiment V). The hypothesis that gross overestimators were less likely to make use of cues than children who were accurate at self-assessment was not verified \((\chi^2(1)=0.44, p>0.05)\). In addition, 14 of the 24 overestimators used cues on both trials. Finally, it was found that overestimators were indistinguishable from accurate self-assessors in their use of both types of cues.

Children were also classified according to whether they used cues on neither one or both trials. The two separate 3-way (cue use) ANOVA's for both monitoring and array cues indicated there was no difference in monitoring

* Post-hoc comparisons using a Neuman-Keuls test showed the two older groups were superior in both conditions. \(\text{CR}_{N-K}=22.99, p<0.05, \text{CR}_{N-K}=24.15, p<0.05)\).
scores between the three groups, for either of the cue types analysed.

The relationship between strategy maintenance and perceived effectiveness of the strategy was also analysed. All children who incorrectly claimed to have remembered all items were rejected from the analysis. Children were categorised according to whether their self-assessment scores indicated they perceived that available cues improved, reduced or did not influence memory. It was argued that children who used cues, and perceived their performance as improving with cues, should maintain that strategy over both cued trials. Table 15 shows strategy maintenance in the three groups. Two features of the table are worth noting: ten children continued to employ the strategy despite the fact that they perceived it as reducing performance and secondly few children did not maintain a strategy they felt did improve performance. Thus while fifteen children behaved in accordance with initial predictions, sixteen did not.

Conclusions

The majority of the results obtained in the present study are consistent with those of Experiment V. Again there is strong evidence for gross overestimation of performance by younger children, although this has improved somewhat by the age of five. However, although children of this age may not be able to estimate absolute
levels of performance, their estimates do change when the level of performance changes, indicating they are in some way sensitive to performance. Thus, children's estimates of their performance reflect the fact that their actual performance is better when monitoring cues are present, i.e. when such cues are present, their estimates are higher.

The experiment was also designed to investigate how children's estimations of their own performance influence their strategy use. There was no evidence that children who grossly overestimate memory, and claim to perform perfectly, actually make less use of cues than more accurate estimators. It was also predicted that children who assess accurately should make maximal use of monitoring cues, and minimal use of array cues. It was found that children following either of these optimal strategy paths did not demonstrate greater ability to assess their own memory.

However, this may not be conclusive proof that no relationship holds between self-assessment and strategy use. The above hypothesis need not be correct that optimal strategy users should be best at monitoring their own performance. As the assessment data indicate, children may not be able to judge their absolute level of performance but be able crudely to detect when performance changes. It is this skill, rather than absolute judgments, which may be crucial in determining strategy
maintenance. A more sensitive test of the relationship between self-assessment and strategy use follows from this. Children should maintain a strategy if it is detected as improving memory, and to this end, it is not crucial that absolute levels of performance are detected, rather than they can isolate a relative change in performance. The experiment attempted to assess whether strategy maintenance was influenced by children's detection of such relative changes. Again no relationship was found, although there may be other post-hoc explanations for this. It may be that children find it difficult to remember assessments of performance when they have to retain this information across trials. In addition, relative changes may be small (e.g. one or two items) and therefore difficult to detect. If changes in performance due to strategy use were made sufficiently large, it might be that young children could detect such changes and consequently modify strategy behaviour. *

4.9 Conclusions

The last two experiments/provide further counter-evidence against metamemory theories. In Experiment V, two, and in Experiment VI, three hypotheses derived from metamemory theory were subjected to test. Only one of these hypotheses was supported by the evidence, and it was not replicated in the following experiment.

* This may be a somewhat insensitive test of the relationship between maintenance and effectiveness because children have only two trials in which to assess the effectiveness of various cues.
The strength of these claims must, however, be questioned in the light of the reservations expressed above. If the experiments are indeed insensitive, then they do not provide convincing evidence against the metamemory hypothesis. Despite this, the results are consistent with two studies investigating the relationship in older children (Flavell et al, 1970; Kelly et al, 1976).
5.1 Introduction

This Chapter addresses the problem of strategy access. There are both general and specific reasons for addressing the problem. The general reasons lie in the pervasiveness of the phenomenon of the production deficit, and the implications of this deficit for theories of both memory and cognitive development. The specific reasons lie in the findings of the previous set of experiments, which investigated the use of cueing strategies. Both Brown (1978) and Flavell (1971) have predicted that access should be related to monitoring skills, but no evidence was found for this.

Chapters 1 and 2 reviewed a number of studies which indicate that young children have problems in spontaneously accessing cognitive routines which are in their behavioural repertoire and which benefit memory. The failure to access can occur both before and after instructions in strategy use, as the Keeney et al (1967) experiment shows. They found that children could be induced to engage in simple rehearsal after a minimal amount of training, but that children would not continue to use the trained strategy when the experimenter no longer prompted them to do so. The phenomenon of failure
to access appropriate cognitive routines is not limited to memory, however, for both Bruner (1966) and Donaldson (1978) offer accounts of conservation failure which appeal to the notion of access. Other studies (e.g. Gelman, 1969) have employed training procedures to demonstrate that children are capable of generating conservation responses some years before the spontaneous appearance of these skills. The problem of access is therefore an important one, because of its pervasiveness in different development domains.

A number of accounts of memory development (e.g. Flavell, 1971; Brown, 1978) suggest that strategy access may be influenced by monitoring; more specifically that children's assessments of their memory performance determine the nature and extent of their strategy use. Experiments V and VI found little evidence for the predicted relationship. It was suggested that there may be a number of reasons for this: (a) children may not monitor accurately; (b) they may not be able to retain the results of the assessments of performance over trials, and thus not be in a position to compare any changes in performance resulting from the use of different strategies; (c) they may actually have difficulty in making the comparison between differences in performance; (d) they may not correctly attribute such changes to changes in strategy use.

Some recent studies of strategy maintenance provide
evidence that these factors may be important. The experiments of Kennedy and Miller (1976) and Borkowski et al (1976) bypassed the problems which monitoring, evaluating and rationalising changes in memory may provide for young children. They achieved this by directly informing children of the relationship between their performance changes and strategy use. Children given such feedback on the effects of training strategy use were found to maintain those strategies. In contrast, children who were not given this information did not maintain.

As I argued in Chapter 2, however, feedback is not the only mechanism by which strategy maintenance can be achieved. Not only is strategy maintenance possible in the absence of feedback (e.g. Bjorklund et al, 1977-Ornstein et al, 1977) but the above manipulation of providing feedback confounds the various explanations of maintenance failure suggested previously. Other feedback experiments do allow us to separate out the various explanations. Thus Ringel and Springer (1980) and Heisel and Ritter (1981) have shown that children have difficulty in monitoring strategy effectiveness, in evaluating it, and in attributing performance changes to strategy use.

Ringel and Springer employed a task of memorising lists of categorisable words. Subjects were given one of three types of feedback about their performance. One group
were told they were performing better, and that this was because they were employing the trained strategy. Another group were simply told after the session in which they used the strategy, that they were performing better, but no attention was drawn to the fact that the strategy was responsible. The final group received no feedback. Ten-year-olds maintained the strategy if informed about their improvements in performance, and 6- and 8-year-olds only did so when this information was related to strategy use. Control groups not given this information did not maintain. Heisel and Ritter (1981) used a similar manipulation of feedback-and-explanation, feedback and no information. They employed a spatial location task. The results showed a similar pattern to those of Ringel and Springer. Five-year-olds maintained when given information only about strategy effectiveness, whereas 3- and 4-year-olds required that this connection be made explicit before they showed maintenance.

Thus we have evidence that children have difficulty in evaluating changes in performance, and also in interpreting these changes as being the result of strategy use. These conclusions are consistent with the results of Moynahan (1976) who found using questionnaire methods, that information about performance level was related to strategy use. Experiments V and VI also suggest children may have difficulties in accurately monitoring their performance.
The present chapter examines some of the conditions under which children can be induced to monitor trained strategies and also investigates the possible explanations of the failure to monitor suggested earlier in this section.

5.2 Experiment VII Does feedback influence strategy maintenance?

Introduction

The present study attempted to replicate the results obtained by Kennedy and Miller (1976), whose experiment is itself a modification of Keeney et al (1967). The experiment differs from the Keeney et al study only in that feedback is given to one group of trained producers before the maintenance task. In the Kennedy and Miller experiment, non-rehearsing children were first instructed in the use of rehearsal. Following instruction, half the subjects were told they were "doing much better" when they used the strategy. The other half of the subjects were not given this information. Only the subjects given feedback maintained the strategy when they were not explicitly requested to use it. The present experiment consists of three phases: diagnosis, training and transfer. In the first phase, children are tested to see whether they spontaneously employ verbal rehearsal when required to remember the serial order of a set of pictures indicated by the experimenter. It is predicted that children
who rehearse should outperform those who do not. Children who do not rehearse are then taught to do so, which should elevate their performance to the level of the spontaneous rehearsers. Following training, half the children induced to rehearse are given verbal feedback about their performance. It is predicted that these children will continue to use the strategy when not directly instructed to do so. In the absence of such reinforcement, maintenance should not occur.

Method

Subjects: The subjects were 53 children aged between 6 and 7 years. All subjects took part in the initial session, and 24 subjects participated in both sessions.

Apparatus: The stimuli consisted of pictures of six common objects: chair, cup, brush, saw, clock and pan. These were randomly arranged before each test trial. In order to prevent the children looking at the cards during the retention interval they wore a space helmet with an opaque vizor. The vizor was put down during the retention interval, and raised for presentation and test.

Procedure: The children were tested individually. Both presentation of the tasks, and the scoring were conducted by one experimenter. The children were initially given training in the concept of "same order" using toy animals. They were given a series of pretrials to familiarise them with the task and with the use of

* All subjects attended the same primary school in Cupar, Fife.
the helmet. The children were told to look at each picture as the experimenter pointed to it, and then to lower the vizor on instruction. A 15s retention interval elapsed during which the experimenter modified the array. The children were then told to raise the vizor and to point to the same items as the experimenter in exactly the same order. They were also told that it did not matter if the spatial location of the items had altered. Following Kennedy and Miller (1976) the number of items on 10 subsequent trials was 5-4-3-4-5-3-2-3-4-5. Following the series of 10 trials the children were asked how they had tried to remember the pictures, and also asked to name all the pictures.

The criterion used for identifying producers was whether they employed rehearsal on nine of the 10 test trials. If they rehearsed on none or one and failed to report a strategy they were categorised as Non-producers. Only the children classified as Producers (6) or Non-producers (18) were involved in the second session which took place 3 days later. The children's recall was also scored for how many items they correctly remembered.

The second session which took place 3 days later, only involved the Producers and Non-producers as indicated above. The Non-producers were paired according to their recall scores in the first session. They were
then randomly assigned to Feedback or No-Feedback groups. All the children were given a brief pretrial to confirm the diagnosis of Session 1. None of the children showed strategy use in this pretrial which differed from their previous diagnosis.

For the Producers, the procedure was identical with the first session; they received 10 trials in the order previously given. Non-producers in both groups were given instructions in strategy use with a different set of pictures. The experimenter told them, "This time when I point to each of the pictures, I want you to say its name. When I've finished pointing at the pictures I want you to put the vizor down like you did last time, but this time you've got to keep on saying the names of the pictures over and over again to yourself" (Experimenter then demonstrates). There then followed a series of practice trials. On the initial trials, the experimenter rehearsed the items with the child during the retention interval. This continued until the experimenter was convinced the child was conversant with the strategy. Following this instruction, the children were given the same 10-trial sequence as they had received in the first session. Before each trial the experimenter reminded the children of the need to repeat the names of the pictures in order.

Following these 10 test trials the experimenter
suggested that both he and the child probably needed a rest. During the brief rest period he said to the child in the Non-producer-Feedback group "Goodness me, you're doing much better when you're saying the names over and over again to yourself. Saying them over and over again must help you to remember them, mustn't it?" This was not said to either the Producer or Non-producer-No-Feedback groups. They were told, "My, you must be tired after trying to remember all those pictures. Let's have a rest before we do last few".

The experimenter then said to both the Non-producer groups: "We're going to have three more shots now. I'm not going to tell you to say the names over and over again any more. You can say them if you want to, but you don't have to. Okay?" The transfer trials were then administered. They consisted of 3, 4 and 5 items and were identical to the last three instructed trials.

The rehearsal and recall data were scored as in the previous session. The present experiment departed from the Kennedy and Miller (1976) procedure by not awarding children prizes after each session.

Results

Three different analyses were conducted; the first
investigated the relationship between rehearsal and performance; the second analysed the effects of training on memory; and the third examined the effects of feedback on strategy maintenance.

Session 1 The recall data indicated that Producers (Mean = 24.50) performed significantly better than Non-producers Mean = 16.94, \( t_{(22)} = 2.85, p<0.01 \).

When asked about how they had attempted to remember the pictures only four children claimed to have employed a strategy. All these children said that they had rehearsed the names of pictures. All these children were in the spontaneous rehearsal group according to their overt strategy use.

Session 2 Following training for the Non-producer groups, recall scores for the 10 test trials were compared for the Producer and Non-producer groups. The respective mean scores were 23.84 and 21.86 and there was no overall difference between the groups, \( t_{(22)} = 1.25, p = 0.22 \). The fact that there is now no statistically significant difference in performance between the groups suggests that rehearsal training has been successful and also that the rehearsal strategy was largely responsible for the initially observed differences in performance between the groups.

If we compare observed rehearsal on the final three trials
of Session 2 (i.e. the maintenance trials), we find that of the No-Feedback group, one child abandoned rehearsal completely, two now rehearsed on two trials and five maintained the strategy. For the trained group who received feedback, three children rehearsed on two trials, and the remaining six rehearsed on all three trials. The difference between Non-producer-Feedback and Non-producer-No-Feedback groups was not significant (Fisher Exact p = 0.27), nor was there a difference in rehearsal levels between Producers and the Non-producers-No-Feedback groups (Fisher Exact p = 0.18).

Analysis of strategy maintenance in the three groups was conducted by a comparison of trials 8-10 (henceforth known as Block 1) and trials 11-13 (Block 2). The reason for comparing these trials is that the items in them are identical, but they are separated by the rest period, during which the feedback group were informed of their effectiveness of strategy use. The recall data for these blocks are shown in Table 16. The table suggests that although the performance of the Producers is relatively unchanged over the two blocks, both Non-producer groups are influenced by feedback and the new instructions. The data were subjected to a 3 (Group) x 2 (Block) ANOVA for repeated measures. In contrast to Kennedy and Miller, there was no overall effect of blocks (F(2, 47) = 0.01, ns), nor was there a group x block interaction (F(2, 47) = 0.75, p = 0.47).
In conclusion, there were no differences between the experimental groups either for observed rehearsal, or for concomitant recall.

Discussion

The results for the first session and the first ten trials of the second session provide evidence for a much documented phenomenon in memory development: the production deficit. Children who showed no signs of spontaneous rehearsal could be induced to use the strategy when they were given minimal instruction. The effectiveness of the strategy was demonstrated by the fact that their recall performance when rehearsing was elevated almost to the level of spontaneous strategy producers.

The present study also replicates two other results reported by Kennedy and Miller. In the test of strategy maintenance, when the children were not directly instructed to use the strategy, Producers and Non-producers given feedback both maintained strategy use. The results are not consistent, however, with respect to the Non-producer-No-Feedback condition. Kennedy and Miller and the earlier experiment of Keeney et al (1967) both report that children given no feedback information do not continue to employ the strategy when they are not under direct instruction.

How, then, are we to account for this discrepancy? One
explanation may lie in the procedural differences between the experiments. Both the two earlier studies employed relatively long time intervals (of six weeks) between Sessions 1 and 2 (Keeney et al) and 3 weeks (Kennedy and Miller). Children may realise that a strategy is effective by means other than being informed this by the experimenter. They may, for example, compare performance with and without strategy use and spontaneously decide on the benefits of the strategy. In order to do this they must remember their assessment throughout the period between the Sessions. We must bear in mind, also, that children do not realise that such a comparison may be helpful and so are unlikely to make deliberate attempts to remember the level of performance in Session 1.

These problems may be much reduced by the procedure used in the present experiment. The interval between Session 1 and Session 2 was 3 days. In the present task, spontaneous judgements about strategy effectiveness may be possible, given that the effects of strategy use are large (i.e. it almost doubles performance) and thus easily detectable. In addition, other studies indicate that children in this age range are well able to assess their own performance accurately (Berch and Evans, 1973; Bisanz et al, 1978).

In conclusion, information about strategy effectiveness may well be a sufficient condition for strategy maintenance. It is not necessary, however, for under the
conditions reported in the present experiment, children maintained a strategy without such information. This suggests that under certain circumstances children may spontaneously infer strategic effectiveness, a speculation which is examined in Experiment VIII.

5.3 Experiment VIII: Does strategy effectiveness influence maintenance?

The previous experiment indicated that under certain circumstances strategy maintenance occurs in the absence of feedback. This result is contradictory to most of the received literature on attempts to train strategies, but there have been a number of studies which have found maintenance without the provision of feedback. Thus the studies of Keeney et al (1967), Cole, Gay, Glick and Sharp (1971a), and Scribner and Cole (1972) report no transfer of trained studies, in contrast to the findings of Bjorklund et al (1977) and Ornstein et al (1977) who did find maintenance without feedback.

These contradictions may be resolved, however, if we
analyse the exact conditions of the experimental tasks. It was argued in the introductory sections of this chapter, that children may have difficulty both in evaluating the effects of strategy use, and in interpreting these effects. The processes of evaluation and interpretation may well be simplified if the effects of strategy use are large and hence easily detectable. Thus, if using strategies results in massive changes in performance, then these effects will be easily monitored. The size of strategy effects may also be crucial if children are not adept at monitoring: effects may have to be large before they are detectable. Interpretation may also be influenced by the size of strategy effects, because small effects could be explained by factors other than strategy use, such as practice. If effects are large, such interpretations of performance change are not possible.

The present experiment therefore set out to examine whether maintenance in the absence of feedback is related to strategy effectiveness, i.e. the amount by which a strategy improves performance. Two groups of subjects were taught the same strategy, but the conditions of the experiment were arranged so that for one group strategy use produced massive changes in performance. For the other group, strategy use did not result in such large changes. It was hypothesised that the group whose performance underwent massive changes following strategy use would be more likely to maintain the
strategy in a number of related tasks.

The experiment involved two groups of 3 - 5-year-old children who were taught the strategy of using pictures of animals to cue the locations of animals they had hidden. Each child hid the animals at different locations, and the experimenter placed pictures of the animals face-down outside their hiding-places. The strategy under study was whether children would use the pictures to help them remember where the animals were hiding. Both groups were taught the same strategy but the perceived improvement resulting from strategy use differed for the two groups. This was achieved by giving the two groups different numbers of items to remember in the no strategy and training phases. The control group who were given 3 items to remember in the no strategy and training phases, performed reasonably well without strategies, and so when they were taught the strategy of cueing, the change in their performance was not enormous. In contrast the experimental group had to remember the locations of 7 animals. They performed poorly in the no strategy phase, but performance improved to ceiling when they were taught the cueing strategy. For this group, the changes in performance resulting from strategy use were therefore highly detectable. The experimental group should therefore

11 The inferential cueing strategy of Experiments I-VI was not used in this study, because it was necessary to find a strategy which leads to large improvements in performance when it is used. This does not occur with the inferencing strategy.
perceive that strategy use is highly effective; it elevates performance from floor to ceiling levels. In contrast, performance changes should not be as large for the control group, who were performing reasonably well before they used the strategy. The influence of strategy effectiveness on transfer was assessed by examining strategy use in two other tasks. The first differed from the training task in the materials and locations used, but the trained cueing strategy could still be used. This was labelled the near transfer task. In the far transfer task, it was investigated whether children could use a variant of the strategy in encoding the location of an animal in order to remember it later. In both these transfer tasks it was predicted that the initial differences in perceived strategy effectiveness between the groups would lead to greater transfer for the experimental group.

Method

Subjects: The subjects were 60 preschool children who ranged in age from 3;3 - 5;2. They were equally divided into the usual three age groups, and the mean ages were 3;4, 4;2 and 4;11. All of the children had taken part in earlier experiments on cueing.*

Procedure: The experiment consisted of a pretrial phase, a training phase and two transfer tasks. The training phase and transfer tasks were identical for both experimental groups, but the pretrial phase differed in the number of items used on each trial.

*Two children, one from the youngest and one from the middle age group, did not complete the procedure. They were replaced by other, matched, children.
Pretrial and training: The procedure for the pretrial phase was identical to that of Experiments I - III, with the children being introduced to the policeman and the hiding animals. The hiding animals were the small plastic farm animals used in the previous experiment. The 7-item group hid a pig, a dog, a sheep, a duck, a hen, a cow and a goat. The 3-item group hid the pig, sheep and hen. The animals were hidden in the plastic cups used in previous experiments. After the two pretrials the experimenter produced a set of photographs identical in size to the original animals, and asked the children to put the animals together with their pictures. Again, a series of hints were used until the children finally agreed that the animals were identical to their photographs. The experimenter then said "This time, we're going to do it a bit differently, you hide the animals and I'll put their pictures outside like this (Models hiding and putting picture outside). Now when you want to remember which animal is in this house, you just look at the picture and then you'll know".

The children were then given two further trials in which they hid the animals and the experimenter placed the appropriate cue outside each location. The locations were then probed by the policeman, and if the children failed to use the cues the experimenter employed a series of hints to ensure that they did so. If the children did not use cues initially the experimenter said "Is there anything we can do to help us remember which animal
is hiding here?" If the children still didn't use the
cues, the experimenter said, "Why don't you look at the
picture?" There was a possibility that the few-item
group would be less likely to use the cues than the
many-item group even on the training sessions. This
was controlled by matching the 7-item and 3-item groups
for the strength of prompting required to initially
induce the strategy. Nine children in each group required
prompts, and a total of 28 prompts were given to each
group.

Near transfer: After the 2 trial training phase the
experimenter told both groups of children that they would
now play a different game. He showed them five brown
boxes which were placed on a circular turntable. The
children were shown 5 zoo animals:— a tiger, an elephant,
a polar bear, a kangaroo and a monkey. They were told,
"this time when the animals hide you have to close your
eyes while I turn this (indicates turntable) round (the
experimenter then hides animals). Now look, because I
turned it round the animal (names it) who was here, is
now over here. (Repeats for two other animals)." The
use of the turntable on the transfer task means that
direct memory solutions are not possible. Children
must therefore employ some other means if they are
to respond correctly. The experimenter than produced a
puppet, who he said wanted to 'play the game first'. The
experimenter was thus able to show the children what they
were supposed to do by modelling with the puppet. Following
this, the experimenter said that the puppet would now watch while the children had their turns. The experimenter then produced photographs of all the animals and told the child that each animal had a picture. He then told the children to hide the animals while he would put the pictures in the right places. This time the picture cue was placed on top of the box. The children all received two sets of trials on this task. On the first trial the experimenter (in the guise of the policeman) searched every location. If children did not use cues, then he did not prompt them to do so. On the second trial he did prompt, using hints similar to the pretrial, asking first: "Is there anything we could do to help us remember which animal is hiding here?" and if this failed: "Why don't you look at the picture?" Prompts were used for each location probed.

**Far transfer:** All the children were given a second transfer task which was substantially different from the first and similar to that used by Ritter (1978). In this task, six cups were placed on the turntable, and the children informed these were 'houses'. In addition six model pigs were placed at one side of the turntable.* They were then introduced to 'the naughty little pig' - a model piglet of the same type as the animals used in previous experiments. They were told "This is the naughty little pig. Do you know why he's naughty? Because he's always running away and hiding. He hides in one of these houses (Experimenter hides piglet) and I turn them round

* The apparatus (Appendix V). is shown in Fig. 2
while you close your eyes. Now, can you find him? The game is that you have to find him first time. Do you want a shot? Remember, you've got to find him the first time." The experimenter then gave the child at least two pretrials, explaining if the child was unsuccessful, that the idea of the game was to find the piglet first time. If the children happened to correctly guess where the piglet was hidden they were given the pretrial until they had failed the task twice. These pretrials were to indicate to the children that they could not rely on the strategy of searching each location until they found the piglet, because the rules of the game forbade this. In order to correctly locate the piglet, the children had to find some way of making distinct the location where it hid. What was of interest was whether the children would think to employ the large pigs for this purpose. Again it was predicted that children receiving the 7-item pretrial in the first phase of the experiment would be more likely to transfer the cuing strategy. Again a graded series of prompts was used to induce the strategy; if children did not employ it spontaneously:

P₁ "Can you think of anything we could do to help us find the little pig the first time?"

P₂ "Can we use these (indicating six large pigs) to help us find the little pig right away?"

P₃ "Would putting any of these (pointing to six pigs) on here (indicates cups and turntable) help you find the little pig the first time?"

12 'Shot' is the Scottish idiom for 'go'.
little pig right away?"

P₄ "If we put this pig on here (revealing hidden piglet, concealing once more and putting pig onto baited cup) will that help?"

Once the children had actually baited the cup, whether spontaneously or under prompting, they were given a retrieval trial. They closed their eyes, the experimenter rotated the turntable, and asked them to find the little pig the first time.

The children were then asked a series of questions probing their knowledge of the complete strategy. This was tested by presenting several situations in which the original successful strategy could not be used, and asking them for predictions of performance given these circumstances. In addition they were given a modified version of the strategy and asked to predict its success.*

The first question (Q₁) involved a single distinctive cue (only one pig) but the pig was placed on a cup two positions away from the baited container. The additional information of identifying and remembering the piglet's spatial location relative to the cue, is necessary for success. Every child underwent a retrieval trial. It was clear from this trial whether children were using the strategy in a strict rote-reproductive fashion, using a modification of the strategy or simply answering 'yes' to every question.

* The stimulus configurations for the various knowledge questions are shown in Figure 3, Appendix V.
The ambiguous cue condition ($Q_2$) comprised 'the-pig-on-the-baited-cup-strategy', but also three other pigs arranged to make the cue ambiguous.

The final question ($Q_3$) required prediction for a modified version of the strategy. This time the baited cup was rendered distinct by placing pigs on every other cup.

It was predicted that if children did not grasp the principle of distinctiveness, but believe that the presence of a cue somehow 'induces' the piglet to be underneath, they should respond incorrectly to all these questions.

Results

Pretrials As expected the 7-item group performed worse than the 3-item group on the no-strategy pretrial illustrated in Table 17. The group scores are not directly comparable, however, because they receive different numbers of items. The data were thus reclassified into three categories: (a) children who failed to remember any items on at least one trial; (b) children who remembered all the items on one trial; (c) the remaining children. A $\chi^2$ analysis on this data indicated differences between the groups ($\chi^2(2) = 21.83$, $p<0.001$). Table 18 shows the number of children who required explicit prompting to use the strategy during the training phase,
where an explicit prompt included one or more references to the pictures. Several children did require one prompt of the form "Is there anything we could do to help us remember..?", but these were not scored as requiring explicit prompting. The number of children requiring explicit prompts decreases with age, although it is not statistically significant $\chi^2(1) = 2.07$, $p = 0.15$.

Near transfer Table 19 shows the effect of perceived efficiency on the first transfer trial, with children receiving the 7-item pretest showing more cue use on the first (unprompted) transfer trial. Those who saw the strategy as efficient were significantly more likely to use cues on one or more occasions $\chi^2(1) = 5.83$, $p = 0.015$. Overall, the tendency to transfer also increased with age $\chi^2(2) = 7.98$, $p = 0.02$.

On the second near transfer trial children received prompts if they did not spontaneously use the picture cues. The children were then given scores, depending on the explicitness of the prompts they required. An implicit prompt ("Can you think of anything we could do to help us remember..?") was scored 1 point, and explicit prompts ("Why don't you look at the pictures?") was scored as 2 points. The mean totals for each age group in each condition are shown in Table 20. The number of children who required at least one prompt decreased with age, although this trend was not significant $\chi^2(1) = 2.95$, $p = 0.15$. 
The findings that older children were more likely to transfer irrespective of perceived effectiveness, combined with the fact that young children required more explicit cues to elicit the strategy initially suggested a further hypothesis: children who required little initial prompting should be more likely to transfer than children who needed explicit prompts. This was not verified for either transfer trial $\chi^2(1) = 0.27, p = 0.60$, $\chi^2(1) = 1.60, p = 0.20$.

Far transfer Table 21 shows the mean number of prompts which were required to elicit the distinctive cueing strategy in the far transfer task. For the purpose of analysis children were classified according to whether they required explicit prompts ("If we put this pig on here, will that help?"). There were no effects of perceived strategy effectiveness $\chi^2(1) = 0.12, p = 0.73$. In addition there were no age trends $\chi^2(1) = 0.74, p = 0.39$.

The questions about the far transfer task suggested similar conclusions. Children were credited with correctly answering a question, if they gave the correct verbal response, and searched the location consistent with their response. Thus, for $Q_3$ when pigs were placed at every location except the baited cup, the child must respond correctly that this configuration will help search
and also search under the cup without the large pig.

Table 22 indicates the number of correct responses, but there was no overall effect of perceived strategy success

\[ \chi^2(1) = 1.17, p = 0.56 \]. The number of correct responses also showed a developmental increase \[ \chi^2(2) = 8.1, p = 0.005 \].

The hypothesis that children who required prompting to employ the strategy on pretrials should show less tendency to transfer was also tested for both measures of the far transfer task. Again there was no indication that initial prompting on the picture cues, predicted far transfer as measured by prompting, or questions respectively

\[ \chi^2(1) = 0.17, p = 0.69, \chi^2(1) = 1.01, p = 0.31 \].

Finally, it was hypothesised that for the far transfer task alone, children's knowledge about cue application may be related to their readiness to use a particular strategy. They were dichotomised into low (or 1 question correct) versus high (2 or 3 correct) knowledge subjects and strong (0-3 prompts) versus weak (4-5 prompts) required to elicit the strategy. No relationship was found between knowledge and initial prompting necessary to elicit the strategy.

5.5 Conclusions

The experiment indicates strong support for the hypothesised relationship between strategy effectiveness and
maintenance. Subjects who received 7 items on no-strategy pretrials greatly improved performance following training, in contrast with the 3-item group who underwent much smaller performance changes. The size of these changes appeared to influence application of the strategy in new situations. The 7-item group continued to use the strategy under conditions where no experimenter prompts were given, and several aspects of the task were modified. This was not true of the 3-item group who did not show the same level of maintenance.* Strategy effectiveness did not however influence transfer to a task which required a rather different form of the strategy.

It was argued that young children may have problems in evaluating performance change and attributing this to strategy use. The present experiment was designed in order to make the evaluation of performance change simpler, by making the effects of strategy use large and hence detectable. It may be, however, that children's problems lie not in evaluating performance change, but in interpreting it. Children may, for example, believe that performance changes are the result of practice, rather than strategy use. The above experiment may have induced maintenance, not by making the evaluation component simpler, but the result of making strategy effects large may be to exclude interpretations in terms of practice which cannot produce such effects.

* One problem with this interpretation lies in the fact that the 7-item group received more practice with the cuing strategy in the instruction condition. Thus, they used cues to find animals at 14 locations, compared with the 6 locations of the 3-item group.
5.4 **Experiment IX: Is information about effectiveness sufficient for transfer?**

This experiment attempted to distinguish between the explanations of maintenance failure. Two groups of children were given different feedback as to the results of their strategy use. One group was given no information about how strategy use had changed performance. The other group was given evaluative information that they were performing better, but no interpretation of this improvement was offered.

It was argued that if children's problems with strategy maintenance lie in their inability to evaluate performance change, then providing this information should lead to maintenance. However, if their problem lies in interpretation and not evaluation then both groups should be as likely to maintain, because both groups will be in possession of the same information.*

Children from the youngest age group in the last experiment were tested. This is because most of the older children in the previous experiment maintained the strategy even in the 3-item condition, suggesting experimenter evaluation would not be of much benefit to them. Additionally, Experiments V and VI have shown that self-assessment skills are poor in this age range.

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* This procedure should also control for possible practice effects. It was suggested that one reason why the 7-item group transferred, was that they received 14 cued-recall trials in contrast to the 6 received by the 3-item group. The present experiment gives both groups the same initial training.
Method
Subjects: The subjects were 20 children in the age range 3;2 - 3;9. Their average age was 3;6. All children completed the procedure and none had participated in the previous experiment.

Method: The children were divided into two equal groups. The control group received the instructions and tests given to the subjects in Experiment IX. The only difference for the experimental group was that the experimenter gave them some indication of their performance by saying after the instruction trials "You know you're really doing much better than you were before". Both groups were given 3-items only in the pretrial and instruction phases.

Results

Table 23 illustrates the effects of evaluative information. The group who were given this information made more spontaneous use of cues on the first trial of the near transfer task, and required fewer prompts to induce them to use cues on the second trial. A t test was conducted on the number of locations at which the children spontaneously employed cues over both trials. Children who were given evaluative information were much more likely to employ cues spontaneously \( (t_{(18)} = 2.32, p = 0.03) \).

In the previous experiment, it was suggested that transfer may be related to the ease with which a child evokes the strategy under instruction. It was predicted that initial
prompting should be negatively correlated with transfer as measured by spontaneous cue use. However, this relation was not significant for either control ($r_{(8)} = 0.39$, $p = 0.27$) or experimental ($r_{(8)} = 0.56$, $p = 0.10$).

The data were also analysed to investigate whether evaluative information influenced performance on the far transfer task. There was no difference between control and experimental groups either in degree of initial prompting necessary to induce the strategy, or in the children's answers to the prediction questions $t_{(18)} = 0.268$, $p = 0.21$; $t_{(18)} = -0.006$, $p = 0.99$.

**Conclusions**

It was argued that two reasons may underlie children's failure to maintain strategies they have been taught: either they cannot detect changes in performance or they can detect such changes but fail to attribute them to strategy use.

The experiment presented children with information about the change in their performance following strategy use. It was found that children seemed to have few difficulties in attributing such changes to strategy use, because nearly all of them spontaneously used the strategy on all transfer trials. The control group, not given this information, showed much lower levels of maintenance. Verbal feedback did not influence performance on the
far transfer trials, when the task demands were radically altered. The experiment supports the conclusion that an inability to monitor and assess performance changes underlies the failure to maintain.

5.5 Conclusions

One of the initial aims of this chapter was to investigate the reasons underlying children's general failure to maintain or transfer strategies they have been taught. Any conclusions drawn from these experiments may well additionally apply to spontaneously occurring strategies. The corollary of explaining failures to transfer is that we are able to find conditions in which transfer does occur, and also suggest possible mechanisms by which changes occur in the type and area of application of the child's memory strategies.

It was initially hypothesised that children have problems in evaluating changes in performance due to strategy use and also in interpreting these changes and correctly attributing them to strategy use. Experiments VIII and IX indicate that for the cueing strategy studied here, children have problems in evaluating or detecting changes in performance. Thus, if children are directly informed about performance changes (Experiment IX) or performance changes are made extremely obvious (Experiment VIII) we do find evidence for transfer to a similar task. These results apparently contradict a number of studies.

* Although in Experiment VIII strategy effectiveness is confounded with the original amount of training each group received.
which suggest children also have a problem in interpreting performance change, even if evaluation is achieved (e.g. Heisel and Ritter, 1981; Mœynahan, 1976; Ringel and Springer, 1980). As was noted above, the process of interpretation may well depend on the strategy under study and on the size of the performance changes it induces.

The suggestion that children have difficulty in evaluating performance change is consistent with the results of Experiments V and VI which demonstrated young children's inability to accurately assess the accuracy of their memory performance. It may well be that the improvements in monitoring skills in the preschool years can explain the increases in maintenance with age in both 7-item and 3-item groups in Experiment VIII.

In order to evaluate, children do not only have to assess the level of their performance, they must also retain this assessment during the interval between no-strategy and strategy training trials. This problem of retention was made simple by reducing the interval between these trials in Experiments VIII and IX, however, Experiment VII suggests the duration of this interval may well influence spontaneous maintenance. Thus, Keeney et al (1967) and Kennedy and Miller (1976) report no spontaneous maintenance of a trained rehearsal strategy. In contrast, Experiment VII did find such maintenance using a procedure in which the no-strategy/strategy instruction interval was 3 days. In both the above experiments this interval
was much longer in duration. Thus, remembering one's assessment of performance may present problems to the young child, especially when the procedure used in training experiments do not suggest a reason for paying attention to one's level of performance.

These conclusions allow us to explain a number of other experimental results. Bjorkland et al (1977) and Ornstein et al (1977) both report maintenance only when children were taught highly effective category sort and rehearsal strategies. These results are completely consistent with those of Experiment VIII. Effective strategies induce greater performance changes and are thus more detectable. Also Heisel and Ritter (1981) report that older children spontaneously maintain a spatial retrieval strategy, but children below the age of six years require information about changes in performance following strategy use, before they will transfer. A similar result is also reported by Ringel and Springer (1980) for categorisation study strategies. These experiments are perfectly consistent with the above explanations of maintenance failure, in terms of inability to assess and remember assessments of performance. As both of these abilities increase with age, they will make it unnecessary for the experimenter to supply information about evaluation to older children.

In conclusion there are a number of reasons why young children may fail to transfer or maintain strategies, and the present set of experiments offers evidence that the effectiveness of the strategy in modifying performance,
and the presence of external feedback may influence transfer. The results of Experiment VII, combined with those of Kennedy and Miller (1976) and Keeney et al (1967) also suggest that the time interval between pre-trials and instruction may be crucial. I obtained transfer with a short time interval, and no feedback, in contrast to those experiments which report no transfer without feedback. The importance of such a factor must at present remain speculative, because it has not been experimentally demonstrated. In addition to these external factors, transfer will be influenced by the abilities of the particular subject group. Changes in the ability to monitor and remember assessments of performance may well interact with these factors.

Finally, it was suggested in the opening sections of this chapter that studies of maintenance and transfer might offer information about mechanisms of change in memory. It might be argued, however, that the present set of experiments can tell us nothing about developmental change because they have only demonstrated maintenance of strategies, and not that trained strategies are generalised to different situations. As I have argued elsewhere, the criterion of generalisation is too strict, because it misrepresents changes in naturally occurring behaviours. Naturally occurring behaviours are initially limited in their zone of application, and so maintenance is an adequate criterion for inferring change.

If this is the case, then the present set of experiments suggests two mechanisms which are responsible for change in the use of memory strategies. The first, feedback, occurs
when some other person (experimenter, teacher, parent or peer) is present to interpret the results of the child's behaviour. This may well be a powerful mechanism because many of the teaching situations in our society do have this set-up. The second, self-assessment, occurs in the absence of such information, and may well emerge much later in development. The importance of self-assessment probably greatly depends on the strategies being monitored and the exact learning situation.
CHAPTER 6 CUE USE, INTROSPECTIONS AND THE STUDY OF TEXT

6.1 Introduction

One recent focus of research in developmental psychology has been on the preschooler. The aim of this research has mainly been to dispute what Gelman and Gallistel (1978) call "the negative characterisation of the preschooler" by demonstrating that very young children do possess some social, logical and memory skills (e.g. Brown, 1975; Donaldson, 1978; Gelman, 1978). A common theme in all this research is that the nature of the task itself may be crucial in determining the level of the child's performance. Tasks which fit into the ecology of the young child, i.e. those which "make human sense" (Donaldson, 1978) or "fit the head of the child" (Brown, 1975) are far more likely to elicit precocious competence.

The early chapter describe a number of experiments which investigated children's use of different types of cues in making inferences in the service of memory. The cues consisted of objects identical to those hidden (array cues) or leaving the animals at previously searched locations exposed (monitoring cues). (See Chapters 4 and 5 for a more detailed explanation.) In neither case do the cues or memory task model a natural memory situation.
This same criticism can be made of most other studies of cueing. Given the importance of ecological factors in the accounts cited above, it was thought important to investigate similar issues to those dealt with in Chapters 4 and 5, i.e. those of cues and inferencing, but using more naturalistic materials.

6.2 Experiment X: Do children use pictures to disambiguate text?

This experiment investigated children's use of a picture as a source of information about the text. Three issues were examined:

(1) Will young children make use of pictures to disambiguate stories which are read to them, and if they do, is it the case that older children are more efficient in their use of pictorial information?

(2) What insights do young children have into their own mental processes? In particular, can they introspect about how well they have understood or remembered a story?

(3) What is the relationship between introspections and strategy behaviour? Is children's study behaviour or memory influenced by their knowledge of their own mental processes?

Introduction

The procedure used in this experiment is based upon a
number of studies conducted on adults by Bransford and his colleagues (Bransford and Johnson, 1973; Bransford and McCarrell, 1977). In a series of studies they demonstrated that both comprehension and recall of ambiguous text is vastly improved by providing information by means of a picture or story title. One of the stories used by Bransford and Johnson (1973) ran as follows:

The procedure is really quite simple. First you arrange things into different groups according to their make-up. Of course, one pile may be sufficient depending on how much there is to do....

Subjects provided with the title of the passage (Washing Clothes) reported that it is easily comprehensible and were able to recall much of the passage verbatim. Subjects not given such information rated the passage as difficult to comprehend and recalled very little in the memory test.

An explanation for this result is offered by Haviland and Clark (1974) who account for the results in the following way: comprehension is seen as a process of inference construction in which a picture or title can provide information which constrains the range of inferences which can possibly be made. Thus, the knowledge that the passage is about washing clothes allows the subject to infer that 'arranging things into different groups according to their make-up' is the process of separating white from coloured clothes or that 'pile' refers to a pile of clothes. It is clearly far simpler to construct an internally consistent chain of inferences
when setting information is provided than when it is absent.

If memory and comprehension are indeed dependent on a process of inference-construction, using setting information as a source of premises, we may expect developmental trends in performance on this task for the following reasons:

1) Young children may fail to use setting information altogether. A study by Ritter et al (1973), in which pictures were provided as retrieval cues demonstrated that on some occasions, young children, aged 3 - 5 years failed to make use of the pictures to recall the names of absent objects. Similar results with older children have been reported by Kobasigawa (1974) who also used a retrieval task. Seven-year-old children failed to use cards to cue sets of highly associated objects (e.g. a picture of a zoo to cue bear, lion and camel). Other studies (e.g. Gordon and Flavell, 1977; Kobasigawa and Middleton, 1972) also show the failure of young children to exploit cues provided to aid their retrieval.

2) Even if children do think to consult cues, evidence suggests they may make less efficient use of the cues provided. Kobasigawa (1977) found that some children may use the cue cards provided, but instead of using the card to access all category-related items, they recall a single category item, and then refer to the next card. Since in the present experiment the context is visual,
evidence from experiments on visual search strategies is also relevant. Mackworth and Bruner's (1970) research on recognition memory suggests there may be qualitative changes in visual search strategies in young children. If such changes do occur, it may well be that older children will elicit more relevant information from picture cues.

(3) Assuming that children can efficiently access information from picture cues, there may be a final reason to expect developmental changes in performance on this task. It may be that the ability to combine information, i.e. inferencing, develops. While this has been a contentious issue as far as transitive inferences are concerned, the general consensus is that the types of inferences required for text processing should develop with age, (e.g. Paris, 1978b; Trabasso and Nicholas, 1980). These sorts of inferences are largely inductive but require much social, motivational and causal knowledge of the world, and should consequently increase as children's knowledge base becomes enriched.

Despite the persuasiveness of these theoretical arguments, empirical studies have failed to find evidence for older children's more efficient use of contextual information in text processing. Indeed, some of the studies which follow have failed to find any effect of contextual information on memory. Brown, Smiley, Day, Townsend and Lawton (1977a) provided children with two different contexts
or no context and tested recognition and recall for a core story given to all groups. Recognition measures showed no qualitative effects of context, nor did the groups provided with context out-perform the no context group. Recall measures, however, did show developmental trends, with older subjects tending to produce more context-relevant intrusions. This suggests both that context does influence recall, and that older children are more likely to make use of it.

In contrast, Omansen, Warren and Trabasso (1978) found no influence of contextual information on recall. The three groups of 8-year-olds were given one of two contexts or no context and the same core story. A recall test showed no advantage to the groups given context, although a questionnaire which tested children's ability to make inferences about material not explicitly stated in the story did depend on the provision and type of context provided.

A third study conducted by Harris, Mandias, Meerum-Terwogt and Tjintjelaar (1989) is perhaps closest to the original Bransford and Johnson (1973) experiments. Unlike the Brown et al and Omansen et al experiments the story was genuinely incomprehensible without context. Harris et al found that context (provided by a title) massively improved the recall of 8- and 10-year-old children. They did not find that older children make more efficient use of this information.
The above experiments suggest two factors may be crucial to any attempts to investigate young children's use of contextual information. The first concerns the importance of the context in disambiguating the text. Both the Brown et al and Omansen et al stories were comprehensible without contextual information. Under such circumstances context may make possible certain elaborations or embellishments to the text, but not radically influence comprehension and consequently, memory. In contrast, very little understanding could be derived from the Harris et al stories without their titles. In the present study, an attempt was made to ensure that certain parts of the story would be ambiguous without context.

The other issue concerns the measure used to assess the influence of context. It was decided to assess this by asking a series of questions about the story. This method was employed because of its greater sensitivity to context effects (as evidenced by both Brown et al, and Omansen et al) and also because young children have difficulty with any form of recall task (Brown and Murphy, 1975).

A second problematic feature of the above experiments is the inconsistent evidence for developmental increases in the use of context. They only appear in one measure in the Brown et al and Omansen et al experiments, and Harris et al found no effects. This lack of evidence for developmental trends may well be attributable to the ecological factors referred to earlier. All the
experiments reviewed investigate children of school age. It may be that by this stage of development children have already had large amounts of practice at information integration. Recent accounts of language development stress the role of context in the child's comprehension (e.g. Shatz, 1978; Clark, 1977; Macnamara, 1973). In addition, children may well be familiar with the specific skill of integrating information from different sources (e.g. adults' comments, pictures, peer reactions) with the story itself. This may explain why previous studies which had not looked at children younger than 5 years have failed to find the predicted interaction. For this reason, it was important to investigate the relationship in very young children, and so preschoolers were used.

Another problem with previous studies is that the effects of context have been inferred from various memory measures without investigating processes underlying this. It has already been suggested that young children may not use contextual information in the way older ones do, and so the study behaviour of subjects was also recorded. Contextual information was provided in the form of pictures accompanying the spoken text, and it was predicted that young children would not study the pictures for as long as older children. The differences in study behaviour should be reflected by performance in the memory test for the contextualised stories.

A second aim of the study was to investigate very young
children's abilities to judge their state of comprehension and memory. A recent review by Flavell and Wellman (1977) suggest that such abilities undergo large changes in the early school years. Studies indicate that children younger than 8 years are poor at making judgements about the adequacy of instructions (Markman, 1977), the importance of different parts of text to its central theme (Brown and Smiley, 1977) and at detecting contradiction or anomaly (Flavell et al, 1981; Harris et al, 1981; Markman, 1979). All the above experiments require sophisticated judgements and it may be that even preschoolers are capable of answering simple questions about their understanding of memory for text.

This is an important problem, because the ability to monitor comprehension has implications for both study and memory behaviour. In the present experiment, children realising they have not understood a part of the text may attempt to clarify this by consulting an alternative source of information (the picture). We should therefore expect a close relationship between the ability to monitor memory and study behaviour.

Self-monitoring was assessed by asking the children a number of questions about comprehension and recall before and after recall had taken place. Before recall, children were asked first which story they had understood better, and then which they had remembered better. After recall they were asked which had been best remembered. On all
occasions they were asked to justify their choice. This made it possible to investigate whether children realise the relationship between comprehension and memory, i.e. that what they best understand will be best recalled.

The speculations about the relationship between self-monitoring and strategy use are not limited to text comprehension and memory. Recent theoretical accounts of cognitive development (Brown, 1978; Flavell, 1978) have stressed the importance of highly general skills like self-monitoring for many cognitive tasks. However a recent series of empirical studies (Bisanz et al, 1978; Cavanaugh and Borkowski, 1980; Kelly et al, 1976; Moynahan, 1973, and Salatas and Flavell, 1976a) have all failed to find evidence for a strong relationship between memory performance and knowledge about memory. The present study should enable us to investigate that relationship on a task and with an age group which have not been much studied.

**Method**

**Subjects:** The 36 subjects were randomly drawn from three playgroups in St. Andrews, Scotland. They were equally divided into three age groups, 3;0-3;9, 3;10-4;6, and 4;7-5;3. Their mean ages were 3;5, 4;2 and 4;10 respectively. All of them had taken part in Experiments II or III.

**Materials**

Two stories, one about a girl called Mary and her dog
Fido, (M and F) and another about a girl called Jenny and her mother (J and M) were used. Each story had an associated picture, but this was not presented in all experimental conditions. The stories were made as similar as possible; both took approximately the same time to read aloud, and both had a similar story structure (see Stein and Glenn, 1979). Both stories and questions are presented in Appendix 2.

Procedure: All the subjects were read two stories, one with a picture providing setting information, the other without. Half the subjects in each age group were read Mary and Fido with its associated picture and Jenny and her Mummy with no picture. The other half were given the picture with Jenny and her Mummy, but not with Mary and Fido. The order of presentation was counterbalanced across subjects. In order to engage interest in the task of remembering the stories and also to allow systematic questioning, the children were introduced to a monkey puppet called 'Silly Monkey'. The experimenter explained that Silly Monkey had an appalling memory and asked them whether they would help the monkey by trying to remember the stories and answer the questions he asked about the stories.

The experimenter then read each story to the child and the monkey, mentioning in passing that one of the stories had a picture and drawing the child's attention to the picture before the story was read. (This story
is called Jenny and her Mummy and here's the picture which goes with it).

After both stories had been read, the experimenter consulted the puppet and asked the children whether Silly Monkey could ask them some questions about the stories. The monkey then posed the first metacognition question which was either to predict comprehension or memory - 'Which story was easier to understand?/Which story will be easier to remember?'. These will be referred to as comprehension and prediction questions. The child was then asked to justify this choice. The order of the comprehension and memory questions and the order of mention of the two stories in the questions was again counterbalanced across subjects.

The monkey then asked the child a series of ten specific questions about each story (see AppendixII). The questions probed structurally similar parts of the two stories and required answers only a few words long. If a child failed to respond, the monkey repeated the question.

After this memory test, the child was asked another metacognition question - 'Which story was easier to remember?' - to test the child's ability to assess his own performance after recall. This will be referred to as the post-diction question. The whole experimental procedure was video-taped.
Results

Memory performance Table 24 illustrates the performance of the three groups on the memory questions. Two features of the figure are worthy of comment. Firstly the ability to answer such questions increases with age, and secondly performance is superior when pictures are provided. The importance of both these features is verified by the results of statistical analysis. A 3 (Age) x 2 (Picture/No Picture) x 2 (Story Order) x 2 (Picture with J and M/Analysis of Variance Picture with M and F)/confirmed that both Age (F(2, 24) = 10.53, p << 0.001) and Picture/No Picture (F(1, 24) = 33.89, p << 0.001) effects were significant.* There was no Age x Picture/No Picture interaction, suggesting older children do not make more active use of contextual information (F(2, 24) = 0.34, p = 0.71), although this result may possibly be contaminated by a ceiling effect, as the oldest group were performing at 91% in the picture condition. There were no effects due to story differences, order of presentation or which story was accompanied by the picture.

Study behaviour The amount of time children spent looking at the picture during story telling is shown in Table 25. No clear pattern emerges and a 3 (Age) x 2 (Order of Presentation) x 2 (Picture with M and J/Picture with M and F) ANOVA confirms this. There were no effects for any of these factors. This is contrary to one of the experimental predictions.

* Post-hoc tests using Neuman-Keuls revealed that this was due to the superiority of the oldest group.
Monitoring Self-assessment skills were computed for the subjects by comparing their responses to the monitoring questions, with their performance as assessed by memory probes.13 Table 26 shows the percentage of children at the different age levels who responded correctly to the three monitoring probes. The scores for the three questions are collapsed together, and categorised according to whether children obtained either scores of 0 or 1, or scores of 2 or 3 correct responses. A $\chi^2$ analysis on this data indicated developmental trends ($\chi^2(2)=6.30$, p=0.04). When the questions were analysed separately, there was only a trend for the memory prediction questions ($\chi^2(2)=7.25$, p=0.03). This result suggests that the overall developmental trend is mainly the result of improvements with age, of responses to this question. Although justifications were requested following probes, only eight children actually offered them and six of these were in the oldest group. Of these only three children made any reference to the picture. The main explanation offered by the other children, was that the 'easier' story was the one which was shorter.

13 The use of the subjects' own performance scores, as the criteria for assessing self-monitoring is in contrast to other studies (e.g. Harris et al., 1980) which assumed that subjects would perform better on the stories with pictures, and assessed monitoring scores against this. Not all subjects in the present experiment did remember more of the picture-story and so the use of the Harris et al procedure would have been inappropriate. Even if children are inaccurate in their comprehension monitoring and select the incorrect story as being best understood, if they understand the relationship, they should, select the same story (incorrectly) for memory prediction.

* In both cases this was due to the superiority of the oldest group over the two others ($\chi^2(1) = 3.98$, p 0.05; $\chi^2(1) = 4.03$, p 0.05).
In addition to demonstrating that monitoring skills increase with age, it is important to establish the accuracy of children's responding given that chance responding would result in 33% correct performance. Children's responses to the questions were either to select one of the stories or to say that neither was easier. If they made such judgements without monitoring, they would therefore have a 33% chance of responding correctly. Application of the Binomial test indicated that performance for the Memory Prediction and Memory Post-diction questions was above chance (z=3.36, p<0.01, z=2.65, p<0.01) respectively, although this was not true for the Comprehension question (z=1.23, p=0.22). Separate analyses at each age level indicated that only the oldest group performed above chance, and they did so on all three questions (z=2.14, p=0.03; z=3.98, p<<0.001; z=2.14, p=0.03; for Comprehension, Memory-Prediction and Memory-Post-diction).

A second aim of the monitoring analysis was to test whether children appreciated the close relationships between comprehension and memory. If children do realise the association between these processes, one might expect the same response to both comprehension and memory prediction questions. This prediction was tested against chance for all groups, using the Binomial test. Although there was an overall effect (p<0.03), only the oldest group showed it when the groups were individually analysed (p<0.001).

Finally memory prediction and post-diction scores were
compared for the three groups. There were no group effects, nor was there a superiority of post-diction over prediction in the overall analysis (Overall McNemar $\chi^2=2.50$, $p=0.11$). To summarise the results of the self-assessment data: monitoring skills increase with age during the preschool years, and by the age of five years children perform above chance on simple questions about comprehension and memory for text. In addition, this oldest group appreciates the relationship between comprehension and memory. There was no evidence for the contention that young children are better at post-dicting than predicting memory.

**Monitoring, Study Behaviour and Memory Performance**

A correlational analysis was conducted to examine the effect of study time on memory. It is clear that other factors, in addition to study time, may influence children's memory for the story with the picture. Memory need not be mediated by study alone, as is demonstrated by the fact that children can remember the story without a picture. The contribution of this factor and the contribution of age were both partialled out. Such an analysis revealed no relationship between study time and memory for the story with the picture ($r'(32)=0.30$, $p=0.12$), where $r'$ is the Pearson product-moment correlation when both factors have been partialled out.

It was also suggested that children who were better at assessing the state of their memories would be more systematic in their study behaviour, and so the relation between self-assessment scores and study time was examined. The partial correlation coefficient was significant ($r'(33)=0.55; p=0.001$), when age was partialled out.
These relationships were also analysed for each age group individually. There was no support for the view that the relationship between self-assessment and study time, increased with age.

In summary, study time predicts memory in the picture condition, but the correlation is not significant if we allow that study time is also related to memory in the no-picture condition. Self-assessment skills do however, seem to induce more careful study behaviour.

Discussion

The present experiment demonstrates that providing contextual information in the form of a picture helps very young children to remember stories more accurately. It therefore supports the findings of Bransford and Johnson (1973) for adult subjects, and Harris et al (1980) for older children, who tested memory by recall measures. A number of other studies do not report consistent effects of context for recall measures of memory (Brown et al, 1977a; Omansen et al, 1978); however, both those studies did find effects of context when questionnaire methods like those in the present experiment were employed. The present result is therefore not discrepant with any of the above findings. Additionally, as was argued in the introduction, whether or not contextual effects are
obtained in recall depends on the ambiguity of the text itself. If context is necessary for understanding the story, it is likely to influence memory. If context provides superfluous or redundant information it may not be incorporated in this way.

There was no evidence that older children made more active use of the contextual information. Younger subjects were as adept at combining information from pictures and text in order to answer memory questions. This is consistent with the data of Harris et al (1980) who used an almost identical procedure. In contrast, Omansen et al (1978) found developmental increases in the ability to answer questions requiring inferences combining text and context, and Brown et al (1977) report an increase in theme-relevant intrusions in recall. It may well be, however, that such inconsistency may be explained by differences in the types of inferences required and ability to make these may well differ across inference types. As Paris (1978b), Nicholas and Trabasso (1980) and Trabasso and Trabasso and Nicholas (1980) argue, there are many types of inferences and we lack an adequate taxonomy to analyse their differences. Although it remains to be demonstrated that there are actually differences in the inference types used in the inconsistent studies, this is a highly plausible explanation.

In addition to the empirical studies, a number of theoretical arguments were advanced supporting the view that
use of context should increase with age. Other studies showed that young children sometimes completely failed to use cues (Kobasigawa, 1974; Ritter et al, 1973) or used them inefficiently (Kobasigawa, 1977); they were poor at visual search (Mackworth and Bruner, 1970) and finally there may be developments in the ability to make inferences (Paris, 1978b).

One possible explanation of the failure to find such developmental trends is that the above experiments all investigated the deliberate use of inferencing. Now, while this experiment actually gives children instructions to remember, it may well be that their behaviours such as picture study are not deliberate strategies to remember, but simply attempts to understand a story which interests them.

The study also attempted to establish the relationship between study time and performance. There was no evidence that children who studied the pictures for longer actually remembered better. It may be that study time is not a good means of tapping the processes underlying study, because it confounds how long children look with what they look at.

The experiment also investigated young children's abilities to make judgements about the state of their own memories. It was found that 5-year-olds can correctly judge which of two studies is easier to understand and
can pre- and post-dict memory performance, although few subjects were able to justify their responses. This result is in marked contrast to other studies, e.g. Markman (1977), Brown and Smiley (1977) and Harris et al (1981) which conclude that the ability to assess one's own performance does not emerge before the age of 8. This discrepancy may be resolved by consideration of both the complexity of the tasks used to assess metacognition in those experiments and the simplicity of the judgements required in the present study. For example, Markman required that subjects not only realise that the instructions they had been given were inadequate to play a game, but that they demonstrate this by questioning an experimenter. Similarly the ability to rate units of text in terms of their relation to the central theme of a story (Brown and Smiley, 1977) and the detection of anomaly (Harris et al, 1981) would seem to demand fairly sophisticated metacognitive skills.

This provides further support for the arguments of Chapter 3, that there is no single age at which a particular metacognitive item develops. Children's ability to assess their memory for text is clearly dependent on the complexity of the judgements we require them to make in order to demonstrate that knowledge, and also the means by which we allow them to demonstrate it.

The study also investigated the relationship between self-assessment skills and study behaviour. While it
was found that self-assessment predicted study time, there was no relationship between study time and memory performance. The data do not, therefore support the argument that self-assessment closely determines memory. In this respect they are consistent with the data reported in the earlier experiments on the inferential cuing strategy.

6.3 Experiment XI: How efficient are children in their use of pictures to aid text comprehension?

The present experiment attempts to extend the results of the previous experiment, by investigating children's use of an array of pictures to answer questions about a story they had just heard. There were three major questions to which the study addressed itself:
(1) How readily do children think to consult pictures as a means to answering questions about a story they have been told? (Evocation).
(2) How skilled is children's search of a picture array? (Efficiency).
(3) Are evocation and efficiency related? Are children who are adept at a particular strategy more likely to evoke it than those who are less proficient?

Introduction

The previous experiment demonstrated that very young children were remarkably skilful at combining information
from a single picture with a story they had just heard read aloud. It may be that experience in listening to stories with adults drawing attention to accompanying pictures may well contribute to this skill.

This experiment was therefore designed to investigate in more detail the extent of children's skill in using pictures to help understand and remember text. Children were first told a story aloud, and as the experimenter read, he placed the card relevant to each part of the story, face-down in front of the children. Afterwards he asked them a series of questions about the story. The questions probed information which was not actually stated in the stories, but could be found by combining information from the stories with that in the pictures.

The first aim of the study was to investigate how readily children would think to consult the pictures in order to answer the questions. A study by Ritter et al. (1973) found that children would readily employ high-associate pictures to cue hidden objects when the cues were visible, but not when the cues were face down upon the floor. Similarly, Kobasigawa (1974) reported that 7-year-olds failed to use high-associate cue cards to access the names of a set of pictures. In the present study, children's readiness to employ cues was assessed by the number and explicitness of the prompts required to elicit cue use.

The study also investigated the efficiency of cue use.
There are a number of reasons to suggest young children may not be adept at picture search. Kobasigawa (1974) also reports that young children used multiple retrieval cues (i.e. one card to cue several animal names) in a highly unsystematic manner. Instead of retrieving all the names associated with one cue, they would remember one, and then look at the next cue. On returning to the cue, they would often access the name they had retrieved on the last occasion. In addition, experiments on children's search of small-scale and natural environments suggest that preschoolers are incapable of limiting their search to appropriate areas (Drozdal and Flavell, 1975; Wellman et al., 1979). For example, Wellman et al found that children would search certain locations, despite possessing information which would lead them to infer that the missing object could not be there. In the present picture-search task, it is also possible to limit the area of search. If the question probes information late in the story, there is little point in searching the early cards. It was of considerable interest to see whether children would realise this. This skill was examined under two different retrieval conditions. In the first, the experimenter asked questions in a sequence which followed the order of events in the story. In the second, questions probed the events of the story in a random order.

A final question concerns the relationship between the ability to use a strategy, and the ease with which it is
evoked. Flavell (1970) and several Russian authors (Istomina, 1975; Leont'ev, 1975) have argued that efficiency and evocation are related, but it is not clear whether this has ever been tested. If the relationship does hold, we should expect children who show systematic search to require little prompting to access the strategy.

Method

Subjects: The subjects were 36 children between the ages of 3;2 and 5;2. They were divided into the usual age groups, with mean ages, 3;5, 4;2, and 4;10 respectively with 12 children in each age group.*

Procedure: Prior to any testing the experimenter spent some time in each nursery school introducing the children to a glove puppet called 'Silly Monkey'. (The same puppet was used in the previous experiment). By means of a number of memory games, the experimenter impressed upon the children that Silly Monkey had an appalling memory and required a lot of assistance in any game of this kind.

When this introduction was complete the experimenter tested the children individually in a separate room. They were then shown Silly Monkey again, and it was suggested that they play Silly Monkey's favourite game, which is listening to stories. The experimenter said "Now we're going to listen to some stories. I want you to help Silly Monkey to remember the stories,

* None of these children had participated in any previous experiment.
'cos you know he's got a very bad memory. If you remember the stories you'll be able to answer Silly Monkey when he asks you about the stories. Are you both (points to child and puppet) ready, because I'm about to tell the stories? I've got the stories here, written underneath these pictures (offers child a very brief glimpse of the set of pictures, each with part of the story written underneath). Now as I tell you the story, I'm going to put the pictures down here in front of you."

The experimenter then proceeded to tell the story, face down placing cards so that they lay/in order from left to right in front of the child. There were seven pictures in total. When the story was complete, Silly Monkey whispered something in the experimenter's ear. The experimenter then said to the child, "Oh dear, guess what's happened. Silly Monkey has forgotten the story. Can he ask you some questions about it?" *(PTO)*

The Monkey then asked the child a series of six questions, all of which required the children to look at the cues in order to answer. If children failed to employ the pictures the experimenter prompted them with the following series of hints:

$E_1$: Can you think of anything you could do to find out the answer? (Repeat question).

$E_2$: Why don't you look at the pictures? They might help you to find the answer. (Repeat).
Previously the experimenter had only briefly shown the children the pictures. There then followed a series of hints suggesting that the picture would be useful in recall. So although there was nothing in the initial part of the procedure to suggest picture consultation, the hints were increasingly explicit in indicating this. What was of interest was how often the children needed to be told to use cues during the question phase.
If children still failed to look at the pictures, the experimenter then explicitly indicated the relevant picture and if necessary the relevant part of this picture:

E₃: I think we should look at this picture. Now.... (Repeat question).

E₄: Look here (Experimenter indicates relevant part of the picture) Now.....(Repeat question).

Many children spontaneously or under implicit prompting began to search the pictures. The experimenter noted their pattern of search as they turned the pictures over. If the child terminated the search unsuccessfully, the experimenter offered a further prompt:

P₁: Why don't you look at another picture? (Repeat question).

If the children again terminated search unsuccessfully, or if they found the correct picture, but failed to answer the question, the experimenter said:

P₂: I think it's this picture we should look at. (Repeat question).

If the child still failed to answer, then the experimenter explicitly indicated the relevant part of the picture.

P₃: Look here.....Now, (Repeat question).

The children received two stories with six questions for each story. The stories were called George the Owl has an Idea and Mick the Duck goes on an Adventure. They were adaptations of two children's stories using
7 of the 12 pictures which went with the original story. They were of approximately equal length. The stories and pictures III and IV respectively are included in Appendices. As already described, in one case question order followed story sequence and in the other the questions were random. Story order, randomness of which story, and whether questions were initially sequential or random was counterbalanced at each age level.

Results

The data for the amount of initial prompting to induce picture-use, prompting during search, and the number of cards searched are all analysed separately. This has been done despite the fact that the measures are not independent (e.g. a high degree of initial prompting or prompting during search should reduce the number of cards searched). The fact that the measures are not independent does mean, however, that the separate analyses are conservative in any results they yield.

(a) Prompting to evoke strategy use

Table 27 indicates the mean score for prompts required to induce strategy use at the different age levels, over all trials. Children requiring the most explicit hint (E_4) were given a score of 4, those requiring E_3 to produce the strategy were given a score of 3, and so on for the respective cues. These scores were summed over questions and stories. As Table 27 indicates, very few hints indeed
were required to induce the children to consult the pictures. Despite the fact that few prompts were required to initiate picture search only one child spontaneously consulted the pictures. In addition, there were no developmental trends. This was verified by conducting a 3 (Age) x 2 (Order of Presentation) x 2 (Story) x 2 (Random/Sequential Question Order). There were no significant effects.

(b) Efficiency of Search

Two different measures were taken of efficiency of search. These were the number of prompts required and the number of cards searched to arrive at the correct answer.

The scores for the prompt analysis were analysed in an identical manner to the above analysis. Prompts $P_1$, $P_2$ and $P_3$ were scored 1, 2, and 3 respectively and the data are shown in Table 28. The data were again subjected to 3 (Age) x 2 (Order of Presentation) x 2 (Story) x 2 ANOVA (Random/Sequential Question Order). This time, age differences did emerge ($F(2, 24) = 3.53, p=0.04$)*, and it was also clear that with random questions more directive prompting was required ($F(1, 24) = 5.72, p=0.025$). Table 28 indicates that while older children are equally good under conditions of random or sequential questions, and younger children equally poor under such conditions, the questions' manipulation does seem to influence the behaviour interaction of the middle group. This was not, however, statistically significant ($F(2, 24) = 1.292, p=0.29$).

* Post-hoc comparisons using Neuman-Keuls indicates the oldest group required less prompting than either of the younger groups ($CR_{9-10} = 17.00, p<0.05$).
The second measure of efficiency was the total number of cards searched. The results are indicated in Table 29. Overall the number of cards searched does decrease with age, and random questions again produce less efficient search than sequential questions. The data were analysed in a 3 (Age) x 2 (Order) x 2 (Random/Serial) analysis of variance. The effects of Age (F(2, 24)=3.45, p=0.048) and question type were significant (F(1, 24)=8.78, p=0.007).

The data for card search were also subjected to a further set of analyses to establish why older children needed to search fewer cards to arrive at solution. Table 30 shows the frequency with which children were able to select the correct card first time. It is clear from the table that Serial questioning leads to far more direct solutions than Random questioning. This conclusion was supported by a $\chi^2$ analysis, when data from the 0-3 cells and 4 and 5 cells was collapsed. ($\chi^2(1)=24.99$, p<0.001). A $\chi^2$ analysis of the data collapsed across these cells also indicates age differences in direct search ($\chi^2(2)=9.72$, p=0.03)*. If the data for random and serial question order are considered separately, a different picture emerges. There are no age trends for direct search for the random order questions, but analysis for serial questions suggests large differences between the age groups ($\chi^2(2)=11.70$, p=0.003). This was because of the superiority of the two older groups ($\chi^2(1)=6.3$, p<0.02). The reason for the greater direct search skill of the older

*Post hoc comparisons using Neuman-Keuls showed a difference between the oldest group and the two youngest ones ($\text{CR}_{N-K}=28.08$, p<0.05).

**This was due to the two older groups showing more direct search than the youngest ($\chi^2(1)=3.86$, p<0.05).
children emerged from a detailed analysis of search patterns. It was found that a large number of children were employing a search strategy in which they started at the left of the array, and turned over each card from left to right in sequence. If the questions follow story sequence, then children are able to produce a large number of direct searches, simply by turning over the card next in sequence to the one they used to answer the previous question.

Children were classified as using this strategy if they accessed five of the six cards in correct sequence, starting at the first card. Sixty percent of the children were classified as employing this strategy on the serial questions, and twenty-five percent of the children used it on the random order questions. The differential use of the strategy according to question order was statistically significant ($\chi^2(1)=6.91$, $p=0.009$). Separate analyses for the different question orders showed that older children were more likely to use the strategy than younger children for serial questions ($\chi^2(2)=6.17$, $p=0.04$), but not for random questions (Fisher exact $p=0.23$).

A number of other strategies were also isolated. One involved a sequential search from left-to-right, or right-to-left. The criterion used for such a search was any three pictures accessed in correct sequence. Children were more likely to search left-to-right (i.e. in story sequence) than right-to-left. ($z=2.80$, $p=0.005$). Older children showed slightly more use of such exhaustive

* Again this was the result of the superiority of the two older groups ($\chi^2(1)=4.53$, $p<0.04$)
strategies although this trend was not significant.

The final prediction of the experiment concerned the relationship between evocation and efficiency. Two separate analyses were conducted for the directive prompts and for the number of cards searched. In each case, the contribution due to age was partialled out. The initial prompt-directive prompt analysis yielded a correlation of $r_{(233)} = 0.35 \ (p=0.10)$ and the initial prompt-card search yielded a correlation of $r_{(233)} = 0.26 \ (p=0.32)$. A Pearson group by group analysis did yield two significant correlations for the oldest group ($r_{(10)} = 0.54, \ p=0.03$; $r_{(10)} = 0.51, \ p<0.05$).

**Discussion**

The data on initial prompting suggest that children require some assistance before they will consult face-down pictures even when they know these pictures relate to the text they have just heard. This may not be surprising, since the children may not have known that they were supposed to use pictures. Even given this problem of realising picture relevance, the children still need to be told a number of times to use the pictures.

In addition, there were no developmental trends for the evocation prompts. The younger children would turn over the pictures as readily as the 5-year-olds. What was interesting, however, was the difference in efficiency of search among the groups. The younger children seemed to understand that it was appropriate to look at the cards,

*The correlation coefficients and their significance levels are derived from the analyses of Cohen and Cohen (1975).*
but they were unable to find the relevant card without the assistance of the experimenter.

The older children showed greater skill at accessing the appropriate card, and combining the information in it with the information from the story they had heard. This was demonstrated by them requiring fewer prompts to find the appropriate card and give the answer. Older children also searched fewer cards before finding the relevant one.

In addition to these developmental differences, it was clear that there was a massive difference in performance between the random and sequential question conditions. This cannot be explained by memory factors, as the presentation was the same for both stories. A closer examination of the search patterns suggests the reason for the superiority of the sequential condition. In this condition, children searched efficiently by closely following the story sequence by their search. Questions about the early part of the story elicit immediate search of the appropriate (left-hand) end of the array. On later questions, the children bypass the early pictures which they have already searched, and directly access pictures later in the sequence. Some measure of the accuracy of their sequential search is shown by the fact that ten of the oldest group managed to access the appropriate picture on four out of five trials, at their first search attempt.
The results reported suggest precocity in initial cue use by the younger children, who require the same amount of initial prompting as the older group. Analysis of their search behaviour suggests, however, that initial cue use may not be the result of deliberate strategies. These children will readily consult the array of pictures, but require much prompting before they can isolate the appropriate picture. It is as though they realise that consulting the pictures is somehow appropriate, but have no idea of exactly how they are to be used. Their willingness to consult pictures may also be influenced by the experimenter's hints and their previous experience of listening to stories from which they have derived the notion that pictures 'go with' stories.

The above analysis suggests that stimulus structure and previous experience with particular materials does influence the behaviours children produce.

The results of strategy search are also amenable to this type of analysis. At face-value, the data suggest that young children are capable of conducting highly sophisticated searches which bypass pictures which have already been consulted. This conclusion is somewhat problematic for a number of reasons. It contradicts the results of other studies which have found little evidence for such sophisticated search strategies (e.g. Drozdal and Flavell, 1975; Wellman et al, 1979), and also the results of Experiments II and III which show young children are
poor at keeping track of previous correct solutions. Two pieces of evidence suggest that children's search patterns may not be the result of complex eliminative strategies. Firstly, the use of the eliminative search strategy is limited to the sequential question condition, and secondly the strategy itself may be explained by a simple heuristic. The heuristic is to turn over the card to the right of the one just searched. The behaviour looks even less like a complex inferential strategy if we bear in mind that left-to-right exposure is the norm when adults read stories with children. These speculations combined with the finding that children in the random condition showed far more left-to-right than right-to-left searches, strongly suggest that left-to-right search is an overlearnt behaviour for the materials used in this study. It just happens to be appropriate and effective in achieving recall, when questions respect this ordering.\textsuperscript{14} The findings that young children may consult pictures without understanding how they can help memory, and older children employ "strategies" which are highly dependent on the nature of the task materials, suggests that behaviours may be highly influenced by the subjects' previous experience with the task. It may be that subjects' actions are more the result of overlearnt routines with certain materials than intentional plans designed to benefit memory. In

\textsuperscript{14} This should not be taken to indicate that there is no evidence for "cognitive" strategies which rely on inferencing. In fact, the existence of such strategies is demonstrated in the random question condition, in which direct search frequency was above chance.
this respect the results are consistent with the speculations of Ryan et al (1970) and Gordon and Flavell (1977) about cuing behaviours. These experimenters suggest children may often use cues appropriately, in a manner which facilitates memory, but without any understanding of how this comes about.

6.4 General Conclusions

The two experiments in this chapter apparently indicate that young children are capable of employing highly sophisticated memory strategies when familiar materials such as stories are used. Thus, Experiment X suggests that preschoolers will readily consult a picture in order to disambiguate text, and that 3-year-olds are as able to do this as older preschoolers. Experiment XI offered two examples of precocity: 3-year-olds are as likely to use picture cues to answer questions about text as 5-year-olds; and all groups show some ability to avoid the search of redundant pictures. There are a number of reasons to suggest these may not be intentional strategies, however. Firstly, the behaviours are highly-dependent on the presence of particular stimulus-structures. Thus, children's use of pictures to help understand text (Experiment X) is disrupted by having the pictures placed face-down in front of them, rather than immediately visible. (Experiment XI). If children were employing some form of deliberate cueing strategy, the visibility of the cues should make little difference to their usage. The stimulus-dependent

* Although as I have already noted, the children may not have realised they were supposed to use cues.
nature of "strategic" behaviours is also shown by the fact that the "efficient" search strategy of Experiment XI is only evoked when sequential questions are used. Finally it was found that 3-year-olds in Experiment XI would turn over pictures when questioned about text, but had no idea of how exactly to use these pictures. In all three cases, it seems that what we are describing are overlearnt behaviours which are appropriate to the materials in question, which are not intentional plans to benefit memory, but which just happen to have memory pay-offs.

There are some theoretical implications which can be drawn from these studies. The first is that recent accounts of memory which stress the preschooler's ability to employ intentional strategies (e.g. Wellman, 1977a) may overestimate deliberate memory abilities in this age range. Secondly the finding that not all "strategic looking" behaviours are intentional may explain how some strategies come to enter the child's repertoire. A possible mechanism by which this is achieved may be that under memory instructions young children produce behaviours which/not directed to memory goals. These behaviours are overlearnt and dependent on the child's normal activities in the task in question. If the behaviours happen to benefit memory and the children detect this, or they are given feedback, the behaviour may enter the repertoire as an intentional strategy.
CHAPTER 7 CONCLUSIONS

7.1 Introduction

In this concluding chapter I wish to focus upon three different sets of issues. The first two directly concern the data. Two reviews of memory development, (Flavell, 1971 and Brown, 1975) offer descriptions of the preschooler as being largely incapable of deliberate memorising largely as a result of deficits in metamemory. They argue that increases in children's knowledge of their own memory processes is largely responsible for the rapid development of strategic memory skills in the early school years. In contrast, Wellman (1977a) reviewed a number of experiments which demonstrate the ability of preschoolers to use intentional strategies, and conducted further studies that demonstrated some metamemory knowledge in this age group (Wellman, 1977b, 1978). Since the majority of the experiments I conducted have studied preschoolers, it should be possible to determine which is the more accurate depiction of the memory skills of this age group.

The second problem addressed is that of change. It will be argued, in contrast to Brown (1975, 1978) and Flavell (1971), that memory development is not the result of changes in metamemory. In fact, I shall argue that
exactly the opposite view is the case, and that metamemory development is itself the result of the development of memory strategies.

Finally, I shall discuss how the views offered here reflect on a number of recent controversies in developmental psychology. I shall discuss the issue of context-specificity, and offer a number of reasons why behaviours do not generalise across situations. I shall then look at competence in preschoolers, and the characterisation of adult memory and focus on the general issue of change in memory skills. In conclusion, I investigate the role of the environment and suggest it offers some insights into the above problems.

7.2 Memory in preschoolers

In his 1971 article 'What is memory development the development of?', Flavell concluded that "deliberate memorizing looks like a clear instance of planful, intentional, goal-directed, future-oriented behaviour, and such behaviour is hardly the stock-in-trade of the typical 4-year-old". (p. 276) This view is endorsed by Brown (1975) who argues that "the young child does not seem to realize that he needs to memorize". (p. 112) In direct contrast to this Wellman (1977a) reviews five studies which clearly indicate the use of intentional memory strategies. In addition he found that preschoolers had some idea of the importance of certain memory variables such as the number of items or length
of study time (Wellman, 1977b, 1978). It is clearly of some importance to establish the exact nature of pre-school memory and metamemory because, as Gelman (1978) has argued for cognitive development, this has clear implications for our model of development.

On the face of it, we have in this thesis a number of experiments which suggest a high degree of sophistication with deliberate memory strategies. Thus, children as young as 3 years will make use of cues which enable them to infer the identity of animals they cannot see. They will also readily consult a picture placed in front of them while they are listening to a story. Again this behaviour results in improvements in memory. If picture cues are placed face-down in front of the children they are a little less willing to consult them, but they do so after some prompting by the experimenter.* In addition, the older children show highly efficient search behaviours; they directly consult the relevant picture, without redundant search of previous locations.

A similar picture seems to emerge from the monitoring studies. Although children cannot accurately assess the absolute level of their performance, they can detect changes in their performance on the spatial location task. By the age of five, they also demonstrate some ability to monitor the state of their understanding, and predict memory for text. The transfer tasks also suggest that, if strategy-use results in large performance changes, this

* This need for prompting may arise from children's failure to realise that they were meant to consult cues.
influences the generalisation of the strategy, which implies that children as young as three can detect such effects.

This picture of the preschooler with a large and flexible range of strategic and monitoring skills is extremely misleading, because if we consider the "strategic" behaviours in more detail, it becomes clear that many of them do not deserve such a description. If a behaviour is to be classified as intentional, it is clear that it should be directed towards the achievement of some goal. If we consider the monitoring data for the experiments it becomes clear that strategy use was independent of its effect on performance.

Considering first the spatial location task, four pieces of evidence suggest that looking at cues was unrelated to the goal of remembering. Firstly, children who estimated that they were performing at ceiling without cues, still looked at the cues when they were provided, as much as children who estimated lower levels. (Experiments V and VI). The overestimators should not have used cues because there was no need for them to do so. Similarly in Experiment VI children did not seem to modify their behaviour in accordance with memory goals. Thus there was no evidence that children who perceived cue use as improving performance were more likely to maintain cue use, or that those perceiving a decrease in performance dropped the behaviour. Finally, in Experiment VI children continued to use array cues despite the fact that they did not influence
performance. An additional piece of evidence that cue use was certainly not strategic is that some children looked at the cues without making the inference. Now some of these were in the youngest group, so it might be argued that they were unable to make the inference. However as inferencing was at ceiling for the older groups, this argument cannot be made for those groups. Cue use in the story comprehension task also looks suspiciously involuntary. Despite the avid attention paid to the picture, children in the two younger groups were unable to establish that it affected performance, and only five of the older children could explain this.

Another reason for arguing that behaviours may not be intentional is that they are "stimulus-driven". One manifestation of this might be that the behaviour depends critically on a particular stimulus configuration, any modification to which changes the behaviour. So, we might argue that if children were intentionally studying the picture in Experiment X (one cue text comprehension) according to the strategy of using pictures to improve memory for text, we should not expect a minor modification (placing the cards face-down)* to influence use of the strategy.¹⁵ For the younger children, in Experiment XI (7 Pictures cues and Text), behaviour also looks "stimulus

¹⁵ This finding cannot be attributed to any peculiar feature of this experiment. The same result is reported by Ritter et al (1973) using a different procedure and materials.

* As I have explained earlier, however, there are problems with making inferences from this failure to spontaneously consult face-down pictures.
driven". The children will readily turn over one or two pictures at the experimenter's suggestion, but go no further in using the pictures to answer his question. Finally the search behaviours shown by the children in this experiment are also highly dependent on the structure of the stimulus. The "direct search" strategy under sequential questioning also seemed highly related to stereotypical activities when young children look at books. This is not to say that all the children were producing the behaviour without attention to memory goals, merely that left-to-right search is a high probability response when adults ask children questions about stories in picture books. In fact, some children may discover the strategy by such a means. They may produce the behaviour on prompting from the experimenter, and find that the pictures enable them to answer the questions. This 'accidental discovery' route may provide an important means by which new behaviours enter the strategic memory repertoire.

In conclusion therefore, although Wellman has evidence for some clear examples of strategy use in very young children, the results of the present studies suggest that many 'strategic-looking' behaviours may not be intentional plans invoked to mediate memory. This argument is strengthened by recent reviews of organisational factors in memory by Ornstein and Corsale (1979) and Lange (1978) in which they argue that observations of clustering in young children are not strategic but the involuntary
effect of the child's semantic system. Likewise Gordon and Flavell (1977) and Ritter (1976) argue that cue use in young children has rather more of the characteristics of stimulus-response behaviour than intentional strategy use.

7.3 What develops?

If it is indeed the case that much of the behaviour of preschool children in memory situations is involuntary, we must explain how it is that such behaviours come to be used as deliberate memory strategies. It was argued that cue use (in the spatial location task in particular) looked to be largely independent of memory performance. How then do young children learn to associate their behaviour with memory goals?

It is argued that two mechanisms may be responsible for this: feedback and self-monitoring. Both are means by which children become aware of the implications of their behaviour for memory. In the case of feedback, others such as peers, parents or teachers give them information about the results of the behaviours they have just produced. It is clear that if we are to understand the importance of a process such as feedback in the development of memory or other cognitive skills, we must study its role in the natural environment. In addition, as Heisel and Ritter (1981) and Ringel and Springer (1980) have shown, there may be different types of feedback. Younger
children may not only require information about changes in their performance, but may also need this information to be specifically attributed to the behaviours they have produced. Experiment IX demonstrates that information about the effect of picture cueing on performance does significantly influence transfer of this strategy.

Another mechanism by which children may become aware of the effects of their behaviours is by self-monitoring. Spontaneous checking of memory performance may lead them to attribute changes in performance to these behaviours. Of course, the effectiveness of such a mechanism depends crucially upon the monitoring skills of the young children and also upon the size and detectability of the changes which result from the use of experimenter-induced behaviours. One reason why behaviours may not generalise to serve the memory function is that young children are unable to detect the effects that they have upon performance. Experiments V and VI show that preschoolers are not able to make accurate absolute judgements about the level of their performance on the spatial memory task. In addition such changes were relatively small (one or two items), and may not have been detectable. The importance of making performance change detectable was shown in Experiment VIII in which cueing behaviours which resulted in large improvements in performance were more likely to lead to strategy transfer than less effective cueing strategies. One other factor which seems to influence detectability of induced strategy use is the interval
between the assessment (no strategy) session and the instruction (induced strategy) session. Young children may not be able to make a comparison of performance if the interval between non-use and use is long in duration.* It is argued that the discrepancy between Experiment VII and the Kennedy and Miller (1976) and Keeney et al (1967) studies may be due to such memory factors. It is also possible that the size of the change in performance following induced strategy use also influences children's interpretations of what is responsible for such change. If strategy effects are small, they may be attributed by the children to other factors such as practice.

It is clear that a number of factors interact to influence the detection of the effects of induced and involuntary behaviours. Appeal to such factors may explain the absence of transfer in other experiments where the subjects are older children who are capable of accurate monitoring (e.g. Rosner, 1971).

It has been argued that young children's production of certain behaviours in memory situations suggests these behaviours are not intentional strategies invoked to benefit memory. These behaviours may be produced for two reasons: either adults instruct children to produce them, or children invoke them for some reason other than to remember better. These I shall call instructed and involuntary behaviours respectively. It is also argued that two mechanisms, feedback and self-monitoring may be responsible for the conversion of both types of behaviours into memory strategies. Instruction may be one setting in which teachers induce certain behaviours and

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*This factor was suggested by a comparison of the results of Experiment VII with Keeney et al (1967) and Kennedy and Miller (1976), it was not experimentally determined.
provide feedback about the effects of such behaviours on memory. The question of how involuntary behaviours develop is more problematic. Monitoring is not likely to be the mechanism of change for two reasons. Firstly, for monitoring to be effective, there has to be a change in behaviour, in order that children can monitor the effects of behaviour change on memory performance. In most situations where children do produce such involuntary behaviours, there is no such behaviour change. A second reason why monitoring may not provide a good explanation of strategy development is that monitoring is not accurate in young children, although, as Experiments V and VI show, they are not totally insensitive to the level of their own performance. Feedback is also problematic as an explanation of strategy development from involuntary behaviours because adults may not always be present to provide it.

The above account suggests how involuntary behaviours already in the repertoire but serving other ends, and instructed strategies might come to serve the memory function. It leaves a number of other factors unexplained, such as the origins of involuntary behaviours, the later development of intentional strategy use, and improvements in monitoring skills. I shall now try to answer these questions.

The glib answer to the problem of the development of involuntary behaviours is that they are activities (or cognitive structures) which have developed in other areas of cognition and language. Thus the skills of looking at pictures while comprehending text, and also searching
pictures in story sequence, are learnt during the child's considerable experience of listening to stories.\(^{16}\)

Similarly, inferencing may be crucial in the development of perception (Bryant, 1974) and language (Macnamara, 1972) and hence have developed in these areas. Experiment IV however, shows that the particular type of inference required in the spatial memory task may not have fully developed in the early preschool years. This may be one reason why use of the inferencing strategy increases during the preschool period. Chi (1978) has demonstrated that 5-year-olds are much slower to name objects than adults. It may be that changes in underlying skills such as naming and sequencing of names are responsible for the emergence of the rehearsal strategy. Indeed research on the development of rehearsal by Kingsley and Hagen (1969) and by Ornstein and his colleagues (e.g. Ornstein and Naus, 1978) suggests that rehearsal skills are constrained by the speed of naming. Thus Kingsley and Hagen report that 5-year-olds were unable to rehearse items in sets of two or three "despite understanding in principle what was required of them".\(^{p.45}\) Ornstein and Naus found that adults were unable to rehearse items in sets of more than five. Similarly it may be that older children's greater facility with category structure, as documented by Rosinski et al (1975) enables them to apply this knowledge in the sort of category-sort strategy reported by Moely et al (1969).

\(^{16}\) There is a deeper argument that the very structures which underlie the comprehension of stories are derived from the structure of everyday episodes.
If memory development does depend on developments in other areas of cognition, we might expect that subjects with no knowledge of those areas would have few available strategies. This was substantially what Chi (1978) found. Subjects who were highly competent at chess-playing were much better at remembering chess positions than subjects with little chess ability. In summary then, developments elsewhere in cognition or language produce either activities (Experiments X and XI), or cognitive structures (Rosinski et al, 1975) which are then utilised for memory goals. The argument bears a similarity to the cognition hypothesis advanced by Cromer (1974) to explain language development, which concluded that although some sequences in language development could be explained by changes in the cognitive system this could not account for all such sequences. In particular, the development of certain aspects of syntax seems to be the result of changes internal to the domain of language.

Similarly, changes in cognition, language and social activities do not appear to be sufficient to explain all of memory development. The model proposes that strategies are limited to behaviours which are produced either because they are what the child normally does in that situation (e.g. name objects, look at pictures with stories) or because the experimenter suggests them. These become strategies once the child becomes (or is made) aware of their positive effect on memory performance. (cf. McShane's 1979, 1980 theory of the development of naming). However
this model cannot explain what many people consider to be the essential feature of adult memory - its creativity. (e.g. Reitman, 1970). The model can only explain generalisation - how behaviours already in the repertoire can become part of the memory system. According to Reitman, adults are not limited in this way, but can invent 'new' behaviours to meet situational demands. How is this freedom from involuntary or elicited behaviours brought about? According to Flavell (1971) and Brown (1978) it is the result of the development of knowledge about memory. Knowledge about memory variables, limitations, processes and situations enables the adult to generate an appropriate strategy to meet a particular situation. I wish to make two points about metamemory: the first concerns its existence and the second its relationship to memory behaviour. No-one would deny the mass of evidence indicating that people are in possession of a wide range of facts about memory, and that this body of knowledge undergoes large increases with age. Any theory of memory or cognitive development must therefore offer some explanation of this. What may be the case, however, is that its role in explaining memory has been overestimated. Although this matter will be dealt with in more detail later I shall briefly discuss the metamemory-memory relationship, before returning to the subject of how metamemory itself develops.

It has already been argued that one feature of adult memory is the ability to invent 'new' strategies to meet the
demands of a novel memory task. If we examine what is generally implied in this account, we find that the routine generated to solve the novel problem is a modification of a routine used elsewhere in cognition to solve a different problem. This suggests that 'novel' behaviours crucially depend on developments elsewhere in the cognitive system. It may be that part of the adults' proposed ability to generate more novel problem solutions than the child can be explained by the fact that adults have more routines available. In conclusion, part of the flexibility and ability to modify strategies to meet new demands, which is commonly attributed to metamemory may be explained by increase in the number of cognitive routines available elsewhere in the child's repertoire. To give an example, children show an increasing tendency with age, to cluster together items of the same taxonomic category in recall (Ornstein and Corsale, 1979). It is unclear how much of this is due to changes in the child's conceptual system and how much to the intentional instigation of a category-structured retrieval plan. My point is not that metamemory and intentional strategy use is unimportant in memory, merely that some of the developments explained by appeals to metamemory may be the results of developments elsewhere in the system.

All this does nothing towards explaining how metamemory ('the body of knowledge') itself might develop. It is possible, however, that the model offered for the
development of early strategies may shed some light on this. It was argued that involuntary or induced behaviours influence memory and that the child becomes aware of this. This awareness is probably induced by feedback, as monitoring is unlikely to be very efficient in very young children, although on simple searches it may be obvious whether or not a behaviour is successful. By one means or another, then, young children become aware that the things they do have implications for memory. If children come to realise that this applies over a variety of contexts, then they may form the rule that behaviours influence memory. This is the concept of strategy which underlies all other developments in metamemory. Extensions to this knowledge may follow from the realisation that different behaviours have different effects on memory which may lead the child to an awareness of the structure of strategies. It may well be possible that metamemory does influence strategy use in older subjects under certain circumstances, but such influence has yet to be demonstrated. In the present discussion I wish merely to point out that the concept of metamemory may not be necessary to explain many of the phenomena for which it has been invoked, and also that the origins of metamemory may be in involuntary routines.

Finally there is the question of the development of monitoring. It is clear that there is no single cognitive

17 All this knowledge may not be conscious, and may only be accessed when specific questions are asked which probe it.
entity which represents monitoring, because it can consist of a whole range of different skills ranging from the simple detection of the result of an action (an ability in no way unique to man) to the complex multi-factor interpretations of one's own behaviour which are a feature of adult social cognition. Since this is the case there is no one age at which 'the ability' to monitor will emerge. Thus, the child's ability or monitoring skill, will depend on the information-processing demands of the particular situation. Thus, in the spatial location task, accurate monitoring required children to compare the responses they had generated with the actual animals situated under each cup. This requires both retention (of the names) and comparison skills. In addition the experimenter asked the children to make a decision about each location. This is clearly more demanding than the global approximations which were necessary in Experiment X.

Given the important role assigned to the development of monitoring in this account, it might be argued that we have not solved the problems of memory development, but resituated them in a new construct. This is not the case for we have some idea of the processes underlying monitoring. In addition, it has been clearly demonstrated that the information from monitoring (or procedures which avoid the necessity for monitoring) do influence strategy selection. Also there are a number of factors which we can manipulate to investigate its effectiveness.
7.4 Relevance of these results for recent issues in developmental psychology

7.4.1 Context-specificity

One of the features of Piaget's theory of cognitive development, which has given rise to an enormous amount of recent controversy is the assumption of the context-freeness of cognitive-structures. According to Piaget, once a structure enters the child's repertoire, it immediately generalises to all appropriate situations. There have been any number of experimental demonstrations that this is not the case (e.g. Donaldson, 1978), but more recently a number of models of development have built in the assumption of context-specificity. Thus Keil (1981) offers an account of development in which thought is domain-specific. A different approach has been adopted by Fischer (1980) who argues that specific environmental experiences determine the differential rates of development of different cognitive acquisitions.

The experiments conducted here provide evidence for the context-specificity of memory, but they also suggest that there are a number of different reasons underlying the failure of a routine to generalise across situations. These results suggest that memory, like cognition, is context-specific, but that accounts which attempt to offer a unitary explanations of context-specificity (e.g. Donaldson) are misleading.
The first type of context-specificity is the failure to evoke a behaviour or skill which is clearly 'in' the cognitive repertoire. Thus some children do not spontaneously rehearse (Experiment VII) or use pictures to cue the locations of objects (Experiments VIII and IX) and yet they can be induced to do so by minimal amounts of prompting or training. This sort of production deficit has been widely reported in the literature (e.g. Flavell, 1970) and the standard demonstration has been to show (a) the absence of a behaviour when the experimenter does not prompt it; and (b) its presence following instruction or prompting. The experiments reported here also include a different type of context-specificity which seems to be amenable to the same sort of analysis. In Experiment XI children did not consult pictures to answer questions about text, and yet they readily did so when listening to stories (Experiment X).* This also seems to be a type of production deficit, but one which is influenced by the structure of the experimental materials and not by experimenter intervention. These results are similar to the findings of Cole et al (1971a) and Moely and Shapiro (1971) who demonstrated that using blocked presentation of taxonomically related items in lists (i.e. all items from the same category are presented together) induced recall patterns which reflected category structure. This was much reduced when presentation order randomised category items. The influence of the structure of the materials is also demonstrated in Experiment XI where use of the direct search strategy was

* I have already noted the problems with this conclusion.
influenced by question order and its relation to story structure.

Another example of the failure to evoke a behaviour 'in' the repertoire occurs in the transfer experiments (Experiments VIII and IX). The children who fail to transfer are obviously capable of producing the behaviour in the training session, but do not do so in the new situation. One factor which seems to influence strategy evocation in transfer seems to be the effectiveness of the behaviour. Thus, if children are given information about the efficiency of a given behaviour (Experiment IX) or the behaviour is more efficient and they can detect this (Experiment VIII) they are more likely to generalise it.

Yet another factor which seems to influence context-specificity is age. Thus, older children seem to have fewer production deficits (Flavell, 1970), or are more likely to transfer strategies (Experiment VIII). This has generally been attributed to the intentional operation of memory, in which developments in metamemory enable children to 'consider their thoughts as cognitive objects' and hence apply them across a variety of situations. This explanation may not be entirely necessary however if we allow that behaviours (or strategies) generalise across more situations with age. This may be related to the underlying development of the behaviour. Thus, young children lack the ability to name quickly
and to sequence items - it is therefore hardly surprising that their rehearsal skills are limited. Similarly Esposito (1975) has demonstrated that the overlearning of a response facilitates positive transfer.

A completely different reason for context-specificity is evidenced in Experiments I, II and III. Children seem to produce the inferential skill in Experiments II and III despite its absence in Experiment I. Such differences are not limited to the youngest group, who have deficits in the inferencing skill (Experiment IV), but also occur in the two older groups. The reason for the failure to inference in these groups would seem to lie in deficits in auxiliary skills: children are unable to keep track of the objects at previous locations, and in consequence lack the information necessary for the inference. Similarly, some children did not look at the monitoring cues and were unable to make the inferences until the experimenter indicated the cues.

Thus four factors seem to influence the context-specificity of memory skills, these being the stimulus environment, information about skill effectiveness, age, and deficits in auxiliary skills. I shall now attempt to relate this to other research on cognitive and language development.

The notion that features of the stimulus environment influence the skills produced has been advanced by both Bruner (1966) and Donaldson (1978). These authors both
argue that cognitive skills first emerge in a privileged set of contexts and gradually generalise until their usage reflects that of adults. In neither case is it clear whether skills are thought to be innate - i.e. if we could find the 'right context' such skills would be in evidence in neonates. If not, then the theories should state how change occurs. If either of these arguments is to provide the basis of a principled account of cognitive development it is clear that they must offer (1) an analysis of situations to enable us to predict whether or not they are privileged and (2) an account of the generalisation process which enables behaviours to be evoked under the appropriate circumstances. I shall be more concerned here with the analysis of situations offered by the two accounts, the problem of developmental change will be discussed in a later section. Bruner's argument seems to be that cognitive skills will emerge much earlier if we manipulate the experimental context to avoid them invoking the wrong set of rules. Bruner offers support for his position by the demonstration that liquid conservation responses are generated by young children when one feature of the environment is manipulated. This involves the removal of 'perceptual seduction' which is achieved by conducting the transfer of liquid behind a screen. However, Bruner gives no analysis of a dimension of 'perceptual seductivity'.

The same can be said for Donaldson's synthesis. In contrast to Bruner, she does however offer some suggestions
about the features of the situations in which we might find early emerging cognitive skills. Donaldson argues that if we manipulate the structure of the situations in order that they "make human sense" (p. 24) or that the "motives and intentions of the characters are entirely comprehensible, even to a child of three" (p. 24), then performance increases. Additionally she argues that children and adults pay different attention to language "the difference between child and adult... lies in the amount of weight that is given to sheer linguistic form" (p. 63). Unfortunately, although these suggestions do have some plausibility they are not tied to a principled analysis. Thus, it is not possible to arrange situations along the dimension of "human sense" in order to predict which cues will best induce precocious skills.

The present set of experiments suggests that at least two factors are crucial in determining what skills emerge in different situations: the amount of prompting given by the experimenter and the structure of the materials used. The experiments quite clearly show a decrease with age in the amount of prompting required to elicit a skill, which is not immediately evoked. What determines whether behaviours are 'immediately evoked' however? The crucial factor here would seem to be what children would normally do in the situation when there is no memory demand. For this it is clearly necessary that we analyse children's behaviours in the natural environment.
From such an analysis it might be possible to offer reasons for some of the sequences reported here. This clearly also relates to the question of the structure of the materials. This structure can only be defined relative to the everyday cognitions and actions of the child. Thus, we have the finding that children do not look at face-down pictures to answer questions about text, but will do so when the pictures are presented along with the text. If we look to ecology we find that children have little experience of face-down consultation, but frequently listen to stories and look at pictures. Thus, there are differences in structure between the two situations, with structure being defined relative to the child's normal activities. Similarly more children produce a 'direct search' strategy in the sequential question procedure of Experiment XI because it is an activity more closely related to their normal picture search strategy than is random search. This type of analysis can be extended beyond children's overlearnt activities to their internal constructs. Thus we may argue that children have a set of concepts derived from their experience with the natural environment (e.g. scripts, story grammars, and prototypes) and that stimuli which are 'well-formed' relative to these constructs will induce appropriate memory skill earlier than those stimuli which are less 'well-formed'. Thus Corsale (1978) has demonstrated that lists of words containing category prototypes induce category sorting in 8-year-olds whereas lists of less salient category members do not do so.
Similarly Mandler (1979) reviews a number of experiments suggesting similar results for story grammars, and room scripts.

Other recent research in cognitive development suggests the influence of the ecology of the situation and the structure of the materials. Thus Rosch et al (1976) found children were able to sort basic-level categories several years before they were able to do so with superordinate categories. The influence of what children normally do with materials or how they act in particular situations is also evidenced by studies of communication (Shatz, 1978) and semantic development (Clark, 1973b; Trehub and Abramovich, 1978).

All this is to say that ecology is important, and that if the skill we wish to study does occur in the natural environment, then it will first emerge in those situations which most closely model the natural environment. While this type of analysis is useful for comparing and sequencing ecological versus non-ecological versions of the same situation, it is clearly inadequate for comparisons of very different situations, or for behaviours which do not occur naturally. Thus cumulative rehearsal (saying items in sets of three) and generating bizarre images are not naturally occurring behaviours and an ecological analysis would not tell us much about them.

The notion that children may fail to produce a routine
in their repertoire because they lack auxiliary skills, is also to be found elsewhere in developmental psychology. Thus, Bryant and Trabasso (1971) argue that children fail the Piagetian inference task because they lack the skills to encode the premise information. When children are trained so that such information is overlearned, we find they are able to make transitive inferences. Siegler (1978) has offered a similar argument for deficits in children's early understandings of the principle of moments. Deficits in auxiliary skills may not only occur in encoding, children may well be capable of generating some skill, but be unable to reveal this because they lack adequate response skills. Many recent studies have demonstrated that we have severely underestimated the skills of infants because we have demanded criterial behaviours not in the repertoire. A similar argument has been made by Brainard (1973) concerning the use of verbal protocols as evidence for conservation abilities.

What generalisation may we draw from all these studies? Firstly, it seems that whether or not a particular skill emerges in a given situation is a complex interaction between the task demands, and the skill itself and in some cases the provision of information about strategy effectiveness. One immediate implication of this is that there seems to be no 'one age' at which a particular skill emerges, and so the task of the developmental psychologist becomes the analysis of the exact form of the skill which does emerge, and also the amount of
support which the environment provides for the behaviour. As I have already argued, there are a number of ways in which the environment can provide this type of support. At the stimulus end, these can include prompting or placing the skill in the context in which it is normally used. The environment might also avoid the necessity of involving auxiliary skills, by itself providing the information necessary for the skill (e.g. Experiments II and III). In addition, it may provide information about skill effectiveness (e.g. Experiments VII and VIII) which render monitoring unnecessary. One way of viewing all these findings is to conclude that as children grow older they become less and less dependent upon this sort of environmental support.

7.4.2 Competence in preschoolers

A second major problem for Piagetian theory in recent years has been the demonstration of precocious logical skills. Such demonstrations offer a serious difficulty for the theory; although the late emergence of skills can be "explained" by appeal to notions such as horizontal decalage, the finding that preschool thought is in some respects comparable to that of adults undermines one of the central assumptions of Piagetian theory.

The suggestion that thought is similar in adults and children exactly contradicts a fundamental tenet of the theory that thought undergoes structural changes,
and that the thought processes of adults and children are qualitatively different.

Given the importance of the issue, what is the status of the evidence for precocious preschool thought? Certainly claims about early competence have been made in a number of different domains, e.g. number development (Gelman and Gallistel, 1978), perspective-taking (Borke, 1977; Shatz and Gelman, 1973), quantity conservation (McGarrigle and Donaldson, 1975), concept formation (Rosch, Mervis, Gray, Johnson and Boyes-Braem, 1976), class inclusion (Markman and Siebert, 1976) and scientific concepts (Siegler, 1978). This research has led several reviewers (e.g. Keil, 1981; Nelson, 1977) to conclude that thought processes are fundamentally similar throughout development.

However attempts to replicate such work suggest that such claims may be unjustified, and in some cases, simple rules have been discovered which will explain precocious 'logical' behaviours. Thus, Shatz (1978) has argued that simple context-derived rules will explain the apparently complex communicative skills of very young children. McShane and Morrison (in press) have also argued that responses which would seem to require advanced knowledge of liquid quantity relations are explicable by a simple perceptual rule. Similar arguments have also been advanced by Trabasso, Isen, Dolecki, McLanahan, Riley and Tucker (1978) for class inclusion and Breslow (1981) for transitive inferences.
The same sorts of issues have also arisen in recent studies of memory development. Early claims (Flavell, 1970) and Brown (1975) of the preschooler's incompetence at generating intentional strategies for remembering, and even their inability to recognise the need for memory, have been falsified by numerous demonstrations of intentional strategy use (Wellman et al, 1975; Yussen, 1974; Yussen et al, 1975). However the present set of studies suggest that in some cases, apparently strategic behaviours may not be the result of intentional memory plans. This is also supported by the results of studies by Ritter (1978) and Gordon and Flavell (1977).

If we accept for the moment that the demonstrations of preschool precocity are not all the result of false positive errors, then we are left with the conclusion that preschoolers are capable, in some situations, of great logical feats, but these skills do not emerge in Piagetian tests. We may therefore characterise the abilities of the preschooler as being highly context-dependent.

7.4.3 The nature of developmental change

As Gelman and Gallistel (1978) so cogently argue, it is crucial that we understand the nature of thought in preschoolers if we are to understand and model the process of change in development. Knowledge of the starting-point will clearly influence both how we conceptualise
later developments, and will profoundly influence the mechanisms of transition we propose.

To this end, it is important that we correctly characterise the nature of memory in the later stages of development. I have just noted that memory seems to be highly context-specific in preschoolers. If it turns out to be the case that memory also happens to be context-specific in adults then our mechanism of change will have to be much less radical than if memory becomes decontextualised.

It is necessary first therefore that we characterise the nature of memory in adults. Flavell (1971) and Brown (1978) offer us accounts of adult memory which seem to be derived from the suggestions of Reitman (1970). A major characteristic of adult memorisers (according to these accounts) is the problem-solving nature of their skills. Adults are described as being better able to modify strategies to meet particular memory demands, or to invent new strategies if none are available. This is explained by the development of a central executive system (Brown, 1977, 1978) which has access to a large body of knowledge about memory and available cognitive routines. This system selects routines to meet particular demands, monitors their effectiveness and modifies them if necessary. The knowledge of important memory variables and of available routines enables routines to be freed from their original context, and employed for other functions in the cognitive system. This knowledge
of available routines should result in the generalisation of routines across a variety of contexts.

How accurate a picture of adult memory is this, however? There are a number of reasons for believing that adult memory may be rather less creative, adaptive and context-free than the above account claims. In a summary of recent developments in the levels-of-processing literature, Jenkins (1979) offers a convincing case that adult memory is highly context-specific.

The memory phenomena that we see depend on what kinds of subjects we study, what kinds of acquisition conditions we provide, what kinds of materials we choose to work with, and what kinds of criterial measures we obtain. Furthermore, the dependencies themselves are complex; the variables interact vigorously with one another (p. 431).

In addition we can find evidence that adult memory is prone to the same sorts of deficits as the immature memory system. Thus Rohwer, Raines, Eoff and Wagner (1977), found that most 17-year-olds had a production deficit for the use of an elaboration strategy in learning word pairs. Similarly Bower (1970) reports enormous improvements in memory when college students were instructed in the method of loci. Finally, a study by Chi (1978) suggests that context-specific knowledge rather than age is crucial in determining performance in remembering chess positions. She reports few examples of adults inventing strategies or adapting them from elsewhere in the cognitive system. It appears that even in adults, strategies may be limited in their domain of application.
This suggests two conclusions: that adult memory may be much more similar to memory in children; and secondly that metamemory may play much less of a role in adult memory than has previously been claimed. This is not to imply that metamemory itself does not change with age, but that such changes do not directly affect the memory system.

If it is the case that preschool and adult memory are similar, this has important implications for an account of developmental change. The large differences described by Flavell (1970, 1971) and Brown (1975, 1978) provide major problems for any such account, because they imply a major change in the nature of the memory system. It is clear that such a discontinuity is much more difficult to explain than the small differences suggested in the present account. It has already been argued that one mechanism by which memory may develop is by 'borrowing' behaviours from other parts of the cognitive system, or by instruction. External feedback and monitoring may explain how these routines become connected with memory goals. This account provides an explanation as to how intentional memory may first emerge, and it can be extended to cover adaptivity and generalisation. Intentional memory may first emerge from the accidental or involuntary evocation of a routine, and the child becoming aware of this either by reinforcement or by monitoring. The account can also explain how strategies become more general. As children grow older the number of routines in their repertoire will increase, as will the number of
occasions on which routines are related to memory. It has also been argued that the rate at which routines enter the memory repertoire may well be influenced by developments in the ability to self-monitor. As this develops, children will become increasingly sensitive to the effects of their behaviour. The problem of how strategies become better adapted to memory goals, may be the result of this increase in the number of available strategies. The metamemory-based account suggests this adaptiveness is the result of the subject's ability to modify a strategy to meet particular goals. It may be, however, that older subjects simply have more strategies and are able to meet these demands by evoking another strategy rather than by modifying the one previously in use. A final quality mentioned by Brown and De Loache (1978) in their description of memory in the expert is creativity. Even given the problems of defining such a term, there does not seem to be a vast amount of evidence to suggest this characteristic in adult memory. In cases in which it does occur it seems to be dependent on vast knowledge of an area which allows the generalisation argument suggested earlier, as an alternative to appeals to metamemory.

It could be argued that the present account does not allow for the development of novel memory strategies, but strategies need not originate only from elsewhere in cognition - it is likely that many are introduced through instruction in schools.
What is the role of metamemory in all of this? As I have already said, the increase in metamemory is a developmental phenomenon which remains to be explained. I have argued that the initial development of metamemory may be the result of feedback on early strategy usage. Metamemory was originally invoked, however, to explain the differences in memory between adults and children (Flavell, 1970; Brown, 1975). As I have now argued that much of memory in both adults and children does not have the knowledge-driven characteristics of this account, its importance as an explanatory construct is much reduced. In addition, most of the studies attempting to demonstrate the relationship between metamemory and memory have failed to do so (see Chapter 3), the exceptions being studies in which children were given information about strategy effectiveness which are built into the account offered here. All this suggests there are severe problems with the metamemory-driven model of memory. This is not to say that memory never has the intentional problem-solving character described in the early accounts, and that knowledge of memory does not influence performance, but that models of memory which appeal to metamemory are inadequate to explain the data. In view of this it is suggested that we attempt to explain the development of memory skills without appeal to such a construct.

This account has a number of implications for general models of development, and mechanisms of change in such models. Firstly it is important that we correctly
characterise not only the initial state of the system (as Gelman, 1978 argues) but that we arrive at an accurate description of the skills of the adult. There are some parallels between the discussion of memory development above, and recent findings in cognitive development. In her summary of empirical research on Piaget's theory, Boden (1979) concludes that

> Recent experimental research has shown Piaget to be wrong on many points, such as the inability of children at a given age to carry out certain types of 'more advanced' thinking....And adults, by contrast, are considerably less logical in much of their reasoning than Piaget's theory would lead one to expect. (p. 152)

It was also argued that the differences between child and adult skills will greatly influence the mechanism of change. If adult and child abilities are much more closely related and both context-specific then it is clear that any mechanism we propose will be itself specific, and need not be enormously powerful, as the changes to be explained are quantitative rather than qualitative in nature.

There are parallels between other theories of development and the account of the development of intentional memory, and the mechanism by which routines come to serve the goal of memory. A number of other theories suggest that a major feature of development is the increased access to cognitive routines, and the use of these routines to serve new functions (e.g. Fodor, 1972; Rozin, 1976). Other theories have argued that existing routines are used in a qualitatively different way, following the development of reflectivity which enables the child to use the routines
in a logical "decontextualised" manner. (e.g. Donaldson, 1978; Vygotsky, 1962; 1978). If these are to serve as adequate accounts of development they must specify: (1) the reasons for the original constraints on routines; and (2) the mechanism by which increased access is made possible. In addition some of these theories allow for the creation of 'new' routines. If this is the case, how is the creation of new routines possible, and what contribution does this make to development?

If we deal first with the question of initial constraints we find that none of the theories provide a principled explanation. Fodor's account is no more than a series of suggestions about possible domains of early competence, no reason is given as to why these are favoured. Rozin (1976) goes somewhat further in suggesting that early skills may be constrained by genetic factors. Thus children develop first in those domains which are important for their early environment. This line of reasoning also seems to underlie the suggestions of Donaldson (1978) that thought is initially predominantly "social", but as has already been suggested (p.300) she has not proposed criteria by which "social" situations may be isolated. Similarly Vygotsky provides little in the way of description of early thought.

The theories are similarly flawed in their explanations of increased access. Rozin and Fodor offer no account of how this might occur. Both Vygotsky and Donaldson
suggest that children's increased ability to analyse the structure of early thought is responsible for their increased control over its different functions. This change is attributed in both cases to the development of a conventional sign system. Thus Donaldson suggests that the onset of reflectivity is determined by the development of the skills of reading and writing, and Vygotsky argues that thought is modified by the internalisation of spoken language. While there is evidence that literacy influences thought, this is often confounded by other variables such as the use of a cash economy or collective farming, (Scribner and Cole, 1973), and the account does leave unspecified precisely how this change is brought about. There have also been a number of attempts to test the hypothesis that the internalisation of speech is responsible for a modification in processes of thought. The results of these studies have largely suggested that language and thought functions develop in isolation (Jarvis, 1963; Wilder, 1968; Miller, Shelton and Flavell, 1970). There is an additional problem for the theories of Donaldson and Vygotsky. A number of recent volumes on adult cognition (e.g. Claxton, 1981; Johnson-Laird and Wason, 1977) have suggested that adult thought, like memory, may well be context-specific. If this is the case, then the theories may well be mischaracterising the nature of adult thought, and misrepresenting the means by which increased access is made possible.

The theories are also silent on the issue of novel
behaviours. Although Fodor and Rozin seem to allow the new routines may emerge, they do not explain how they emerge, nor how frequently behaviours enter the repertoire in this manner. It is not clear where Donaldson or Vygotsky stand on this issue.

The theory of memory development proposed here would seem to have some advantages over the these theories. Although it is yet not possible to specify exactly the constraints on early memory skills, it is argued that strategies emerge from overlearnt routines in the child's everyday activities, and a mechanism is provided by which these routines come to serve memory goals. There is also evidence from other areas of cognition that a mechanism such as social feedback can bring about change. (Doise et al, 1975; McShane, 1979; 1980; McShane and Whittaker, in press; Russell, 1982). The notion that early strategies are routines developed elsewhere in the cognitive system and are initially evoked in an involuntary manner has also been suggested by Lange (1978), Paris (1978a) and Brown and De Loache (1978), but none of these accounts suggest the mechanism by which involuntary behaviours come to serve memory functions.

7.4 Memory and the Environment

Ecology and Research in Memory I wish finally to point out the ways in which our present models of memory fail to take into account the influence of the environment. I shall not discuss recent ecological theories of development
(e.g. Wilcox and Katz, 1981), for as they are formulated they are not much different from the more traditional cognitive approach (McShane and Whittaker, 1982). I shall firstly discuss differences between the types of memory problems people encounter in everyday life, and the sorts of remembering they have been asked to carry out in laboratory studies. I shall then illustrate in the more immediate influence of the environment/inducing memory related behaviours, and in modifying the use of such behaviours.

The types of problems which occur in the natural environment seem very different from those we study in the laboratory. In the early 70's there were a number of attacks on the ecological validity of memory experiments (e.g. Jenkins, 1974) but these largely resulted in researchers modifying the stimuli they used. Thus, instead of having subjects remember word lists, the task was changed to remembering stories or taxonomically organised lists. There are a number of ways in which such studies still do not approximate to everyday life. Firstly the task demands, in particular the need for verbatim recall, do not model the demands of the natural environment. In addition, when faced with demands such as those of the laboratory task, most subjects would naturally respond by producing strategies, which avoid verbatim remembering. One such strategy might be to use external aids, such as note-taking or writing down verbatim or tape-recording the story. We do not attempt
complex internal mnemonics when attempting to remember what to buy at the shops, we simply sit down and write a list. In addition there are a number of conventional memory aids available which avoid the necessity of remembering, such as books or computer files.

All this suggests that the goals of memory, and the means available for achieving those goals may be radically different in laboratory and naturalistic situations. Given recent statements about the context-specificity of memory skills, it is difficult to see what laboratory studies can tell us about remembering in natural contexts. It has been argued, in defence of laboratory studies, that they tap the same sort of skills as the school situation demands. Standard examinations such as 'O' and 'A' levels do require the production of large amounts of information in the absence of memory aids, such as notes or books. However the situation differs from the laboratory in that verbatim reproduction of information is not demanded, nor did learning all take place 'in the head'. In everyday life, the encoding skills we most often require are the skills of organising information in external storage systems in such a way that it can be easily accessed, e.g. by setting up filing systems, by taking notes, by photo-copying, or writing diary entries. The retrieval skills are those of accessing the desired information from these external sources. Access and storage do require cognitive processes, but they are of a different order from those described in traditional memory.
Ecology also has profound influences on young children's memory development. Thus while they will have to remember certain things e.g. their way around their immediate environment, few memory demands are placed upon them, because other people do all their remembering for them. Thus, they will seldom be asked to find their way around novel environments, because they will generally be accompanied by adults. If they lose anything (toys, books, clothes) the chances are that an adult will be available to find the lost object. Thus, when Kreutzer et al (1975) asked 5-year-olds how they would remember a friend's birthday party, the majority of those who suggested a strategy said they would ask someone else to remind them.

What then is the status of the present set of experiments in the light of such criticism? The experiments do appear to be naturalistic in a number of ways. Firstly, they involve the consultation of external information sources (pictures monitoring and array cues). In addition, an adult provides some structuring of activity, by suggesting particular actions, or by providing feedback. The activities the child is asked to carry out are in most cases familiar ones, e.g. remembering stories, being asked questions about stories, and there were no demands for verbatim recall.
In addition to the environment influencing the types of problems we select for study, it is important that it is incorporated as a variable in any theory of memory.

Environment as stimulus

It has already been argued that task instructions, the materials and the amount of prompting are all factors in the stimulus environment which influence the accessing of a routine. Any predictive account of memory must incorporate their interaction, and also allow for the fact that these influences of the different stimulus components may change with age.  

Environment as mechanism for change

Finally Experiments VIII and IX suggest that the feedback which the environment provides may be crucial in structuring the area of application of a particular routine. However, we have not established that this mechanism is actually in operation in the natural environment, although it seems likely that such feedback will be provided in the school setting. In order to assess the importance of this factor, we must study the environment of the child to establish if and when such reinforcement

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18 E.g. Donaldson (1978) has argued that the influence of the language component of tasks may change with age.
Environment as the basis of strategies

Experiments X and XI suggest that the origins of some strategies may lie in routines from the child's everyday activities. An alternative way in which strategies may have their origins in the environment is by teaching.

The environment may also provide strategies by its influence at a level deeper than the child's everyday activities. The use of taxonomic organisation in remembering word lists can be seen as the application of category knowledge to the domain of memory. However, it has been argued, e.g. Rosch (1977) that categorical organisation has its origins in the structure of the environment. A similar argument has been advanced for both scripts and story grammars (e.g. Mandler, 1979).

Finally, the environment itself may provide search strategies for children, for example, by children asking adults to find objects for them. Perhaps one of the best examples of the role of the environment in affording information to the young child emerged during one of the cueing experiments:

Policeman (to child): "Who's hiding in this house, then?"

Child: "I don't know, let's ask the pig, shall we?"
TABLE 1: Distribution of scores on the first trial

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of children obtaining score of:</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
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<tr>
<td>3;0 - 3;9</td>
<td>3</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
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</tr>
<tr>
<td>4;7 - 5;2</td>
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TABLE 2: Distribution of scores on second trial

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<tr>
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<tr>
<td>3;0 - 3;9</td>
<td>3</td>
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<tr>
<td>3;10 - 4;6</td>
<td>6</td>
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<tr>
<td>4;7 - 5;2</td>
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TABLE 3: Number of children making use of monitoring cues

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<th>Age</th>
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</thead>
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<tr>
<td>3;0 - 3;9</td>
<td>2</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>4</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>4</td>
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</table>
TABLE 4: Number of children making use of array cues

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<th>Both trials</th>
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</tr>
<tr>
<td>4;7 - 5;3</td>
<td>4</td>
<td>7</td>
<td>16</td>
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TABLE 5: Percentage of correct responses at each serial position

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<th>Serial Position</th>
<th>Experimental</th>
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<tbody>
<tr>
<td>Cues</td>
<td>38 25 47 72</td>
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<tr>
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</tr>
<tr>
<td>Cues</td>
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<tr>
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<tr>
<td>Cues</td>
<td>41 44 56 100</td>
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<tr>
<td>No Cues</td>
<td>55 50 38 48</td>
</tr>
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TABLE 6: Number of children using monitoring cues

<table>
<thead>
<tr>
<th>Age</th>
<th>Neither trial</th>
<th>One trial</th>
<th>Both trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
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<td>3;10 - 4;6</td>
<td>1</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>0</td>
<td>1</td>
<td>11</td>
</tr>
</tbody>
</table>
### TABLE 7: Number of children using array cues

<table>
<thead>
<tr>
<th>Age</th>
<th>Neither trial</th>
<th>One trial</th>
<th>Both trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

### TABLE 8: Percentage of correct responses at each serial position

<table>
<thead>
<tr>
<th>Age</th>
<th>Monitoring Type</th>
<th>Serial Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>Monitoring</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Array</td>
<td>34</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>Monitoring</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Array</td>
<td>28</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>Monitoring</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Array</td>
<td>47</td>
</tr>
</tbody>
</table>

### TABLE 9: Percentage of correct responses at each serial position as a function of cue type

<table>
<thead>
<tr>
<th>Cue Type</th>
<th>Serial Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>No Cues</td>
<td>43</td>
</tr>
<tr>
<td>Array Cues</td>
<td>38</td>
</tr>
<tr>
<td>Monitoring Cues</td>
<td>41</td>
</tr>
<tr>
<td>Monitoring and Array Cues</td>
<td>44</td>
</tr>
</tbody>
</table>
TABLE 10: Summary table for analysis of variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF1/ DF2</th>
<th>F</th>
<th>P Value</th>
<th>Mean Square</th>
<th>Sum of Sq</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>3/ 184</td>
<td>12.3729</td>
<td>0.0000</td>
<td>0.0003</td>
<td>26.6409</td>
</tr>
<tr>
<td>GP</td>
<td>2/ 184</td>
<td>4.4217</td>
<td>0.0133</td>
<td>3.1735</td>
<td>6.3471</td>
</tr>
<tr>
<td>MA GP</td>
<td>6/ 184</td>
<td>1.4200</td>
<td>0.2090</td>
<td>1.0192</td>
<td>6.1149</td>
</tr>
<tr>
<td>SE</td>
<td>3/ 552</td>
<td>18.7361</td>
<td>0.0000</td>
<td>7.6340</td>
<td>22.9043</td>
</tr>
<tr>
<td>MA SE</td>
<td>9/ 552</td>
<td>6.3113</td>
<td>0.0000</td>
<td>2.5710</td>
<td>23.1461</td>
</tr>
<tr>
<td>GP SE</td>
<td>6/ 552</td>
<td>1.8047</td>
<td>0.0960</td>
<td>0.7354</td>
<td>4.4125</td>
</tr>
<tr>
<td>SE</td>
<td>18/ 552</td>
<td>0.7372</td>
<td>0.7734</td>
<td>0.3004</td>
<td>5.4071</td>
</tr>
<tr>
<td>MA GP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>184</td>
<td>0.7177</td>
<td></td>
<td>132.0605</td>
<td></td>
</tr>
<tr>
<td>MA GP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS SE</td>
<td>552</td>
<td>0.4075</td>
<td></td>
<td>224.9345</td>
<td></td>
</tr>
</tbody>
</table>

Key
MA are the four cue conditions
GP are the three groups
SE are the four serial positions
SS are the 196 subjects

TABLE 11: Percentage of children making inferences and giving justifications

<table>
<thead>
<tr>
<th>Age</th>
<th>Inference only</th>
<th>Inference with justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>73</td>
<td>50</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>93</td>
<td>71</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>100</td>
<td>91</td>
</tr>
</tbody>
</table>
### TABLE 12: The relationship between children's assessments of memory performance and their actual memory performance

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean assessments</th>
<th>Mean performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>85</td>
<td>43</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>66</td>
<td>45</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>74</td>
<td>50</td>
</tr>
</tbody>
</table>

### TABLE 13: Number of children using particular cues expressed as a function of their post-diction ability

<table>
<thead>
<tr>
<th>Post-diction Ability</th>
<th>No Cues</th>
<th>Monitoring Cues</th>
<th>Array Cues</th>
<th>Monitoring &amp; Array Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate</td>
<td>1</td>
<td>20</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Inaccurate</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
TABLE 14: The relationship between children's assessments of their memory performance under various cuing conditions and their actual level of performance

<table>
<thead>
<tr>
<th>Age</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Cues</td>
</tr>
<tr>
<td></td>
<td>Cues</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
</tr>
</tbody>
</table>

TABLE 15: Number of children maintaining a cuing strategy as a function of its perceived effectiveness

<table>
<thead>
<tr>
<th>Perceived effectiveness</th>
<th>Improvement</th>
<th>No change</th>
<th>Deterioration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>15</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>No maintenance</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE 16: The mean number of pictures correctly recalled on Blocks 1 and 2 by the different groups

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producers</td>
<td>9.61</td>
<td>9.55</td>
</tr>
<tr>
<td>Non-producers-feedback</td>
<td>8.70</td>
<td>9.30</td>
</tr>
<tr>
<td>Non-producers-no-feedback</td>
<td>8.88</td>
<td>8.41</td>
</tr>
</tbody>
</table>
TABLE 17: Percentage of correct responses on the no-strategy pretrials, for the 7- and 3-item groups

<table>
<thead>
<tr>
<th>Age</th>
<th>Seven</th>
<th>Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>23</td>
<td>52</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>25</td>
<td>72</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>42</td>
<td>82</td>
</tr>
</tbody>
</table>

TABLE 18: Number of children requiring explicit prompts to induce the strategy on pretrials after training

<table>
<thead>
<tr>
<th>Age</th>
<th>Prompt</th>
<th>No Prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>2</td>
<td>18</td>
</tr>
</tbody>
</table>

TABLE 19: Number of cues used by children in the 7- and 3-item groups, on the near transfer task when no prompts were given

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean number of cues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 items</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>3.22</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>4.63</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>4.82</td>
</tr>
</tbody>
</table>
TABLE 20: Number of prompts required to induce strategy use on prompted near transfer task

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean number of prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 items</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>1.58</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>0.38</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>0.10</td>
</tr>
</tbody>
</table>

TABLE 21: Mean number of prompts required to elicit strategy use in far transfer tasks

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean number of prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 items</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>3.90</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>3.92</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>4.03</td>
</tr>
</tbody>
</table>

TABLE 22: Mean number of correct responses on far transfer questions

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean number correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 items</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>0.91</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>0.54</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>1.54</td>
</tr>
</tbody>
</table>
TABLE 23: Mean number of cues used and prompts required to induce use of strategy in the near transfer task

<table>
<thead>
<tr>
<th>No evaluative information</th>
<th>2.02</th>
<th>2.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluative information</td>
<td>4.40</td>
<td>0.92</td>
</tr>
</tbody>
</table>

TABLE 24: Number of correct responses given to memory questions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pictures</th>
<th>No Pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>5.34</td>
<td>3.00</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>5.58</td>
<td>3.92</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>9.07</td>
<td>6.81</td>
</tr>
</tbody>
</table>

TABLE 25: Mean time children spend studying the pictures

<table>
<thead>
<tr>
<th>Age</th>
<th>Looking Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>23.52</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>20.14</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>22.02</td>
</tr>
</tbody>
</table>
TABLE 26: Percentage of children correctly answering each type of monitoring question

<table>
<thead>
<tr>
<th>Age</th>
<th>Question type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediction</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>50</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>42</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>92</td>
</tr>
</tbody>
</table>

TABLE 27: Mean prompt score required to induce picture consultation\(^a\)

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td>6.00</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>7.12</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>5.46</td>
</tr>
</tbody>
</table>

\(^a\) Maximum number of possible prompts is 48.

TABLE 28: Mean number of prompts required to direct the strategy

<table>
<thead>
<tr>
<th>Age</th>
<th>Question Order</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Serial</td>
</tr>
<tr>
<td>3;0 - 3;9</td>
<td>3.82</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td>2.43</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td>1.67</td>
</tr>
</tbody>
</table>
### TABLE 29: Mean number of cards searched

<table>
<thead>
<tr>
<th>Age</th>
<th>Question Order</th>
<th>Serial</th>
<th>Random</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;0 - 3;9</td>
<td></td>
<td>9.96</td>
<td>11.64</td>
</tr>
<tr>
<td>3;10 - 4;6</td>
<td></td>
<td>9.85</td>
<td>12.06</td>
</tr>
<tr>
<td>4;7 - 5;3</td>
<td></td>
<td>7.12</td>
<td>9.81</td>
</tr>
</tbody>
</table>

### TABLE 30: Frequency of direct searches

<table>
<thead>
<tr>
<th>Mean Question Type</th>
<th>Number of direct searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>3;5</td>
<td></td>
</tr>
<tr>
<td>Serial</td>
<td>1 1 4 3 2 1</td>
</tr>
<tr>
<td>Random</td>
<td>2 4 3 3 0 0</td>
</tr>
<tr>
<td>4;2</td>
<td></td>
</tr>
<tr>
<td>Serial</td>
<td>1 1 2 0 7 1</td>
</tr>
<tr>
<td>Random</td>
<td>1 5 4 2 0 0</td>
</tr>
<tr>
<td>4;10</td>
<td></td>
</tr>
<tr>
<td>Serial</td>
<td>0 2 0 0 6 4</td>
</tr>
<tr>
<td>Random</td>
<td>2 2 6 2 0 0</td>
</tr>
</tbody>
</table>
APPENDIX I  Predicted distribution of scores if children employ an inferential strategy

<table>
<thead>
<tr>
<th>Number of locations remembered</th>
<th>Number of correct responses</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>4\textsuperscript{a}</td>
<td>4</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>4\textsuperscript{i}</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>0.16</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0.00</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>4</td>
<td>0.04</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>0.21</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.42</td>
</tr>
</tbody>
</table>

The actual distribution of scores will depend upon what the children directly remember, but it is important to note that strategy should never result in scores of three items correct.

\textsuperscript{a} Strictly speaking, there is no need to make inferences when all locations can be remembered by direct memory.
APPENDIX II  Stories used in Experiment X

Story A - Mary and Fido

One rainy day, Mary decided to take Fido for a walk - so she went out and found he was stuck in the door.

'Come out' she said.

'I can't' he said 'I'm stuck'.

So she put a rope round his neck and pulled - but she couldn't pull him out.

'I know!' she said. 'Drop your bone'.

So he dropped it and he came straight out, and had a big drink from his bowl.

Questions

1. At the beginning of the story what did Mary want to do with Fido?
   -> Walk.

2. What was the weather like?
   -> Raining.

3. Why couldn't Fido come out?
   -> He was stuck.

4. Where was Fido stuck?
   -> In the door.

5. How did Mary try and get Fido out first of all?
   -> Rope around neck and pulled him.
6. What happened when Mary pulled Fido with the rope?
   -> He still didn't come out.

7. What did Mary tell Fido to do next?
   -> Drop his bone.

8. What happened when Fido dropped his bone?
   -> He came straight out.

9. What did Fido do straight after he came out?
   -> Drank from his bowl.

10. What sort of an animal was Fido?
    -> A dog.

**Story B - Jenny and her Mother**

Jenny had just finished her cornflakes when her Mummy called out,

'Hurry up, or you'll be late. It's nearly nine o'clock.'

Jenny rushed round. She looked under the table but she couldn't find what she was looking for.

Then her Mummy came in.

'I've found them', she said 'Your schoolbag is under your coat and your ball's behind you.'

**Questions**

1. At the beginning of the story, what had Jenny just finished doing?
   -> Eating cornflakes.

2. What did Jenny's Mummy shout at the beginning of the story?
   -> You're late, it's nearly 9 o'clock.
3. What did Jenny do after her Mummy shouted she would be late?
   -> Rushed round looking for her things.
4. & 5. What was Jenny looking for?
   -> Ball and Schoolbag.
6. Where did Jenny look for the ball and schoolbag?
   -> Under the table.
7. Who found the ball and the schoolbag?
   -> Her Mummy.
8. & 9. Where were the ball and schoolbag?
   -> Behind her, under her coat.
10. Where was Jenny going?
    -> School.
APPENDIX III  Stories used in Experiment XI

Story A - George the Owl has an Idea

George the Owl was always having clever ideas. One night he was in bed when he realised exactly why people have legs. "People have legs so they can walk" he thought to himself. Now George thought this idea was very important. He thought he ought to tell all the animals. He decided he would make a speech in the market square to say why people have legs. Soon everyone heard that George would make a speech. Lucy the Lamb went to see Percy who was standing on the green fence. "George is going to make a speech" said Lucy the Lamb to Percy. "He's going to tell us why people have legs." The animals agreed that George would make his speech in the market square. George went to see the square but it was very dirty. "What can I do?", he said to Mandy the Mouse. "I can't speak in a dirty square." "I'll clean it up!" said Mandy the Mouse. So Mandy cleaned the market square. At last, the day of George's speech arrived. Everyone came to the market square. George stood up and they were all quiet as he began to speak. He began to tell them about why people have legs. Some of the animals were so interested in what George had to say that they wrote it all down. Others just sat and listened. At last George explained why people have legs. "It's so that they can walk", he
"Isn't George funny?" they said to each other "he makes a big speech about something we already know. We already know that people have legs so they can walk."

When George finished his speech he said "Now I've brought drinks for everyone". So everyone went and had a drink except for George who was thinking up his next brilliant idea.

Questions

1. Lucy the Lamb heard about George's idea. She went and talked to Percy about it. What sort of an animal was Percy?

2. Mandy the Mouse offered to clean the market square because it was dirty. What colour was Mandy's jumper?

3. George stood up in the market square and made his speech. What did he hold in his hand when he made the speech?

4. Some of the animals were very interested in what George had to say. Some of them wrote it all down. Which animals wrote down everything George said?

5. After George's speech everyone had something to drink. What did all the animals have to drink?
Mick was a big white duck who lived on a farm. Mick was happy on the farm until one day he heard about the magic stone. He was talking to Rufus the Dog. Rufus told him about the magic stone which would grant you any wish you wanted. Mick was very excited. "I'm going to find the magic stone so I can have all the things I want" he said to Rufus the Dog. So Mick began his search for the magic stone. First he went to the big tree. "Have you seen the magic stone?" he said to the animals who lived in the big tree. "No, we haven't", they said, "but we'll tell you if we see it.". Next he decided to swim up the river to the little village, to look for the stone. He got to the village and an old lady threw him a crust of bread. "Have you seen the magic stone?" he asked the old lady, but she hadn't seen it either. "Bye, bye, old lady", said Mick. Mick swam past the village but round the corner there were five nasty ducks. "Go away" they quacked, "this is our river. You don't belong here!" cried these nasty ducks. So Mick had to turn back because he didn't belong on that river. By now, Mick was very tired, with swimming, so he got out of the river to walk. But he hadn't walked more than ten waddles when he saw a big black thing in his way. He tried to squeeze past it, but it was no use. The big black thing jumped and grabbed him by the neck. Just then Rufus the Dog arrived. Rufus was very cross. "Put Mick down" he barked fiercely. Rufus took Mick home and Mick never
left home again to look for the magic stone.

Questions

1. Where were Rufus and Mick standing when Rufus the dog told Mick about the magic stone?
2. Mick the Duck went to the big tree to talk to the animals who lived there. Which animals lived in the big tree?
3. An old lady threw Mick a crust of bread to eat. What was the old lady carrying on her arm?
4. Mick got chased by some nasty ducks. What colour were the nasty ducks, who told Mick he didn't belong in the river?
5. Mick got out of the river to walk because he was tired, but a big black thing blocked his way. What was the big black thing?


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APPENDIX IV  Pictures used in Experiments X and XI

Experiment X
   a. Mary and Fido
   b. Jenny and her mother

Experiment XI
   c-e Mick the Duck has an adventure
   f-h Ernest the Owl has an idea
APPENDIX V Experimental Apparatus

Fig. 1 Apparatus for Experiments I-VI

Fig. 2, Fig. 3 Apparatus for Experiments VIII & IX
CHILD

EXPERIMENTER

○ Locations of four cups
× Position of monitoring cues
• Position of array cues

Fig. 1.
Fig. 3.

- Baited cup
- Direction of sheep