EXPERIMENTAL STUDIES OF 9-15 YEAR OLD CHILDREN'S USE OF CATEGORISATION IN SOLVING PROBLEMS

by

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A B S T R A C T

This thesis reports seven experiments on how children, aged 9 to 15 years, deal with problems in which categorizing may be used to impose advantageous order on the problem-solving process. The first three experiments present a total of 108 children with Twenty Questions games. There are significant age-related changes in the types of question asked, notably a change from particular to categorical questions. However, these changes are not accompanied by significant changes in problem-solving efficiency as measured by the number of questions required for solution. It is concluded that the half-split algorithm does not develop spontaneously but in response to special pressures which are investigated in Experiments 4 and 5, making a total of 91 children. Experiments 6 and 7 involving a total of 78 children, uses a recall task to examine the use of categorizing as a means of fascilitating recall. In these problems, older children are found to make more spontaneous use of categorizing, while the recall of younger children is greatly improved when they use prior category cues and are instructed how to use these cues.

P R E F A C E

This thesis examines how children, aged 9 to 15 years, deal with two types of problem in which categorising may be used as a means of imposing advantageous order on the problem-solving process.

The first type of problem is the Twenty Questions game. Here, the solver is shown an array of items and has to discover the target item by asking questions, each of which receives a Yes or No answer, and by asking as few questions as possible: success is expedited by categorising the items in such a way that the answer to each successive question will eliminate half the remaining possibilities.

The second type of problem is a recall task. Here, the solver is shown an array of items and, after the array is removed, has to recall as many of the items as possible: success is expedited by recalling according to categories, e.g. recalling that the array contained so many animals, which were such and such, and so many fruits, which were such and such, and so many items of clothing, which were such and such.

CHAPTER ONE

INTRODUCTION TO TWENTY QUESTIONS

This chapter was written in the light of experiences gained from conducting the experiments which will be reported in later chapters. These experiments involved children of average scholastic ability and from three age groups, namely, nine, twelve and fifteen years. The overall aim of the experiments was to uncover age-related differences in the children's dealings with Twenty Questions problems. A subsidiary aim was to discover whether the performances were influenced by the type of material presented, specifically, a random array of pictures, or of printed words, or of numbers.

The stimulus for these experiments was the work reported by Bruner, Olver and Greenfield (1966). That work showed that, over the age range 6 to 11 years, there were clear differences in the way children performed on Twenty Questions games, and that such games were sufficiently rich and yet sufficiently restrictive to provide informative views of the course of cognitive development. Furthermore, Bruner et al introduced the notion of 'constraint seeking' in order to interpret their findings in terms of an attractively coherent developmental progression: over the age range 6 to 11 years, children progressively elaborated and gained control over constraint-seeking processes. The author's experiments set out to study this developmental progression over the age range 9 to 15 years but, in the event, the main overall finding of the experiements was that, while there were striking age differences in the children's performances, there were no statistically significant age differences in the efficiency of performance as measured by the number of questions asked before reaching the solution. In other words, under the conditions used in the experiments, there was good reason to doubt the notion of a developmental <u>progression</u> in constraint-seeking processes, and to question

the very notion of 'constraint seeking' as a basis for interpreting the age-related changes in the children's performances.

Because of the key role of the study by Bruner et al, that study will now be described in some detail.

Section One : The Bruner et al study

The material was an array of 42 coloured drawings, each representing a familiar object such as a doll, garage, pumpkin, umbrella. The pictures were such that they could be categorised in various ways, e.g., articles of clothing, tools, living things. The 42 pictures were displayed in a rectangular array of six columns and seven rows. The participants were ninety boys, thirty from each of grades 1, 3 and 6 of a suburban school near Boston, U.S.A. The mean ages and IQs of the groups were 6:3, untested; 8:4, 121; and 11:4, 117. (Note the above average IQs. If it can be assumed that the average IQ of each group was around 120, then in terms of mental age, the groups represent 7, 10 and 13 years respectively).

The children first participated in a study concerned explicitly with equivalence groupings. Children were shown the array, asked to identify each picture, and then to pick out pictures which were alike; when a group of pictures had been selected, the child was asked to say how the selected pictures were alike. This task of selecting a like group of pictures from the full set of 42 was repeated ten times. The aim was to discover what kinds of categories the children would form, and on the basis of what attributes. The categories thus produced on request would later be compared with the categories produced by the same children when playing Twenty Questions - in which situation, any categorisations which are produced occur, not on request, but as a means of dealing with a problem. In passing, it is worth noting that the preliminary equivalence tasks gave the children considerable familiarity with the pictures and with breaking up the spatial arrangement in which the pictures were displayed. This familiarity may explain why, in the Twenty Questions tasks, there was a marked paucity of questions which categorised pictures by their location, e.g. by row or column in the display. (In the writer's experiments,

spatial questions were fairly common).

Following the first part of the study, each child played two Twenty Questions games with the 42-picture array. In the first game, the target was predetermined to be the 'saw'. In the second, children were told they could ask no more than ten questions, and the target was predetermined to be the 'doll'. In both games, the children were told to find the target by asking questions which would be answered with only a 'yes' or a 'no', and to try to find the target in as few questions as possible.

The questions asked by the children were subsequently classified according to a scheme based on two idealised strategies of play.

> "The first, called 'constraint seeking', is based on a principle close to a theorem in information theory: assume that alternative possibilities are all equally likely, try to eliminate exactly half of the alternatives with each question. You then tend to minimise the number of questions needed over a series of games. This is the idealised statement of the strategy. As seen in practice, the child begins with a general question that groups a large number of specific possibilities into two domains, in one of which the correct answer must lie. This gurantees usable information on each question, since both a positive and a negative response are equally useful to the child, at least theoretically. He then uses the information gained on each question to narrow in on the answer, successively constraining the remaining domain until he can almost derive the correct answer from the information known without actually asking about it directly.
>
> The polar opposite of constraint seeking is called 'hypothesis scanning'. A child simply asks a series of questions, each of which tests a self-sufficient, specific hypothesis that bears no necessary relation to what has gone before. Such sense as there is to the order of questions asked in this strategy seems to be determined by crude orders of likelihood, by associative connection, or by 'prompts' contained in the immediate environment." (p.88).
>
> "All questions asked were classified as constraints, specific hypotheses, guesses, the pseudoconstraints. A constraint is any question general enough to refer to two or more pictures. It must be of a type such that a 'yes' answer cannot solve the problem. Specific hypothesis names a particular object - 'Is it the hammer ?' Guesses are those specific hypotheses that bear no discernible relation to previous constraint questions. They provide an index of the 'unconnectedness' of a subject's search strategy. Pseudoconstraints, like specific hypotheses, refer to only one item in the array. But they are phrased like constraint questions: a single attribute is referred to, but it is one that characterizes only one picture: 'Does it have a sail ?' or 'Does

it bark ?' - thinly disguised efforts to pinpoint the single sailboat or the single dog in the array. They are form without substance, as though the child had learned how to make the question sound 'right' without knowing how to use it appropriately". (p.90).

When the children's questions were classified as indicated above, there were striking differences among the three age groups. These differences were summarised as follows :

"Six-year-olds seek information directly by testing specific hypotheses, eight-year-olds establish some constraints before leaping to hypotheses, while eleven-year-olds postpone specific hypotheses until they have narrowed the possibilities beyond a first set of constraints. The development of strategies for seeking information is towards increasingly connected acts designed to locate relevance by more economical but less direct means". (p.96).

(1) The proportion of constraint to hypothesis questions increases with age.

"Our first-graders went about the game with a strategy of almost pure hypothesis scanning . . . Only five of the thirty six-year-olds asked any constraint-locating questions at all, and not many at that . . . In striking contrast, twenty-six of the thirty eight-year-olds and all of the eleven-year-olds asked some constraint questions." (pp.90-91). "Apparently the older children consider specific hypotheses inelegant. They prefer constraints to such a degree that sometimes pseudoconstraints replace out-and-out guesses . . . A few eleven-year-olds even interpreted the rules of the game as excluding all but a final specific hypothesis, or else asked whether they were allowed any 'guesses'." (p.92).

(2) Narrowing

"Narrowing refers to what one can do after having established some prior constraint - particularly whether one asks a further constraint question or shifts to hypothesis testing. The older children were more likely to narrow the remaining possibilities with further constraint questions, whereas the eight-year-olds tended to leap immediately to specific hypotheses." (p.91).

(3) The attributes on which constraint questions are based. Consider three classes of attribute. Preceptible, e.g. is it yellow ? round ? large ? Functional, i.e. the category is defined in terms of what the depicted object can do (e.g. does it make a noise ?) or of what can be done with it (e.g. can you get inside it ?). Nominal, i.e. the category is defined in terms that are conventional and conventionally nameable,

e.g. is it a fruit ? animal ? toy ? Although this tripartite classification must have been difficult to apply to some of the children's questions, data are reported which shows the following. Functional questions preponderate in all three age groups but, with increasing age, there is a fall in the proportion of perceptible questions and a rise in the proportion of nominal questions. Also, with increasing age, there is an increase in the variety of attributes.

(4) Difference between the first and second games.

> "In the second or restricted game, where the children were limited to ten questions, it would seem that constraint-locating questions would have been encouraged, but our limitations produced no increase in constraints at any of the three ages. As likely as not, the younger children, not able to muster constraint-locating strategies to begin with, were unable to do so when the questions were restricted in number. The older children gave the impression that theywere already using constraint location to the limit of their capacity." (p.91).

(5) Number of questions to reach the target.

> "Six-year-olds take more than twice as many questions to solve the first problem as do eleven-year-olds - an average of twenty-six questions for the sixes, fifteen questions for the eights, and eleven questions for the eleven-year-olds. In the second game, in which the children were limited to ten questions, nearly as many six-year-olds achieved a solution within the limit as did the eight-year-olds, with the eleven-year-olds coming out best: eleven in thirty, twelve in thirty and sixteen in thirty, respectively. We suspect that the good showing of the sixes may have had a little to do with the popularity of the doll [as target item]." (p.93).

Such then was the main study, involving a presented matrix of items, from which the writer's experiments took their point of departure. But it is worth mention that Bruner et al reported a further study involving, not a matrix but a verbally described event, e.g. "A man is driving down the road in his car, the car goes off the road and hits a tree". Children have to find the cause of the accident by asking questions which will be answered Yer or No, and by asking as few questions as possible. Afterwards the children were asked to describe how they played the game and whether they had any system for getting answers. The participants were seventy seven boys aged six to eleven drawn from the first, third and

sixth grade of a Boston school.

In contrast to the matrix type of Twenty Questions, this type is verbal, has unrestricted alternatives, and is less amenable to clearcut scoring. But in general

> "The inquiry serves to reemphasize the development of strategies from one involving discrete questions, each quite unrelated to what went before, each designed to test a self-sufficient, specific hypothesis, to a strategy based upon the derivation of specific hypotheses from previously organized information." (p.99).

There was, however, one striking difference in the results obtained from the matrix and the verbal tasks.

> "The epitome of the difference is provided by the eight-year-olds. They do strikingly better with pictures than with words. With pictures they are like eleven-year-olds. With words, they are more like six-year-olds. It is as if they learn their strategies of information seeking on picturable and discrete materials first, with recourse to perceptual supports, and then later extend the strategies to nonpicturable and less formulated material." (p.98).

Before leaving the Bruner et al study, it is worth commenting on the terminology which Bruner et al use in describing the children's performances. This terminology might be seen as carrying some empirical and untested implications, it could risk imposing certain unwarranted interpretations on what the children are doing.

The key term 'constraint seeking' arises from considering the Half Split Algorithm which, in recent years, has become familiar to computer scientists and which does indeed involve its user in constraint seeking of a stringently planful kind. Thus, the use of 'constraint seeking' might be taken to imply that, with development, children progress more and more closely to, and eventuallyattain the Half Split Algorithm, and that they do so as a kind of natural progression. Such an implication seems to have been drawn by several subsequent investigators. Thus, Ault (1973) remarks "Informal observations suggested that few children, even in the fifth grade, knew that the optimal strategy was to divide the array in half with each question" (p.265) - as though this optimal strategy were common adult knowledge. An empirical question which arises is

whether children older than eleven would, when given Twenty Questions, spontaneously use the Half Split Strategy. This possibility has been put to the test by the writer, and has been found wanting.

Again, the terms 'constraint seeking' might lull the unwary into assuming that children view Twenty Questions almost as a dry exercise in deductive logic, an exercise concerned only with establishing constraints in the matrix and with eliminating possibilities. The experimenter is certainly at liberty to treat children's questions merely in terms of the constraints they establish and the alternatives they eliminate, but it cannot be assumed that children will necessarily take this view of what is presented as a game, that they will necessarily be unconcerned with the personality of the experimenter and with game-like social interactions with the experimenter, and that they will necessarily be concerned to minimise the number of questions they ask. In brief, it can readily happen that there is a discrepancy between the restricted information-processing view of the experimenter and the view which a child takes of the Twenty Questions game, and to describe the child as engaged in 'constraint seeking' might tempt the investigator to overlook this discrepancy in viewpoint.

The terms 'hypothesis testing' and 'constraint seeking' might also lull the unwary into imposing unwarranted interpretations on the children's questions and into overlooking certain distinctions. In less interpretative terms, a 'hypothesis question' simply means a 'particular question' which asks about one particular item in the display, and one item only. In practice, a succession of particular questions may be apparently haphazard or may be ordered in some very apparent sequence which takes account of earlier particular questions and anticipates later particular questions. A 'constraint question' simply means a 'category question' which asks about more than one item in the display.

A succession of category questions may be apparently haphazard and may fall far short of effectively eliminating items. Again, the succession may be linear in that the questions eliminate a succession of non-overlapping groups of items, or may be hierarchically nested in that they narrow from a category to a constituent sub-category to a constituent sub-sub-category. The term 'narrowing' as used by Bruner et al blurs the sometimes useful distinction between linear and hierarchical sequences of category questions.

Section Two : Subsequent Studies of Twenty Questions

The study of Bruner et al showed that Twenty Questions, as played by children from six to eleven years, revealed a developmental progression in the children's elaboration and control of information-seeking skills. Subsequently, twelve studies of Twenty Questions were published up to 1977, after which there seems to have been a drop in interest. These studies were: Ault (1973), Denney (1972, 1974, 1975), Denney and Denney (1973, 1974), Denney, Denney and Ziobrowski (1973), Denney and Connors (1974), Eimas (1970), Laughlan, Moss and Miller (1969), Siegler (1977), and Van Horn and Bartz (1968).

These studies extended the study of Twenty Questions. They varied the presented matrix of items, both qualitatively and quantitatively. They involved subjects ranging in age from six years to ninety. They varied the rules by which the experimenter played the game, e.g., the target item might be undecided at the outset and the experimenter's answers made conditional upon the questions asked so as to ensure that the target would not be located by lucky accident or before some minimum number of questions had been asked by every player. The studies measured efficiency of play by the number of questions to solution, and by some measure of the number of alternatives eliminated per question. The commonest variable examined was the proportion of particular to categorical questions. There were few successes at measuring the sequential organisation of successive questions.

There is little to be gained by reviewing these studies with regard to their individual aims and findings. Rather they will be considered for the light they cast on the question: what develops when people, children or adults, become more proficient at Twenty Questions ?

Consider the extreme case of an intelligent adult who plays game after game of Twenty Questions under circumstances which provide him with a very strong incentive to solve each game in the fewest possible number of questions. He has, in short, both the opportunity and incentive to become an expert in economical questioning. What would his eventually expert performances look like ?

At the start of each game, he would engage in global planning and forethought. He would inspect the array in search of means by which he could partition it into two equal, or nearly equal, sub-sets, and he would probably also consider the likely future implications of the partitioning. Thus his search for his opening question would occur in the context of complex considerations about the future course of the game as a whole, his familiarity with the material presented, his ability to verbalise his questions unambiguously, his need to keep cumulative track of the information he will gather about items which he has excluded and items which remain possible. All this global planning would occur before he asked his very first question.

As the game proceeded, he would fill out the local details of his overall plan, e.g., evaluating the implications of an answer just received and considering his next follow-up question. The expert, then, would engage in a lot of cognitive work at a variety of different evaluation and decision-making levels, and this work would be embedded throughout in a schematic plan devised at the outset of the game. In conclusion, the expert's performance would be complex. It would involve, not one ability or skill, but many. It would involve his familiarity

with the material, his vocabulary, his knowledge of his own strengths and weaknesses as a gatherer and conserver of information, his skill in global planning and, within global planning, his skill in planning locally. It would involve his knowledge of Twenty Questions as a problem type. At any time, he could be discomforted by being presented with material which he did not know how to partition into successive halves or did not know how to describe verbally. But, interestingly, if such material were repeatedly presented he would have the incentive to devise appropriate classifications and words for it.

As he became more and more expert, he would more frequently solve each game in the optimally economic number of questions. It would not be a matter of his using fewer and fewer questions but of his approaching that number which is the theoretical minimum for each size of array, e.g., an array of 128 items would take 7 questions, no more and no less. Likewise, the number of possibilities excluded by each of his questions would approach the optimal value of 0.5. He would use very few particular questions as contrasted with category questions: indeed, only his final one, or possibly two, questions would be particular.

Now consider children aged 6 to 11 years who are suddenly called upon to play a few games of Twenty Questions, and consider the age-related differences in the children's performances. How far are these differences comparable to the developments of the adult who dedicates himself to becoming an expert to economical questioning ? The broad answer appears to be that there is very little comparison. By the standards of the highly experienced expert, eleven-year-olds are novices with little appreciation of Twenty Questions as a type of formal problem. They make virtually no use of global planning and have scant regard for economical questioning. In so far as eleven-year-olds ask fewer questions than six-year-olds, it is not so much a consequence of their greater global planning and forethought as of their disposition to

ask categorical rather than particular questions and, in small part, their occasionally greater skill in local, short-range handling of information. In short, it is probably misleading to apply the model of the individually developing expert to the cross-sectional data obtained by presenting a few Twenty Questions games to children who differ in age. One investigator who was misled in this way was Denney. Specifically, he was misled into assuming that an increase in the use of category questions reflected an increase in information-seeking ability which meant a decrease in the number of questions asked in reaching the solution.

Denney (1972) had worked on cognitive-style dimensions, such as reflective-impulsive cognitive tempos, and the effects of observational learning (modeling) on such dimensions. He took up Twenty Questions as providing "a dimension of cognitive behaviour that is clearly involved with ability differences than preferential differences among children" (p.811). He adopted the terminology of Bruner et al and the aim of his study, and some of his later studies, was expressed as follows: "Children at various levels in their transition from hypothesis seeking to constraint seeking are exposed to various conceptual-strategy models. The general predition for this study is that children at different levels of conceptual-strategy development will be differentially responsive to the various conceptual-strategy models." (p.812). Thus at the outset there was a preconception of constraint-seeking as a kind of unitary ability dimension along which children progressed as they grew older. This preconception was reinforced by using the term 'constraint-seeking ability' alongside 'constraint-seeing questions' to mean simply category questions.

Denney used a standard Twenty Questions procedure as a pre-test and also as post-tests in order to assess the effects of various modeling sessions. The standard procedure was two games with the same 42-pictures

array used by Bruner et al. Each game had a predetermined target; and if the child failed to locate the target by the twentieth question, the child was told the solution. Denney (1972, 1974, 1975) used this standard procedure as a pre-test for a total of 20 different experimental groups of children in the age range 6 to 10 years. A total of 304 children was involved in the studies. Taking a bird's eye view of these pre-tests, they show two main things. First, over the age range 6 to 10, there is a large and consistent increase in the proportion of category questions asked, roughly about 5% at 6 years and 50% at 10 years. But by contrast, over the same age range, there is no markedly reliable difference in the average number of questions to solution. Over the twenty experimental groups, the average number of questions per game ranges from 12 to 17 with an overall average of 14.5, and there is no clear association with age. Denney (1974) was taken aback by this dissociation between the percent of category questions and the number of questions to solution. "The number of questions required to solve . . . failed to decline significantly across grade levels. . . . The reason for this failure is not clear. Indeed, the determinants of efficient information processing as reflected in [the number of questions] scores remain somewhat of a mystery. . . . One begins to suspect that [these] scores are relatively less reflective of the child's underlying capacity to intergrate the information gained through his questions and more reflective of the saliency, for each child, of the instruction to try to solve the problems with the fewest possible questions." (Denney, 1974, p.1074).

The main conclusion to be drawn from Denney's comment, and from his large body of data, is that, for the children involved, the economic use of questioning did not rank high among the aims of playing Twenty Questions. (This conclusion carries the corrollory, not noted by Denney, that the striking age-related shift from particular to categorical questioning does not arise directly from attempts to use questioning

economically). This main conclusion is supported by considering the effects which Denney's training procedures had on children's subsequent play. He used a total of six different training procedures, along with control procedures. However, there was only one procedure which had a significant effect in reducing the number of questions to solution. This procedure of 'cognitive modeling' merits consideration, especially in comparison with a similar procedure of 'exemplary modeling' which was ineffective.

In the 'cognitive modeling' experimental condition, there were twelve children for each of the age groups, 6, 8 and 10 years. Each child took a Pre-test of two Twenty Questions games; then one week later underwent the training procedure which was immediately followed by a Post-test; then two weeks later took a Follow-up test administered by a new experimenter who had no knowledge of which training procedure the child had received. The mean number of questions required for solution (on the two games aggregated) was as follows. For 6 years: Pre-test, 34: Post-test, 22; Follow-up, 24. For 8 years: 34; 21; and 21 respectively. For 10 years: 26; 16 and 20 respectively.

Now consider the 'exemplary modeling' procedure and the 'cognitive modeling' procedure in turn. 'Exemplary modeling' involved eleven 15-item arrays of simple pen-and-ink drawings of common objects. The child observed a female adult acting as questioner on the five even-numbered training arrays. The model asked a total of 17 effectively used category questions and received a total of 11 No and 6 Yes answers. Thus the child saw another player who was using between three and five questions on each game and was using only category questions. The child alternated games with the model and assumed the role of questioner on the six odd-numbered training arrays.

The 'cognitive modeling' procedure followed exactly the same pattern

but with one crucial difference: the model explicated her considerations about the playing of the game.

> "Prior to asking each question, the cognitive model verbalized her strategy as though she were talking to herself. Prior to asking a question, the model's remarks covered the following points: (a) she was looking at all of the pictures in the array; (b) she was looking for a way in which some of the pictures were alike; (c) she designated a constraint and named all the pictures belonging under that constraint; (d) she formulated her question around the constraint and discussed the advantage of asking such a question (e.g. "So if I ask 'Is it a tool?' that will tell me a lot about which picture it might be"). After asking her question and receiving her answer from the experimenter, the model then covered the following points in her self-verbalization: (a) she named the items she could eliminate on the basis of the answer to her question; (b) she commented on how advantageous it was to be able to eliminate so many pictures with one question; (c) she remarked that she would be able to solve the problem with only a few questions if she continued to ask constraint-seeking questions and that that was how one played the game best; (d) she named the items which remained for consideration and proceeded with the 20-Questions Procedure. Children appeared to have greater difficulty using the information gained by questions answered with a "no". For this reason, whenever the model received a "no" response to a particular question, she stressed in her subsequent remarks that the situation still allowed her to eliminate a number of alternatives and to narrow in on the correct answer". (Denney, 1975, p.480).

The crucial difference, then, between 'exemplary modeling' and 'cognitive modeling' was that, in the latter, the child was exposed to some of the behind-the-scenes considerations involved in using questions economically. The exposure to 'exemplary modeling' merely led children to ask more categorical questions, whereas exposure to 'cognitive modeling' led them to ask more categorical questions and also to use these questions more economically. This does not imply that the 'cognitive modeling' procedure, which could not have lasted for more than half-an-hour, gave the children total insight into the intricacies of Twenty Questions, nor that all of the model's verbalised considerations were picked up. However, it does imply that the children picked up, and subsequently used, at least some of the component ways of proceeding which are involved in economic questioning, i.e., they were receptive to, and able to use, some of these higher-order procedures and, to this extent, their Pre-test

performances had not drawn fully on their abilities to use questions economically. It also implies that, in regard to these children, economic questioning cannot be seen simply as a familiar, top-down procedure, and all the children need is to have it pointed out to them that this is the procedure they are expected to use when playing Twenty Questions.

In summary and with regard to children in the age range 6 to 10 or 11 years, there emerges from Denney's substantial body of experimental work a general, two-part picture which is consistent with Bradley's (1976) intensive, and largely unsuccessful, attempts to teach the half-split algorithm to children of 10 and 11 years. The first part of the picture is that when children between 6 and 10 or 11 are presented with Twenty Questions, they do not spontaneously assume that the game demands economical questioning, and it is not a simple matter to bring this demand home to them. (It is plausible to assume that the demand for economical questioning is not one which the children have much encountered in their everyday lives). What can be done is to provide explanations and illustrative examples from which the children can pick up some of the local, short-range procedures which economical questioning requires; and having picked up some such procedures, the children may then use them, parrot fashion, and may thereby achieve more economical questioning without, so to say, understanding what is happening. Simple procedures such as asking categorical questions rather than particular questions, are readily picked up, whereas higher-order procedures, such as seeking for a question which will exclude half the possible alternatives, are less readily picked up. The second part of the general picture is that when the children are presented with Twenty Questions, they spontaneously differ, according to age, in the type of question they ask. Six-year-olds proceed to ask mostly about particular items whereas 11-year-olds ask mostly about categories of items. The spontaneous questioning preferences of the older children may, on occasion, result in more

economical questioning but their bias arises, not from any clearly formulated concern for economical questioning but, somehow, from their general disposition which presumably reflects their current everyday, real-life interests.

This general, two-part picture of 6 to 11 year olds is the background for the writer's experiments with 9 to 15 year olds. But before introducing these experiments, mention should be made of the remainder of the Twenty Questions publications which followed the study by Bruner et al.

Denney and Denney (1973, 1974) studied adults, both middle-aged and elderly. In 1973, the Denneys presented their standard Twenty Questions test to ten middle-aged (26-46) and ten elderly (75-90 years) women. The groups differed markedly with the older group asking fewer category questions, requiring more questions to arrive at solutions, and asking a larger proportion of redundant questions. In 1974, the Denneys examined the effects of modeling procedures on 42 men and women, aged 70 to 90 years, who asked no categorical questions on a Twenty Questions pre-test. The subjects were divided into three experimental groups. In all groups, use was made of four 20-item arrays of pictures. During 'exemplary modeling', subject and experimenter took turns at trying to find which picture the other was thinking of and the experimenter, when acting as questioner, asked 'constraint-seeking questions'. During 'cognitive modeling', the same procedure was followed but the experimenter now verbalized his strategy while formulating and using his questions. In the control condition, the subject alone tried to find which picture the experimenter was thinking of, and the experimenter did not take turns as questioner. All three groups were given a post-test. Both modeling conditions effected an increased use of categorical questions and a decrease in the number of questions required to solution: after training, the subjects in these groups performed as well as the middle-aged women in the 1973 study. The only difference between the effects of the two modeling procedures was that 'cognitive modeling' resulted in the subjects'

asking significantly more novel (non-modeled) category questions. The control treatment had no effect on post-test performance. What is striking about these findings is the ease with which these elderly adults profited from modeling as compared with the ways young children reacted to similar modeling. This indicates that "an intact, efficient questioning strategy was within the problem-solving repertoires of the elderly. The modeling procedures apparently served only to elicit this strategy, and this elicitation effect happened very rapidly in most of the subjects". (1974, p.458). In accounting for this, the Denneys emphasize "the lack of environmental press for elderly persons to employ sophisticated and efficient problem-solving approaches" (p.458).

Siegler (1977) studied 13 and 14 year olds and was interested in the efficacy of giving them instructions which emphasized planned questioning. He also examined variations in the presented array. He used four 24-item matrices with six rows and four columns. Two arrays contained the numbers 1-24, in orderly arrangement in one case and in random arrangement in the other case. Two arrays contained the letters A-X, ordered in one case and random in the other. His expectations, which were confirmed, were that subjects would find it easier to work systematically with the ordered than with the random arrays, and with the numbers than with the letters. The reasoning behind the latter expectation was that adolescents would be more likely to know that the numbers 1-24 were divisible and redivisible into equal halves than to realise that A-X could be similarly divided.

In conducting the actual games, Siegler used an ingenious procedure to which his highly structured arrays lent themselves. He did not predesignate a particular item as correct but answered each question on the basis of minimal elimination of alternatives. To illustrate, Between 4 and 14 ? No (which eliminates 11 items while Yes would eliminate 13), Between 15 and 22 ?, Yes (which leaves 8 items while No would leave

5 possibilities). This procedure continued until the subject had narrowed down to one item which was then designated correct. Thus the subject would always have to ask a minimum of five questions and unsystematic subjects would never stumble onto the correct answer.

Turning to Siegler's manipulation of introductory instructions, in Experiment 1, with 30 boys and 30 girls, he gave the following:

> "Today we're going to play a game where you need to guess what number I am thinking of. You can ask me any question you want that I can reply to with a yes or a no answer; the idea is to figure out my number in as few questions as possible. Remember, you're going to try to figure out what number I'm thinking of. Now I'm thinking of a number between 1 and 24." (p.397).

The subject was given the matrix and the questioning started.

In Experiment 2, with 20 boys and 20 girls, the presentation was exactly as above but then continued as follows:

> "I want you to plan ahead the sequence of questions you will ask; the idea is to ask questions that rule out as many answers as possible, no matter what my answer to the question is. In other words, you want to ask questions so that you will be able to find the correct answer quickly, no matter what answer I give you. If you think of the best questions possible, you will be able to solve the problem in five questions. So try to get as close to five questions as possible. Do you understand ? You have 3 minutes to plan your questions. Write down the questions you think of so that you don't forget them." (p.399).

When the three minutes were up, the subject was reminded of the permissible format of the questions and of the goal of economical inquiry. The questioning then started.

The augmented instructions produced a significant reduction in the number of questions the subjects asked but, interestingly, only in those subjects who took a letter matrix first and a number matrix second, and not in those who took numbers first and letters second. The reason for this asymmetry was that there were two circumstances which independently evoked more economical questioning: being given numbers rather than letters, being given augmented instructions rather than unaugmented.

These two inducements to economical questioning did not compound together to evoke even greater economies. These effects are shown in Table 1,1 which also shows that, although these 13 and 14 year olds could be induced into more economical questioning, they did not get near the 5 questions which was the optimal minimum. Siegler examined in detail the plans which subjects wrote out in Experiment 2, and commented as follows:

> "The picture that emerges, then, is that all adolescents made plans, almost all started their inquiry sequences by asking one or more planned questions, at some point thereafter the plans were abandoned or exhausted and never returned to, and the plans led to more informative inquiries when they were used." (p.400).

Table 1,1 - Mean number of questions asked

Letters first and numbers second			
Random matrices.	Expt.1, letters, 14.0.	numbers, 12.8	
	Expt.2, letters, 9.9.	numbers, 8.9	
Ordered matrices,	Expt.1, letters, 10.1.	numbers, 11.8	
	Expt.2. letters, 9.3.	numbers, 9.0	
Numbers first and letters second			
Random matrices.	Expt.1, numbers, 9.7.	letters, 10.2	
	Expt.2, numbers, 7.9.	letters, 8.6	
Ordered matrices.	Expt.1, numbers, 8.4.	letters, 8.5	
	Expt.2, numbers, 7.9.	letters, 8.3	

The remaining published studies add little to the general picture of Twenty Questions which has already been developed, except to show some effects of varying the presented materials. Van Horn and Batz (1968) working with 6, 7, and 8 year olds presented their array in either an ordered or a random fashion. They found that the ordered, as contrasted with the random, array elicited more category questions from the 6 year olds but not from the 7 and 8 year olds. Laughlan, Moss and Miller (1969) worked with children of 9, 11 and 13 years and were mainly interested in the effects of two training (modeling) procedures. They used two types of array, one pictorial and one verbal, but found no performance differences between the two. Eimas (1970) worked with children aged 8, 10, 12 and 14, and with undergraduates. He used three types of material to fill a matrix of either 8 or 16 cells. In one condition,

all cells were filled by the same letter. In a second, cells were filled with the numbers 1-8 or 1-16. In a third, each cell was filled by a different and distinctive visual pattern. He found that Twenty Questions performance improved over the age range studied and, at most ages, was better with the visual patterns than with either of the other two types of material. Finally, Ault (1973) worked with children aged 6, 8 and 10. When her 24-picture array was ordered rather than random it elicited more category questions from the 6 and 8 year olds but not from the 10 year olds.

Section Three : The present experiments

The study by Bruner et al could be taken as suggesting a general developmental picture as follows. When we present Twenty Questions problems to progressively older children, we tap a progressively increasing ability to use questions economically. This ability shows itself in the children's spontaneous dealings with the problems and, furthermore, the ability developes as a result of general maturation and of learning opportunities and pressures which are the common lot of normal children growing up in normal environments. The subsequent literature on Twenty Questions gives reason to doubt this picture, at least with regard to children in the age range 6 to 11 years. The literature can be taken to suggest instead that children develop more economical questioning in the Twenty Questions problem in response to opportunities and pressures which, in one way or another, emphasize the issue of economical questioning; these opportunities and pressures are not the common lot of average children who grow up in average environments. Against the background of these considerations, the writer's experiments dealt with children who were of average scholastic ability and in the older age range of 9 to 15 years. When given Twenty Questions problems, would these children show an age-related increase in the

spontaneous use of economical questioning ?

Fifteen year olds were chosen as the oldest group because they were the oldest children available in the unselected school population; some pupils leave school when they reach sixteen, and children at school after that age are a selected sample. Twelve year olds and nine year olds were chosen to provide a fairly wide age range for study. A total of 108 children (boys and girls)[36] of each age, 9, 12 and 15 years took part in the first three experiments which aimed to discover the spontaneous procedures the children would use in Twenty Questions problems. All three experiments employed a visually presented array of 24 items arranged in rows and columns: in Experiment 1 the items were coloured pictures of common objects, in Experiment 2 the items were printed words which named these same objects, and in Experiment 3 the items were numbers. These 24-item arrays were smaller than the 42-item array used by Bruner et al and by Denney. A smaller array was chosen mainly because it was decided that each child would play four successive games, to reveal possible practice effects, and it was judged that four games with an array of more than 24 items would require a longer testing session than could reasonably be asked of the pupils and their teachers.

The writer began with the picture array and the word array experiments. The two arrays represented the same objects, in one case as a coloured picture and, in the other case, as a written word naming the object shown in the picture, e.g. a picture of a soldier corresponded to the written word 'soldier'. However, once the experiments were launched they revealed that the question-and-answer dialogue of Twenty Questions could, on occasion, contain ambiguities. When a question was asked by a child, it was sometimes unclear what the child had in mind. Sometimes the questions were formulated in clumsy, ambiguous wording, and sometimes the child was thinking about the items in a way which was not conventional but based on idiosyncratic and affective properties derived from the

child's personal, real-life experiences. These occasional ambiguities caused the writer some unease about the scoring which should be given to certain questions, and also about the possibility that he, in his role as experimenter, might sometimes misinterpret a question and thereby give a child a misinformative answer which would unintentionally obstruct the child's progress in the game. Accordingly, the number array was devised on the grounds that numbers, moreso than pictures or words, lent to unambiguous classification and subject-experimenter communication.

The writer performed the pictures experiment first, then the words experiment, and then the numbers experiment. However, as the experiments proceeded they prompted the writer to re-examine the data he had earlier obtained and, increasingly, to work back and forth across the accumulated data of the three experiments as a whole. Thus it turned out more convenient to report the three experiments in the reverse of the order in which they were done. Chapter Two reports the numbers experiment, Chapter Three the words experiment, and Chapter Four the pictures experiment.

The three experiments, taken together, showed age-related differences in the children's spontaneous dealings with the Twenty Questions problems. At different ages, children were disposed to ask certain kinds of questions rather than others, and the questions they asked were differentially influenced by whether the array contained numbers or words or pictures. However, there were no clear differences with regard to the economical use of questions. Accordingly, Experiment 4 was done to see whether children could be pressed into using more economical questioning. Eighteen children of each age, 9, 12 and 15 years, took part in the experiment which used the same three arrays and the same general procedure as before but emphasized, as an approach to playing the game, the method

of successive spatial halving. This method was a version of the half-split algorithm which was based, not on the contents of the items, but on the spatial locations of the items within the rectangular matrix of the display; in this method the actual contents of the display, numbers or words or pictures, are irrelevant. Each child was given a verbal description of the method, then given four Twenty Questions problems, then involved in practical demonstrations of the method, and given a final Twenty Questions problem. These attempts, to press the children into using the method of successive spatial halving, had extremely limited success and showed that the method was not one which was readily picked up by the children. Experiment 4 is reported in Chapter 5.

Experiment 5 was then undertaken in an attempt to press children even more emphatically into using the method of successive spatial halving. The experiment, less formal than the others, worked with the writer's own school pupils in a normal classroom situation. There was a class of 29 16-year old boys, and a class of 29 12-year old boys. The number display was used, the method of successive spatial halving was stressed, and attempts were made to emphasize the method by involving the class in its use in games which the children played competitively with each other. These attempts met with substantial, but not total, success in getting the children to use questions economically. The results indicated that, while the economical use of questions was not beyond the reach of many children, its appearance required special opportunities and pressures which did not normally come the way of average children up to the age of 15 or 16 years. Experiment 5 is reported in Chapter Six. Chapter 7 briefly surveys the writer's five experiments on Twenty Questions.

CHAPTER TWO

EXPERIMENT ONE

20 Questions with a Number display

The first experiment involved 36 children, each playing 4 successive games with a Number display comprising 24 different numbers.

1 ### Reasons for choosing a number display

After playing a number of games with 9 and 12 year olds in pilot studies involving Picture and Word displays it was decided that a Number display would help to reduce the ambiguity of the questions asked by the children as well as making the experimenter's answers less susceptible to misunderstanding without destroying the natural atmosphere of the E-S interaction.

Ambiguity in the 20 Questions situation

Most of the published research in this area has concentrated on the information processing characteristics of the experimental situation and it is easy to see why. Each child must combine skills in categorisation with an ability both to ask questions and to use the information contained in the answers to construct and maintain a task-appropriate strategy. This strategy involves the co-ordination of various cognitive skills, any one of which is at various levels of sophistication in each child, which thus, in turn, may dictate the kind of strategy which is adopted by each child.

Whilst it is useful to bear these points in mind when reading through accounts of children playing 20 questions, one must be careful not to make assumptions about their behaviour which cannot be justified.

There are two points in the experiment where unjustifiable assumptions can be made, the first is in playing the game and the second is in scoring it.

It is very difficult to do anything about the first source of error. When playing the game with a child simple yes or no answers

are required to each question and on the spot decisions have to be made without giving any additional information to the child by means of lengthy pauses, facial expressions or involuntary actions which could suggest to the child more than a simple yes or no answer could possibly convey. To do this consistently and still maintain a natural-seeming situation in which the child does not feel threatened is difficult, especially when one is asked ambiguous questions. Thus the first source of error can be reduced by minimising the amount of non-verbal feedback given to the child as much as is possible by using an experimenter who is aware of the clues which children may be looking for and who purposely avoids using them.

The second source of error is linked very closely to the first in so far as at some time a decision has to be made and acted upon as to what particular cards in the display any one question refers to. A direct question "is it that ?" is unambiguous providing both the child and the experimenter can agree, usually by pointing or labelling, on the item in question. Difficulty arises when the child asks a category question which defines a group whose boundaries are ambiguous, either because the child isn't really too clear what he or she wants to know or simply because the English language is remarkably vague when it comes to labelling a certain concept. An example of this is the question "is it red ?" When this question was directed at the picture display used in the pilot study any one of a number of answers could be given but a plain yes or no in itself would nearly always be insufficient. For adequate communication to take place in such a situation both the child and the experimenter have to share the same perception of the display and the same concept of "redness". If these two elements do not coincide exactly an ambiguous interchange of information will ensue. On the other hand, being human and having experience in the probabilistic nature of most, if not all conversation, one can make a working assumption,

based on expression in facial features and in voice which considerably reduces the chance of misunderstanding each other's message. If one is interested in the sequential use and organisation of questions directed at locating one item from a display of 24 others, one cannot hope to have a true recording of proceedings if one merely considers the interchange of words used, as does this and subsequent experiments.

Some measure of control can be introduced into this second source of error by using a display with clearly defined group structures, and as such the use of numbers considerably reduces the possibility of a child constructing a group which cannot be clearly identified verbally. For this reason the display shown in Fig. A. was constructed.

Fig. A. Number Display

67	24	44	12
53	45	31	21
29	63	13	64
16	51	68	36
38	52	47	59
46	19	33	26

The numbers used in the display were carefully chosen so as to balance the frequency of occurrence of any one digit and be easily separated into six well known categories each of 4 members. The six categories and their members were as follows, tens (12, 13, 16, 19), twenties (21,24, 26, 29), thirties (31, 33, 36, 38), forties (44, 45, 46, 47), fifties (51, 52, 53, 59) and sixties (63, 64, 67, 68). It was also intended that an equal number of odd and even numbers were included within each category, but due to an oversight, the fifties category only included one even number! As Fig. A. shows the numbers were arranged in a 6x4 array and the category members dispersed at random.

2 Participants

The 36 children came from 3 age groups, 9, 12 and 15 years and all children were chosen by their class teachers as being of average ability. The exact details of the group are as follows :

12 x 9 year olds (7 boys, 5 girls) mean age 9 yrs.7 months (range 9.00 - 9.10)
12 x 12 year olds (6 boys, 6 girls) mean age 12 yrs.7 months (range 12.00 - 12.11
12 x 15 year olds (5 boys, 7 girls) mean age 15 yrs.3 months (range 15.00 - 15.11

3 Materials

The numbers were printed on 6cm x 8cm cards which in turn were stuck to a 64cm x 52cm cardboard sheet so as to make an array 4 columns wide by 6 rows deep. When in use the display was placed on a table between the experimenter and the child.

4 Procedure

Children were brought individually from their classroom to a room in the school and made to feel at ease. After settling themselves on the opposite side of a table from the experimenter the display was uncovered and the experimenter told the child that they were going to play a game with the numbers on the sheet. What followed can be described in terms of two phases.

Phase 1: item identification - Each child identified all 24 numbers row by row to the satisfaction of the experimenter. This was done so as to ensure that the child could both read what was written on each card and also to address their attention to the 24 numbers constituting the display. No-one had difficulty doing this task.

Phase 2 : 4 games - This phase began with standard instructions as follows: "we are going to play a game with these numbers. I have chosen one of them and you have to find out which one it is by asking me questions. You can ask me any question you like about the card I have chosen - remember it is one of these (pointing to display) - but I can only answer 'yes' or 'no'. You might say 'something something something', and I could say 'yes', or you could say 'something something something' and I could say 'no'. You can ask any sort of question you want, but if you can find out the card by asking only a few questions, it's better than asking a lot".

Although every effort was made to give straight 'yes' or 'no' replies to each question, from time to time the experimenter had to request the child to phrase a question in a form to which a yes or no reply could be given.

The target item chosen for the first game was 13, for the second 36, for the third 52 and for the fourth game 67. The choice of these items was random except that each came from separate rows and columns in the display. Fortuitously, these numbers were of increasing magnitude from game to game.

The transition from one game to the next was conducted with minimum fuss and was introduced with the words: "Now I've chosen another card", or similar words. The entire proceedings were recorded on tape, and subsequently transcribed.

Phase 3 : Scoring - The transcriptions of each game played were analysed both from a quantitative and a qualitative point of view, but in order to appreciate the methods devised to achieve this, it is useful to sample some of the games that were played.

RESULTS

The results are examined from a number of points of view in order to capture as much as possible of the richness of the children's performances. These examinations of the results will be reported in the order in which they were carried out, and then reviewed in a concluding summary.

SAMPLE GAMES

This section considers the global quality of the games as played by the children and uses a detailed description of two sessions in order to try to capture the spirit of the performance and convey the different styles in which younger and older children approached the task.

NINE YEAR OLDS

The 9 year olds as a whole reacted to the strange man 'who wanted to see them' with little apprehension once their eyes fell upon the display which they were told was a 'game'. From then on they tackled the situation with gusto and frequently laughed and talked to themselves as they were considering what to do next.

As a result of this the experimental games were rather lively interchanges in which it became clear that whilst some children may have had a good idea of the sort of questions which seemed to be useful, the overriding concern was to locate the target item by any means available and to enjoy doing so, rather than to evolve, and rigorously keep to some careful plan of attack.

For example, Sharon (age 9 years 6 months) entered the room shyly, sat down, and after volunteering her birthdate and telling me that it was in December (but not Christmas Day) proceeded to read out the numbers in the display, row by row. Whilst being told to ask 'as few questions as possible', her eyes were flickering across the display; then she opened her first game with a question which sounded as if she had some strategy in mind.

S "Is it in that line ?" (she pointed haphazardly towards the left-hand side of the display.)
E "Can you show me what you mean ?"
S "That line, is it a number in that line ?" (again she pointed to the left-hand side of the display.)
E "Show me the line, point to it with your finger"
S "That one . . . here". (She pointed to column one)
E "Is it in the first column, (spoken for the benefit of the tape recorder), - er No it isn't."

Despite the "apparent" accuracy of the question as a purely verbal statement, it could have referred to any one of 8 lines of cards on the display, so it needed to be accompanied by a physical gesture - pointing - in order to make the communication of information unambiguous enough for the kind of answer this game requires.

Unfortunately, one could argue that the persistant demands of the experimenter for absolute clarity may have forced Sharon into being more specific than she originally intended. If her voice said, "Is it that line ?" yet her finger pointed to a greater area of the display, could she possibly have intended to say "Is it in these lines ?", or even, "It is in this half ?"

Having played the number game, and two other kinds of 20 Questions game with over 40 children of Sharon's age, I think it is safer to assume that discrepancies between speech and action like the one mentioned above are best regarded as displays of 'ego-centricity' (Piaget 1926), whereby the child naturally assumes that the other person can automatically comprehend the intended meaning of some utterance, even if (as in some cases) the child may not fully understand it himself!

However, once established in the procedure of tackling the display column by column, Sharon continued:

S "Is it in that one ?" (pointing to second column.)
E "N..No it isn't"
S "In that one ?" (pointing to third column.)
E "Yes it is, it's in the third one".

Sharon now had a choice of 6 numbers to choose from.

S "I'll have a good guess" (furtively) "Ubble, bubble, ubble bubble . . . 31 ?"
E "No"
S "mm . . . mm . . . 13 ?"
E "Yes".

For some reason Sharon suddenly dropped her very structured and orderly attack once she had achieved her first objective, namely to locate the correct column; once she had to impose her own grouping structure on the items in that column she resorted to simple guessing. When presented with her next game she seemed to temporarily forget about strategy and plunged straight into guessing.

E "Right, altogether I've chosen 4 numbers, and that was the first one. Now I've chosen a second one and you have to find out what it is . . . I've chosen another one . . ."
S "33 ?" (a number in the same column as 13)
E "No".
S "68 ?" (Another number in the same column as 13)
E "No".
S "Forty er . . . forty er . . . 47 ?" (and another!)
E "No"
S (Immediately) "Is it in that one ?" (She pointed to the first column.)
E "Mm. . . is it in the first column ? No it isn't."
S (immediately) "Is it in that one ?" (she pointed to the second column.)
E "Is it in the second column - No".
S "In that one ?" (she pointed to the fourth column.)
E "Is it in the fourth column ? Yes."
S " . . . 12 ?"
E "No".
S "36 ?"
E "Yes".

Looked at objectively, without reference to the preceding game or the nature of the interchange between Sharon and myself, this second game seems to be rather disjointed. However, if one considers the fact that Sharon may have interpreted my instructions as meaning, "I have chosen a second number from column 3", her questioning can be seen to follow on from the preceding game; thus having asked about 31 and 13 in game one she queries 33 and 68 in the second game. Only two numbers remain, 47 and 44 and her indecision, "forty er . . . forty er . . . 47", may have been due to her natural reluctance to make a choice between two equals, but it may also have afforded her the time to work on the unspoken signals which I was most probably giving her unintentionally in my gestures, facial expression and bodily posture. After thus exhausting the possibilities of column 3 she turned to columns 1 and 2, skipped column 3 and correctly located column 4 before returning to guesswork in order to narrow down the 6 numbers at her disposal.

Two games were to follow, but the novelty of the situation seemed to have slightly worn off, for Sharon was more willing to add variety to her responses!

E "Right, I've got another number, and you've got to find out what it is." "Come on".
S "That line ?" (She pointed vaguely to column 4 again.)
E "Which ? Show me!"
S "That line!" (her hand described circles above column 4.)
E "Which! Show me which way ?"
S "In that ?" (She pointed to column 4.)
E "Er . . . No."
S "In that line ?" (She indicated column 3.)
E "It's not in the fourth and it's not in the third. No."
S "In that one ?"
E "No, it's not in the first one".

This only leaves column 2, but the way she groups her subsequent guesses of items in this column suggests she is beginning to impose a sequential order on to her questioning.

S " . . . 24 ?" (First number: column 2)
E "No."
S (Musically) "63 ?" (Third number: column 2)
E "No"
S "Oh . . . hang on . . . 45 ?" (Second number: column 2)
E "No"
S "No ? . . . oh! (sigh) . . . 52?" (Fifth number: column 2)
E "Yes"

Sharon cleverly avoided the mistake made by many of her classmates, i.e. asking a question of a row or column that was the only one left unquestioned. However, despite having faith in the target item being among the top 3 numbers in column 2, (notice the sigh), she failed to ask the best sort of question - (that of halving) and when faced with only three numbers to choose from, prudently she chose the middle one. In her final game she exhibited either remarkable intuition or lots of luck - as did other of her classmates.

E "Very last one, we've got one more to do".
S "In that line ?" (She pointed to column one)
E "Yes, it's in the first column."
S " . . . 67 ?"
E "Yes! - What made you choose that one ?"
S " . . . I don't know".

And with that she returned to her classroom.

Sharon's four games are fairly typical of the 11 other children in her age group, in so far as the range of questions asked differed from pure guesses to questions referring to physical groups of cards. But she was untypical in the sense that she very rarely asked a question which was either partially or wholly redundant; the more remarkable therefore to find that 6 out of 12 children played at least one game in which the target was located by their third question!

Thus the 9 year olds, as a whole, tended to rely strongly on questions which could have been used more efficiently if they had managed to develop a simple overall strategy, yet even without this, they seemed to proceed fairly effectively.

FIFTEEN YEAR OLDS

At the other end of the scale the 15 year olds seized the opportunity of playing the game as a chance to exercise their powers of categorisation, not always with success. Fiona (15 years 5 months) concentrated on the properties of the numbers which made up the display rather than the position of each card within the rows and columns of the display matrix. After rushing through phase 1 as rapidly as possible she plunged into the game with a series of interesting but rather wasteful questions.

S "Ahm . . . does it add up to 9?"
E "No."
S "Is it an even number ?"
E "No."
S "Is it between 10 and 50 ?"
E "Yes."
S "Is it in the twenties ?"
E "No."
S (in rapid succession) "thirties ?"
E "No."
S "forties ?"
E "No."
S " . . te . . . tens ?"
E "Yes".

Her first question was inappropriate, ambiguous, or because each number on the display was over 12, and if she meant, "do the two digits added together make 9?" she was not expressing herself clearly. Her second question, despite referring to half the display, did not give her much in the nature of easily usable information because the odd and even numbers were erratically distributed throughout the display thus making visual grouping of unquestioned numbers very difficult. Her third question narrowed the field of possibilities down to 8 numbers (13, 19, 21, 29, 31, 33, 45, 47) yet her next question referred only to two of these numbers (21, 29) and her next to two more (31,33) thus leaving four numbers unquestioned (13, 19, 45, 47). This was a rather wasteful exercise,executed at great speed,without signs of a full appreciation of the information contained within each answer. After discovering that the target was not among the forties she only had two numbers to choose from (13 and 19) yet rather falteringly she asked, (as if in confirmation)

whether the target was amongst the tens! Only two numbers effectively remained.

S "Is it below 15 ?"
E "Yes."(using all the information given this made 13 the target item)
S "A hm . . . is it below 6?"
E "No!" (there were no numbers below 6 on the board.
S "Is it above 11 ?"
E "Yes!" (All the numbers in the display were above 11)
S "Is it 13 ?"
E "Yes!"

Fiona went on in this vein for three further games, repeating herself, questioning items which were not in the display, and entangling herself in a clumsy web of category-based questions. Using methods similar to this, all 12 x 15 year olds completed 4 games each, yet not one of them managed to locate the target item in, or under 3 questions,as had 6 of the 12 x 9 year olds!

Timing

At this point it is worth mentioning that although no efforts were made to time each game as it was played, when the tape recordings were compared it was found that both the total time taken for each game and the pauses between questions were similar for each age group. Each game usually took about one minute to complete.

Scoring

It was thought best to assemble the most basic numerical data in one table before asking more analytical questions. Tab (1,1) shows the number of games successfully completed arranged according to the number of questions asked.

In order to arrive at these totals the final target naming question was included. Although this, at first, may seem to artificially raise the number of questions asked by children using a CQ strategy, in fact, when one examines the games it becomes obvious that unless the final PQ is included (which names the target item),it is not always clear from the pattern of preceeding CQs that the child will certainly follow the

TAB (1,1)

The number of games completed in a given number of questions by each age group.

No. of Questions	9 years						12 years						15 years					
	Game						Game						Game					
	1	2	3	4	Tot	A	1	2	3	4	Tot	A	1	2	3	4	Tot	A
1																		
2				1	1	1												
3		3	2	1	6	7			1		1							
4	1	1		1	3	10	1	1		3	5	6	2				2	2
5	4		1	3	8	18	4	1	4	3	12	18	1	2	5	4	12	14
6			3	3	6	24	1	2	2	2	7	25	4	1	1	2	8	22
7	3	1	1	1	6	30	1	2	3	2	8	33		2	2		4	26
8	2	5	2		9	39	2	3	1		6	39		1			1	27
9							2				2	41	3		1	3	7	34
10		1	1		2	41	1	1			2	43	1				1	35
11	1				1	42							1	2		1	4	39
12									1		1	44		1	2	1	4	43
13								1			1	45		2	1		3	46
14										1	1	46						
15	1				1	43												
16								1		1	2	48						
17																		
18			1		1	44										1	1	47
19			1		1	45												
20																		
21- 25				1	1	46												
26- 30														1			1	48
31- 35																		
36- 40		1			1	47												
41- 45																		
46- 50																		
51- 60																		
61- 70																		
71- 80				1	1	48												
81- 90																		
91-100																		
Totals	12	12	12	12	48		12	12	12	12	48		12	12	12	12	48	
Medians	7	8	6½	5½	6½		6½	7½	6	5½	6		6	9½	6½	7½	7	

Each entry shows the number of children who completed a particular game in the number of questions shown.

logical progression of information and locate the target. Assumptions, based on information theory, that the child at any one time possessed sufficient information to locate the target, even when, to the experimenter, there seemed to be only one possible card left to locate in the display, were frequently shattered by the whimsical behaviour of both young and older children. Experience showed that one could never be sure that the child had located the target until they named it!

TAB (1,1) Number of questions to solution.

(i) Differences between age groups - Much to the surprise of the experimenter it was found that the younger children completed more games in fewer questions than did the older children. If one traces the cumulative total number of games completed per number of questions asked (Column A) one can see that more games (i.e. 10) are completed by the 9 year olds in 4 questions than by any other group. The 9 and 12 year olds seem to complete approximately equal numbers of games in 5 to 10 questions and it is only by the 11th and subsequent questions that the number of games solved by the 15 year old group compares favourably with the performance of the 9 year olds. Comparing the median scores, as a group, the 12 year olds required fewer questions than any other group.

(ii) Comparison with half-split algorithm (HSA) - As mentioned in Chapter 1 the HSA is the most efficient search procedure of a symbolic representation of a body of knowledge available, given the binary nature of the answers provided in the 20 Questions game. Including the final, possibly redundant target naming question, the HSA, if used perfectly, could locate the target item in the 24 card display in a minimum of 5 questions and a maximum of 6.

From TAB (1,1), it can be seen that half the games played by the 9 and 12 year olds were completed in or under 6 questions whilst it took 7 questions for half the 15 year olds games to be completed. Furthermore, if one compares the number of games completed within 4 questions by each

group, 9 years (10 games), 12 years (6 games), 15 years (2 games), it becomes obvious that the youngest children not only seemed to locate the target with greater economy of questioning than the others but they also seemed to be far more efficient than the most efficient strategy; the HSA.

(iii) Measuring Efficiency - There have been a number of systems devised to measure the efficiency of sequential questions as used in the 20 Questions situation (see Siegler 1976) but they, either by design or oversight, assume that the subject is using a strategy of questioning which progressively approximates to the HSA.

The present experimenter attempted to evaluate and modify these various quotients and methods of measurement, but they all required certain assumptions to be made which could not be justified.

a) Tailoring the answer given by the experimenter so that the child always had more than half the display to choose from made the assumption that the experimenter and subject both shared exactly the same concept of what category the CQ defined.

b) Evolving a quotient based on the number of display items "eliminated" by each question made the assumption that the child understood the eliminative nature of the information contained in each successive question.

c) Attempts to progressively mask "eliminated" sections of the display required the assumption to be made that both participants shared the same concept of what category the CQ defined and it also required the experimenter to make such an intrusion into the child's reactions to the situation that the game would no longer seem natural.

Perhaps the safest measure of efficiency is a simple comparison of the number of questions needed to locate the target item, TAB (1,1), so from now on all reference to 'efficient' questioning strategies will be based on this definition of efficiency.

Types of Question asked.

The questions which the children asked were classified according to several different schemes each representing the various methods of categorisation employed by the children in their attempt to narrow down the display in order to locate the target.

Particular vs Categorical Questions.

The most obvious difference noticed in the questions asked was between a question which referred to a particular item and a question which, either apparently or actually, referred to more than one display item. Questions which referred to one display item could vary between a precise statement such as, "is it number 36 ?" to a hurried jab at the display with a hand hovering over a certain card and a mumbled, "that ?" These questions will be referred to as Particular Questions or PQs.

Those questions which referred to more than one item were by various means employing categorisation and so they will be termed Category Questions or CQs. These CQs came in many different guises, from the concrete, "is it in this row?" to the rather abstract, "is it a multiple of 3?" More will be said of these variations later. Within these questions based around categories were found some hybrid questions, having the outward form of CQs but the function of PQs. The existence of these Pseudo-Category Questions or PCQs (Particular/Category Questions) was a fascinating although arduous discovery which came to light when the protocols were analysed for meaning in the hope that some quotient of successive question efficiency could be developed. The following protocol of Robert's (9) first game shows not only the various types of question available but it also illustrates the ambiguity in communication which thwarts any attempt one may make at developing a "question efficiency quotient" which does not rely on unwarranted assumptions.

Protocol	Possible meaning, taking into consideration previous questions & answers.	Possible meaning, ignoring previous questions & answers.	Question Type
1 Robert: "Has it got a 3 in it ?" Exp. "Yes"	53, 38, 63, 31, 13, 33, 36	= ditto	CQ
2. Robert: "and a 6 ?" Exp. "No"	63, 36	67, 16, 46, 68, 64, 26	CQ
3 Robert: "Has it got a 5 ?" Exp. "No"	53	45, 51, 52, 59	PCQ
4 Robert: "Got a 1 ?" Exp. "Yes"	13, 31	16, 51, 19, 21	CQ
5 Robert: "13 ?" Exp. "Yes"	13	= ditto	PQ

The first question is fairly unambiguous and, providing Robert had not inadvertently missed one of the 3's in the display, we can fairly accurately suggest that the category of items Robert suggested contained the seven numbers indicated. This first question is of the CQ type.

Robert's second question was worded in such a way, (by the inclusion of 'and') as to suggest that he wished the original category of seven numbers to be further divided into those numbers made up of both the digits 3 and 6 and those numbers with a 3 but without a 6. This is where one has to be careful and remember that we are playing a game with an enthusiastic 9 year old who wants to win; we are not conducting an exercise in logical thinking with a computer program.

There is no absolutely certain way we can be sure that Robert meant exactly what we interpret his utterances to mean, and even with the benefit of hindsight we cannot eliminate the possibility of erroneous interpretation, but only try to reduce it. Accordingly, Robert's second question was taken to mean, "is the target item 63 or 36 ?" whilst the possibility that he harboured the other six numbers listed was always present. As this question referred to more than one item it was a CQ.

The third question asked did not overtly make reference to the previous two questions asked so it could have been interpreted as a further request to subdivide the original category of numbers with a 3 in it or it could be seen as a completely new line of thought with only tenuous links with previous questions and answers. In the context of the game situation Robert gave the impression that he was trying to narrow down the original category of numbers with a 3 in, in which case, the form of his question was that of a CQ but its function was that of a PQ, hence it was scored as a PCQ.

Robert's fourth question was subject to the same possibilities of misunderstanding as his third question, but in either interpretation it still referred to more than one item so it was scored as a CQ.

The final question was completely unambiguous, referring to one number only and thus it was scored as a PQ.

From this close-up view of a game one can begin to appreciate some of the subtleties which underlie the apparently innocuous game of 20 Questions.

TAB (1,2)

Number of questions of each type asked by each group (percentage shown in brackets) and the number of children who asked each type of question.

Question Type	9 years		12 years		15 years	
	Child-ren	No. of questions	Child -ren	No. of questions	Child -ren	No. of questions
PQ	12	315 (72%)	12	94 (28%)	12	125 (31%)
PCQ	5	23 (5%)	7	29 (8%)	2	31 (8%)
CQ	10	102 (23%)	12	215 (64%)	12	248 (61%)
Grand Total		440 (100%)		338 (100%)		404 (100%)

TAB (1,2) shows the number of PQ, PCQ, CQ and the total number of questions asked by each age group. For the sake of comparison, percentages

are shown in brackets and the number of children using each type of question is shown.

The principal feature of this table is the massive shift with increasing age from PQ to CQ. This shift was statistically significant [2 way ANOVA, Age x PQ/CQ interaction; $F = 6.79$, $p < 0.005$, $df = (2,66)$]. There was also a significant difference in the number of CQs asked as a function of age, [1 way ANOVA, $F=13.514$, $p < 0.001$, $Df = 2,33$)]. Adopting the $p < 0.05$ significance level, further 1 way ANOVAs showed no significant age differences in the number of PQs asked, [$F = 2.83$, $df = (2,33)$], or in the number of PCQs asked [$F < 1$, $df = (2,33)$], or in the total number of questions asked to solution, [$F < 1$, $df = (2,33)$].[1]

Thus from the evidence of TABS (1,1) and (1,2) we can see an age-related shift from using mostly PQs to using mostly CQs, yet this change was not accompanied by an increase in efficiency. This result was the exact opposite of what was expected.

VARIOUS STRATEGIES

If one starts with the assumption that PQs are no more than pure guesses and that CQs are attempts to break down the display in some ordered fashion, then the present results can be explained sufficiently well as to allow each part of the explanation to be examined separately.

First, the PQs asked by all groups, but especially (because of their quantity) by the 9 year olds, must have been guided by something a lot less arbitrary than pure chance. Secondly, the CQs used by all groups, but especially (because of their quantity) by the 12 and 15 year old groups, were not used efficiently, despite their potential logical power.

WHAT GUIDED THE PQs ASKED ?

As has been said, PQs, by the fact that they refer to one item only,

1. In order to carry out these statistical tests the number of questions asked per question type, as well as the total number of questions asked by each child were averaged over the 4 games played so that each child's performance was reduced to an average score on each of the 4 variables, PQ, CQ, PCQ and TOTAL. Where it was thought that the distribution of some data may not have conformed to the normal distribution, the parametric tests were compared with equivalent non-parametric tests. In all cases what was significant or not significant remained significant or not significant.

can be regarded as pure guesses, but only in certain situations, for in some circumstances, the PQ could be seen to be directed by some non-random, goal-orientated forces. In practice,three distinct types of PQ were found to be in use by each age group.

Three types of Particular Question

a) The Direct PQ - This PQ was the nearest question to a pure guess, it was a question directed at one particular item, with no apparent dependence on any preceding question, it was, as it were "out of the blue!"

b) The Hypothesis PQ - This PQ was connected to an immediately preceding category question in that the PQ named items defined in the category located by the CQ. To keep the scoring system free from the need to make arbitrary judgments about whether a PQ was a hypothesis or a guess, only PQs immediately following a CQ were considered as possible hypotheses.

c) PQs connected to preceeding PQ by location - This PQ was a guess, but it formed part of a chain of PQs directed at immediately adjacent items in the display, and as such, these questions could be seen as crude attempts to follow a strategy based on spatial position.

TAB (1,3) Distribution of the various types of PQ used (showing the number of children using each type, how many they used and the percentage of the grand total accounted for by each PQ type.)

PQ type	9 years			12 years			15 years		
	No.of child-ren	No. of quest-ions	% of grand total	No.of child-ren	No.of quest-ions	% of grand total	No.of child-ren	No.of quest-ions	% of grand total
Direct	8	129	29.3%	2	7	2%	4	31	7.7%
Connected by location	3	115	26.1%	0	0	0	1	1	0.2%
Hypotheses	9	71	16.1%	12	87	25.4%	12	93	23.0%
Total		315	71.6%		94	27.8%		125	30.9%
Total as in TAB (1,2)			72%			28%			31%

TAB (1,3) shows that nearly all the PQs asked by the 12 and 15 year olds were hypotheses whilst only ¼ of the 9 year olds PQs were hypotheses.

In fact, out of 315 PQs asked by the 9 year olds, 129 (41%) were guesses, whilst out of 94 PQs asked by the 12 year olds, 7 (7%) were guesses and of the 125 PQs asked by the 15 year olds, 31 (25%) were guesses. From this it is clear that the 12 year olds were less inclined to resort to guessing than either the 9 or 15 year olds. [$X^2 = 41.05$, $p < 0.005$, $df = 2$].

PQs connected by location.

TAB (1,3) shows that 115 PQs, that is 26.1% of all the questions asked by the 9 year olds, were PQs connected to preceding POs by location, yet only 3 children used them. A closer study of these games shows that two of them, Colin (37 PQs of this type) and Jane (50 PQs of this type) used no CQs at all, whilst Craig, who used 28 PQs connected by location, only used 4 CQs, the same "is it even ?" in each game.

There is strong evidence in these results to suggest that PQs connected by location are evidence of an attempt by children, who couldn't see an easy way of remembering their questions, to evolve a strategy based on a kind of domino progression through the display.

As these children did not use spatial CQs it may have been that they simply hadn't allowed their thoughts to crystallise into seeing the value of one CQ rather than a collection of PQs. Certainly Jane seemed to be satisfied with the possibility of striking "lucky" with her PQs, for she continued using PQs (with spasmodic intervals of PQs connected by location) in her final game until she located the target with her 75th question. Altogether she had repeated 30 of these PQs and yet not once did she venture a CQ.

It is highly improbable that a sheer desire to feel the immediacy of knowledge contained in the answer to a PQ, (lacking in answers to CQs,) prevented her from using a CQ. After the first 20 questions she was definitely getting more frustrated with her lack of progress and if the knowledge that a less direct, but more economical type of questioning was available to her she would have had the incentive to use it. It seems likely that she wasn't able to handle the organisational demands required

of a CQ strategy, so she didn't attempt one.

Only one other child used PQs connected by location, the 15 year old Mark, who used 1 after an unsuccessful attempt to use CQs and hypotheses broke down into a serious of pure guesses.

WERE NINE YEAR OLDS "LUCKY"?

In the 48 games played by the nine-year old group, there was a total of 10 games in which the target was located by asking four questions or less. This finding seemed, at the time, to raise suspicions that the nine-year olds were somehow unusually "lucky" in their questioning and that their "luck" might arise from two main sources of bias, namely, the experimenter and the display: the experimenter's reactions might unintentionally provide some cues to which the nine-year olds were more sensitive than were the older children, and the display might evoke some bias in the questions which were asked by the children. As this section shows, these suspicions about "luck" were without foundation.

First, consider the purely statistical probability of locating the target by asking a random succession of particular questions. With the display of 24 items, there is one chance in 24 of locating the target on the first question. Assuming that the first guess is wrong and not subsequently repeated, then there is one chance in 23 of locating the target on the second guess, one chance in 22 of locating it in the third guess, and one in 21 of locating it in the fourth guess. Thus, by the time the fourth guess is made, the chance of having located the target is 1/24 plus 1/23 plus 1/22 plus 1/21. When the second game is started, the first game has been solved and, if we assume that the child deletes a discovered target item from further consideration, then the chance of guessing the target of the second game is 1/23 on the first guess, 1/22 on the second, 1/21 on the third, and 1/20 on the fourth guess. With the third game, and following the same argument, the chance of guessing the target on the first, second, third and fourth question is 1/22, 1/21, 1/20, and 1/19. Likewise, with the fourth game the chances are, respectively, 1/21, 1/20, 1/19, and 1/18.

Thus, over the four games as a whole, the cumulative possibility of guessing target items after having asked four questions per game is 1/21 plus 1/20 plus 1/19 plus 1/18. In the experiment, each of 12 nine-year olds played 4 games and, so, out of the 48 games the number of games which would be solved after four questions per game would be 48/21 plus 48/20 plus 48/19 plus 48/18, i.e. 9.89.

In short, if the nine-year olds had guessed at a succession of particular items in the way just outlined, the total number of games which would be solved after asking four questions per game would be 9.89 which is close to the actually obtained number of 10. Thus, in terms of the above argument about guessing, the nine-year olds were not excessively "lucky". Interestingly, the details of these 10 games, shown in Table (1,4)A, reveal that these games were not in fact, tackled by the kind of guesswork which has just been considered. In 9 out of the 10 games, the children proceeded by asking one or more category questions which they then followed by a hypothesis question.

TAB (1,4)A Details of the 10 games concluded in 4 questions or less, by the 9 year old group

Games involving Direct or Direct linked Questions i.e. Guesses								Games not involving Direct or Direct-Linked Questions i.e. Pure Guesses excluded							
Name	Game No.	Direct	connected by location	Hypothesis	PCQ	CQ	Total	Name	Game No.	Direct	connected by location	Hypothesis	PCQ	CQ	Total
Craig	2	3	0	0	0	0	3	Robert(A)	2			1	0	2	3
								Robert (B)	3			1	0	2	3
								Robert (B)	4			2	0	1	3
								Samantha	2			1	1	1	3
								"	4			1	2	1	4
								Louise	2			1	0	3	4
								Sharon	4			1	0	1	2
								Judith	1			1	0	3	4
								"	3			2	0	1	3

Before leaving the nine-year olds who solved games in 4 questions or less, it is worth mentioning why it was thought plausible that nine-year olds, as contrasted with older children, might have been more sensitive to cues given unintentionally by the experimenter.

Although every effort was made to present the games in a consistently uniform way, it was impossible to conduct the experiments in a strictly depersonalised fashion. The experimenter had to put the children at ease, explain the procedure to each child's satisfaction, and exchange smiles and laughter when the child thought something amusing. It was strongly felt that the different age groups reacted differently to the situation and to the experimenter. Typically, the nine-year olds were the most willing to communicate and interact: many talked about similar games they played, about brothers and sisters, their birthdays, what presents they liked and, in general, when given any opportunity to chat, they chatted. The 12-year olds were typically less chatty although they gave the impression of being keen and willing to pursue the games intelligently. The 15-year olds were generally either ill at ease and slightly suspicious or else they treated the game as childish and unworthy of serious consideration until they began to discover how tricky the game could be.

In the light of these impressions about age-related differences in the children's approaches to the experimental situation, it seemed possible that the experimenter's reactions would differ accordingly and that he might be more likely to give inadvertently helpful cues to the more chattily informal children.

The possibility of such experimenter bias could be eliminated by using a mechanical procedure involving microphones, closed circuit television and loudspeakers. Each child would receive tape-recorded instructions, uniformly spoken answers, and uniform pauses between question and answer. However, such mechanisation would also introduce many unnatural constraints into the situation and remove it from the interpersonal context in which

children play games in everyday life. In short, uniformity of procedure would be gained at the cost of artificiality which might, in itself, introduce changes in the way the children approached the game.

An alternative way of controlling experimenter bias would be to replicate the experiments more frequently using different experimenters and different children in the hope that involuntary cues might cancel out. The next two experiments go some way to achieving this kind of control insofar as they involve different children, albeit with the same experimenter and with slightly different displays (pictures or numbers).

FURTHER POSSIBLE SOURCES OF BIAS

The number display was designed so as to avoid any obvious clustering of related numbers and the four successive target numbers were chosen so as to occupy different rows and different columns. It is conceivable that this plan of having successive targets in different rows and columns could have been assumed by the children who could have used the plan to determine their choice of questions. However, there was no evidence during the playing of the games that any children did make use of such an assumption, and none mentioned it.

It is possible that some of the children might have told their friends about the game when they returned to the classroom, and they might have mentioned the target numbers. Such an occurrence would certainly have helped the children who came later to the experiment because the target numbers were the same for each child. But again, there was no evidence that any of the children made use of such information or that it helped any of the children to guess correctly at the target numbers. Only one of the games was completed in four questions by pure guessing.

Another source of bias is that there may have been some items in the display which somehow attracted more questions than others. For example, when a child was guessing, did certain cards attract more guesses than others? This question can be answered by comparing the distribution of PQs asked of

each card in the display. Column A of Table (1,4)B shows correlations between the distribution of Direct Questions asked about each card for one age group and by another age group. These correlations are insignificant and thus suggest that no particular cards invited more PQ guesses than any other.

TAB (1.4) B Correlations between the number of Direct Questions asked about each card by each of the 3 age groups. Similar correlations for 1st and 2nd choice Hypotheses also shown.

← PQs →

Correlation between Direct		Hypothesis 1	Hypothesis 2
9 yrs & 12 yrs	r = Zero	+0.8746**	Zero
9 yrs & 15 yrs.	r =0.1603	+0.7356**	Zero
12 yrs & 15 yrs.	r =0. 215	+0.7629**	+0.563 *

Pearsons r with 22 df * r 0.537 p 0.01 ** r 0.652 p 0.001

A related source of bias is that certain cards might be more "typical" than others of a certain category. For example, when a child has asked a CQ and established a category, is the child more likely to ask about a particular item in that category than about some other item in the category ? This question is difficult to answer directly because of the ambiguity involved in deciding the exact nature of the category intended by each CQ. However, even while acknowledging this ambituity, it is possible to consider the distribution of hypothesis PQs which follow CQs. Column B of Table (1,4)B shows the correlations between the Hypothesis PQs asked by different age groups. Column C shows the corresponding correlations between second choice Hypotheses. What is shown, especially by Column B, is that: if children located the correct category by using a CQ, they did not select their within-category question at random, but tended to make similar choices about which card to ask about. In other words, within a category, certain cards struck the children as more "typical" of the category than did other cards.

In concluding this section about possible sources of bias, it should be mentioned that by far the most conspicuous source of bias lay, not in the material nor in the experimenter, but in the age-related disposition of the children to approach the game by asking CQs rather than PQs. Tables (1,5), (1,6), and (1,7) show some breakdown of the type of question asked by the three age groups. What is most evident is the disposition, which increases with age, to ask CQs at the expense of PQs. It is this tendency which enables the 9-year olds to score a few quick successes and which prevents the 15-year olds from doing likewise. What is also of importance is that, despite the older children's bias towards asking CQs, there is no statistically significant overall trend towards increasing efficiency in playing the game. In other words, the older children are more disposed to ask CQs rather than PQs but they do not use their CQs in a strategically efficient manner.

SPATIAL vs. NUMERICAL CATEGORISATION

One of the findings of Bruner's (1966) study of Twenty Questions was that with increasing age the basis of categorisation employed to generate questions moved from a predominant use of perceptual qualities to a more

TAB (1,5) HOW EACH 9 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME

9 YEARS	GAME 1						GAME 2						GAME 3						GAME 4						PQ	PCQ	CQ	Total
	Direct	connected by location	Hypothesis	PCQ	CQ	Total	Direct	connected by location	Hypothesis	PCQ	CQ	Total	Direct	connected by location	Hypothesis	PCQ	CQ	Total	Direct	connected by location	Hypothesis	PCQ	CQ	Total				
	← PQ →						← PQ →						← PQ →						← PQ →									
Jonathan	3	0	1	0	4	8	4	0	0	0	4	8	1	0	0	0	4	5	0	0	2	0	5	7	11	0	17	28
Robert A	0	0	1	1	3	5	0	0	1	0	2	3	0	0	1	3	4	8	1	0	1	2	2	6	5	6	11	22
Craig	6	1	0	0	4	11	3	0	0	0	0	3	9	9	0	0	0	18	6	18	0	0	0	24	52	0	4	56
Colin	6	1	0	0	0	7	9	27	0	0	0	36	2	6	0	0	0	8	3	3	0	0	0	6	57	0	0	57
Paul	0	0	5	0	3	8	0	0	7	0	1	8	0	0	2	1	7	10	0	0	2	0	4	6	16	1	15	32
Roger	1	0	3	0	2	5	0	0	4	0	4	8	0	0	3	0	3	6	0	0	1	0	4	5	11	0	13	24
Robert B	1	0	2	2	2	7	2	0	1	2	3	8	0	0	1	0	2	3	0	0	2	0	1	3	9	4	8	21
Samantha	0	0	1	2	2	5	0	0	1	1	1	3	0	0	1	4	1	6	0	0	1	2	1	4	4	9	5	18
Louise	0	0	3	1	3	7	0	0	1	0	3	4	0	0	2	1	3	6	0	0	2	1	2	5	8	3	11	22
Sharon	0	0	2	0	3	5	2	1	2	0	3	8	0	0	4	0	3	7	0	0	1	0	1	2	12	0	10	22
Judith	0	0	1	0	3	4	0	0	4	0	3	7	0	0	2	0	1	3	0	0	4	0	1	5	11	0	8	19
Jane	10	5	0	0	0	15	7	3	0	0	0	10	9	10	0	0	0	19	43	32	0	0	0	75	119	0	0	119
																									315	23	102	440
Totals	27	7	19	6	29	87	27	31	21	3	24	106	21	25	16	9	28	99	53	53	16	5	21	148				

Grand Totals

TAB (1,6) *HOW EACH 12 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME*

12 YEARS	GAME 1						GAME 2						GAME 3						GAME 4									
	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Ian	0	0	1	4	5	10	0	0	1	1	6	8	0	0	1	1	3	5	0	0	1	2	3	6	4	8	17	29
Darren	0	0	3	0	6	9	0	0	2	0	4	6	0	0	1	0	4	5	0	0	1	0	4	5	7	0	18	25
Andrew	0	0	1	0	4	5	0	0	1	1	6	8	0	0	1	1	5	7	0	0	1	2	2	5	4	4	17	25
Richard	0	0	3	2	3	8	0	0	1	0	6	7	0	0	1	0	2	3	0	0	2	0	2	4	7	2	13	22
Julian (A)	0	0	2	1	4	7	0	0	6	0	10	16	0	0	1	1	5	7	0	0	1	1	2	4	10	3	21	34
Nicholas	0	0	1.	2	1	4	0	0	1	2	1	4	0	0	1	1	4	6	0	0	3	3	8	14	6	8	14	28
Debbie	0	0	4	0	2	6	0	0	4	0	4	8	0	0	2	0	3	5	0	0	10	0	6	16	20	0	15	35
Julie	0	0	1	1	6	8	1	0	1	0	8	10	0	0	2	1	4	7	0	0	1	1	4	6	6	3	22	31
Susan	1	0	2	0	6	9	2	0	4	0	7	13	3	0	1	0	8	12	0	0	1	0	3	4	14	0	24	38
Tina	0	0	2	0	3	5	0	0	2	0	5	7	0	0	1	0	7	8	0	0	2	1	4	7	7	1	19	27
Marishka *	0	0	1	0	4	5	0	0	1	0	4	5	0	0	1	0	5	6	0	0	1	0	4	5	4	0	17	21
Fiona	0	0	2	0	3	5	0	0	1	0	5	6	0	0	1	0	4	5	0	0	1	0	6	7	5	0	18	23
Totals	1	0	23	10	47	81	3	0	25	4	66	98	3	0	14	5	54	76	0	0	25	10	48	83	94	29	215	338

*half-split strategy throughout

Grand Totals

TAB (1,7) HOW EACH 15 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME

15 YEARS	GAME 1						GAME 2						GAME 3						GAME 4									
	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	Direct	Connected by location	Hypothesis PQ	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Howard	0	0	4	0	2	6	0	0	1	0	6	7	0	0	1	0	4	5	0	0	1	0	4	5	7	0	16	23
Mark	5	1	0	0	0	6	0	0	10	0	2	12	0	0	7	0	2	9	10	0	0	0	8	18	33	0	12	45
Ian	0	0	2	0	4	6	0	0	2	0	4	6	0	0	2	0	4	6	0	0	1	0	4	5	7	0	16	23
Kevin	0	0	1	0	9	10	0	0	1	0	4	5	0	0	2	0	10	12	0	0	1	0	10	11	5	0	33	38
Stephen	0	0	1	0	3	4	0	0	3	0	8	11	0	0	1	0	4	5	0	0	1	0	4	5	6	0	19	25
Fiona	0	0	1	0	10	11	3	0	2	0	8	13	0	0	3	0	4	7	0	0	2	0	7	9	11	0	29	40
Lynn	0	0	1	0	4	5	8	0	6	0	16	30	0	0	3	0	4	7	0	0	3	0	6	9	21	0	30	51
Julie	0	0	1	0	5	6	0	0	2	0	3	5	0	0	1	0	4	5	0	0	1	0	5	6	5	0	17	22
Deborah	0	0	1	5	3	9	0	0	1	7	3	11	0	0	1	3	1	5	0	0	2	3	1	6	5	18	8	31
Caroline	0	0	2	1	6	9	0	0	2	3	3	8	0	0	1	8	4	13	0	0	1	1	7	9	6	13	20	39
Louise	0	0	1	0	3	4	0	0	1	0	6	7	0	0	2	0	3	5	0	0	1	0	4	5	5	0	16	21
Sandra	2	0	2	0	5	9	0	0	3	0	10	13	3	0	1	0	8	12	0	0	3	0	9	12	14	0	32	46
																									125	31	248	404
Total	7	1	17	6	54	85	11	0	34	10	73	128	3	0	25	11	52	91	10	0	17	4	68	100				

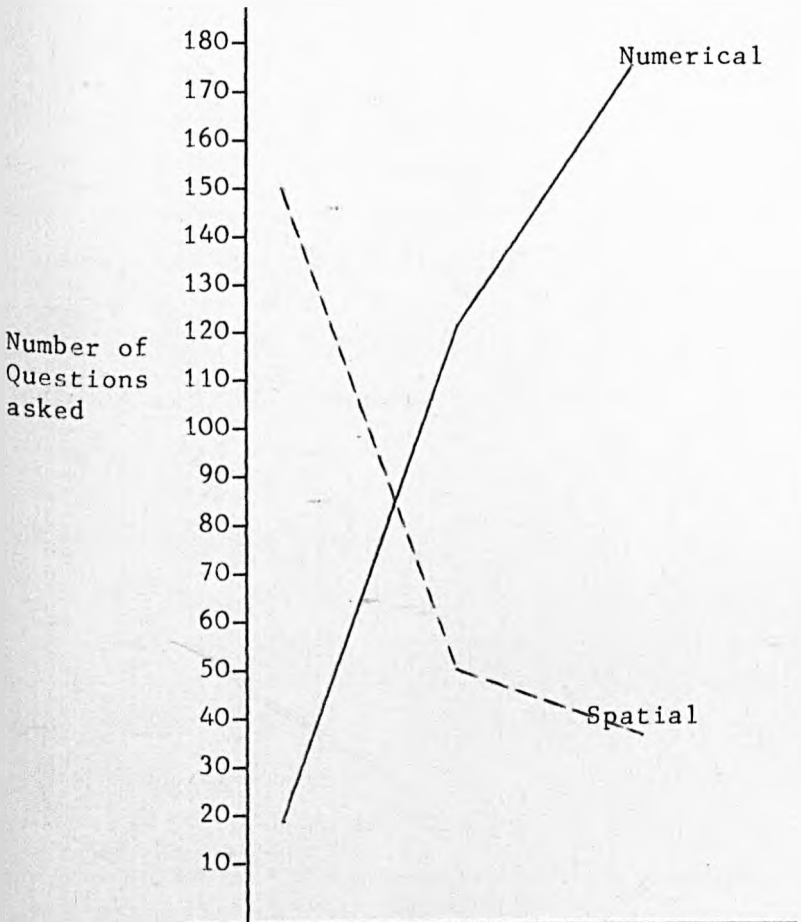
Grand Totals

varied basis of classification which relied heavily on the name of a certain group of items. His children moved from using perceptual to nominal bases of classification with increasing age, whilst each age group used "functional" questions, a type of question which asked, "what can I do with it?"

In the present experiment it was found that very few "functional" type questions were used [9 years no Functional CQs, 12 years 5 Functional CQs, 15 years 13 Functional CQs], but there was a dramatic polarisation in the type of categorisation used by each age group and this corresponded with the shift from perceptual to nominal basis of classification observed in Bruner's study. If one gathers together all the questions which involved the spatial (not perceptual) categorisation of the display, both PQs and CQs, and compares them with the number of purely numerical questions directed at the display, a dramatic age related shift from spatial to numerical categorisation is revealed, FIG. B (p.55a).

Perceptual CQs were excluded from this particular analysis due to the fact that they did not discriminate between the three age groups as clearly as the overtly spatial questions and also because they referred to what was on each card rather than its spatial position in the display. Similarly Perceptual CQs were not included in the numerical analysis because the depth of categorisation involved in formulating a Perceptual CQ went no further than a visual scan of the display, whereas to formulate a numerical CQ the child had to go beyond the information visually presented in the display and create categories in which to fit the display items.

FIG. B COMPARISON OF THE NUMBER OF QUESTIONS ASKED INVOLVING SPATIAL OR NUMERICAL CATEGORISATION OF THE DISPLAY.



	9 yrs.	12 yrs.	15 yrs.
Numerical	19	121	175
Spatial	150	50	36

Numerical questions include all CQs directed at the contents of the display.

Spatial questions include PQs linked by location, Row/Column CQs, Half Split CQs and Fragment CQs.

Perceptual CQs ("Has it got a 3 in it?" "Does it begin with 4?") are excluded but their inclusion would make little difference.

9 yrs. 48 CQs
12 yrs. 44 CQs
15 yrs. 38 CQs
[See TAB 1,10) A]

SPATIAL vs. NUMERICAL CQs

In considering the results of each child's categorisation, the CQs themselves, it made sense to include 'Perceptual' CQs, as the working definition of the two sorts of CQ clearly discriminated between those questions directed at the visual display and those most definitely directed at the child's own conception of the display.

TAB (1,8) Distribution of spatial/perceptual vs. numerical based CQs

	SPATIAL/PERCEPTUAL		NUMERICAL		TOTALS	
	Number of CQs asked	% of Grand total	Number of CQs asked	% of Grand total	Number of CQs asked	CQs as % of Grand total
9 years	83	19%	19	4%	102	23%
12 years	94	28%	121	36%	215	64%
15 years	73	18%	175	43%	248	61%

TAB (1,8) shows that when children use CQs, the younger children prefer spatial questions while the older children prefer numerical questions. $[X^2 = 79.1, p < 0.005, df = 2]$

These numerical questions, preferred by the older children, were of the following sort:

"is it odd ?"

"is it above 36 ?"

"is it below 50?"

"is it between 60 and 70 ?"

"Is it divisible by 3?"

This approach gave great scope to the categorising abilities of the older children, so much so that in the light of the fortuitously efficient performance of the 9 year olds one wonders if the skills of memory and organisation available to the older children could keep pace with their questioning.

The other type of questioning was popular with all age groups, but as TAB (1,8) shows, this spatial or perceptual type made up the majority of the younger children's CQs. The most frequent examples of these questions were :

"Is it in this row ?"

"Is it in this half ?"

"Is it over here ?"

"Has it got a 3 in it ?"

"Does it begin with a 4?"

Under the circumstances, the 9 year olds tended to adopt the kind of CQ which best suited their powers of organisation and memory which, quite fortuitously, happened to be the most efficient type of question for the task. The 15 year olds seemed to have been tempted into using more advanced, or at least more complicated methods of categorisation which, inadvertently, placed a greater strain on their powers of organisation.

SKILLS REQUIRED FOR EACH TYPE OF QUESTIONING

Spatial questions were directed at the actual display in front of the child. When a child asked, "is it in this row?", he or she pointed to the physically present display and interacted with it at a concrete level. Providing that the questions referred to visually identified chunks of the display, the task of remembering where the target may possibly be rested principally upon the child's visual memory.

Numerical questions required the child to go further than a concrete interaction with the display. In order to formulate a numerical CQ the child had to scan the contents of the display and then impose some form of classification on the assorted numbers before him. If the display had been made up out of the numbers 1 to 24 and if they had been arranged in sequential order then the spatial and the numerical analysis would have been nearly equivalent but in reality the numbers were randomly distributed in the display and they were purposely not sequential, being six groups of four numbers, (each chosen from a multiple of ten between 10 and 70) in which the odd and even numbers were evenly distributed with as little repetition as possible.

Given these circumstances, once a method of categorisation based on numerical content was initiated there was very little possibility of mapping the progress of questioning directly onto the display, everything had to be carried in the head.

TAB (1,8) shows that the 12 and 15 year old children used considerably more numerical questions than the 9 year olds and this is what one would expect from this older group's growing understanding of the world, it is in keeping with their increasing grasp of categorisation. In the context of the 20 questions game the choice of numerical CQs, especially with the given display, imposed heavy demands on the skills of organisation and memory that, to a large extent, must have been still insecurely developed in the 12 and 15 year old children.

TAB (1,9) Distribution of illicit and repeated questions (PQs + PCQs + CQs)

AGE	Illicit (items not in display)	repeated
9 years	5	36
12 years	6	9
15 years	15	44

TAB (1,9) shows how many questions were directed at items not in the display (For instance, "is it between 70 and 80?", "is it 15?") and how many questions which were repeated in the same game.

The interesting result shown in TAB (1,9) is the amount of mistakes made by the 15 year olds. One can imagine the 9 year olds having problems remembering which items they had questioned considering the amount of PQs they used, but the 15 year olds who responded so overwhelmingly to the numerical categories in the display obviously had difficulty keeping track not only of the display items but of their own questions, a problem not encountered with as much difficulty by the 12 year olds.

To illustrate the effects of these demands on the children concerned

it is illuminating to follow the progress of one 15 year old (Sandra) using a numerical approach and one 9 year old (Judith) using a spatial approach to the problem. One must pay close attention to the way in which the load on the memory for items, "eliminated" is organised.

SANDRA 15 years; 4th game

Question numbers are shown in red next to eliminated (/) numbers. Numbers in square brackets indicate target category

[67]1,5	~~24~~ 1,3	~~44~~ 1	~~12~~ 1
~~53~~ 2	45	~~31~~ 4	~~21~~ 3
~~29~~ 3	[63]5	13	[~~64~~]1,5
~~16~~ 1	~~51~~ 2	[~~68~~]1,5	~~36~~ 1,4
~~38~~ 1,4	~~52~~ 1,2	47	~~59~~ 2
~~46~~ 1	19	~~33~~ 4	~~26~~ 1,3

Questions	Answer	Memory of eliminated items
1 Is it even ?	X	16, 38, 46, 24, 52, 44, 68, 12, 64, 36, 26
2 is it in the 50s ?	X	53, 51, 52, 59
3 is it in the 20s ?	X	29, 24, 21, 26
4 is it in the 30s ?	X	38, 31, 33, 36
5 is it in the 60s ?	✓	67, 63, 68, 64
6 64 ?	X	already eliminated question 1
7 68 ?	X	" " " 1
8 is it in the 30s ?	X	repeat question 4
9 it's not in the 40s	?X	
10 in the 50s ?	X	repeat question 2
11 in the 60s	✓	repeat question 5
12 67 ?	✓	

We can never be presumptuous enough to use the word "eliminate" when it comes to interpreting the effect of cumulative questions asked by an individual child, as we simply do not know whether they can remember what they have asked, or whether they are more interested in what they haven't asked. In either case Sandra asked very sensible questions up to question 7 but her memory simply failed her, and looking at the complex arrangement of questioned items she had to remember, it is not perhaps surprising that she got muddled up, she simply overloaded her system !

JUDITH 9 years : 2nd game

~~57~~ 1	~~24~~ 2	~~44~~ 3	~~12~~ 6
~~53~~ 1	~~45~~ 2	~~31~~ 3	21
~~29~~ 1	~~63~~ 2	~~13~~ 3	~~64~~ 5
~~16~~ 1	~~51~~ 2	~~68~~ 3	[36] 7
~~38~~ 1	~~52~~ 2	~~47~~ 3	59
~~46~~ 1	~~19~~ 2	~~33~~ 3	~~26~~ 4

Questions	Answer	Memory of eliminated items
1 Is it in column 1 ?	X	column 1 57, 53, 29, 16, 38, 46
2 is it in column 2?	X	column 2 24, 45, 63, 51, 52, 19
3 column 3 ?	X	column 3 44, 31, 13, 68, 47, 33
[it must be column 4]	X	
4 is it number 26 ?	X	26
5 number 64 ?	X	64
6 number 12 ?	X	12
7 number 36 ?	✓	

The main points of comparison to notice between these two games are that Judith seems to have known what she was doing all the time; notice the fact that she could accurately assume that the target was in column 4 without requiring a confirming 'Yes' reply from the experimenter. Her haphazard questioning of the final row is not deviated by the three failures (questions 4 to 6) because she is sure she is on the right track, unlike Sandra who gives up after her 7th question.

It is interesting to note that both girls have to remember which questions and/or numbers which have been asked, Judith questions 21 items before she receives a positive answer, whilst Sandra asks either 23 or 18 depending on whether one counts the doubled up questions before she received a positive answer. Sandra was older, and as intelligent for her age group as Judith, yet the simple strategy employed by Judith enabled the younger girl to maximise her abilities whilst the more intelligent sounding strategy of Sandra merely confounded the older girl's capabilities.

From the evidence of TAB (1,8) it would seem that the 9 year olds had better fortune with their CQs because they were not tempted into using the many and varied types of categorisation in their questioning, which was so prevalent in the performance of the older children.

THE USE OF PSEUDOCATEGORIES (PCQs)

Age Differences

The following table taken from TAB (1,2) shows the distribution of PCQs asked by each age group. No significant age differences were found [X^2 = 3.256, with 2 df].

	No. of children	No of questions	% of grand total
9 years	5	23	5%
12 years	7	29	8%
15 years	2	31	8%

How they were used

All the PCQs acted as hypothesis PQs in that they immediately followed a CQ which referred to the category into which the PCQ was directed. Furthermore there were significantly more PCQs imitative of Spatial CQs than there were PCQs imitative of Numerical PCQs [t= 8.61, $p < 0.05$, 2 tail with 70 df].

Of the 83 PCQs asked, 75 took the form of Spatial CQs in that they referred to the spatial position of a certain card in the context of the display as a whole, for instance, the child would ask: "is it in that row?" [when the correct column was already known] or they referred to the appearance of a particular number, such as, "has it got a 3 in it ?" [when the other digit was already known]. Only 8 Numerical type PCQs were asked and these were all used by the same 12 year old who asked questions such as: "Is it in the twenties?" [when the second digit was already known].

From this evidence it would seem that PCQs were attempts to imitate CQs once a particular category had been successfully located.

WHAT GUIDED THE CQs ASKED ?

1, TAB (1,10) A Distribution of Perceptual/Spatial CQs

	PERCEPTUAL			ROW/COLUMNS			HALF SPLIT			TOTALS		
	No. of children	No. of CQs	% of grand total	No. of children	No. of CQs	% of grand total	No. of children	No. of CQs	% of grand total	No. of children	No. of CQs	% of grand total
9 yrs.	5	48	11%	5	35	8%	0	0	0	8	83	19%
12 yrs.	6	44	13.1%	5	29	8.6%	2	21*	6.2%	10	94	28%
15 yrs.	4	38	9.4%	3	35	8.6%	0	0	0	7	73	18%

* This figure includes 7 CQs which were directed at uneven fragments of the display.

TAB (1, 10)A shows that there was essentially very little difference between the age groups in terms of the children who used spatial or perceptual CQs. Fewer 15 year olds than 9 or 12 year olds used these types of CQ, but this was characteristic of the older children who were more interested in the contents of the display rather than its appearance.

The 12 year old group performed interestingly, for 10 out of the 12 children used this type of question and two girls from the group attempted to use Half Split type CQs. Julia mixed her Half Split CQs with other CQs but Marishka tried valiantly to stick to a spatial CQ strategy in each of her four games, two of which were perfect examples of the HSA in action. The protocol and accompanying diagram below depict one such game.

MARISHKA 12 years :1st game

1 Marishka	"What side have you put it on, that side or that side . . . that side ?	CQ (Half split)
E	"Yes"	
2 Marishka	"Is it in this rectangle ? This one?" [pointing]	CQ (Half split)
E	"Yes"	
3 Marishka	"Is it on this side ?"	CQ (Half split)
E	"Yes"	
4 Marishka	"Is it in any of these two squares ?"	CQ (Fragment)
E	"No"	
5 Marishka	"That one, 13"	PQ (Hypothesis)

The red numbers indicate the items defined by the questions of that number.

67	24	44 1,2,3,4	12 1,2
53	45	31 1,2,3,4	21 1,2
29	63	[13] 1,2,3,5	64 1,2
16	51	68 1	36 1
38	52	47 1	59 1
46	19	33 1	26 1

2. THE DISTRIBUTION OF THE NOMINAL PQs

So far we have seen that the older children not only asked more CQs than PQs but that the type of CQs asked involved them in a greater degree of categorisation than the CQs asked by the 9 year olds. One telling indication of this latter point was the amount of questions asking "is it above N?" or "is it below N?" or the rather useful sounding "is it odd ?" or "is it even ?" asked by each age group.

The interesting point about these questions is that not only did they indicate the type of categorisation which each child was employing they also showed how much attention they were paying to the display and how much they were attempting to create a semblance (at least) of an intelligent, goal-directed, efficient questioning strategy.

"IS IT ODD?" "IS IT EVEN?" CQs

TAB (1,10) B Distribution of "Is it odd/even?" CQs
(Showing the number of children using them and how many they asked.)

	Number of children using this CQ type	Number of CQs asked	% of grand total
9 years	3	18	4.1%
12 years	9	66	19.5%
15 years	9	54	13.4%

TAB (1,10) B shows that ¾ of the 12 and 15 year old children found the logically sounding, "is it odd ?" or "is it even ?" question particularly attractive, perhaps because it seemed to be the most obvious way of cutting down the size of the target category. The trouble with this approach was that the items located in the answer to the question were disseminated in such a haphazard way across the

display that locating subsequently useful questions and remembering what items remained became increasingly more difficult.

"IS IT ABOVE N?" "IS IT BELOW N?" CQs

TAB (1,10) C Distribution of "is it above N?", "is it below N?" questions showing where N was a number contained in the display or not. (Showing the number of children using them and how many they asked.)

	N IN DISPLAY i.e. "is it above/below 36 ?"			N NOT IN DISPLAY i.e. "is it above/below 30 ?"		
	No. of children using this CQ type	No. of CQs asked	% of grand total	No. of children using this CQ type	No. of CQs asked	% of grand total
9 yrs.	0	0	0	0	0	0
12 yrs.	0	0	0	4	34	10.1%
15 yrs.	2	5	1.2%	7	80	19.8%

TAB (1,10) C shows that one third of the CQs asked by the 15 year olds (80 questions) were quite clearly not directed at the display physically present before them but they were used to sift the child's mental conceptualisation of the display.

If a child asked, "is it above 30?" they were obviously going beyond the information given in the actual display before them, because it contained no multiples of 10. In order to have arrived at this question the child would have had to scan the display, recognise the numerical relationships possibly at work in the display, then generate a question based around a more easily memorised number.

Few people would argue that it is easier to memorise multiples of ten than discrete, (and often changing), pairs of digits, and therefore it is not surprising to find that nearly all the questions asked involving the definition of a numerical group ["is it above 30?", "is it below 60?"] involved numbers not physically present in the display. The children were obviously trying to impose order onto what appeared to be numerical chaos.

The same pattern of results was found in the "is it between N^1 and N^2?" type question as is shown in the following table.

TAB (1,10) D Distribution of "Is it between N^1 and N^2" CQs

	N^1 & N^2 IN DISPLAY			N^1 & N^2 NOT IN DISPLAY		
	No. of children	No. of questions	% of grand total	No. of children	No. of questions	% of grand total
9 yrs.	0	0	0	1	1	0.2%
12 yrs.	0	0	0	4	16	4.7%
15 yrs.	2	16	4%	3	7	1.7%

The significance of this result lies in the fact that this type of CQ reveals, unambiguously, when a child is trying to formulate a mental reconstruction of the display and it contrasts perfectly with the spatial CQs used predominantly by the 9 year olds. [It is in locating clearly defined questions such as these that the number display becomes a more efficient experimental tool than either a picture or a word type].

TENDENCY TO USE THE SAME QUESTIONS IN SUCCESSIVE GAMES.

As has been shown in the protocols given, some children seemed to continue a line of thought from one game to the next. One can suggest various reasons for this, either the child was unconsciously running one game into the next or some kind of conscious strategy was being developed. To check this, each child's 4 games were scrutinised to see whether similar questions were repeated from game to game. When this was completed it became apparent that the 12 year olds as a group seemed to be repeating more questions in the later games. TAB (1,11).

TAB (1,11) The number of children in each age group who repeated more than half the questions asked in the previous game.

	in game 2	in game 3	in game 4
9 years	2	0	3
12 years	3	5	8
15 years	0	5	2

Given this basis to work on it was decided to see if the questions which were repeated were CQs or PQs. If they were PQs then it would

signify that the child was fixated on a certain group of individual numbers, perhaps "lucky numbers", whilst a pattern of repeated CQs would indicate the presence of a more logical strategy of narrowing down the target category by eliminating sub-categories.

TAB (1,12)A Percentage number of repeated questions which were CQs. (Take each percentage from 100 to give % use of PC and PCQ) Total number of repeated questions asked is given in brackets.

	in game 2	in game 3	in game 4
9 years	46% (24)	33% (27)	20% (60)
12 years	89% (28)	85% (26)	90% (30)
15 years	82% (22)	68% (38)	88% (32)

TAB (1, 12) A shows that with successive games the 9 year olds tended to repeat more PQs whilst the 12 and 15 year olds tended to repeat more CQs in games 2 and 4 than in game 3.

Whilst this is a useful table it could be argued that the younger children, using more PQs, can reasonably be expected to repeat more of them. To get a closerpicture of any strategies at work, the number of category questions (CQs) repeated compared with the number of CQs asked in each successive game was analysed. If a child was developing a system such as progressive halving (using whatever type of CQ) one could expect the same CQs to be asked in each game.

As it was, on average each group tended to repeat half the CQs asked in each successive game.

Analysing these figures on an individual level, one can see in TAB (1,12) B the number of children in each group who repeated at least half their CQs. It could be argued that these children were attempting to develop some kind of CQ strategy.

TAB (1,12) B The number of children in each group who repeated more than half their CQs in successive games.

	from game 1 in game 2	from game 2 in game 3	from game 3 in game 4
9 years	5	4	5
12 years	6	6	9
15 years	2	7	4

If this were the case, then, clearly, the 12 year olds were more successful in establishing a routine of questioning than were the 15 year olds, and this in turn would account for the more efficient all-round performance of the 12 year old group.

SUMMARY

1) THE GAMES THEMSELVES

The games played were definitely social interactions and any attempt to formalise the experimental situation would undoubtedly have reduced the richness of the encounters.

2) 9 YEAR OLDS vs 15 YEAR OLDS

a) The 9 year olds located the target item, using fewer questions than that needed by the HSA more times than the 15 year olds.

b) The 9 year olds asked more PQs than CQs whilst the 15 year olds asked more CQs than PQs.

c) Of the CQs asked by the 9 year olds most were directed at spatial characteristics of the display whilst the majority of the CQs asked by the 15 year olds were directed at the numerical content of the display.

3) 12 YEAR OLDS

The 12 year olds performed very well indeed and at times they actually surpassed the performance of the 15 year olds.

a) As a group the median number of questions asked to solution was 6 compared with 6½ for the 9 year olds and 7 for the 15 year olds, in fact the 48 games played by the 12 year olds were completed in 338 questions, that is 66 questions fewer than the 15 year olds and 98 questions fewer than the 9 year olds.

b) The 12 year olds used fewer PQs (28%) than the 15 year olds (31%) and they used more CQs (64%) than the 15 year olds (61%).

c) Children in the 12 year old group repeated more CQs from game to game than any other age group; this may be taken as an indication that the 12 year olds were, as a group, making a greater effort to establish a CQ strategy than either the 9 or 15 year olds.

d) More 12 year olds used PCQs than any other group and this probably reflects their inexperience in discriminating between the sound of a CQ and its function in relation to preceeding questions.

e) Out of the 108 children tested in Exp. 1, 2 and 3 only one child, the 12 year old Marishka, successfully attempted a HSA, only two other children used Half Split CQs and one of them was the 12 year old Julia in the present experiment.

Experiments 2 and 3 (Chapters 3 and 4)

20 Questions using picture or word displays.

The original pilot studies used two displays, one with 24 assorted picture cards, the other with 24 corresponding word cards, each word being the label of a picture card. These two displays were used to investigate the possibility that words, being rather abstract, and rather free of perceptual distractions would enable children to maintain a higher level of performance in a 20 questions game than with a picture display. The theoretical justification for this experiment was simply based on the fact that in two experiments, one with pictures and words Barham and McMahon (1975) and one with numbers, shapes and words Bradley (1976) there seemed to be evidence suggesting that children were distracted by too much perceptual stimulation and they were more liable to maintain a grasp of their questioning strategy (as evidenced by their choice of question) when the display was perceptually undemanding, even abstract or symbolic.

This finding seemed to run in opposition to the experiments of Bruner et al (1966) which were designed to investigate the general law that children's thinking developed in three broad stages, enactive, ikonic and symbolic. The experiments which have most bearing on the 20 questions task were conducted by Bruner, Mosher and Hornsby who showed that when 6, 8 and 11 year olds were told to categorise a picture display and then play 20 questions with it the 8 and 11 year olds tended to ask category questions in more abundance and with less reliance on perceptual characteristics than did the 6 year olds.

When another group of children were asked to account for a road accident it was found that the 6 and 8 year olds were at about the same level as far as being able to ask connected questions whilst the 11 year olds managed to link their questions successively.

Mosher and Hornsby's experiment indicated that perceptual material encouraged younger children to maintain a theme in their questioning which broke down when this perceptual prop was taken away. The two later studies indicated that, far from being a prop to assist strategic thinking, perceptual material distracted the child whilst more structured, formal, even symbolic material, gave assistance.

Thus, the early pilot studies set about seeing if a word display, being symbolic, would enable younger children to maintain an older type of questioning not present when a picture display was used.

In conducting these experiments, the difficulties involved in scoring the games played, due to the ambiguity of category boundaries with each CQ asked, led the experimenter to develop the number display used in Exp.1.

In the light of the results obtained in Exp.1 it was decided to increase the size of the pilot study investigation and re-analyse the results to see if the younger children were making better use of their questions than the older children as well as ascertaining the effect of changed material.

CHAPTER THREE

Experiment 2

20 Questions using a Picture display

AIM

To see if the 9 year old children use their CQs more effectively than the 15 year olds when using a picture display. To check the results and general conclusions obtained in Exp.1

PARTICIPANTS

Altogether 36 children from 3 age groups, 12 x 9 year olds (5 boys, 7 girls) mean age 9 years 8 months; 12 x 12 year olds (6 boys, 6 girls) mean age 12 years; 12 x 15 year olds (5 boys, 7 girls) mean age 15 years 4 months.

Each child was chosen by the class teacher as being an average child so the teacher was left to choose from across the ability range.

MATERIALS

As in Exp.1 a 64 cm x 52cm cardboard sheet was used, on which 24, 6cm x 8cm coloured picture cards were mounted in 4 rows, 6 columns deep. These picture cards were all illustrations from children's story books and they represented members of six distinct categories, 4 animals, 4 items of clothing, 4 fruits, 4 men, 4 buildings and 4 vehicles.

These items were randomly intermixed such that no two cards from the same category were side by side and, where possible, not even adjacent on a diagonal, and in these positions they were stuck to the cardboard sheet. The arrangement was as shown in FIG B.

FIG. B. PICTURE DISPLAY

soldier	lemon	rabbit	(2)tractor	hat	apple
shop	car	(1)postman	pig	school	bus
orange	house	horse	dress	(3)socks	milkman
(4)cow	mittens	banana	sailor	fire engine	farm

The target items in successive games were as shown, game 1 postman, game 2 tractor, game 3 socks, game 4 cow. These items were in the same position in the display as the target items used in the numbers experiment.

PROCEDURE

As in Exp.1, the children were individually brought from the classrooms and allowed to identify all 24 Picture cards by naming and pointing to them (Phase 1) before playing 4 games of 20 Questions (Phase 2).

The same instructions as used in Exp.1 were used only with suitable changes to suit the pictorial rather than the number material.

The individual items in each category were as follows :

ANIMALS - cow, horse, pig, rabbit

CLOTHING - hat, socks, dress, mittens

FRUIT - apple, orange, banana, lemon.

MEN - postman, milkman, soldier, sailor

BUILDINGS - school, house, shop, farm

VEHICLES - fire engine, car, tractor, bus

TAB (2, 1) The number of games completed in a given number of questions by each age group.

No.of Questions	9 years GAME 1	2	3	4	Total	Running Total	12 years GAME 1	2	3	4	Total	Running Total	15 years GAME 1	2	3	4	Total	Running Total
1	1				1	1	1				1	1						
2							1	1	1		3	4						
3	1		3		4	5				1	1	5			1	1	2	2
4	1	1	1	1	3	9		1	4	1	6	11	2	2	1	3	8	10
5	1	4	1	1	7	16	1	2		3	6	17		4	5	3	12	22
6	2	2		2	6	22	2	1	1	2	6	23	2	1	1	1	5	27
7	1		1	1	3	25	2	2	1	2	7	30		3	1	3	7	34
8	2	1	2		5	30		3	1		4	34	2	1	1		4	38
9				1	1	31		1	1	1	3	37	3		1		4	42
10		1			1	32	3				3	40	1	1	1		3	45
11		2	1	2	5	37				1	1	41						
12	2				2	39			1		1	42						
13										1	1	43						
14	1			1	2	41		1			1	44						
15																		
16				2	2	43							2				2	47
17																		
18			1		1	44												
19		1			1	45	1				1	45						
20			1		1	46												
21				1	1	47			1		1	46						
22																		
23																		
24																1	1	48
25																		
26																		
27																		
28																		
29																		
30																		
31									1		1	47						
32																		
33			1		1	48												
34							1					48						
Totals	12	12	12	12	48		12	12	12	12	48		12	12	12	12	48	
Medians	6½	6	7½	10	7		7	7	6½	6	7		8½	5½	5	5	6	

Each entryshows the number of children who located the target in the no. of questions shown

RESULTS

TAB (2,1) shows that there are no significant differences in efficiency as a function of age. [1 way ANOVA; $F = 1.693$, $p < 0.05$, $df = (2,132)$].

The interesting results obtained in Exp.1 (to the effect that up to the 4th question 9 year olds were more efficient than 12 and 15 year olds) were not observed in the present experiment

TYPES OF QUESTION ASKED

TAB (2,2) The number of questions of each type asked (percentage of total shown in brackets) and the number of children who asked each type of question [in square brackets]

Question type	9 YEARS Child -ren	9 YEARS No. of questions	12 YEARS Child -ren	12 YEARS No. of questions	15 YEARS Child -ren	15 YEARS No. of questions
PQ	[12]	325 (75%)	[12]	212 (54%)	[12]	102 (31%)
PCQ	[5]	16 (4%)	[8]	41 (10%)	[8]	23 (7%)
CQ	[8]	89 (21%)	[11]	140 (36%)	[12]	206 (62%)
Grand Total		430 (100%)		393 (100%)		331 (100%)

TAB (2,2) shows a massive shift from using PQs to CQs with increasing age, just as was found in Exp.1. This shift was statistically significant [2 way ANOVA, Age x PQ/CQ interaction; $F = 9.124$, $p < 0.001$, $df = (2,66)$] One way ANOVAs conducted on the number of questions asked of each question type as a function of age showed statistically significant differences in the use of CQs, [$F = 9,088$, $p < 0.001$, $df = (2,33)$], and PQs [$F = 4.456$, $p < 0.025$, $df = (2,33)$], but no significant differences in either the use of PCQs [$F = 1.351$, $df = (2,33)$] or in the total number of questions asked to solution, [$F = 1.319$, $df = (2,33)$].[1]

1. In order to carry out these statistical tests the number of questions asked per question type, as well as the total number of questions asked by each child were averaged over the 4 games played so that each child's performance was reduced to an average score on each of the 4 variables, PQ, CQ, PCQ and TOTAL. Where it was thought that the distribution of some data may not have conformed to the normal distribution, the parametric tests were compared with equivalent non-parametric tests. In all cases what was significant or not significant remained significant or not significant.

Despite the fact that progressively older children asked progressively fewer questions in total, an analysis of variance showed that the variation of questions asked within each group was too broad to make the variation in scores between groups significant.

It would be tempting to suggest that this experiment shows a relationship between the increased use of CQs and the reduction of questions needed to solution, but a close analysis of TAB (2,2) shows that this reduction is primarily due to a rapid reduction in the use of PQs (reducing at just over 100 questions per age group) rather than a rapid increase in the number of CQs being asked, (increasing at the rate of just over 50 questions on average for each age group). Thus, any reduction in the amount of questions being asked by the older children lay in the fact that they were asking fewer PQs than the younger children rather than in using their CQs more efficiently.

WHAT GUIDED THE PQs asked ?

In Exp.1, three types of PQ were studied:

a) The Direct PQ - being the nearest to a pure guess, having no apparent dependence on any preceding question.

b) The Hypothesis PQ - being connected to an immediately preceding CQ by referring to an item located in the category defined by the CQ.

c) PQs connected to preceding PQ by location - this PQ referred to an item which was adjacent, in the display, to the item questioned in the immediately preceding PQ.

In the present experiment a further type of PQ was studied.

d) PQs connected to preceding PQ by unstated category - this PQ referred to an item from the same category as the immediately preceding PQ. The accepted categories were those purposely built into the display; people, clothes, fruit, transport, animals or buildings.

TAB (2, 3)A Distribution of the various types of PQ used.
(Showing the number of children using each type, how many they used and the percentage of the grand total accounted for by each PQ type).

PQ Type	9 Years			12 years			15 Years		
	No.of child-ren	No.of quest-ions	% of grand total	No.of child-ren	No.of quest-ions	% of grand total	No.of child-ren	No.of quest-ions	% of grand total
Direct	8	132	30.6%	10	77	19.6%	6	22	6.6%
connected by location	8	92	21.4%	3	19	4.8%	0	0	0
connected by category	8	34	7.8%	4	30	7.6%	0	0	0
Hypotheses	7	67	15.6%	10	86	21.9%	12	80	24.2%
Total	12	325	75.4%	12	212	53.9%	12	102	30.8%
Totals as in TAB (2,2)			75%			54%			31%

TAB (2,3) A shows that with increasing age, fewer Direct PQs were asked when hypothesis PQs were used with greater frequency.

THE CONNECTEDNESS OF PQs

TAB (2,3)A shows clearly that with increasing age the amount of pure guesses fell dramatically; the 9 year olds asked 325 PQs of which 132 (41%) were guesses, the 12 year olds asked 212 PQs of which 77 (36%) were guesses whilst the 15 year olds asked 102 PQs of which only 22 (22%) were guesses. There was obviously a clear trend towards organising questions before using them by the older children but TAB (2,3)A shows that the younger children, whilst not overtly using CQs, were definitely making some efforts towards organising their questions.

PQs connected by location

8 x 9 year olds linked some of their PQs together in a chain of questions which followed a discernible route through the display. Sometimes consecutive PQs referred to items adjacent in the same row or column of the display whilst at other times the items were adjacent but on a diagonal so that chains of these PQs often described a snake-like progression through the display.

Of these 8 x 9 year olds, 4 of the most frequent users of this type of PQ (accounting for 66 of the 92 questions asked) used no CQs at all, rather striking evidence to show that this type of PQ was the precursor of spatial CQs. One child, Gary, used 18 PQs connected by location but he also used 10 CQs and an inspection of his protocol suggests that he did not want to repeat any CQ asked in a previous game so he resorted to PQs.

In the light of the evidence gained in Exp.1, which showed that younger children showed a greater tendency to categorise the display according to spatial or perceptual characteristics whilst older children categorised the display according to the content of each item, it is interesting to note that only 3 x 12 year olds used PQs connected by location whilst not one 15 year old was found using this PQ type.

Of the 3 x 12 year olds who used PQs connected by location, one, Paul (who used 11 out of the 19 PQs asked) used no CQs whilst the other two, Gavin (6 PQs) Sheena (2 PQs) used PQs connected by location when their disorganised CQ strategy broke down and they lost direction.

PQs connected by an unstated category.

Whilst 8 x 9 year olds used this sort of PQ and only 4 x 12 year olds used them, the 12 year olds used considerably more. This is in keeping with the noticeable trend of older children to concentrate on the contents rather than the perceptual characteristics of each display card.

In order to use a PQ connected by an unstated category, a child must have scanned the display and then have gone beyond the information given in order to recognise the categories shared by a pair of items. This process can be seen as an intermediate stage between the pure guess and the use of a CQ.

Of course,the presence of PQs linked in this manner cannot be taken as conclusive evidence that a child was consciously working through categories, but on the other hand, the experimenter often had the impression that a series of PQs were connected by an idiosyncratic chain of thought which could not easily be detected without fear of making unwarranted assumptions. Certainly, even with the limited but easily identified 6 categories used to locate this type of PQ, the results shown in TAB (2,3)A show that the type of categorisation witnessed in the use of CQs has its parallels in some PQs, and these PQs are used by the children who have not yet used CQs as their predominant question type.

TAB (2,3)B GAMES COMPLETED WITHIN 4 QUESTIONS

	9 years	12 years	15 years	Total
Exp. 1	9 games	6 games	2 games	17 games
Exp. 2	9 games	11 games	10 games	30 games

As TAB (2,3)B shows all the age groups in Exp.2 managed to complete as many games within 4 questions as the 9 year olds in Exp.1. Given the fact that only 3 games out of the 48 games played by each group could be concluded within 4 questions by chance factors alone, it would seem to suggest that, with the present Picture display, either the enhancing factors which affected the performance of the 9 year olds in Exp.1 were made available to the older groups or the factors which inhibited the performance of the 12 and 15 year olds using the Number display were not encountered when they played with the Picture display.

As was suggested in Exp.1 the older children responded to the many possible categories in/contents of the Number display to a greater extent than the 9 year olds and this eagerness to categorise numerically often led older children into asking inefficient questions, thus lengthening their games. Upon immediate inspection it seems reasonable to suppose that in Exp.2 all the children reacted towards the categories embedded within the Picture display in a similar way, much the same way as the 9 year olds in Exp.1 reacted to the Number display.

TAB (2,4)A shows the type of questions which were asked in all 30 games whilst TAB (2,4)B gives the protocols of each game.

From these tables one can see the high proportion of 15 year olds' games involving 3 CQs (6/10 = 60%) compared with the 12 year old (2/7 = 30%) and 9 year old (0/7 = Zero) groups. Similarly,fewer hypotheses were needed by the older groups, 8 out of 10 games played by the 15 year olds involved more CQs than hypothesis PQs compared with 5 out or 7 games by the 12 year olds and 3 out of 10 games played by the 9 year olds. Clearly the older children wanted to be fairly sure of their choice before they ventured a hypothesis PQ, unlike the younger children.

If one compares the number of games in which a second CQ was asked after a preceding CQ had received a "yes" response from the experimenter a clear age difference emerges between the groups.

For the 9 year olds only one child, Paula, in her first

game made any attempt at backing up her successful CQ "Is it on the second row?" with another CQ. Unfortunately, despite the power of her choice of CQs she obviously didn't fully appreciate their potential, because in asking as a second question "Is it that way?" she was actually referring to only one card,thus she was using a PCQ.

In the 12 year old group three games involved the use of 'confirming' CQs but they were all played by the same boy Stephen A. In contrast all seven 15 year olds who located the target within 4 questions played at least one of these games using a "confirming" CQ.

TAB (2,4)A Details of the 30 games played and completed in or under 4 questions.

Games including Direct PQs connected by location and PQs connected by unstated category									Games in which Hypotheses were the only PQs asked.							
			PQs connected by								PQs connected by					
Name	Game No.	Direct	location	Unstated category	Hypotheses	PCQ	CQ	Total	Name	Game No.	Direct	location	Unstated category	Hypotheses	PCQ	CQ	Total
9 years																	
Raymond	1	1	0	0	0	0	0	1	Jefferey	3				1	0	2	3
Julie	1	2	1	1	0	0	0	4	Paul	3				1	0	2	3
									Sharon	2				3	0	1	4
									Sharon	3				2	0	1	3
									Paula	1				1	0	2	3
									Paula	3				3	0	1	4
									Paula	4				2	0	2	4
12 years																	
Stephen A	2	1	0	0	0	1	2	4	Stephen A	3				1	1	2	4
Richard	3	1	0	0	0	1	0	2	Stephen A	4				1	1	2	4
Paula A	1	1	0	0	0	0	0	1	Gavin	2				1	0	1	2
Mandy A	1	1	0	0	0	1	0	2	Michael	3				1	0	3	4
									Paula A	4				2	0	1	3
									Diane	3				1	0	3	4
									Mandy A	3				3	0	1	4
15 years									Kevin	2				1	0	3	4
									Andrew	4				1	0	2	3
									Philip	4				1	0	3	4
									Paul	3				1	0	3	4
									Tracy	1				1	0	3	4
									Tracy	4				2	0	2	4
									Sally	1				1	0	3	4
									Sally	2				1	0	3	4
									Sally	3				2	0	1	3
									Mandy	4				1	0	2	3

TAB (2,4)B** The questions asked by those children who located the target in 4 questions or less

Name	Game No.	Total	
9 years			
* Raymond	1	1	Postman? ✓
* Julie	1	4	Hat ?✗ Socks?✗ Car?✗ Postman ?✓
Jefferey	3	3	Do you eat it ?✗ Wear it ?✓ Socks?✓
Paul	3	3	We eat it ?✗ We wear it ?✓ Socks?✓
Sharon	2	4	Ride on it ?✓ Horse ?✗ Car ?✗[can't ride on a pig!] Tractor?✓
Sharon	3	3	Wear it ?✓ dress ?✗ socks?✓
Paula	1	3	Is it on the second row?✓ Is it that way?✓ Postman?✓
Paula	3	4	5th row down this way?✓ This one?✗ School?✗ Socks?✓
Paula	4	4	2nd row?✗ last row?✓ farm?✗ cow?✓
12 years			
* StephenA	2	4	Has it got wheels?✓ is it red?✓ does it put out fires?✗ tractor?✓
* Richard	3	2	Do you put it on your feet?✓ socks?✓
* Paula A	1	1	Is it the postman?✓
* Mandy A	1	2	Does he carry letters?✓ Postman?✓
Stephen A	3	4	Has it got wheels?✗ is it orange?✓ Do you put it on your feet?✓ socks?✓
Stephen A	4	4	Has it got legs?✓ Do you ride on it?✗ Get milk from it?✓ cow?✓
Gavin	2	2	Is it red?✓ Is it the tractor?✓
Michael	3	4	Is it round?✗ Is it large?✗ Is it red?✓ Is it a pair of socks?✓
Paula A	4	3	Is it an animal ?✓ horse?✗ cow?✓
Diane	3	4	Is it a fruit?✗ An animal?✗ Do you wear it?✓ socks?✓
Mandy A	3	4	Do you wear it?✓ Hat?✗ dress?✗ socks?✓
15 years			
Kevin	2	4	Man made?✓ Do you ride it?✓ Is it a service?✗ tractor?✓
Andrew	4	3	Food?✓ a sport?✗ cow?✓
Philip	4	4	Is it man made?✗ Do we eat it?✓ Does it live on a farm?✓ a cow?✓
Paul	3	4	Is it man made?✓ Do you wear it?✓ Are there two of them?✓ socks?✓
Tracy	1	4	Is it a fruit?✗ Is it a person?✓ Does he wear a uniform?✓ Is it a postman?✓
Tracy	4	4	Is it a building?✗ Animal?✓ Is it a horse?✗ cow?✓

TAB (2,4) B cont.

Name	Game No.	Tot -al	
Sally	1	4	Can you eat it ?✗ Does it walk ?✓ Is it a public service?✓ Postman.✓
Sally	2	4	Can you eat this one?✗ Do you wear it?✗ Is it mobile?✓ Tractor ✓
Sally	3	3	Do you wear it?✓ Dress?✗ Socks.✓
Mandy	4	3	Is it an animal?✓ Is it used for sport?✗ A pig?✗ a cow.✓

*Games played involving no CQs.

** Equivalent to TAB (1,8)

Two games were completed by pure chance, both the 9 year old Raymond and the 12 year old Paula located the target in their first question of the first game. There is perhaps evidence to suggest that these children were told by their classmates, but statistically it is possible for them to have just been "lucky"!

TABS (2,5) (2,6) and (2,7) give details of the types of question asked by each child in each game; (see pages 84, 85 and 86).

PATTERNS IN THE MATERIAL

As in Exp.1 the number of PQs directed at each item in the display was checked to see if certain items attracted more attention than others.

TAB (2,4) C Correlations between the number of Direct PQs asked about each display card and also between groups for their first two hypotheses

Correlation between	Direct PQ	First Hypothesis	Second Hypothesis
9 & 12 yrs. r =	0.0	0.7226 **	0.243
9 & 15 yrs. r =	0.177	0.6657 **	0.5291 *
12 & 15 yrs. r =	0.1882	0.3325	0.49*

Pearsons r with 22df *$r > 0.423$ therefore $p < 0.05$ ** $r > 0.652$ therefore $p < 0.001$

Correlations of the first and second choice hypotheses in all the games TAB (2,4)C showed that the first hypotheses asked by the 9 year olds tended to be those shared by both the 12 and 15 year olds, thus supporting the idea that certain items may have been more representative of their categories than others. The correlation between the 12 and 15 year olds

TAB (2,5) HOW EACH 9 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME

9 Years	Direct location	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Raymond	1	0	0	0	0	0	1	5	5	0	0	0	0	10	3	2	0	0	0	0	5	4	10	2	0	0	0	16	32	0	0	32
Jeffery	0	0	0	3	0	5	8	0	0	0	3	0	2	5	0	0	0	1	0	2	3	0	0	0	4	0	2	6	11	0	11	22
Paul	0	0	0	4	0	1	5	2	1	2	2	1	3	11	0	0	0	1	0	2	3	0	0	3	4	0	2	9	19	1	8	28
Richard	7	6	1	0	0	0	14	5	0	0	0	0	0	5	5	5	1	0	0	0	11	11	8	2	0	0	0	21	51	0	0	51
Gary	1	0	0	9	0	2	12	3	6	3	3	0	4	19	6	7	4	0	0	1	18	4	5	1	1	0	3	14	53	0	10	63
Dominic	4	4	0	0	0	0	8	4	4	0	0	0	0	8	12	6	2	0	0	0	20	3	3	0	0	0	0	6	42	0	0	42
Sharon	0	0	0	1	4	7	12	0	0	0	3	0	1	4	0	0	0	2	0	1	3	4	2	3	3	0	4	16	18	4	13	35
Colette	0	0	0	1	1	4	6	0	0	0	3	0	3	6	0	0	0	1	2	5	8	0	0	0	2	2	7	11	7	5	19	31
Paula	0	0	0	1	1	1	3	0	0	0	1	1	3	5	0	0	0	3	0	1	4	0	0	0	2	0	2	4	7	2	7	16
Julie	2	1	1	0	0	0	4	4	2	0	0	0	0	6	21	8	4	0	0	0	33	4	2	1	0	0	0	7	50	0	0	50
Gillian	1	1	1	0	0	3	6	7	3	1	0	0	0	11	6	1	1	0	0	0	8	3	0	1	0	0	1	5	26	0	4	30
Karen	0	0	0	2	3	2	7	0	0	0	2	0	3	5	0	0	0	2	1	4	7	0	0	0	3	0	8	11	9	4	17	30
Total	16	12	3	21	9	25	86	30	21	6	17	2	19	95	53	29	12	10	3	16	123	33	30	13	19	2	29	126				

PQ	PCQ	CQ	Total	
325	16	89	430	Grand Totals

TAB (2,6) HOW EACH 12 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME

12 years	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Stephen	1	0	0	0	2	3	6	1	0	0	0	1	2	4	1	0	0	0	1	2	4	1	0	0	0	1	2	4	4	5	9	18
Richard	1	0	0	0	13	5	19	0	0	0	3	1	2	6	1	0	0	0	1	0	2	0	0	0	2	0	3	5	7	15	10	33
Gavin	1	0	3	0	0	6	10	0	0	0	1	0	1	2	10	6	12	0	0	3	31	2	0	0	2	0	3	7	37	0	13	50
Michael	0	0	0	2	0	8	10	1	0	0	2	1	3	7	0	0	0	1	0	3	4	0	0	0	2	1	3	6	8	2	17	27
Gerard	0	0	0	3	0	4	7	0	0	0	4	0	4	8	7	0	1	1	11	2	21	1	0	0	6	0	2	9	22	11	12	45
Paul	20	6	8	0	0	0	34	4	4	1	0	0	0	9	8	1	3	0	0	0	12	12	0	0	1	0	0	0	13	68	0	0	68
Paula	1	0	0	0	0	0	1	1	0	0	1	0	3	5	0	0	0	4	0	5	9	0	0	0	2	0	1	3	9	0	9	18
Jane	0	0	0	2	0	5	7	0	0	0	3	0	4	7	0	0	0	2	1	5	8	0	0	0	2	0	4	6	9	1	18	28
Sheena	1	1	0	3	1	4	10	4	1	0	3	1	5	14	0	0	0	3	0	3	6	1	0	0	4	0	6	11	21	2	18	41
Diane	1	1	0	2	0	2	6	0	0	0	4	0	4	8	0	0	0	1	0	3	4	0	0	0	4	0	1	5	13	0	10	23
Michelle	0	0	0	1	1	3	5	0	0	0	1	0	4	5	0	0	0	2	1	4	7	0	0	0	1	0	6	7	5	2	17	24
Mandy	1	0	0	0	1	0	2	0	0	0	2	2	4	8	0	0	0	3	0	1	4	0	0	0	3	0	2	5	9	3	7	19
																												Grand Totals	212	41	140	393
Totals	27	8	11	13	18	40	117	11	5	1	24	6	36	83	27	7	16	16	15	31	112	17	0	1	28	2	33	81				

TAB (2,7) *HOW EACH 15 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME*

15 Years	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct	connected by location	connected by unstated category	Hypothesis	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Kevin	0	0	0	1	0	8	9	0	0	0	1	0	3	4	0	0	0	1	1	6	8	0	0	0	1	1	5	7	4	2	22	28
Andrew	2	0	0	1	1	6	10	0	0	0	1	0	4	5	0	0	0	1	2	6	9	0	0	0	1	0	2	3	6	3	18	27
Philip A	1	1	0	0	0	4	6	1	0	0	1	0	5	7	0	0	0	2	0	3	5	10	0	0	10	0	4	24	26	0	16	42
Philip B	1	0	0	1	0	6	8	0	0	0	2	0	3	5	0	0	0	1	1	4	6	0	0	0	1	0	3	4	6	1	16	23
Paul	0	0	0	1	2	5	8	0	0	0	1	0	4	5	0	0	0	1	0	3	4	0	0	0	2	1	4	7	5	3	16	24
Sharron	1	0	0	1	2	5	9	0	0	0	2	0	6	8	1	0	0	2	0	7	10	0	0	0	3	0	4	7	10	2	22	34
Judith	0	0	0	1	0	5	6	0	0	0	1	1	3	5	0	0	0	1	2	2	5	0	0	0	3	0	2	5	6	3	12	21
Tracy A	0	0	0	1	0	8	9	0	0	0	2	0	4	6	0	0	0	1	0	4	5	0	0	0	1	0	5	6	5	0	21	26
Christine	0	0	0	5	4	7	16	1	0	0	1	1	7	10	0	0	0	1	2	4	7	0	0	0	2	0	3	5	10	7	21	38
Tracy B	0	0	0	1	0	3	4	0	0	0	2	0	5	7	0	0	0	3	0	2	5	0	0	0	2	0	2	4	8	0	12	20
Sally	0	0	0	1	0	3	4	0	0	0	1	0	3	4	0	0	0	2	0	1	3	0	0	0	3	0	2	5	7	0	9	16
Mandy	1	0	0	3	2	10	16	0	0	0	2	0	5	7	0	0	0	1	0	4	5	0	0	0	2	0	2	4	9	2	21	32
																												Grand Totals	102	23	206	331
Totals	6	1	0	17	11	70	105	2	0	0	17	2	52	73	1	0	0	17	8	46	72	10	0	0	31	2	38	81				

second choice hypotheses shows, as was the case, that the target was often located in the second hypothesis by the older children. This perhaps reflects the greater variety of categories involving the target item generated by the older children.

TAB (2,8) THE ROLE OF EACH PCQ ASKED

PCQ	Used as a Direct PQ	Used as a Hypothesis PQ	Total
9 years	5	11	16
12 years	31	10	41
15 years	3	20	23

TAB (2,8) shows that the 12 year old group tended to use their PCQs as direct PQs thinly veiled as CQs whilst the 9 and 15 year old groups tended to use their PCQs to narrow down categories already defined in a preceding CQ, thus using their PCQs as hypotheses PQs. Why this should be so, is not clear, however a reasonable explanation could account for PCQs as some kind of natural phenomena accompanying the development of CQ questioning.

It would make sense to find that those children who were just mastering the technique of using CQs should make mistakes when trying to use them. As the PCQ is no more than a PQ which sounds like a CQ it would follow that inexperienced questioners would learn to make "the right noises", that is, to make their questions sound like the more advanced CQs, before they fully understood the logical implications of CQ type questions.

For example, Richard, in his first game asked 19 questions and of these 13 were PCQs; "is it a fruit?" (CQ) [no] - "do people go there to buy things?" (PCQ) [no] - "does it live in a stable ?" (PCQ) [no] - "does it put out fires?" (PCQ)[no] - "do animals live there?" (CQ) [no]- "does he deliver milk ?" (PCQ) [no] - "do children go there?" (PCQ) [no] - "is it something you put on your hands?" (PCQ) [no] - "Is it something you drive ?" (CQ) [no] - "something you wear on your head?" (PCQ) [no]- "something you live in?" (PCQ) [no] - "something you put on?" (CQ) [no] - "somewhere where you go to learn ?" (PCQ) [no] - "something that goes

round full of people ?" (PCQ) [no] - "something that drives on a farm?" (PCQ) [no] - "someone on a boat?" (PCQ) [pause, no] - "something you eat ?" (CQ) [no] - "somebody who delivers letters?" (PCQ) [yes] - "postman!" (PQ) [yes].

The frustrating aspect of this sort of questioning is that the first positive reply from the experimenter can only come once the correct card has been located and it would seem, from Richard's game, that the exercise had developed into a race to get a "yes" answer. Out of the 13 PCQs asked by Richard, there was not one which attempted to narrow down the categories located in a previous CQ simply because his CQs were wide of the mark. Looking more closely at his questions the sequence he followed was as follows:

CQ	PCQs in translation !
1 is it a fruit?	2 shop? 3 horse? 4 fire engine? (linked by location to Farm) →
→ 5 do animals live there?	→ 6 milkman) → 7 school? 8 gloves?
9 is it something you drive?	10 hat? 11 house? (linked by location to mittens) →
→ 12 something you put on?	13 school? (repeat) → 14 bus? 15 tractor? 16 sailor? (linked by location to banana) →
→ 17 something you eat?	18 postman? 19 postman!

In attempting to follow Richard's train of thought one can see that he wasn't being completely random but following a visual path through the display, often questioning adjacent items or basing CQs on adjacent items. It could be argued that he genuinely confused PCQs with CQs themselves, for instance "do animals live there?". The fact that animals may live in a house or a school may have been forgotten if his eyes fell on the farm after questioning the adjacent item, the fire engine, in question 4.

As in Exp.1, one must ask, which display did these children actually have in mind when they asked their questions, the one in front of them or

their own categorised mental conception of the display ?

WHAT GUIDED THE CQs ASKED ?

In Exp.1, it was found that with increasing age there was a dramatic shift away from using spatial characteristics of the display as bases of categorisation and an increase in the use of categories based on the numerical content of the display.

In the present experiment no numbers were used but children had the opportunity to work with categories developed out of the picture content of the display. To a large extent the sorts of content based CQs used by the children corresponded to the "Functional" and "Nominal" category questions found by (Bruner 1966).

FUNCTIONAL CQs

Bruner found that nearly all his American children used this sort of question and it acted as a transitory type of question halfway between a pure guess with a PQ and a more formally stated category question having its base of equivalence in a commonly accepted category name (such as food, animals etc). By asking "can I eat it" or "can I sit on it?" Bruner argued, the child placed himself as a frame of reference between the objects and therefore began to establish modes of categorisation based on what he or she could do to things.

In the present experiment most Functional CQs were of the type, "Is it mobile?" "can we ride on it?" "can you eat it?" "can you wear it?" but a close study of the wording of these CQs did not suggest that the use of "I" or "we" indicated the presence of a desire to establish the child or the experimenter as a frame of reference.

NOMINAL CQs

Bruner et al (1966) concluded that the older children preferred using these sorts of CQs whereby the category shared by all items had a commonly accepted name, such as fruit, vehicles, buildings etc. Six nominal categories were "built-in" to the present display, fruit, buildings,

vehicles, men, clothes and animals but any commonly accepted and named category could be made into a CQ, for instance, "is it a person?" "is it edible?" and "is it mechanical?"

SPATIAL vs CONTENTS BASED CATEGORISATION,

It would be tempting to change this heading to Spatial vs Nominal categorisation but that would be wrong because Functional CQs were based on the content of the display without having the grammatical format of a nominal CQ; after all the categorisation underlying the questions "is it edible" and "can you eat it?" was the same despite the noticeably different modes of expression.

FIG.C shows the distribution of questions generated by categorising the display spatially, (PQs connected by location + Row/Column CQs) plotted against the number of questions generated by categorising the display according to its contents (PQs connected by unstated category, Functional CQs and Nominal CQs).

FIG.C shows that with increasing age nearly all the questions asked were based on a content rather than a spatial categorisation of the display.

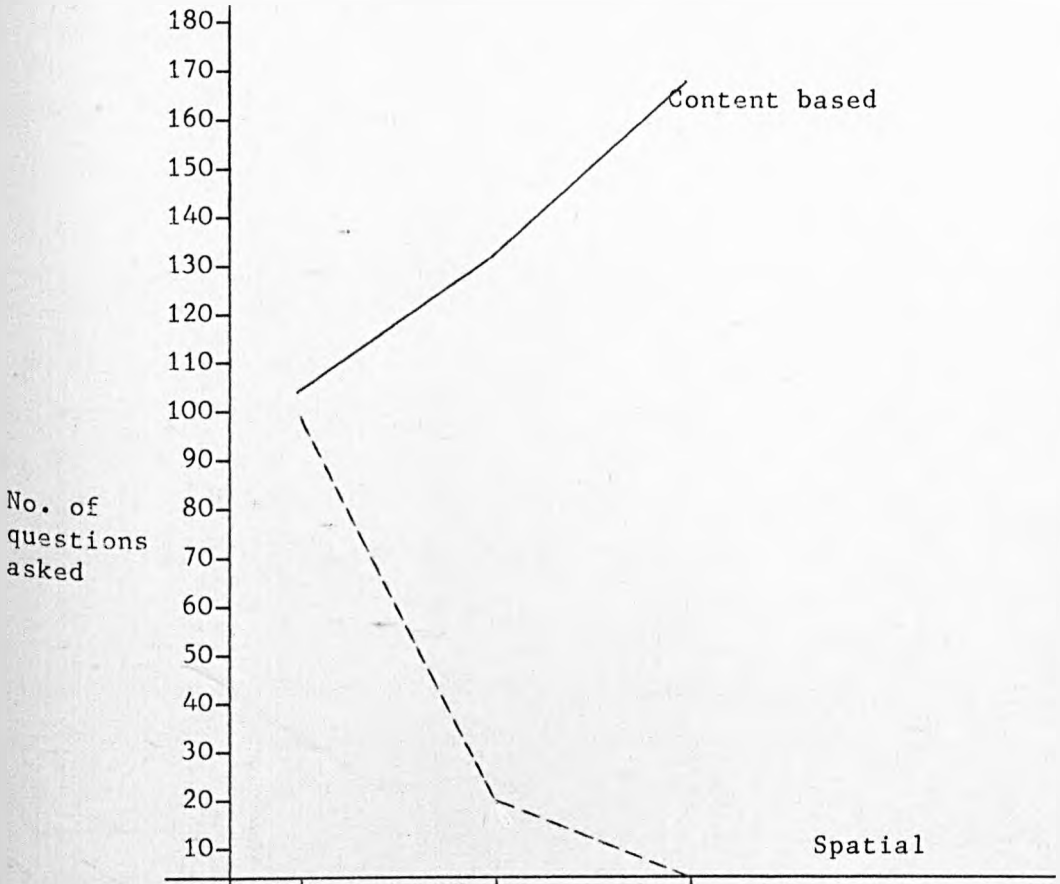
TAB (2,9) A Distribution of Perceptual/Spatial, Functional and Nominal based CQs

	Perceptual/Spatial				Functional		Nominal		Totals	
			Row/Column							
	No.of CQs asked	% of grand total	No.of CQs asked	% of grand total	No.of CQs asked	% of grand total	No.of CQs asked	% of grand total	No.of CQs asked	% of grand total
9 yrs	12	3%	7	2%	49	11%	21	5%	89	21%
12 yrs	39	10%	0	0	47	12%	54	14%	140	36%
15 yrs	39	12%	0	0	50	15%	117	35%	206	62%

TAB (2,9)B Distribution of illicit and repeated questions (PQs, PCQs & CQs

Age	Illicit (items not in display)	Repeated
9 yrs.	5	22
12 yrs.	1	18
15 yrs.	0	3

FIG. C. COMPARISON OF THE NUMBER OF QUESTIONS ASKED INVOLVING SPATIAL OR CONTENT-BASED CATEGORISATION OF THE DISPLAY



	9 yrs.	12 yrs.	15 yrs
Content based	104	131	167
Spatial	99	19	Ø

TAB (2,10) Number of children using each question type and the percentage of the total number of CQs asked by each question type.

	Perceptual / Spatial				Functional		Nominal		Total
	No.of child-ren	% of CQ total	No.of child-ren	% of CQ total	No.of child-ren	% of CQ total	No.of child-ren	% of CQ total	% of CQs asked
9 yrs	4	13%	1	8%	6	55%	5	24%	100%
12 yrs	5	27%	0	0	10	34%	9	39%	100%
15 yrs	8	19%	0	0	9	24%	11	57%	100%

PERCEPTUAL/SPATIAL, FUNCTIONAL AND NOMINAL CQs.

TAB (2,9) A shows the distribution of Perceptual, Functional and Nominal CQs used by each group. For greater clarity the spatial and Perceptual CQs are clearly distinguished to show which CQs referred to the

position of the card relative to the display as a whole ["Is it in this row ?" "Is it in this column ?"] and those CQs that referred to the visual content of each card ["Is it red?", "Is it round?"].

TAB (2,9)B shows the distribution of illicit and repeated questions whilst TAB (2,10) shows in greater detail who used the various CQ types and what percentage of the CQs asked by each group was devoted to each CQ type.

From TAB (2,9)A one can see that with increasing age there was a definite trend towards using more Nominal questions, "is it a fruit ?" "is it a man?", "is it a vehicle?" etc. TAB (2,9)B shows that this increase in interest in the content rather than the position of the display cards was not accompanied by an increase in illicit or repeated questions nor did the 9 year olds (who still used a lot of PQs) make as many mistakes in remembering what questions they had asked in the same game. In fact TAB (2,9)B follows the expected age-related decrease in the number of mistakes which, surprisingly, was not found to be the case in Exp.1.

TAB (2,10) shows the number of children who asked at least one question of each CQ type and the percentage of the total number of CQs asked accounted for by these children. From both these tables one can see that a move from perceptual/spatial to nominal questioning is not as striking as was seen in Exp.1.

The progression seems to be that of using a certain type of question with more relish than any other then passing on to the next type of question without discarding the earlier type completely. For instance, in the use of Functional questions the 9 year olds either used a lot of them or used none at all, whilst many more older children used Functional questions, only less frequently.

With nominal questions more older children used them more often than with younger children.

In the light of Exp.1 it is quite interesting to note that the only child who used a Row/Column CQ was a 9 year old (Paula). It would seem that using a Picture display seems to have made it possible for all age

groups to range their questions both at the display and their own mental conception of it. The Picture display certainly seems to have encouraged the younger children to engage in more categorisation based on the content of the display rather than its visual appearance.

This was quite a surprising result because one would have expected the 9 year olds to have asked a lot more perceptual questions such as "is it red?" "is it round?" given the noticeable preference for spatial/ perceptual categorisation found in Exp.1. In fact the older children used more perceptual questions and the neat age related increase in the depth of categorisation [perceptual ⟶ Functional ⟶ Nominal] described by Bruner only seems to have been present in the distribution of Functional and Nominal questions where there was a pronounced age related shift away from using Functional to Nominal CQs as the main CQ, with increasing age.

Of these questions the most popular Functional questions were:
"Do you wear them", "Does he deliver things?" "Can we eat it?"
"Does it move?" "Can we ride it?"
whilst, not surprisingly, the most popular nominal questions followed the built-in categories of the display:
"Is it a vehicle?" "Is it a man?" "Is it a fruit?" "Is it a building?"
"Is it an animal?" "Is it a piece of clothing?"

TENDENCY TO USE THE SAME QUESTIONS IN SUCCESSIVE GAMES.

In Exp.1. it was noticed that some children were continuing a line of thought not only within games, but between them as well, almost as if the four games were continuous. TAB (2,11) shows the number of children who repeated more than half the questions asked in the previous game.

TAB (2, 11) The number of children in each group who repeated more than half the questions asked in the previous game.

	in game 2	in game 3	in game 4
9 years	1	2	4
12 years	3	3	2
15 years	4	2	1

AS TAB (2, 11) shows not many children seemed to have formulated a routine which lasted for more than half the questions asked in a successive game. To be fair, many 15 and 12 year olds did repeat certain nominal questions in nearly all their games, but this practice rarely followed any more than 3 questions before an original tack was followed, often with mixed success.

In researching this table it became obvious that the older children were approaching a strategy of using selective CQs whilst the younger children seemed to prefer a chain of hopeful PQs. TAB(2,12) shows the distribution of CQs amongst all the repeated questions asked by each group.

TAB (2, 12) Percentage number of repeated questions which were CQs. (Take each percentage from 100 to give percentage use of PQ & PCQ). Total number of repeated questions asked is given in brackets.

	in game 2	in game 3	in game 4
9 years	30% (20)	18% (33)	25% (44)
12 years	46% (24)	68% (22)	53% (19)
15 years	100% (24)	100% (23)	93% (15)

This table clearly shows that with increasing age the proportion of questions repeated tended to be CQs. This is in sharp contrast with the results obtained in Exp.1 (TAB 1,12) where the 15 and 12 year old groups were virtually indistinguishable.

This tendency to repeat CQs is clearly an attempt by some children to develop a category questioning strategy, indeed a closer study of the number of CQs asked in each successive game showed that considerably more older children repeated at least half the CQs asked in their previous game, especially in games 2 and 3 (TAB 2,13) A.

EFFICIENCY OF CQ STRATEGY

Surprisingly, those children who repeated at least half the CQs asked in their preceding game tended to ask fewer questions to solution in this subsequent game and this was seen to be the case for all age groups. The

figures in brackets in TAB (2, 13) show the number of children who both repeated more than half the CQs and located the target in fewer questions than in their preceding game.

This is clear evidence to show that children who repeated more than half the CQs which they had asked in the immediately preceeding game were more efficient than the children who did not. [6=3.612, $p < 0.001$, in a 2 tail test with 8 degrees of freedom].

TAB (2, 13)A The number of children using at least half the CQs asked in their preceeding game (Numbers in brackets indicate the number of these children who also asked fewer questions to solution than in their preceeding game).

	in game 2	in game 3	in game 4	Number of children common to all
9 years	3 (2)	3 (3)	3 (1)	2
12 years	5 (5)	4 (3)	4 (3)	0
15 years	7 (6)	9 (6)	3 (2)	1

An interesting point emerges from this table and that is the relatively small number of children who continued repeating their CQ strategy through all their games. Most children in the 15 year old group used the same CQs in games 1, 2 and 3 then diverted their CQs in game 4. To a lesser degree, this trend was also present in the behaviour of the 12 year old children too. This pattern is shown in TAB (2, 13)B.

TAB (2,13) B Number of children common to each game in TAB (2,13)A

	in games 1 & 2	in games 2 & 3	in games 3 & 4	common to all
9 yrs. common	3 (2)	2 (2)	2 (1)	2
new		1 (1)	1 (0)	
12 yrs. common	5 (5)	2 (1)	1 (0)	0
new		2 (2)	3 (3)	
15 yrs. common	7 (6)	6 (3)	2 (1)	1
new		3 (3)	1 (1)	

This table shows that, despite the success of certain types of CQs, the 12 and 15 year olds who repeated them from game 1 to game 3 were not so eager to repeat them in game 4. From this it would seem that, far from developing a routinised set of CQs, these children were simply experimenting with CQ types and changing them, regardless of success, from game to game.

This shows up clearly in the 15 year old group's behaviour between games 3 and 4. Despite 6 out of 9 children having successfully located the target in fewer questions in game 3 than in game 2 only 2 children actually repeated more than half these CQs in game 4.

At the other extreme the 9 year olds who did hit on a set of useful questions stuck to them with greater diligence (these were Paula who sensibly stuck to a Row/Column strategy and Jeff who kept asking "can you wear it?"). A closer analysis of the repeated questions asked by the 12 and 15 year olds shows that these CQs were nearly all Nominal ("is it a fruit?", "is it a person?" "is it a building" etc.) and that after using these in 2 or 3 games the child simply used other phrases often involving different CQ types.

IN CONCLUSION

The remarkable behaviour of the 9 year old children in Experiment 1 involving the number display was not discovered in the present experiment and it is suggested that whilst older children are tempted to categorise beyond their levels of strategic questioning with a number display they are more adept with a picture display. In this experiment definite age differences were observed between the three groups in nearly all aspects of questioning investigated. Older children tended to use CQs more than PQs and younger children tended to use PQs in preference to CQs as was found in Exp.1. Interestingly ,it was found that children from each age group developed CQ strategies which were quite effective but more older children did so and they also showed greater flexibility in their CQ questioning overall, than did the younger children.

SUMMARY

1) PICTURES vs. NUMBERS.

The dramatic age related shift from using PQs to CQs observed in Exp.1 was also found in Exp.2 although the corresponding age shift from using spatial/perceptual categorisation to content based categorisation was not so striking.

2) GENERAL

a) On nearly all measures there was a clear age difference between the three groups.

b) More spatial questions were asked by the 9 year olds, the 12 year olds asked very few and the 15 year olds asked none.

c) Of those children who did use CQs the 9 year olds showed a preference for Functional CQs whilst the 15 year olds used more Nominal CQs.

d) The number of repeated questions decreased with age.

e) In terms of a strategy over 4 games the 15 year olds used a selection of recurring CQs whilst the 9 year olds favoured a chain of hopeful PQs.

f) Of those children who repeated more than half the CQs asked in the previous game all were rewarded by locating the target in fewer questions than in their previous game. This was the only measure showing any evidence for the development of a CQ strategy leading to a reduction in the number of questions asked to solution.

In general terms the older children used more CQs and took fewer questions to solution but this trend was not significant nor sufficient evidence to suggest a cause and effect connection.

CHAPTER FOUR

Experiment 3

20 Questions using a Word display

AIM

To investigate the questioning of 9, 12 and 15 year olds with a Word display in the light of results obtained in Experiments 1 and 2 with Number and Picture displays.

PARTICIPANTS

Altogether 36 children from 3 age groups 12 x 9 year olds (6 boys, 6 girls) mean age 9 years 4 months; 12 x 12 year olds (6 boys, 6 girls) mean age 12 years 5 months; 12 x 15 year olds (5 boys, 7 girls) mean age 15 years 3 months.

Each child was chosen by the class teacher as being an "average" child so the teacher was left to choose from across the ability range.

MATERIALS

As in Exp.1 and 2 a 64cm x 52cm cardboard sheet was used, on which 24, 10½cm x 7½cm cards were mounted in 6 rows, 4 columns deep.

These cards bore the names of the picture items used in Exp.2. Each word was written with a capital first letter and subsequent low case lettering similar to that used in junior schools, e.g.

FIG. C. SAMPLE CARD

These words came from six distinct categories, 4 animals, 4 items of clothing, 4 fruits, 4 men, 4 buildings and 4 vehicles. The cards were arranged in exactly the same positions as those used in the picture display in Exp.1, the only difference being the elevation of the cardboard sheet. In Exp.1 six ran along the top whereas in this display four cards ran along the top. This change was made to make best use of the horizontal space for lettering on each card, the arrangement was as follows; (Fig. D).

FIG. D. WORD DISPLAY

Cow	Orange	Shop	Soldier
Gloves	House	Car	Lemon
Banana	Horse	Postman	Rabbit
Sailor	Dress	Pig	Tractor
Fire Engine	Socks	School	Hat
Farm	Milkman	Bus	Apple

PROCEDURE

As in Exp.1 and 2 the children were individually brought from their classrooms and allowed to identify all 24 cards by pointing to, and naming them (PHASE 1). It must be added that all the 9 year olds could read each card and particular care was taken to ensure that any card which the child stumbled over was fully "readable" by the time the next phase was begun.

After familiarising themselves with the display the children then played 4 games of 20 questions (PHASE 2).

The same instructions were used as in Exp.1 and 2, the only changes being "words" instead of "numbers" or "pictures", as one would expect. As in Exp.2 the targets for the four consecutive games were (1) postman, (2) tractor, (3) socks and (4) cow.

TAB (3, 1) The number of games completed in a given number of questions by each age group.

No. of questions	9 years						12 years						15 years					
	Game 1	2	3	4	Total		Game 1	2	3	4	Total		Game 1	2	3	4	Total	
1	2			1	3	3												
2	1	1			2	5			2		2	2	1		1	1	3	3
3	2			2	4	9							1	1		2	4	7
4		2		1	3	12		1	1	4	6	8		1		1	2	9
5	1	4	1	2	8	20	3	2		1	6	14	3	1	1	1	6	15
6	2	1	2		5	25	2	2	2	2	8	22	2	1	3	2	8	23
7	3	2	1	2	8	33	1	3	4	2	10	32	1	2	1	3	7	30
8			1	1	2	35	4	2	1	1	8	40	2	4	3	1	10	40
9									2		2	42		1	2		3	43
10		1	1		2	37							1		1		2	45
11			1	2	3	40		1		1	2	44						
12													1				1	46
13	1		2		3	43												
14							1				1	45						
15			1		1	44		1		1	2	47						
16							1				1	48						
17																		
18														1		1	2	48
19																		
20			2		2	46												
21																		
22																		
23																		
24																		
25				1	1	47												
26																		
27																		
28		1			1	48												
29																		
30																		
Totals	12	12	12	12	48		12	12	12	12	48		12	12	12	12	48	
Medians	5½	5	10½	6	6		7½	7	7	6	7		6	7½	7½	6	7	

Each entry shows the number of children who located the target in the number of questions shown.

RESULTS

TAB (3,1) shows the number of games completed plotted against the number of questions asked per game. One can see immediately from column A (running total) that the 9 year old group completed more games in fewer questions than the 12 and 15 year old groups right up to the 8th question, by which time 2/3 of all games played were completed. Surprisingly, many children from all age groups located the target item within 4 questions, 12 x 9 year olds, 8 x 12 year olds and 9 x 15 year olds.

EFFICIENCY

As the median scores show, the 9 year olds managed to complete half their games in 6 questions whereas both the 12 and 15 year olds took 7 questions. A strange feature of TAB (3,1) is the sharp increase in the number of questions used by the 9 year olds in their third game (median 10 questions). Quickly comparing the results of Exp.1, 2 and 3 [in TABS (1,1), (2,1) and (3,1)] it would seem that the first two games played by the present 9 year old group were concluded in fewer questions than any other age group in any of the 3 conditions, whilst in their third game, they used more questions than any other age group in any of the three conditions.

TYPES OF QUESTIONS ASKED

TAB (3,2) The number of questions of each type asked (percentage of total shown in brackets) and the number of children who asked each type of question [in square brackets]

Question type	9 YEARS Child-ren	9 YEARS No. of questions	12 YEARS Child-ren	12 YEARS No. of questions	15 YEARS Child-ren	15 YEARS No. of questions
PQ	[12]	275 (74%)	[12]	105 (31%)	[12]	100 (30%)
PCQ	[4]	22 (6%)	[9]	39 (11%)	[8]	38 (12%)
CQ	[8]	76 (20%)	[12]	196 (58%)	[12]	190 (58%)
Grand Total		373 (100%)		340 (100%)		328 (100%)

TAB (3,2) shows that the shift away from using predominantly PQs to using mostly CQs with increasing age was found in this experiment as was the case in Exps. 1 and 2.

This age related shift was statistically significant, [2 way ANOVA, Age x PQ/CQ interaction; $F = 17.457, p < 0.001$, $df = (2,66)$]. One way ANOVAs conducted on the number of questions asked of each question type as a function of age showed statistically significant differences in the use of CQs, [$F = 9.78$, $p < 0.001$, $df = (2,33)$] and PQs, [$F = 8.759$, $p < 0.005$, $df = (2,33)$], but no significant differences in either the use of PCQs, [$F < 1$, $df = (2,33)$] or in the total number of questions asked to solution, [$F < 1$, $df = (2,33)$].[1]

As can be seen from TAB (3,2) the performance of the 12 year olds was almost identical to that of the 15 year olds in the number of PQs, PCQs and CQs that were used.

WHAT GUIDED THE PQs ASKED

As the Word display was designed as a parallel display to the one using Pictures the same PQ analysis was applied to the results and TAB (3,3)A shows the distribution of the 4 types of PQ

TAB (3,3)A Distribution of the various types of PQ used. (Showing the number of children using each type, how many they used and the percentage of the grand total accounted for by each PQ type).

PQ Subtype	9 YEARS			12 YEARS			15 YEARS		
	Child-ren	Questions	%	Child-ren	Questions	%	Child-ren	Questions	%
Direct	9	105	28.2	4	14	4.1	3	6	1.8
Connected by location	5	85	22.8	1	2	0.6	0	0	0
Connected by category	6	23	6.2	3	5	1.5	2	6	1.8
Hypothesis	7	62	16.6	12	84	24.7	12	88	26.8
Total	12	275	73.8	12	105	30.9	12	100	30.4

TAB (3,3)A shows that with increasing age the amount of pure guesses fell dramatically; the 9 year olds asked 275 PQs of which 105 (38%) were guesses, the 12 year olds asked 105 PQs of which 14(13%) were guesses whilst the 15 year olds asked 100 PQs of which only 3(3%) were guesses.

1. In order to carry out these statistical tests the number of questions asked per question type, as well as the total number of questions asked by each child were averaged over the 4 games played so that each child's performance was reduced to an average score on each of the 4 variables, PQ, CQ, PCQ and TOTAL. Where it was thought that the distribution of some date may not have conformed to the normal distribution, the parametric tests were compared with equivalent non-parametric tests. In all cases what was significant or not significant remained significant or not significant.

Despite the fact that the 9 year olds resorted to pure guesses, 105 PQs, they also used 108 PQs involving some unstated organisation.

PQs connected by location.

Five 9 year olds resorted to this type of question and between them they accounted for over 1/5th of the questions asked by the whole group whereas only one 12 year old asked two questions and no 15 year olds asked any. Clearly, in the absence of using spatial CQs, whose potential may have been outside the experience of four of the five 9 year olds (who, incidentally used no CQs at all,) these children executed a spatial strategy without overtly naming it.

One child, Elaine, used 5 PQs connected by location and 4 CQs of the perceptual kind but a closer study of her protocol shows that the same CQ was used in each game, "Does it begin with a H" [House, Horse, Hat] with no success so she proceeded with an assortment of PQs.

Examining all the data from the three experimental conditions no evidence was found to identify a clear connection between the use of PQs connected by location and simultaneous use of spatial CQs. Only one child, the 12 year old Christopher A, in the present experiment used both in his first game, but there is little to suggest that the PQs connected by location were intended to act as an unstated spatial CQ as the protocol, and accompanying diagram show.

Christopher A : Game 1

1. Chris "Is it in this row?" [row 4]	CQ (Row/Column)
E "No"	
2. Chris. "Is it vertical or across ?"	CQ (Row/Column)
E "Pardon?"	
3. Chris. "Does it go from that way or down to that way ?"	PCQ
E "All the cards are either one way or another aren't they?"	
4. Chris [visibly amused] "Does it begin with a G?"	PCQ (only gloves)
E. "No"	
5. Chris "Does it begin with an S?"	CQ (perceptual)
E. "No"	
6. Chris "Is it the car?"	PQ (direct)
E "No"	
7. Chris "Horse ?"	PQ (connected by location)
E "No"	
8. Chris "Banana?"	PQ (connected by location)
E "No"	
9. Chris "Postman?"	PQ (Direct)

Cow	Orange	Shop(5)	Soldier(5)
Gloves(4)	House	Car(6)	Lemon
Banana(8)	Horse(7)	Postman(9)	Rabbit
Sailor(15)	Dress(1)	Pig(1)	Tractor(1)
Fire Engine	Socks(5)	School(5)	Hat
Farm	Milkman	Bus	Apple

PQs connected by an unstated category

Despite the fact that half the 9 year olds used this sort of PQ they used very few of them as did the 3 x 12 year olds and the 2 x 15 year olds.

As was the case with the PQs connected by location, most of the 9 year olds using PQs connected by an unstated category used no CQs at all, Kevin, Darren, Sharon and Lynn most often used this type of PQ in chains of two and at the most three links long, rarely listing the contents of a whole category before plunging into further usually direct PQs.

The two 9 year olds who also used CQs, Christopher B and Elaine, used their PQs connected by unstated categories to complement their CQs, in that they didn't contradict any information previously given, whilst

the 12 year olds used them as hypotheses.

Of the two 15 year olds who used this PQ type Judy only used one whilst Jane used 5 and she used them very obviously in place of stating a CQ.

Jane, 15 years : 3rd game

1. Jane "Is it an animal ?"	CQ (Nominal)
E "No"	
2. Jane "Is it a motor thing?"	CQ (Nominal)
E "No"	
3. Jane "Is it a person?"	CQ (Nominal)
E "No"	
4. Jane "Banana?"	PQ (Direct) [three categories left]
E "No"	
5. Jane "Orange ?"	PQ (linked by unstated category - fruit)
E "No"	
6. Jane "Lemon?"	PQ (linked by unstated category - fruit)
E "No"	
7. Jane "Is it a building?"	CQ (Nominal) [apple + clothes category left]
E "No"	
8. Jane "Hat?"	PQ (Direct)
E " No"	
9. Jane "Gloves?"	PQ (linked by unstated category - clothes)
10. Jane "Socks?"	PQ (linked by unstated category - clothes)

By her tenth question only two items remained unquestioned, the apple and the dress. Clearly there seemed to be a continuum underlying the use of this type of PQ through each of the age groups marked by an increasing awareness of the dependence of each PQ on previous questions.

GAMES CONCLUDED WITHIN FOUR QUESTIONS

TAB (3, 3) B Games concluded within 4 questions

	9 years	12 years	15 years	Total
Exp. 1	9 games	6 games	2 games	17 games
Exp. 2	9 games	11 games	10 games	30 games
Exp. 3	12 games	8 games	9 games	29 games

In TAB (3, 3) B the number of children successfully locating the target within 4 questions in each of the display conditions were compared. It was found that children from all age groups in the words display condition managed to solve the same in fewer questions than one would expect even by chance or by using the most efficient logical strategy.

To recap, the 9 year olds in the Numbers display condition performed in this respect far better than the 12 or 15 year old group. This was explained in terms of the fact that whereas the 9 year olds were responding to the more obvious patterns in the display material the 12 and 15 year olds were too concerned with constructing elaborately categorised CQs to equal the fortuitously successful approaches made by the 9 year olds.

In the Picture display condition all groups equalled the performance of the 9 year olds in the previous experiment. It was noticed that all age groups tended to use CQs to locate the target category then locate the target with hypothesis PQs within 4 questions but the older children seemed to prefer more precise location with a CQ before hazarding a hypothesis.

In the present experiment, as TAB (3, 4)A shows, the children performed almost exactly as did those in the Picture display condition. There were some differences, whereas in Exp.2 the 15 year olds asked more CQs than the 12 year olds in the present experiment, the 12 and 15 year olds were virtually identical. No 12 year old located the target item within 4 questions by pure guesswork.

TAB (3, 4)A Details of the 29 games played and completed in or under 4 questions.

Games including Direct, Direct-linked and Hypothesis-like PQs									Games in which hypotheses were the only PQs asked							
Name	Game No.	Direct	Direct linked	Hypothesis-linked	Hypothesis	PCQ	CQ	Total	Name	Game No.	Direct	Direct-linked	Hypothesis-linked	Hypothesis	PCQ	CQ	Total
9 years																	
Kevin	2	4						4	Frank	4				1		3	4
Darren	4	1						1	Pat	1				1		1	2
Sharon A	1	1						1	Pat	2				1		1	2
Elaine	1	2					1	3	Lisa	1				2		1	3
Lynn	1	1						1	Lisa	4				2		1	3
									Sharon B	2				3		1	4
									Sharon B	3				2		1	3
12 years																	
									Christopher	3				1		1	2
									Christopher	4				3		1	4
									Thomas	2				1		3	4
									Mandy	4				1		3	4
									Hayley	3				1		1	2
									Hayley	4				3		1	4
									Christine	3				1	1	2	4
									Christine	4				1	1	2	4
15 years																	
Gillian A	1	1				1		2	Gillian A	2				1	1	1	3
									Gillian A	4				1		1	2
									Jane	4				1		2	3
									Joanne	2				2		2	4
									Joanne	3				1		1	2
									Michael	1				1	1	1	3
									Anthony	4				1		3	4
									Karl	4				1		2	3

TAB (3, 4)B The questions asked by those children who located the target in 4 questions or less.

Name	Game No	Tot -al	
9 years			
Kevin	2	4	"orange?" X "fire-engine?" X "rabbit?" X "tractor?" ✓
Darren	4	1	"cow?" ✓
Sharon A	1	1	"postman" ✓
Elaine	1	3	"House?" X "begin with an H?" X "postman?" ✓
Lynn	1	1	"postman" ✓ [Are you thinking about him posting letters because I like the people who post letters!]
Frank	4	4	"Is it sour?" X "Does it grunt?" ✓ "4 legs?" ✓ "cow" ✓
Pat	1	2	[I only want to ask one question] "Is it on the outside or the middle, er the middle?" [socks, dress horse; school, pig, postman] ✓ postman ✓
Pat	2	2	"Middle?" X tractor? ✓
Lisa	1	3	"Is it a man?" ✓ "milkman?" X "postman?" ✓
Lisa	4	3	"Is it an animal?" ✓ "rabbit?" X "cow?" ✓
Sharon B	2	4	"Do you drive it ?" ✓ "car?" X "fire engine?" X "tractor?" ✓
Sharon B	3	3	"Do you work at it ?" X "lives on a farm?" ✓ "cow?" ✓
12 years			
Christopher	3	2	"That row?" [column 2] ✓ "socks?" ✓ [He watched my eye movements]
Christopher	4	4	"That row? [column 1] ✓ "sailor?" X "farm?" X "cow?" ✓
Thomas	2	4	"is it a vehicle?" ✓ "Does it carry lots of people?" X "is it used for working with?" ✓ "tractor" ✓
Mandy	4	4	"Is it a person?" X "something you eat?" ✓ "is it an animal?" ✓ "cow?" ✓
Hayley	3	2	"Is it an animal ?" ✓ "cow" ✓
Hayley	4	4	"Is it clothing?" ✓ "dress?" X "gloves?", X "socks" ✓
Christine	3	4	"Is it human?" X "clothing?" ✓ "wear it on your feet?" ✓ "socks" ✓
Christine	4	4	"Is it human?" X "animal?" ✓ "milk?" ✓ "cow?" ✓
15 years			
Gillian A	1	2	"Does he deliver letters?" ✓ "postman" ✓
Gillian A	2	3	"Is it a fruit?" X "is it driven on a farm?" ✓ "tractor" ✓
Gillian A	4	2	"Is it a farm animal?" ✓ "cow" ✓
Jane	4	3	"Is it an animal?" ✓ is it edible?" ✓ "cow" ✓
Joanne	2	4	"Is it an animal ?" X "transport?" ✓ "Fire engine?" X "tractor" ✓
Joanne	3	2	"Is it clothing?" ✓ "socks" ✓
Michael	1	3	"Is it human?" ✓ "Does he work for the post office?" ✓ "postman" ✓
Anthony	4	4	"Is it eaten?" ✓ "Is it a fruit?" X "Is it meat?" ✓ "is it a co ✓
Karl	4	3	"Is it an animal?" ✓ "a farm animal?" ✓ "cow" ✓

As TAB (3, 4)B shows, there was evidence of guesswork amongst the 9 year olds where three games were concluded in the first question of the first game. There would be grounds for suspicion that these children talked about the game back in their classroom were it not for the fact that the children involved came from separate schools.

Sharon A followed Elaine some half an hour after Elaine had played her 4 games so it could be that Sharon A simply remembered what her friend had said.

It is less likely that Darren heard the answer to game 1 from a girl because at that age boys and girls mutually ignore each other. There is a faint chance that Pat, who preceded Darren into the experimental room whispered the answer to the first game to Darren as they both passed each other. What is fascinating is that a child should remember the solution to game 1 rather than any other game.

To the experimenter's knowledge only one child actually cheated and that was Kevin who took advantage of the fact that for that particular game the experimenter had written the target items on a piece of paper which Kevin was attempting to read back to front as the experimenter was holding it between the fingers of one hand. These points are mentioned because the experimenter was constantly aware that the children were treating these experiments (quite rightly so) as games to be won by any method possible. Fortunately the experimenter had only tested one other child before Kevin and for that the paper had been on the experimenter's knee throughout the experiment. All future experiments were conducted without the paper!

Kevin's second game is included in these results because, despite all the checks made to ensure that no child "cheated", his policy of playing the game was just as much a 'strategy' as any other approach made by the children, in fact many of the younger children who used excessive amounts of PQs (especially direct PQs) may have been playing

for time whilst following more furtive methods of discovery.

All the other games shown on the right hand side of TAB (3,4)A were concluded by the child locating the correct category with an appropriate CQ then narrowing down that category efficiently with hypothesis PQs, an example is 9 year old Lisa's first game:

Lisa "Is it an animal ?"	CQ
Exp "Yes"	
Lisa "rabbit?"	PQ
Exp. "No"	
Lisa "cow?"	PQ
Exp. "yes"	

Not all the 9 year olds were as logical with their CQs; Elaine's first game used a CQ which she simply ignored.

Elaine "Is it a house?"	PQ
Exp. "No"	
Elaine "Does it begin with an H?"	CQ
Exp. "No"	
Elaine "Postman"	PQ
Exp. "Yes"	

As was noticed in the pictures display condition, the 9 year olds who located the correct category with their first question tended to use more PQs to locate the target, whereas the older children more often used further CQs to narrow down the target category even further before they ventured a PQ which was invariably correct. An example of this is 15 year old Anthony's fourth game.

Anthony "Is it eaten ?"	CQ
Exp. "Yes"	
Anthony "Is it a fruit?"	CQ
Exp. "No"	
Anthony "Is it meat ?"	CQ
Exp. "Yes"	
Anthony "Is it a cow?"	PQ
Exp. "Yes"	

This game contrasts nicely with the first game of 9 year old Lisa quoted above.

PATTERNS IN THE MATERIAL

Having so many games concluded within 4 questions casts suspicion on the nature of the display itself, so in order to check that no individual cards, especially the target cards, were somehow more obvious candidates for choice all the non-hypothesis PQs asked of each card were tabulated and a correlation was made between this distribution for each age group. As TAB (3, 4)C shows the distribution of these PQs per card was found to be random which means that no one card was more inviting to any child who wished to guess at the target.

The next step was to see if some cards were more representative of their particular categories than other cards. To do this a similar distribution and between group correlation was made of the first and then second choice hypotheses. As was found in Exp.2 (and to a more pronounced degree in Exp.1) the 9 year olds shared the same group of cards in their first hypotheses with the 12 and 15 year olds thus supporting the idea that certain cards may have been more representative of the categories shared by each age group.

The high correlation between the 12 and 15 year olds in their second choice hypotheses shows, as was the case, that the target was often located in the second hypothesis by the older children.

TAB (3, 4) C Correlations between the number of non-hypothesis PQs asked of each card by each age group and also between the groups for their first and second hypotheses.

Correlation between	Non-hypothesis PQs	Hypothesis 1	Hypothesis 2
9 yrs & 12 yrs.	Zero	+0.5742**	+0.346
9 yrs & 15 yrs	Zero	+0.5355*	+0.3755
12 yrs & 15 yrs.	Zero	+0.4147	+0.8416****

Pearsons r with 22df. (* $r > 0.423$ therefore $p < 0.05$)
(** $r > 0.537$ therefore $p < 0.01$)
(**** $r > 0.652$ therefore $p < 0.001$)

TABS (3,5), (3,6) and (3,7) give details of the types of question asked by each child in each game.

TAB (3, 5) *HOW EACH 9 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME*

9 years	GAME 1							GAME 2							GAME 3							GAME 4							PQ	PCQ	CQ	Total
	Direct	location connected by	stated category connect by un-	Hypothesis	PCQ	CQ	Total	Direct	location connected by	stated category connected by un-	Hypothesis	PCQ	CQ	Total	Direct	location connected by	stated category connected by un-	Hypothesis	PCQ	CQ	Total	Direct	location connected by	stated category connected by un-	Hypothesis	PCQ	CQ	Total				
Kevin	6	0	0	0	0	0	6	3	1	0	0	0	0	4	11	6	3	0	0	0	20	3	5	3	0	0	0	11	41	0	0	41
Gary	0	0	0	1	4	2	7	0	0	0	1	2	3	6	0	0	0	1	3	1	5	0	0	0	2	1	2	5	5	10	8	23
Warren	1	0	0	0	1	4	6	0	0	0	3	0	2	5	0	0	0	3	0	3	6	1	0	0	4	0	3	8	12	1	12	25
Darren	2	1	2	0	0	0	5	3	3	22	0	0	0	28	4	16	0	0	0	0	20	1	0	0	0	0	0	1	54	0	0	54
Frank	0	0	0	1	5	7	13	0	0	0	5	0	2	7	0	0	0	2	3	3	8	0	0	0	1	0	3	4	9	8	15	32
Christopher	1	0	0	3	0	3	7	0	0	0	3	0	2	5	6	0	3	0	0	6	15	0	0	0	4	0	1	5	20	0	12	32
Sharon	1	0	0	0	0	0	1	2	6	2	0	0	0	10	9	4	0	0	0	0	13	6	1	0	0	0	0	7	31	0	0	31
Pat	0	0	0	1	0	1	2	0	0	0	1	0	1	2	1	0	0	5	0	1	7	1	0	0	4	0	2	7	13	0	5	18
Elaine	2	0	0	0	0	1	3	4	1	1	0	0	1	7	9	2	1	0	0	1	13	7	2	1	0	0	1	11	30	0	4	34
Lynne	1	0	0	0	0	0	1	3	1	1	0	0	0	5	7	3	1	0	0	0	11	9	14	2	0	0	0	25	42	0	0	42
Lisa	0	0	0	2	0	1	3	1	0	0	2	0	2	5	0	0	0	3	0	3	6	0	0	0	2	0	1	3	10	0	7	17
Sharon	0	0	0	3	1	3	7	0	0	0	3	0	1	4	0	0	0	1	2	7	10	0	0	0	1	0	2	3	8	3	13	24
Total	14	1	2	11	11	22	61	16	12	26	18	2	14	88	47	31	8	15	8	25	134	28	22	6	18	1	15	90	275	22	76	373

Grand Totals

TAB (3,6) *HOW EACH 12 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME*

12 years	GAME 1							GAME 2							GAME 3							GAME 4							PQ	PCQ	CQ	Total
	Direct	location	connected by	connected by un-stated category	Hypothesis	PCQ	CQ	Total	Direct	location	connected by	connected by un-stated category	Hypothesis	PCQ	CQ	Total	Direct	location	connected by	connected by un-stated category	Hypothesis	PCQ	CQ	Total	Direct:	location	connected by	connected by un-stated category	Hypothesis	PCQ	CQ	Total				
Paul	0	0	0	1	1	3	5	0	0	0	3	1	4	8	0	0	0	2	1	3	6	0	0	0	2	2	4	8	8	5	14	27
ChristopherA	2	2	0	0	1	3	8	1	0	0	3	0	1	5	0	0	0	1	0	1	2	0	0	0	3	0	1	4	12	1	6	19
Mark	4	0	1	0	1	10	16	1	0	1	1	0	8	11	0	0	0	1	0	5	6	0	0	0	3	0	3	6	12	1	26	39
ChristopherB	0	0	0	1	0	6	7	0	0	0	4	0	11	15	0	0	0	1	2	4	7	0	0	0	1	1	3	5	7	3	24	34
Thomas	0	0	0	1	1	3	5	0	0	0	1	0	3	4	0	0	0	2	1	4	7	5	0	1	0	0	5	11	10	2	15	27
David	0	0	0	4	1	3	8	0	0	0	2	1	3	6	0	0	0	2	3	4	9	0	0	0	2	2	11	15	10	7	21	38
Janette	1	0	0	0	5	8	14	0	0	0	1	2	4	7	0	0	0	2	1	4	7	0	0	0	4	1	1	6	8	9	17	34
Mandy	0	0	0	1	0	4	5	0	0	0	1	0	6	7	0	0	0	3	0	6	9	0	0	0	1	0	3	4	6	0	19	25
Julie	0	0	0	2	0	4	6	0	0	0	2	0	3	5	0	0	0	4	0	4	8	0	0	0	5	0	2	7	13	0	13	26
Diane	0	0	0	1	2	5	8	0	0	2	1	0	4	7	0	0	0	2	1	4	7	0	0	0	1	1	5	7	7	4	18	29
Hayley	0	0	0	3	0	5	8	0	0	0	1	0	5	6	0	0	0	1	0	1	2	0	0	0	3	0	1	4	8	0	12	20
Christine	0	0	0	1	3	2	6	0	0	0	1	2	5	8	0	0	0	1	1	2	4	0	0	0	1	1	2	4	4	7	11	22
Total	7	2	1	15	15	56	96	2	0	3	21	6	57	89	0	0	0	22	10	42	74	5	0	1	26	8	41	81	105	39	196	340

Grand Totals

TAB (3,7) HOW EACH 15 YEAR OLD CHILD USED THEIR QUESTIONS GAME BY GAME

15 years	GAME 1							GAME 2							GAME 3							GAME 4										
	Direct location	Connected by	Connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	Connected by	Connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	Connected by	Connected by unstated category	Hypothesis	PCQ	CQ	Total	Direct location	Connected by	Connected by unstated category	Hypothesis	PCQ	CQ	Total	PQ	PCQ	CQ	Total
Michael	0	0	0	1	1	1	3	0	0	0	1	2	2	5	0	0	0	1	2	4	7	0	0	0	2	0	4	6	5	5	11	21
Paul	0	0	0	1	1	6	8	0	0	0	5	0	13	18	0	0	0	1	3	2	6	0	0	0	7	0	11	18	14	4	32	50
William	0	0	0	1	1	3	5	0	0	0	2	0	5	7	0	0	0	1	1	7	9	0	0	0	2	2	4	8	6	4	19	29
Anthony	0	0	0	2	1	2	5	0	0	0	4	1	4	9	0	0	0	1	3	1	5	0	0	0	1	0	3	4	8	5	10	23
Karl	0	0	0	2	0	6	8	0	0	0	4	0	4	8	0	0	0	2	1	3	6	0	0	0	1	0	2	3	9	1	15	25
Helen	0	0	0	1	0	6	7	0	0	0	2	0	6	8	0	0	0	4	0	4	8	0	0	0	5	0	2	7	12	0	18	30
Gillian	1	0	0	0	1	0	2	0	0	0	1	1	1	3	1	0	0	0	6	2	9	0	0	0	1	0	1	2	4	8	4	16
Christine	0	0	0	1	1	4	6	0	0	0	1	2	5	8	0	0	0	1	3	2	6	0	0	0	1	0	6	7	4	6	17	27
Jane	1	0	1	0	0	3	5	0	0	0	2	0	4	6	2	0	4	0	0	4	10	0	0	0	1	0	2	3	11	0	13	24
Judy	1	0	1	3	0	5	10	0	0	0	2	0	5	7	0	0	0	4	0	4	8	0	0	0	2	0	4	6	13	0	18	31
Joanne	0	0	0	1	0	5	6	0	0	0	2	0	2	4	0	0	0	1	0	1	2	0	0	0	3	0	2	5	7	0	10	17
Maxine	0	0	0	1	4	7	12	0	0	0	3	1	4	8	0	0	0	2	0	6	8	0	0	0	1	0	6	7	7	5	23	35
Total	3	0	2	14	10	48	77	0	0	0	29	7	55	91	3	0	4	18	19	40	84	0	0	0	27	2	47	76	100	38	190	328

Grand Totals

TAB (3, 8)A THE ROLE OF EACH PCQ ASKED,

Age Group	Used as Direct PQ	Used as Hypothesis PQ	Total
9 years	12	10	22
12 years	16	23	39
15 years	7	31	38

TAB (3, 8)A shows that with increasing age the PCQs asked tended to be used as hypothesis PQs rather than Direct PQs (as was found to be the case, to a lesser degree, with the PQs connected by location or by a non-stated category). [$\chi^2 = 14.44$, $p < 0.005$, $df = 2$].

Words and Pictures

In an attempt to see if any pattern could be seen in the use of PCQs either by age group or particular users of a certain kind of question all the PCQs asked by each group in each condition were thoroughly examined. To check whether the children who asked a lot of PQs were also responsible for using PCQs a correlation was made between the usage of PQs and PCQs by each age group. It was found that for all ages in each condition the use of PCQs was negatively correlated with the use of PQs, so this means that as a general trend there is proof that the children moved from using PQs to using PCQs in so far as a good deal of children used PCQs instead of PQs.

To check to see whether any general relationship existed between the use of CQs and PCQs, a similar correlation was made for each group, but the results were not so clear cut as in the case of the PQs. There was a strong positive correlation between the use of PCQs and CQs by the 9 year olds in the picture and word display conditions, virtually no correlation for the 12 year olds in any condition and a rapidly decreasing correlation between PCQs and CQs from the numbers to the pictures and then the words conditions by the 15 year olds. The only outstanding result was in the significantly differing variance between the distribution of the 16 PCQs asked by the 5 x 9 year olds in the Pictures condition and the 22 PCQs asked by 4 x 9 year olds who used them in the Words condition.

($F = 3.286 > 2.85$ $p < 0.05$ 11 degrees of freedom).

Once the type of PCQ asked was investigated further it became obvious that nearly all the PCQs asked in the Picture or Word display conditions were imitative of Functional CQs, that is CQs of the type, "can I eat it ?" or "does it move?" As TAB (3,8) B shows nearly all the children who asked PCQs also used Functional type CQs. The first game played by 12 year old Janette shows how this confusion between PCQs and CQs of the Functional type occurred.

TAB (3, 8) B The number of children who used PCQs, Functional CQs and both in the Picture and Word display conditions

PICTURES				WORDS			
No. of children using	Functional			No. of children using	Functional		
	PCQs	CQs	Both		PCQs	CQs	Both
9 yrs.	5	6	4	9 yrs.	4	5	3
12 yrs.	8	10	8	12 yrs.	9	9	7
15 yrs.	8	9	7	15 yrs.	8	10	8

1. J. "Does it live on a farm ?"	CQ (Functional)
E. "No"	
2. J. "Can you eat it?"	CQ (Functional)
E "No"	
3. J. "Can you drive it ?"	CQ (Functional)
E. "No"	
4. J. "Can you buy things out of it ?"	* PCQ (shop) as (PQ Direct)
E. "No"	
5. J. "Can you live in it ?"	CQ (Functional)
E. "No"	
6. J. "Can you wear it ?"	CQ (Functional)
E. "No"	
7. J. "Is it an animal ?"	CQ (Nominal)
E. "No"	
8. J. "Is it a vehicle ?"	CQ (Nominal)
E. "No"	
9. J. "Is it something you wear on your head ?"	* PCQ (hat) as (PQ direct
E. "No"	
10. J. "Is it something you wear ?"	CQ (Functional)
E. "No"	

11. J. "Is it something . . . somewhere you go to learn ?	* PCQ (school) as (PQ direct)
E. "No"	
12. J. "Is it someone that goes on a ship ?"	* PCQ (sailor) as (PQ Direct)
E. "No"	
13. J. "Is it someone that delivers mail ?"	* PCQ (postman) as (PQ Direct)
E. "Yes"	
14. J. "Postman!"	PQ (Direct)
E. "Yes!"	

One possible explanation for the easy confusion of PCQs and CQs of the Functional type may lie in the mental attitude of the player towards the role of the experimenter. The experimenter was always the person who knew which card the player had to discover and it was up to the player, by asking questions of the experimenter to find out which card was the target. It is in this final point where a subtle change of attitude could take place; was the player trying to discover which card from the display was the chosen one, or was the game a contest of personalities in which the display was simply the medium through which a child could pick the brains of an adult ?

The uses of the words 'you' or 'I' in these particular questions were all entirely related gramatically to the display items concerned so there was no evidence to support the possible explanation that PCQs which happened to resemble Functional CQs were directed more at the experimenter's personal choice of card rather than at the target item within the display.

Bearing in mind the eagerness with which the older children in Exp.1 complicated their CQs unnecessarily and the known fact that children tend to learn through imitation, the most satisfactory explanation for the use of PCQs is that they are simply attempts to make PQs sound like CQs. Perhaps the best illustration of this point was made by the 12 year old Christopher in his fourth game.

1. C "Is it an animal ?"	CQ (Nominal)
E. "Yes"	
2. C. "Is it soft to the touch ?"	PCQ (Perceptual)
E. [Pause for thought] "Yes"	
3. C. "Is its gestation period 31 days ?"	* PCQ (rabbit)
E. "What animals have a gestation period of 31 days?	
C. "A rabbit"	
E. "Anything else ?"	
C. "No, not that I know of"	
4. C. "Is it dual purpose?"	CQ (Functional)
E. "Yes"	
C. "Its a cow"	PQ (Hypothesis)
E. "Yes"	

WHAT GUIDED THE CQs ASKED ?

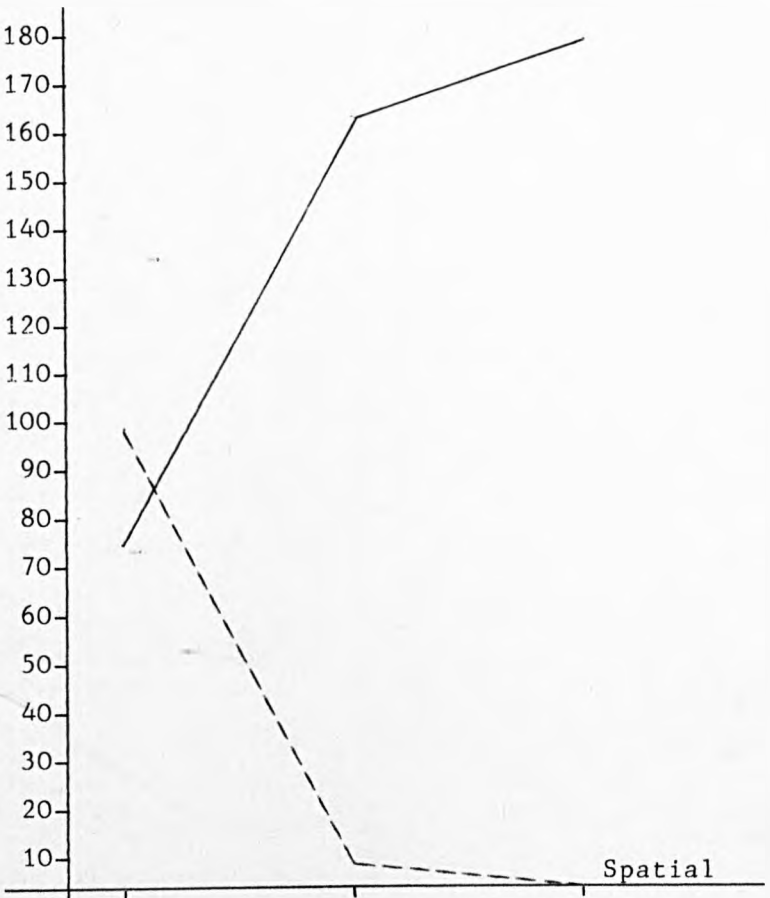
As in Exp.2 children could either direct their CQs at groups sharing a common position in the display ("Is it in this row?" "Is it in that column?" "Is it in this half?") thus using spatial CQs or they could question groups of items sharing some visual characteristic (e.g. "Is it a word with a vowel in it?", "Does it begin with an H?"?) thus concentrating on the perceptual qualities of the items.

Interacting with the display on a deeper level, some children could ask Functional CQs ("Can I ride it?" "Can you eat it?") or they could group the items around a commonly named and shared category such as fruit, vehicles, etc. On a very basic level the children could either generate CQs by concentrating either on the spatial characteristics of the cards or their contents.

SPATIAL vs CONTENT BASED CATEGORISATION

As in the last two experiments, regardless of whether the questions were PQs or CQs all the spatially based questions were plotted by age group next to the number of content based questions. FIG.D shows that the 9 year olds categorised the display according to its spatial characteristics rather than its contents for just over half the questions asked but, the 12 and 15 year olds significantly ignored spatial categorisation in preference for content-based categorisation.

FIG D. COMPARISON OF THE NUMBER OF QUESTIONS ASKED INVOLVING SPATIAL OR CONTENT-BASED CATEGORISATION OF THE DISPLAY



PERCEPTUAL/SPATIAL, FUNCTIONAL AND NOMINAL CQs

Using TABS (3, 9)A, and (3, 10) in conjunction one can detect a pattern of CQ use which changes subtly with increasing age.

TAB (3, 9)A Distribution of Perceptual/Spatial, Functional and Nominal based CQs.

	Perceptual/Spatial				Functional		Nominal		Totals	
	No.of CQs asked	% of grand total	No. of CQs asked	% of grand total	No. of CQs asked	% of grand total	No. of CQs asked	% of grand total	No.of CQs asked	% of grand total
9 yrs	11	3%	13*	3.4%	38	10%	14	3.7%	76	20%
12 yrs	33	10%	5	1.4%	94	28%	64	18.8%	196	58%
15 yrs	17	5%	0	0	58	18%	115	35%	190	58%

* This includes 3 Half Split questions

TAB (3, 10) Number of children using each question type and the percentage of the total number of CQs asked by each question type

	Perceptual		Spatial		Functional		Nominal		Total
	No.of child-ren	% of CQ total	No.of child-ren	% of CQ total	No. of child-ren	% of CQ total	No.of child-ren	% of CQ total	% of CQs asked
9 years	3	14.5%	2	17%	5	50%	3	18.5%	100%
12 years	8	17%	1	2.5%	9	48%	10	32.5%	100%
15 years	5	9%	0	0	10	30.5%	11	60.5%	100%

The 9 and 12 year olds differed little in the distribution of question types used, both groups tended to use more Functional CQs than any other sort whilst the 15 year olds favoured the Nominal CQ more than any other type; this is the first level of change.

The second level of change concerned the number of children using CQs. Only 8 x 9 year olds asked CQs whilst all the 12 and 15 year olds used them. This difference between the 9 and 12 year old groups was basically the only difference observed in their use of CQs, for both age groups shared the same distribution of questions per CQ type whilst more 12 year olds than 9 year olds actually used them.

It would seem that between the ages of 9 and 12 children simply gained confidence in using CQs, showing a slight preference for the Functional type, whilst from 12 to 15, when CQs became the principal type of question used, the most popular CQ became the Nominal type.

TAB (3, 9) B Distribution of illicit and repeated questions (PQs, PCQs, and CQs)

Age	Illicit (items not in display)	Repeated
9 years	0	12
12 years	1	5
15 years	0	0

TAB (3, 9) B shows that the Word display was obviously easy to keep track of because only one question was directed at an item not in it! As could be expected the younger children who used more PQs repeated more questions, whilst the older children seemed to have been in sufficient

command of their questions not to repeat any.

TENDENCY TO USE THE SAME QUESTIONS IN SUCCESSIVE GAMES

TAB (3, 11) The number of children in each group who repeated more than half the questions asked in the previous game.

	in game 2	in game 3	in game 4
9 years	1	2	3
12 years	2	4	1
15 years	4	3	1

TAB (3, 12) Percentage number of repeated questions which were CQs (Take each percentage from 100 to give percentage use of PQ and PCQ) Total number of repeated questions asked is given in brackets.

	in game 2	in game 3	in game 4
9 years	61% (18)	25% (35)	12% (34)
12 years	88% (26)	100% (19)	93% (15)
15 years	92% (26)	96% (28)	100% (12)

If strategies of any description were being developed over the 4 games played one would reasonably expect a certain repetition of useful questions in successive games. TABs (3, 11) and (3, 12) show the amount of questions repeated from preceeding games and the percentage of these were CQs respectively.

From TAB (3, 11) it can be seen that very few children repeated more than half the questions they asked in the preceeding game but of those who did it is interesting to note that more 9 year olds did so in the 4th game, more 12 year olds did so in the 3rd game and more 15 year olds did so in the 2nd game. This pattern is in keeping with the assumption that older children would see the value of repeating useful questions earlier than younger children.

TAB (3, 12) shows that if questions were systematically repeated (or repeated by chance) by a 9 year old they were usually PQs, whilst the 12 and 15 year olds repeated mainly CQs. (This is not merely a reflection of the fact that the 12 and 15 year olds asked more CQs than the 9 year olds, although this fact does have a significant bearing on these results).

EFFICIENCY OF CQ STRATEGIES

TAB (3, 13)A which shows the number of children repeating at least half the CQs they used in their preceeding game also shows that the majority of these games required a greater number of questions to solution. For these children it would seem that a CQ strategy, even of the most basic repetitive kind, was not really efficient, a contrast to the results found in Exp.2.

TAB (3, 13)A The number of children using at least half the CQs asked in their preceeding game. (Numbers in brackets indicate the number of these children who also asked fewer questions to solution than in their preceeding game).

	in game 2	in game 3	in game 4	Number of children common to all
9 years	3 (1)	3 (0)	2 (1)	1
12 years	4 (1)	1 (0)	5 (1)	0
15 years	5 (1)	7 (1)	2 (1)	1

An interesting fact thrown up by this table is the relatively small number of children who stuck to using the same CQs through all their games. TAB (3, 13) B shows the breakdown of TAB (3, 13)A in greater detail as and one can trace the number of children common to the previous game/build up a more accurate picture of any children evolving a continuous strategy.

TAB (3, 13) B Number of children common to each game in TAB (2, 13)A

	in games 1 & 2	in games 2 & 3	in games 3 & 4	common to all
9 yrs. common	3 (1)	2 (0)	1 (1)	1
new		1 (0)	1 (0)	
12 yrs. common	4 (1)	0 (0)	1 (0)	0
new		1 (0)	4 (1)	
15 yrs. common	5 (1)	3 (0)	1 (1)	1
new		4 (1)	1 (0)	

TAB (3, 13) B shows that the 15 year olds as a whole repeated CQs up to their third game before changing tack, whereas the 12 year olds changed after their second game, repeating the questions from game 3 in game 4.

The general result indicated in this table is that very few children who used CQs attempted to evolve a rigid set of questions applicable to each game, although there is more evidence to show that the 15 year olds recognised the efficiency of certain questions earlier than the 12 year olds.

Clearly, by the end of their second game the 4 x 12 year olds who repeated more than half their first game's CQs were ready for a change, whereas of the 5 x 15 year olds in the same position after game 2, 3 of them went on to repeat these CQs in game 3 whilst 4 more 15 year olds decided to repeat CQs asked in their second game.

At the end of game 3 most 15 year olds were ready to change their CQs whilst 3 out of the 5×12 year olds who repeated CQs in game 4 (which had been previously used in game 3) were repeating questions for the first time.

Only two children repeated the majority of their CQs in all 4 games and their choice of questions were indicative of their respective age groups. The 9 year old Elaine kept asking "does it begin with an H?" whilst the 15 year old Maxine kept asking "is it a form of transport?" and "is it a form of clothing ?"

SUMMARY

1) NUMBERS AND PICTURES vs. WORDS

The dramatic age related shift from using PQs to CQs observed in Exps.1 and 2 was also found in Exp.3, although this tended to be concentrated between the 9 and 12 year olds rather than across the three age groups. This was also the pattern for the shift away from spatial to content based categorisation with increasing age.

2) THE 12 YEAR OLDS

In Exp.1 (with the Number display) the 12 year olds at times surpassed the performance of the 15 year olds. In Exp.2 (with the Picture display) the performance of the three age groups was clearly separated according to increasing age. In Exp.3 (with the Word display)

the 12 year olds closely resembled the performance of the 15 year olds, although they never exceeded it.

3) GENERAL

a) The 9 year olds completed ⅔ of the games played in fewer questions than either the 12 or 15 year olds. The median number of questions asked was 6 for the 9 year olds yet 7 for both the 12 and 15 year old groups.

b) The 12 and 15 year olds were similar in the number of PQs, PCQs, and CQs asked but a closer study showed that the 15 year olds used more Nominal CQs.

c) More 9 year olds used PQs connected by location than anyone else, in fact the 9 year olds asked more spatial questions than content questions, the 12 year olds used very few spatial questions and the 15 year olds used none.

d) In contrast to the results of Exp.2 many of those who repeated more than ½ the CQs asked in their previous game, ended up using more questions to solution than in their previous game. There was no evidence to support a link between use of a CQ strategy and a reduction in the number of questions asked to solution.

CHAPTER FIVE

THE METHOD OF SUCCESSIVE SPATIAL HALVING (SSH)

Experiment 4

AIM

To see if children of 9, 12 and 15 years use the method of successive spatial halving in a 20 Questions game when they are first told and then shown how to do so, and to see if different displays (Pictures, Words or Numbers) affect performance.

INTRODUCTION

In the previous experiments, one child used the Half-split Algorithm. Of course, even for someone who is familiar with the algorithm, it is a challenging task to launch and carry though the algorithm in terms of questions based on the content of the items in the displays. However, it ought to be less challenging to implement the algorithm in terms of questions based on the spatial layout. Yet no child used such a spatially based algorithm and, indeed spatially based questions were, overall, distinctly less common than content based questions. Is it possible that some children were familiar with the procedure of successive spatial halving but they did not use it because they assumed it was excluded by the rules of the game, that it would almost be cheating ? Or did they not use it because it happened not to occur to them at the time ? At the other extreme, is it possible that the procedure is not one which most children can readily formulate and manage ? Finally, is it possible that the children were not familiar with the procedure but would, nevertheless, readily pick up and use if it were explained or demonstrated ?

In an attempt to answer these questions, Experiment 4 focussed explicitly on the procedure of successive spatial halving and whether children would use this procedure after they were told about it and after a supplementary demonstration of its use.

SUBJECTS

In total 54 children participated:

18 x 9 yr. olds (9 boys, 9 girls) mean age 9 yrs. 3 months [range 8:10 - 9:09]

18x12 " " (9 boys, 9 girls) mean age 12 yrs. 3 months [range 11:10 - 12:09]

18x15 " " (10 boys, 8 girls) mean age 15 yrs. 3 months [range 14:10 - 15:07]

The children were taken from two schools and chosen as "average for their age" by class teachers. They were individually tested in a separate room in the school, and with the teacher and experimenter respectively choosing and allocating to experimental conditions in random sequence, any effects of localising all bright children in one condition were minimised.

MATERIALS

The same Number, Picture and Word displays as used in Exps. 1, 2 and 3 respectively.

PROCEDURE

Each child was put at ease and told that they were going to play a little game with the display of cards which faced them on the table between themselves and the experimenter, who recorded the child's questions on a notepad. The experiment consisted of 4 phases:

Phase I Item identification

Depending on whether the child was shown pictures, or words, or numbers the child was told to name, or tell the experimenter what was printed on each/one of the 24 card displays. These displays were the same as those used in Exps 1, 2 and 3 and 18 children (6 from each age group) were given either the pictures or the words or the numbers display to play with.

Phase II Instructions and 4 games

Instructions were as follows : "Now I have chosen one of these cards on here, and you have to find out which one I have chosen by asking

questions. But, I can only answer either Yes or No to each question asked.

The sort of question I want you to ask is special.

With each question I want you to halve the number of cards left in the display. So you will say "is it in this half?" and I might say "yes", then you'll say "is it in this half?" and I might say no - so you go on asking questions like this, halving the number of cards left with each question till there is only one left. OK ?" 4 games ensued.

The first game commenced with the words "now I've chosen a card, you find out which one it is". Target items were, in each game, postman (13), tractor (36), socks (52) and cow (67). Each successive game commenced, "now I've chosen another card, you try and find it by asking questions which halve down the number of cards left" [the experimenter's hands demonstrated the cutting action represented]

Phase III Demonstration by role reversed game:

The experimenter asked the child to pick a card but keep it secret from the experimenter. The following conversation ensued:

Exp. "have you picked a card ?"

Child "Yes"

Exp. "Now watch what I do (drawing finger down centre of display and pointing to one half with the whole of the hand) "is it in this half ?"

Child "Yes/No"

Exp. (if the answer was no the exp. said, "well it must be in this side so . . .") (pointing to 6 cards in one corner of the display) "is it in this half" . . . and so on.

With each question the orientation of the dividing line between two groups went from vertical to horizontal and back again. At no time was reference made to rows or columns.

To narrow down the last three cards the experimenter chose two of them and said "is it in these two" and acted accordingly.

Finally, the experimenter said, "Now did you see how I did that ? I

halved the number of cards that were left with each question. Now can you do that ? Can you play a game doing what I did (answers) let's see . . . I've chosen a card now, you find it the way I found yours."

Phase IV Final game

The child attempted a game and was asked to use the same method as that used by the experimenter in phase 3.

Scoring Each question asked by each child was scored either as a Particular Question or as a Category Question. There were three types of category question, one based on content, and two based on spatial attributes of the array. A question was called Spatial Halving if, regardless of its wording or format, it was concerned with the spatial layout of the display and referred to half of the number of still possible items. A Spatial Other question was one which asked about a spatial category of items which did not constitute half of the still possible items. Finally, each game was scored according to whether it involved a completely successful use of the successive halving procedure, or a partially successful use of this procedure, or whether it had no resemblance to the procedure.

Results for the four games played in Phase II are shown in TAB (4,1).

RESULTS

1) The number of children using successive spatial halving - Looking through the number of children who completed at least one SSH game successfully, disappointingly few successes could be found: 6 children were successful in Phase II and 14 in Phase IV. The Phase III role-reversed game did have a significant effect in encouraging children to use the SSH method. Between phases II and IV the number of children successfully using SSH increased [$t = 3.8248$, $p < 0.01$: 2 tail with 8 df] as did the number of children partially using a SSH strategy [$t = 3.355$, $p < 0.01$: 2 tail with 8 df] whilst the number of children not using the SSH method at all decreased [$t = 4.99$, $p < 0.01$: 2 tail with 8 df].

TAB (4, 1) Distribution of questions asked and the number of children successfully using SSH in Phase II (24 games) and Phase IV (6 games) by age and presentation condition.

		PQ	CQ			Total (Av)	No. of children using SSH method			
			Spatial		Content		successfully	partially	not	
			Half	Other						
NUMBERS	9 yrs.	41	4	4	0	49	0	0	6	PHASE II
	12 yrs.	12	9	24	2	46	1	0	5	
	15 yrs.	16	12	7	4	39	1	1	4	
PICTURES	9 yrs.	53	2	5	0	60	0	0	6	
	12 yrs.	18	7	6	9	39	1	0	5	
	15 yrs.	12	17	3	1	33	3	1	2	
WORDS	9 yrs.	16	9	14	0	39	0	2	4	
	12 yrs.	17	6	5	8	36	0	1	5	
	15 yrs.	21	9	9	3	42	0	1	5	
	Averages of 4 games each									
NUMBERS	9 yrs.	9	13	18	0	40	1	0	5	PHASE IV
	12 yrs.	7	21	9	0	37	2	3	1	
	15 yrs.	8	22	2	0	32	3	3	0	
PICTURES	9 yrs.	10	16	11	0	37	0	2	4	
	12 yrs.	8	20	9	0	37	2	1	3	
	15 yrs.	9	23	2	0	34	5	1	0	
WORDS	9 yrs.	11	17	12	0	40	1	3	2	
	12 yrs.	10	13	16	1	40	0	1	5	
	15 yrs.	13	18	13	0	44	0	3	3	

2) The distribution of questions asked in Phases II and IV - Overall the Phase III role-reversed game procedure had the effect of significantly doubling the number of halving questions asked, [$t = 10.75$, $p < 0.001$: 2 tail with 8 df], almost eliminating the number of content based CQs asked [$t = 2.66$, $p < 0.05$ 2 tail with 8 df], and reducing the number of PQs asked [$t = 76.05$, $p < 0.001$: 2 tail with 8 df]. It did not significantly lower the total number of questions asked [$t = 1.6587$] nor did it reduce the number of "other" CQs asked [$t = 0.57$].

3) Age differences in the effects of instruction

9 year olds

In all three presentation conditions, merely asking 9 year olds to employ a SSH method of questioning (Phase II) did not enable any of them to use it successfully. However in Phase III, the 9 year olds using the Words display used more CQs and fewer PQs than the two other 9 year old groups [$\chi^2 = 30.98$, $p < 0.005$: 2 tail with 2 df]. After the Phase III role reversed game instruction there was a considerable increase in the number of spatial questions asked by all the 9 year old groups in Phase IV, the Number and Picture display groups increasing significantly more than the Word display group. [$\chi^2 = 9.486$, $p < 0.001$: 2 tail with 2 df]. This meant that in Phase IV all the groups asked approximately the same number of spatial questions (with no statistical difference in the number of these spatial CQs being halving questions - although their distribution was in the direction of a greater success with the Words).

12 year olds

The 12 year olds in the Numbers display condition used more spatial rather than content CQs in Phase II than either the Picture or Word groups [$\chi^2 = 12.71$, $p < 0.025$: 2 tail with 2 df] yet, despite this, the greater proportion of these CQs were not used as halving questions, a trend in in which they differed from the other two display condition groups. [$\chi^2 = 17.134$, $p < 0.001$: 2 tail with 2 df]. By Phase IV this difference had been reduced to a non-significant level [$\chi^2 = 5$].

15 year olds

Although no significant differences were found between the performance of the three 15 year old groups in Phase II, the direction of all the results indicated a better peformance by those in the Picture material group. Indeed, out of the spatial CQs used by this group significantly more were used as halving questions than any other experimental group in any condition. [χ^2 = 10.121, $p < 0.025$ 2 tail with 2 df].

Ih Phase IV there was little difference between the Picture and Number condition groups, whilst the Words condition group was significantly worse at using their spatial questions to halve the display [χ^2 = 12.96, $p < 0.01$: 2 tail with 2 df], a result in keeping with the fact that no 15 year old in the Words group successfully completed an SSH game.

PRESENTATION DIFFERENCES IN THE EFFECTS OF INSTRUCTION

The three age groups responded to the different material in different ways but some similarities can be drawn between the results of this experiment and those of Experiments 1, 2 and 3.

WORDS

With this display, the 9 year olds were at their most responsive to the injunction to ask halving questions and the 15 year olds were at their most unresponsive to the injunction.

This striking difference between the performance of the oldest and the youngest group most probably reflects the importance given to words by the two age groups. In their school activities the 15 year olds would have had considerably more training in the use and importance of written material than the 9 year olds, therefore it is reasonable to suggest that the older children may have had greater difficulty than the younger children in ignoring the semantic content of the words. As this task required the child effectively to ignore the contents of the cards in order to divide the display spatially, the older children may have experienced a degree of interference between a disposition to categorise by meaning and an instruction to categorise spatially, and may have been impatient

to start on the task of questioning rather than listening to the experimenters' injunctions.

PICTURES AND NUMBERS

In Phase II the 15 year olds in the Pictures display group were at their most responsive to injunctions to ask halving questions and the 12 year olds were at their most responsive to the injunction in the Numbers display group (even though these 12 year olds had some difficulty using their spatial CQs as halving questions).

In Phase IV these differences disappeared so completely that the performance of the Picture and Word groups was virtually identical, both for the 12 year olds and the 15 year olds. The overall lack of superiority by those using the Numbers display is surprising, as this was the display condition in which the greatest number of children asked spatial conditions in Experiments 1, 2 and 3. [$\chi^2 = 7.463$, $p < 0.05$: with 2 df].

Any effects the Picture or Number material may have had on the ability of older children to use the successive spatial halving method seem to have been overcome after the Phase III role reversed game. This contrasts sharply with the observed effects of the Word display.

The general qualitative impression was that a delicate balance exists between the age of the child, the exact nature of the cognitive task to be performed and the degree to which the material either assists or disrupts the child's attempts to succeed. In this particular experiment the combination of a spatial task and word material seems to have worked against the 15 year olds' desire to succeed.

In conclusion to Experiment 4, despite the success of the role reversed game procedure as a form of instruction demonstrating how to

use spatial halving the procedure had very little overall effect on the children other than to increase the number of spatial questions they asked. Thus it was certainly not the case that the successive spatial halving method was easily grasped and used by the children. The absence of this method in Experiments 1, 2 and 3 cannot be attributed to the method being available to the children but merely not brought into use. In so far as the successive spatial halving method is an easy version of the half-split algorithm, the implication of Experiment 4 is that the algorithm is not available to most children in the age range 9 to 15 years.

CHAPTER SIX

THE EFFECT OF VERBAL INSTRUCTIONS ENCOURAGING ADULTS AND CHILDREN TO USE SUCCESSIVE SPATIAL HALVING

Introduction

The implication of Exp.4 is that children in the age range 9 to 15 do not seem to find the SSH method among their repertoire of readily accessible skills. This begs the question, who does ?

Working with the same Number display as used in Exp.4, and the same target items, Crevis and Lewin (1982) as part of an undergraduate study, found that out of 30 fellow undergraduates asked to play four 20 Questions games, only 1 student used a halving strategy. After reading some verbal instructions outlining the "half-split method", all 30 undergraduates were able to play a SSH game successfully.

In a parallel experiment students were given a hint that the target could be located in 5 questions. This hint was not as effective as the written instructions, only 5 of the 30 students responded by using the SSH method. From this it followed that either the written instructions were very good, or the students having the advantage of both age and experience, were in a better position to assemble and maintain the component skills involved in the SSH method than the 9 to 15 year olds encountered so far.

It was decided to try out Crevis & Lewin's instructions, using the same display, on some 12 and 16 year olds.

Experiment 5 The effect of Crevis & Lewin's instructions on the SSH questioning of 12 and 16 year olds.

Aim

To see if 12 and 16 year olds use the SSH method on a Number display after reading instructions to do so.

Participants

29 boys aged 16 (mean age 16.7) and 29 boys aged 12 (mean age 12.5) attending the same Boys Comprehensive School. The 16 year olds were a

5th year 'O' level English set and the 12 year olds were a "top set" English stream. [Two lower stream English sets were also used, 19 boys aged 12 (mean age 12.5) and 14 boys aged 13 (mean age 13.8)].

Materials

In order to present the instructions to a class full of children at once the Number displays used in Exps. 1 and 4 were placed at the top of an A4 sheet of paper and under it were directions outlining the 20 Questions problem; Crevis & Lewin's instructions, and a short postcript set out as follows :

67	24	44	12
53	45	31	21
29	63	13	64
16	51	68	36
38	52	47	59
46	19	33	26

PROBLEM - One of the above numbers has been chosen and you have to find out which one it is by asking (or writing down in your case) questions to which only YES or NO answers will be given

This problem can be solved by using a technique known as the split-half method, which enables one to locate the target number in a maximum of five questions.

The function of each question is to reduce the number of possible choices by half. This is achieved by constructing a question that determines in which half of the array the target number lies.

Once the target number has been placed in one half of the array, subsequent questions of a similar nature to the first reduce the range of possibilities by one half each time.

NOW DO IT - Write your questions on the piece of paper provided and put your hand up. I will come round and give you a yes or no answer.

DO NOT COPY

The Number display was also written on the blackboard at the front of the class.

Procedure

Once the children were settled in separate desks they were given a blank piece of paper on which to write their questions and an instruction sheet (face down). Once they were told to start they read the instructions silently and then put their hand up when they had written a question requiring an answer. The experimenter travelled up and down the rows of desks ticking or crossing the written questions to indicate whether the answers were yes or no. Each boy played one game only.

The question papers were collected and the experimenter conducted two role reversed SSH games on the blackboard giving reasons for each question.

In a way similar to Denney's cognitive modeling procedure the experimenter asked one boy to think of a number and answer the experimenter's questions: each question was followed by an explanation for its choice. The class observed these role reversed games then three more role reversed SSH games were played with boys taking the experimenter's place. Open discussion was encouraged during this procedure after which the boys split into pairs and played an SSH game with their neighbour.

Results

16 year olds - Out of the 29 boys only 4 completed an SSH game after reading the instructions. Ironically out of the 125 CQs asked only 46 (37%) were spatial whilst 79 (63%) were aimed at the numerical content of the display! [This distribution is almost identical to that of Crevis & Lewin's undergraduates BEFORE instruction; Spatial 34% Content 66%].

Following the role reversed games at the blackboard with the accompanied open discussion every one of the 29 boys successfully played an SSH game.

12 year olds - The procedure was slightly modified for this group in that the experimenter read through the instruction sheet with the class before letting them start. Out of the 29 boys 17 completed successful SSH games (albeit 6 of these ending with a guess at the last 3 items) and out of the 109 CQs asked 90 (83%) were spatial and 19 (17%) were directed at the numerical content.

Again following the role reversed games and open discussion at the blackboard all 29 boys successfully completed an SSH game.

Less able boys - When 19 less able boys were given the same instruction only one child managed an SSH game. Out of the 45 CQs asked 33 (73%) were spatial and 12 (27%) were directed at the numerical content: 66 PQs were used! Once the role reversal procedure was completed all 19 boys played a perfect SSH game.

In order to test the effect of the experimenter reading out the instructions to the subjects a further 14 low ability boys aged 13 were tested, but the experimenter did not read the instructions to them. Only 1 boy played a SSH game and of the 37 CQs asked 3 (8%) were spatial and 34 (92%) were directed at the numerical contents. Again after role reversal games all the boys played a perfect SSH game.

In conclusion to Experiment 5, the instructions which Crevis & Lewin found to be helpful in encouraging undergraduates to use an SSH were only partially successful with bright 12 and 16 year olds and not successful with less able 13 year olds.

In contrast to this, the effect of using Denny's cognitive modeling coupled with an open discussion in which boys could hear the problems of other boys facing the same task seems to have met with complete success. Apart from the familiarity of the classroom situation to each boy there was also the friendly rivalry between boys which must also have contributed to the success of this later method, although it is tempting to assume

that, for some of the less able boys, successful performance was very much a situation-dependent task and their grasp of the underlying eliminative principles of successive spatial halving may not have stayed with them much longer than the duration of the experiment. In the absence of understanding, pure imitation (a special characteristic of the less able boy) may have been largely responsible for the dramatic improvement in performance.

SUMMARY OF EXPERIMENTS 4 and 5

1) In Experiment 4 the phase II verbal instructions to use halving questions increased the number of halving questions asked but it did not enable most children to carry out the SSH method.

2) In Experiment 4 the phase III role reversed game had the effect of nearly doubling the number of halving questions asked but there was no related increase in the strategy of halving which one would presume went with an increase in halving questions.

3) In Experiment 5 written instructions which were effective with undergraduates were partially successful in getting 12 and 16 year olds to use a halving strategy but in the absence of having the instructions read to them the 16 year olds still asked $\frac{2}{3}$ content CQs and only $\frac{1}{3}$ spatial CQs.

4) Role-reversed games in a well-ordered familiar environment where the reason for each question was explained proved to be the best circumstances for encouraging 12 and 16 year olds to use or at least imitate the SSH method successfully. In one open forum during a role reversed game at the board one boy suggested that the class should "ignore the numbers altogether", such comments, and others not generally broadcast may have contributed significantly to the educative process.

5) Clearly the half split algorithm and its easier counterpart the SSH method are not spontaneously available among the repertoire of skills employed by the 9 - 16 year old age group.

6) The impression gained from Experiment 4 was that verbal instructions interfered with the 12 and 15 year olds' (but not the 9 year olds') ability to use the SSH method with a word display: their best performance was with the Picture or Number display material.

CHAPTER SEVEN

OVERVIEW OF TWENTY QUESTIONS

The experiments which have been reported encompass some 773 individually monitored games played by 162 children under experimental conditions and 71 children tested in their class groups.

In Experiments 1, 2 and 3 a total of 108 children played 4 games each with a display comprising 24 items. There were nine experimental conditions, each a different combination of age (9, 12, 15 years) and material (pictures, words, numbers). In Exp.4 a further 54 children, under the same experimental configuration were first told how to conduct a halfsplit game, then after their 4 games they were given a practical demonstration of halving via a role reversed game before playing a fifth game themselves.

The purpose of this chapter is to overview the combined results of all 9 experimental conditions in the first three experiments, extracting highlights relating to the following issues. Problem solving efficiency; particular vs. categorical questions; spatial vs content questions; the effects of different display material (and with particular reference to Exps. 4 and 5) the half-split strategy (or SSH method); and a passage discussing a constrained-seeking ability. First, a statistical summary is given of Experiments 1, 2 and 3.

Statistical Summary of Exps. 1, 2 and 3

1) The shift from PQ to CQ with increasing age

In each condition the interaction between age and use of PQ/CQs was found to be significant. This was also found to be the case across the three display conditions, in a 3 way ANOVA (Age x PQ/CQ x Presentation Material) the Age x PQ/CQ interaction was highly significant [$F = 20.6573$, $p < 0.005$, $df = (2.99)$], (see page 141).

2) The shift from spatial to content based categorisation with increasing age.

Only the 9 year olds in the numbers condition used more spatial than

Content based categorisation, from then on and in each condition with increasing age, more content categorisation than spatial categorisation took place. In a 3 way ANOVA (Age x Spatial/Content x Presentation Material) the effect of Spatial/Content was significant [$F = 31.7197$, $p < 0.005$, $df = (2,99)$] as was the interaction between Age and Spatial/Content categorisation [$F = 23,0232$, $p < 0.005$, $df = (2.99)$]. The interaction between Spatial/Content categorisation and Material [$F = 3.3798$, $df = (2,99)$] only becomes significant if a 1 tail test is used. [See page 141].

3) The lack of increased question efficiency with age

Although the increasingly older children in the Picture and Word conditions asked a decreasing number of questions to solution in neither condition was this difference statistically significant, nor was it in the numbers condition where the 12 year olds asked fewer questions than any other group.

A 2 way ANOVA (Age x Material) run on the total number of questions to solution asked showed that neither Age [$F = 0.6505$, $p = 0.8604$, $df = (2.99)$] or Material [$F = 0.0981$, $p=0.9954$, $df = (2.99)$] or the Age x Material interaction [$F = 1.0191$, $p = 0.4102$, $df = (4.99)$] were significant [see page 141].

4) General effects of Age and Material (2 way ANOVA)

	for	Numbers F	Pictures F	Words F
Age x Material	PQ	2.8296	4.456*	8.7596*
	PCQ	Ø	1.351	0.759
	CQ	13.5143**	9.088**	9.88**
	Total	0.6706	1.319	0.559

All F (2,33) * $F > 4.18$ $p < 0.05$ ** $F > 8.77$ $p < 0.001$

ANOVA TABLES

1) The shift from PQ to CQ with increasing age

3 way ANOVA Age x (PQ/CQ) x (Numbers/Pictures/Words). With repeated measures on one variable.

	Source	DF	Mean square	F	p
Between					
	Age	2	206.1157	1.9475	ns
	Material	2	87.1712	0.8236	ns
	Age x Material	4	37.6157	0.3554	ns
Within					
	(PQ/CQ)	1	153.3518	0.8581	ns
B	Age x (PQ/CQ)	2	3691.3379	20.6573	$p < 0.005$
C	(PQ/CQ) x Material	2	219.5601	1.2286	ns
	A x B x C	4	136.7962	0.7655	ns
	Error	99	178.6936		

2) The shift from spatial to content based categorisation with increasing age

3 way ANOVA (with one repeated measure)
Age x (Spatial/Content CQ) x (Numbers/Pictures/Words)

	Source	DF	Mean square	F	p
Between					
A	Age	2	17.166	0.3998	ns
C	Material	2	4.1805	0. 973	ns
A x C	Age x Material	4	18.8055	0. 438	ns
Within					
B	(Spatial vs. Content CQ)	1	2109.3749	31.7197	$p < 0.005$
A X B	Age x Spatial vs. Content CQ)	2	1531.0555	23.0232	$p < 0.005$
B x C	(Spatial vs. Content CQ) x Material	2	224.7638	3.3798*	
	A x B x C	4	41.4861	0.6238	ns
	Error	99	66.5004		

* significant at the $\alpha = 0.05$ level in a 1 tail test (F 3.1504) but not in a 2 tail test (F 3.9253).

3) The lack of increased question efficiency with age

2 way ANOVA
Age x (Numbers/Pictures/Words) based on total number of questions asked.

Source	DF	Mean square	F	p=
Age	2	356.1203	0.6505	0.8604
Material	2	53.7314	0.0981	0.9954
Age x Material	4	557. 912	1.0191	0.4012
Error	99	547.4225		
Total	107			

Problem-solving Efficiency : Experiments 1, 2 and 3

Table 1 shows, for each experimental condition, the number of games (out of 48) completed in eight or fewer questions.

Table 1

	P	W	N	Av
9	30	35	39	34.67
12	34	40	39	37.67
15	38	40	27	39.00

These data summarise, in a reasonably representative way, the efficiency of play in each of the nine experimental conditions. A test of association on the table as a whole showed no significant differences [$\chi^2 = 3.75$, df = 4]. However, analysing each age group and each display condition in turn, significant differences were found in the number of questions asked across the three display conditions by the 15 year olds [$\chi^2 = 10.337$, $p < 0.025$; in a 2 tail test with two degrees of freedom] and across the three age groups by those using the numbers display [$\chi^2 = 10.127$, $p < 0.025$; in a 2 tailed test with two degress of freedom].

Asking Particular versus Categorical Questions

Table 2 shows, for each experimental condition, the ratio of the total number of Particular and Pseudocategorical questions divided by the total number of questions asked (i.e. PQ plus PCQ plus CQ). A low ratio indicated a preference for categorical questions while a high ratio indicates a preference for asking about particular items.

Table 2

	P	W	N	Av
9	0.79	0.80	0.77	0.79
12	0.64	0.42	0.36	0.47
15	0.38	0.42	0.39	0.40
Av.	0.60	0.55	0.51	

These data show that, regardless of material, nines distinctly prefer particular questions while fifteens distinctly prefer categorical questions [χ^2 = 362.8, $p < 0.005$; in a 2 tail test with two degrees of freedom]. The twelves occupy an intermediate position in that their preference is influenced by the material, e.g., with pictures, twelves prefer particular questions and, with numbers, prefer categorical questions [χ^2 = 56.39, $p < 0.005$; in a 2 tail test with two degrees of freedom].[1] There was a significant difference in the ratio of Particulars vs. Categorical questions asked as a function of the material [χ^2 = 24.53, $p < 0.005$; in a 2 tail test with two degrees of freedom].

Asking Spatial versus Content Questions

Table 3 shows, for each experimental condition, the ratio of the number of Spatial questions to the number of Content-based questions asked. A low ratio indicates a preference for Content-based questions while a high ratio indicates a preference for Spatial questions;

Table 3

	P	W	N	AV
9	0.95	1.31	7.90	3.39
12	0.15	0.04	0.41	0.02
15	0	0	0.20	0.006
Av.	0.37	0.45	2.84	

* Footnote

These data show that the incidence of spatial questioning is a function of both age and material. In a 3 way ANOVA (AgexSpatial/Content

1. These Chi squared tests were performed on the number of CQs asked vs. the number of (PQ + PCQs) asked.

*Footnote The numbers of content based and spatially based questions asked were as follows: (From Figs B, C, D).

		9 yrs.	12 yrs.	15 yrs.
NUMBERS	content	19	121	175
	spatial	150	50	36
PICTURES	content	104	131	402
	spatial	99	19	0
WORDS	content	75	163	179
	spatial	98	7	0

x Presentation Material) the interaction between Spatial/Content categorisation and Presentation Material [F = 3.3798, df = (2,99)] was found to be significant if a 1 tail rather than a 2 tail test were used [see p.14]The 9 year olds distinctly prefer spatial questioning and the 15 year olds distinctly prefer content-based questions [χ^2 = 549.26, $p < 0.005$; in a 2 tail test with 1 degree of freedom]. The 12 year olds occupy an intermediate position. The material which most increases the proportion of spatial questioning is the Number material [χ^2 = 135.08 $p < 0.005$: in a 2 tail test with two degrees of freedom].

The effects of different display material

Tables 2 and 3 show that the material with which most CQs and Spatial questions were asked was the Numbers, followed by the Words then the Pictures.

The Picture material emphasised the age differences between the groups whilst the Word and Number material considerably affected the performance of particular age groups. With the Number material the 9 year olds were more efficient than the older children [up to the 4th question, χ^2 = 25.55, $p < 0.005$, in a 2 tailed test with two degrees of freedom]. With both the Number and the Word material, the 12 year olds equalled the 15 year olds in the number of CQs they asked.

Why this should be so seems to lie in the perceived complexity of the various displays.

The Picture Display - was colourful and its content was more perceptually stimulating than that of the spatial configuration presented to the senses by the ordered arrangement of the 24 individual cards. There was no real limit to the type or complexity of categorisation one could use on it, as the information was presented visually, in a form analagous to the way in which the majority of information requiring categorisation is fed to the senses in everday life. Under these circumstances, clear age differences accurately reflected the sum total of daily categorisational experience encountered by each child. In a crude sense the results gained using the Picture display could be used as a baseline from which to measure the effects of each display on the categorisational abilities of each age group.

The Word Display - was simplified verbal synthesis of the many possible categories contained within the Picture display. Its verbal nature restricted the number of possible ways in which it could be further categorised and consequently two important factors were brought into play.

First, the games played with this display were not so much a measure of the daily categorisational experience of each child, but a measure of their experience in manipulating vocabulary. In developmental terms the information suggested a symbolic rather than an ikonic form of processing.

Second, with the Picture material each child wishing to form a

verbal category had to label each picture first. In the Word display these labels were already given, thus in terms of the cognitive load involved in playing the 20 Questions Game, the Word display was less demanding than that of the Pictures. Under these circumstances the 12 year olds were able to use as many category questions as the 15 year olds.

The Number Display - was purely symbolic, and arguably it was the best possible display with which to convey to each child the problem-solving nature of the 20 Questions Game.

Most children do not stop to consider the categorisable nature of the visual world or the words they encounter daily, to a large extent they take these for granted, but the Number display related to a complex symbolic system in a way which was much more conspicuous than either the Picture display or the Word display.

First then, the Number display more obviously directed the children's attention to the complexity of the categorisational task facing them and secondly, some children were encouraged into both seeing the need for a spatial approach to the task and were assisted by the nature of the material into maintaining a spatial strategy of questioning.

The most fascinating aspect of this particular display was the way it encouraged the older children to experiment with highly complicated forms of categorisation which their powers of organisation were not capable of maintaining. The Number material made each age group aware of their own powers of reasoning, the younger children fortuitously stuck to a spatial approach with which they felt comfortable whilst the older children began to flex their numerical categorisational muscles which, unknown to them, couldn't take the strain!

The Half Split Strategy or SSH Method

Despite the fact that this strategy is the most efficient approach to the game of 20 Questions, only one child, out of the 108 children tested in Exps. 1, 2 and 3 used it spontaneously and correctly, whilst in Exp.4 attempts to both encourage and instruct children in the strategy met with limited success. In fact, the only completely successful method of instruction so far encountered with undergraduates was not very productive with either 12, 13 or 16 year olds and it was only after prolonged and open class teaching that these children managed to play a successful Half-Split game.

Why do people not use the Half-Split strategy ? The answer to this must be straightforward; it simply does not occur to some older people that this strategy is appropriate, so they don't use it until it is officially recommended or suggested to them, but the adolescents don't use it for other reasons.

First, some children can't see the purpose of asking indirect questions to get a direct answer to a simple "guessing game", so the issue of a strategy never arises. For others who realise that some form of grouping is necessary the nature of the material dictates the type of categorisation used, and whilst there are stimulating pictures or interesting words in the display any thought of spatial categorisation is neglected. Of those who respond to the problem solving nature of the task by categorising the display spatially, there are only a few who can maintain their attention on a strategy, as the rest seem to be easily side-tracked by the non-spatial content of the display material.

So, left with the few children who can recognise the spatial nature of the problem solving task, and successfully ignore the content of each display, there is a strong possibility that these few will use the Half-Split strategy with a degree of success. Given this, is it worth the effort to each child to discipline their more natural tendencies in order to use this "perfect" strategy ? The answer is no!

Table 4 shows the number of games (out of 48) completed within 5 questions in Exps. 1, 2 and 3. A correct use of the Half Split Strategy would ensure that all 48 games in each experimental cell would be completed within 5 questions and so Table 4 shows the efficiency gap between actual and ideal play. For the purposes of comparison the results of phase 2 in Exp.4 are shown in brackets (out of 24 games) to show the effect of verbal instruction to use halving on similar aged children using the same displays.

Table 4

Age	P	W	N
9 years	16 (10)	20 (4)	18 (8)
12 years	17 (9)	14 (13)	18 (6)
15 years	22 (14)	15 (7)	14 (10)
Totals	48 24	48 24	48 24

This table shows that without any instruction or thought of the halving technique between a third and a half of the games played were successfully concluded within 5 questions in Exps. 1, 2 and 3.

With instruction, on two occasions over half the games played are concluded within 5 questions so given the quite reasonable chance that the target will be 'luckily' discovered within 5 questions by using any questions which happen to come to mind, it is hardly surprising that the children were not spontaneously directed towards evolving the Half-Split strategy for themselves.

Indeed, there are very few occasions when even adults are encouraged to use the Half-Split method. A computer programmer, an engineer or a doctor conducting a fault diagnosis may have cause to use it but even where strictly methodical searches are required the nature of the material rarely lends itself to strict halving, even when the basic techniques of the method are implemented.

In each of these fields circumstances combine to make a disciplined search procedure profitable both in time and effort. In a 'game'

situation a disciplined mental approach is hardly the state of mind one would expect unless some element of competition was at stake, so one can hardly be surprised to find that undergraduates and children don't immediately use the Half-Split Method. With their greater degree of self discipline, especially mental self discipline, it is not surprising to find undergraduates can use the strategy once told what to do, the risk of failure or loss of face is sufficient competition to evoke the necessary mental discipline.

With adolescents the idea of mental discipline is only in its embryonic stages, especially in the age ranges tested and whilst the 'competition' is seen in terms of locating the target within as few questions as possible the more ethereal challenge of maintaining a half split strategy for the experimenter is of secondary importance.

Significantly the only method encountered by the experimenter which worked with the 12 and 16 year olds was traditional class teaching. The aim of the 'lesson' was to follow the Half-Split Strategy and therefore the competition became "let us follow the strategy" rather than "let us locate the item" and under these familiar competitive conditions, where each child was forced to display his understanding in front of others, the necessary impetus to use the Half Split Strategy was found.

Perhaps, if a very large display were used and the chance of "luckily" locating the target item were very remote, there would be sufficient interest in learning a quick, almost "magic", strategy to make the sheer effort involved worthwhile.

A Constraint-Seeking Ability ?

In Chapter One it was mentioned that the discussion by Bruner et al (1966) could be taken as suggesting a notion which, in fairness, Bruner would not intend to suggest. The notion is, that there exists a kind of ability, which is concerned with constraint seeking and which increases as children grow older: the stage of development reached in this unitary kind of ability is testable by playing Twenty Questions.

If such an ability is thought to be a simple characteristic like physical height, then the present experimental results leave no doubt that such an ability does not exist. Games of Twenty Questions would make abysmal psychometric tests.

Nevertheless there are characteristic age differences. With age, children typically change their general style of approach to the game as a social interaction. They change their disposition to ask certain types of question, about aspects of the specific material presented. They change in the cognitive sophistication of their questions, e.g., the use of category questions which are specified by references to items which are not actually present in the display. However these changes do not necessarily go hand in hand with an increase in constraint seeking efficiency: the more sophisticated children often trip over their own

cleverness, indeed the notion of using as few questions as possible is often given little priority in their overall approach to the game.

CHAPTER EIGHT

MEMORY

EXPERIMENTS 6 AND 7

CHAPTER EIGHT

MEMORY CATEGORISATION WITH PICTURES AND WORDS

The following two experiments involved 78 children aged 9 or 12 years old in remembering the items from either the Picture or the Word displays used in Exps 2 and 3 respectively. Whereas in the 20 Questions games children had to categorise the displays in order to evolve CQs, in the present experiments children were encouraged to categorise the displays in order to remember their contents. Two types of categorisation were investigated.

In Experiment 6, 9 and 12 year old children were presented with either the Picture or the Word display and told to remember the items. In order to help them the respective displays were categorised for each child by means of a mask, bearing the categories of all 24 display items, being draped over the display, and 6 category 'cue cards' each referring to 4 display items. The Picture display category cues were pictorial symbols whilst the Word display category cues were the words, Men, Clothes, Fruit, Buildings, Animals and Vehicles. After categorisation the displays were covered up and the children were told to recall the display items first with the cue cards, (cued recall) and then without them (free recall).

In Experiment 7, 9 year old children were either presented with the Picture display or the Word display and told to remember it, only this time the mask previously used on the Picture display was used on the Words display and the Word display mask was used on the Picture display. In this way Word category cues were used to cue the picture display items whilst Pictorial symbols were used to cue the Word display items.

By varying the material to be remembered and the cues used to both categorise and cue it, it was hoped that some light could be shed on the best combination of material and method of cueing.

Previous Work on Cued and Free Recall

This is an exceptionally popular field of work and the quantity of published material is huge but one paper in particular inspired Experiments 6 and 7 and that was Kobasigawa (1974).

Kobasigawa presented 6, 8 and 11 year olds with a display of 24 picture cards which could be divided into 8 categories. Each child was made aware of the link between the display items and the categories when they were given a picture card bearing a drawing which would easily be associated with the 3 display cards that went with it. For instance, the cue card showing a zoo was placed next to the picture card of the bear and Kobasigawa said "in the zoo you find the bear".

Three recall conditions were used. In the first, Free Recall, the number of cards recalled was found to increase with age. In the second, the children were given the cue cards face down and left to use them if they felt like it. Most of the 8 and 11 year olds used them but only 4 out of the 12x6 year olds did so to recall 45% of the items whereas the 8 year olds recalled 66% of the items.

The third condition was cued recall and all three groups recalled 85% of the display items. Clearly,the younger children had remembered the test items but lacked the ability to both recognise and use an efficient recall procedure,whilst the 8 year olds could recognise one but not use it efficiently.

In a follow-up experiment Tumelo, Mason and Kobasigawa (1974) used the same materials only they stuck three blue squares onto each cue card to remind the children that there were three items per category. When left with the cue cards face down the 6½ year olds recalled 20% more in the "informed" condition whilst the 8 year olds performed like 11 year olds. Clearly the children were successfully placing the pictures into memory but the highly ordered tasks involved in retrieval were too complex for the younger children to control effectively without the props provided by the experimenter. With the props successively

removed the age differences between the children become more obvious. As a general age related cognitive trend this phenomenon is termed "production deficiency".

Similar experiments with Words have not been so successful, e.g. Scribner & Cole (1972) gave 7, 9 and 11 year olds 20 random nouns to remember. They were told that these words came from 4 categories and this fact was stressed to both the group left to free recall and the group given cued recall. After three successive trials the cued recall group were performing better than those in the free recall condition, then a new list was given. Measured in terms of the amount of words recalled in category clusters only the 11 year olds from the cued recall group showed any increase in clustering over the free recall group. Perhaps the successive recall trials prevented the younger children from formulating effective control strategies for manipulating their own category cues, or,more likely, the words were just too difficult to remember and organise at the same time.

With particular relevance to Experiment 7 one must ask what sort of category cues children would use when left to themselves. There is plenty of evidence to show that children benefit considerably from using the experimenter's category cues to aid recall (see Kail & Hagen 1977) and that under certain circumstances their own categories are better for retention (Hagen, Jongeward & Kail 1975 [see Kail & Hagen 1977]) but from the plethora of information available, one is tempted to suggest that as a general rule young children are very susceptible to minute changes in nearly all the variables manipulated both within, and between, experiments and that whilst older children can synthesise recall strategies effectively, production deficiency and situation dependence play an ever increasing role in the performance of younger and younger children.

In general terms, Experiment 6 is an attempt to study the effects of 'production deficiency' on 9 and 12 year olds using both Picture and Words

whilst Experiment 7 examines the responses of the 9 year olds to variation in the nature of the material and the way it is cued.

Both experiments, by using the same displays as Exps. 2, 3 and 4 cast some light on the categorizing behaviour involved in these 20 questions studies.

Experiment 6 The effect of cued recall on the performance of 9 and 12 year olds asked to memorise either 24 pictures or 24 words

PARTICIPANTS

52 children from middle class schools; 26 x 9 year olds (15 boys, 11 girls) mean age 9 years 4 months (range 9.0 ⟶ 9.9) and 26 x 12 year olds (12 boys, 14 girls) mean age 12 years 3 months (range 11.9 ⟶ 12.10).

MATERIALS

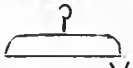
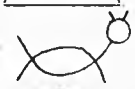
The same 24 item Word or Picture displays as used in Exps. 2, 3 and 4 were used coupled with two masks each bearing appropriate category labels.

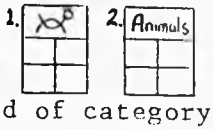
The displays were made up on 64 cm x 52 cm cardboard sheets and either bore 24 coloured picture cards depicting 4 items from 6 categories (each randomly designated to positions in a 6 x 4 matrix) or an identically arranged collection of plain white cards each bearing the name of the corresponding picture card.

The masks were cut from the same size cardboard sheets as the displays, and in them windows were cut through which the 24 display cards could be seen when the masks were placed over their respective displays.

On the Picture display mask, schematic category symbols were drawn under the windows corresponding to a pictured item from that same class in the display. When the mask was placed over the display, each display card was categorised and identified by the relevant category symbol. The symbols (each in a different colour) for each category were as shown in Fig. G.

FIG. G. Details of the two display categories and the category symbols used on the masks and the cue cards.

Word Display Category Cues	Picture Display Category Cues	Corresponding Display Items (randomly distributed within the displays)			
Vehicles		bus	car	tractor	fire engine
Clothes		hat	socks	dress	gloves
Animals		pig	cow	horse	rabbit
Buildings		shop	house	farm	school
Fruit		banana	apple	lemon	orange
Men		soldier	sailor	postman	milkman

In addition to the Picture mask, each symbol appeared on a 4cm x 6cm cue card[1] arranged such that the coloured symbol was at the top with 4 empty squares arranged in a 2 x 2 fashion below. i.e. 

The Word display mask was similar, only instead of category symbols, the words, Vehicles, Clothes, Animals, Buildings, Fruit and Men were used both on the mask and the corresponding cue cards[2] (for each display the same category colours were used).

PROCEDURE

Each child was taken individually to a room in the school and made to feel at ease. The experiment was split into 4 phases.

Phase 1 Item identification:

The child was shown either the Picture or the Word display and the experimenter said, "Take a look at this, there are 24 (Picture/Word) cards there, can you tell me what they are ? " (or in the words display) "can you read them out ?"

With the Pictures the child sometimes used a different label to that used by the experimenter, but these were only corrected if the label used was wrong or potentially confusing. With the Words some children required help, but using the phonetic method (as taught in the school) the child was encouraged to find out what the words meant. [This only happened twice].

Phase 2 Item identification by category

The appropriate mask was then placed over the display and the experimenter brought the child's attention to the category cues under each window. The experimenter then said "In a few minutes I am going to cover up all these cards and ask you to remember as many of them as you can". To emphasise which cards were meant the mask was lifted and the display cards were pointed to.

The experimenter then produced one of the cue cards and said "There are 4 display cards which have this (picture/word) underneath, can you show me where they are and tell me what they are please ?" The child then took the cue card and matched it with the 4 display cards which went with it. All 6 categories were covered with a cue card and the fact that 4 items were in each was stressed in the instructions by the experimenter, saying, "There are four cards which go with this", and so forth.

After the child had completed this matching process at their own pace the display was covered up and the cue cards retained by the experimenter.

Phase 3 Cued Recall

The experimenter held up one of the cue cards, and said "There were four (picture/words) that went with this card, what were they ?" The cue card was handed to the child and they were not handed another cue card until they had recalled all 4 display cards or they had paused for 20-30 seconds.

The order of presentation of the cue cards was random between subjects, but for each subject the order in which they were used in Phase 2 was kept in strict relation to the order used in Phase 3. A Phase 2 presentation A, B, C, D, E, F was always followed by a Phase 3 order B, C, D, E, F, A.

Phase 4 Free Recall

After recall from the 6th cue card had finished the experimenter gathered them in and said, "Can you please tell me as many of these cards, (pointing to the covered display) as you can remember"

The entire proceedings were recorded on tape and subsequently transcribed.

TAB (5, 1) Results of Exp.6

	PICTURES				WORDS			
	9 years		12 years		9 years		12 years	
	Cued Recall	Free Recall	Cued Recall	Free Recall	Cued Recall	Free Recall	Cued Recall	Free Recal
1. Mean number of cards recalled	21.0	16.6	21.31	18.69	17.92	13.46	19.77	15.2
2. Mean number of categories recalled	6.0	5.31	6.00	5.62	5.9	5.38	6.0	5.3
3. Mean number of cards recalled per recalled category	3.44	3.18	3.55	3.34	3.03	2.50	3.29	2.8
4. Mean Z score	—	5.0	—	6.3	—	3.27	—	3.4
5. Total number of repeated items	1	21	Ø	36	1	8	1	20
Total number of intrusive errors	1	1	Ø	2	10	3	20	7

RESULTS

TAB (5, 1) gives a summary of results for Exp.6 (Repeated items or intrusive errors are excluded from the analysis in sections 1, 2, 3 and 4)

1) Mean Number of Cards Recalled

All the children recalled more display cards in their cued recall than in their free recall and these differences were all significant. (Pictures 9 years $T = 3.946$, 12 years $T = 4.977$, Words 9 years $T = 6.9$, 12 years $T = 5.87$, all > 3.055 therefore $p < 0.005$ 12 df).

Generally, the 9 year olds recalled 4 more cards in their cued recall whilst for the 12 year olds the difference between free and cued recall was slightly less.

a) Age differences - In the Picture display condition there was on average just under one card difference for cued recall and just over one

card difference for free recall between the age groups, but the variance between the cued recall of the 9 and 12 year olds was significantly different ($F(12,12) = 4.7555 > 4.155$ $p < 0.01$), thus indicating that the 12 year olds were more consistent in their recall as a group than the 9 year olds.

In the Word display condition the difference between the 9 and 12 year olds free and cued recall was in the region of 2 cards and whilst the variance of the cued recalls was not significantly different, the difference in mean totals was, ($T = 2.028 > 1.71$ therefore $p < 0.05$ 24 df), the 12 year olds recalling more than the 9 year olds.

b) Differences between Display Conditions - The Pictures were recalled significantly better than the Words by both age groups, especially in their free recalls (9 years $T = 2.8254 > 2.064$ $p < 0.05$, 12 years $T = 3.128 > 2.797$ $p < 0.01$ both 2 tail tests with 24 df) where the difference between the Picture and Word recalls was in the region of 3½ cards.

The cued recall procedure narrowed the difference between the Picture and Word display conditions moreso for the 12 year olds than the 9 year olds.

The 9 year olds recalled in the region of 2½ to 3 cards more in the cued recall with Pictures than with Words ($T = 2.671 > 2.492$ $p < 0.025$ 2 tail with 24 df). For the 12 year olds the difference in cued recall between the Picture and Word display groups was only 1½ cards, a difference still large enough to be significant had not the variance in scores between the two presentation groups been significantly different instead! ($F(12,12) = 3.2889 > 3.28$ $p < 0.05$ 2 tail). The variance in recall of those in the Pictures condition was greater than those in the Words condition.

2) Mean number of categories recalled

There were 6 categories from which 4 items could be recalled. In Phase 3 the 6 categories were cued for each child by the experimenter so, providing the child recalled at least one correct category item from all

6 categories they were deemed as recalling from 6 categories. One 9 year old in the Word display condition when shown the cue card for Animals was unable to recall any animal names from the Word display so this accounts for the cued recall score of 5.9 rather than 6 categories recalled for the 9 year old Words condition cell in TAB (5, 1).

a) Age differences - In the Free recall, where each child was left to recall in any way they wished, some "clustered" their recall into categories, whilst others didn't. On average the 9 and 12 year olds in the Words condition recalled words from 5.38 categories each whilst the 9 year olds in the Pictures condition recalled slightly fewer categories (5.31) and the 12 year olds recalled slightly more (5.62). None of these differences was significant, thus indicating that whilst the effects of the cue cards were significant generally as methods of improving recall, it was the effect of the material being remembered which accounted for any differences in recall witnessed between groups.

b) Differences between Display Conditions - Again the effect of the cue cards in so much as they may have influenced the total number of display cards recalled was not marked, therefore one must attribute the earlier mentioned differences between thememorability of the Pictures over that of the Words to the nature of the material itself rather than differences in the effectiveness of schematic or verbal cue cards.

3) Mean number of cards recalled per recalled category

In cued recall the number of display cards recalled was a function of the number of categories recalled and how many cards were recalled from each category. In free recall this process was still at work, although not necessarily in such an ordered way.

As an independent measure of the number of items recalled from each category, for each child the number of cards recalled was divided by the number of categories recalled. For all conditions it was found that significantly more items were recalled per category in cued recall than in free recall (Pictures 9 years $T = 2.2034 > 2.179$ $p < 0.05$, 12 years

$T = 3.699 > 3.055$ $p < 0.01$ both 2 tail tests with 12 df) the largest differences being with the Words material, (Words 9 years $T = 4.41$, 12 years $T = 3.727$ both > 3.055 $p < 0.01$ 2 tail with 12 df).

Clearly the differences in recall between the two displays were largely due to the memorability of the material rather than the efficiency of the category cues.

a)Age differences - In the free recall of both display condition groups the 12 year olds recalled more items per category recalled than did the 9 year olds, although these differences were not significant.

b) Differences between display conditions - In the cued recall both age groups in the Pictures display condition recalled more items per category recalled than their contemporaries in the Words display condition. In the Free recall the same was true in a much more dramatic way, both the 9 and the 12 year olds in the Pictures display condition recalled on average ½ an item more from each recalled category than did those in the Words display condition. These differences were significant (9 years $T = 2.8078$, 12 years $T = 3.2115$ both > 2.797 $p < 0.01$ 2 tail tests with 24 df).

4) Mean Z score

Whilst the three measures of total number of items recalled, number of categories recalled and number of items recalled from each recalled category are fairly comprehensive in their analysis of the results, they do not take into account the way in which the items may be clustered into categorical groups during recall.

Most available measures of category clustering are tied closely to the frequency of recall and, as such, vary in sensitivity depending on the size of the recall total. The 'Z' clustering score developed by Frankel and Cole (1971) is sensitive to both large and small recalls and so a Z score was calculated for the free recall of each child.

a) Age differences - In both display conditions the 12 year olds showed more evidence of category clustering their Free recalls than did

the 9 year olds and whilst this difference was not significant in the Words display condition it was significant in the Pictures display condition ($T = 1.8 > 1.71$ $p < 0.05$ 1 tail with 24 df).

b) Differences between display conditions - For both age groups the children in the Pictures condition group clustered significantly more of their recall than did those in the Words condition group (9 years $T = 2.3426 > 2.064$ $p < 0.01$; 12 years $T = 4.457 > 2.797$ $p < 0.005$, both 1 tail tests with 24 df).

c) TAB (5, 2) the size of each category cluster - In Free recall, items could be recalled individually or in category clusters, 2, 3 or 4 items at a time.

TAB (5, 2)

		Size of category cluster				
		1	2	3	4	Total
Pictures	9 yrs.	31	21	29	14	216
	12 yrs.	30	17	21	29	243
Words	9 yrs.	52	26	17	5	175
	12 yrs.	53	25	17	11	198

TAB (5, 2) clearly shows that the children in the Picture condition group recalled more cards in category clusters of 3 and 4 items than the children in the Words display condition who tended to recall more individual items or clusters of 2 cards at a time.

One can also see that the discriminating factor separating the age groups was that the 12 year olds recalled more full categories (clusters of 4 items) than the 9 year olds.

5) Total number of repeated items and intrusive errors.

A repeated item was scored as such each time the child repeated it. An intrusive error was an item recalled which was not in the display but was an example of one of the six categories used in the display, e.g. for vehicles, "lorry", or for men "Policeman" etc.

a) Age differences - For both age groups hardly any items were repeated in cued recall whilst up to 36 items were repeated in Free recall,

the 12 year olds repeating considerably more than the 9 year olds. This is entirely in keeping with what one would expect. In the absence of the experimenter both cueing the recall categories and reminding the children that 4 display cards went with each category cue the children left to free recall were unable to keep an accurate check on what they had recalled. The 12 year olds recalled more cards so they proportionately repeated more too.

In the Picture display condition very few intrusive errors were made but in the Words condition the 12 year olds made twice as many errors as the 9 year olds, moreso on the cued than the free recall. Bearing in mind the nature of the cueing procedure, which named a category and stressed that four items belonged to it, it is not surprising to find that more children "invented" possible items in this recall condition than in free recall where they had their hands full recalling both the categories and the display items. The fact that the 12 year olds made more intrusive errors than the 9 year olds probably reflects the greater experience of categorisation and knowledge handling skills of the older children.

b) Differences between display conditions - Whereas more children repeated items with the Picture display more children invented possible items with the Word display. Hardly any intrusive errors were made with the Picture display material whilst 40 errors were made with the Words. This is most probably due to the fact that the Picture material, (besides being easier to remember) gave the child less scope for imaginative confusion whilst the Word material, being verbal, with verbal category labels gave more scope for invention. It would have been easier for a child searching the verbal category, 'animals', to 'predict' that "dog" or "cat" were possible display words than it would have been for them to search their visual memory for a card bearing a picture of a dog or a cat. The Word material gave greater scope to the child's powers of making an educated guess, whilst offering fewer opportunities to verify the accuracy of their appropriately categorised guesses.

THE MEMORABILITY OF EACH CATEGORY

In order to see whether certain categories were more frequently recalled successfully than others the number of items recalled from each category by each child was totalled. TAB (5, 3) shows the total number of items recalled from each category (maximum 52) and the number of children recalling all 4 items from that category successfully (maximum 13 children).

Despite the fact that the presentation of cue cards was varied from child to child, certain categories were clearly recalled better than others. The Fruit seemed to have been most frequently recalled (especially with the Pictures condition groups) whilst the Vehicles were recalled worst of all.

Only one category, the Animals was recalled much better with the Words than the Pictures but overall the Animals were among the least recalled items.

In summary,Experiment 6 found that for both age groups the Pictures were remembered better than the Words and this seemed to be more a function of the material to be remembered rather than the efficacy of one type of category cue over another. The 9 year old children benefitted more from cued recall than did the 12 year olds.

TAB (5, 3) The number of items recalled from each category (maximum 52) and, in brackets, the number of children recalling all 4 items from each category (maximum 13 children)

	CUED RECALL				FREE RECALL						
	Pictures		Words		Pictures		Words		Total		Grand
Category	9 yrs.	12 yrs	9 yrs	12 yrs	9 yrs	12 yrs.	9 yrs.	12 yrs.	Pictures	Words	Total
Men	47(9)	48(10)	37(2)	42(5)	44(6)	44(6)	29(2)	31(3)	183(31)	139(12)	322(43)
Clothes	45(7)	48(9)	42(6)	47(10)	20(3)	45(9)	22(2)	36(4)	158(28)	147(22)	305(50)
Fruit	52(13)	51(12)	43(6)	45(8)	47(8)	46(10)	36(4)	37(4)	196(43)	161(22)	357(65)
Buildings	48(9)	46(7)	40(4)	40(3)	42(4)	43(6)	27(0)	31(2)	179(26)	138(9)	317(35)
Animals	41(7)	41(4)	41(6)	43(5)	30(3)	27(2)	33(3)	33(4)	139(16)	150(18)	289(34)
Vehicles	40(5)	43(5)	30(0)	40(2)	33(2)	38(3)	28(0)	30(0)	154(15)	128(2)	282(17)
	273	277	233	257	216	243	175	198			

Experiment 7 The effect of having Pictorial or Word category cues on 9 year olds recalling Pictures or Words.

PARTICIPANTS

26 children from a Middle Class School, (15 boys, 11 girls) mean age 9 years 5 months (range 9.1 → 9.11).

MATERIALS

The same Picture and Word display and the same Picture and Word category masks were used as in Experiment 6.

PROCEDURE

Phases 1 to 4 were identical to those of Experiment 6 save for the substitution of the Word category mask with the Picture display and the Picture category mask with the Word display. Unlike Experiment 6 there was one extra phase.

Phase 5 - Categorised recall without cues - After free recall the experimenter said, "Can you remember when I held these cards up to help you ? I held one card up and you remembered as much as you could from it then I held another card up and you remembered as much as you could from that. Now can you do that, only this time I'm not going to show you each card . . . you try. Can you think of one of the cards, now of the words/pictures that went with it ?".

After each category the child attempted, the experimenter said, "can you think of another card and the words/pictures that went with it?"

RESULTS

TAB (6, 1) gives a summary of results from Experiment 7 along with comparable results for the 9 year olds in Experiment 6.

1) Mean number of cards recalled

All the children recalled more cards in their cued recall than their free recall and these differences were both significant. (Pictures with Word cues P_W T = 5.226, Words with Picture cues W_P T = 6.5354 both $>$ 3.055 $p < 0.005$ 1 tail with 12 df). Generally, between 4 and 5 cards separated the cued and free recalls of both groups, slightly more than that found in Exp.6.

TAB (6, 1) RESULTS OF EXPERIMENT 7

	PICTURES				WORDS			
	Word Cues		Picture Cues		Picture Cues		Word Cues	
	Cued Recall	Free Recall	Cued Recall	Free Recall	Cued Recall	Free Recall	Cued Recall	Free Recall
1. Mean number of cards recalled	22.08	16.54	21	16.6	16	11.23	17.92	13.46
2. Mean number of categories recalled	6	5.54	6	5.31	5.9	4.34	5.9	5.38
3. Mean number of cards recalled per recalled category	3.68	2.95	3.44	3.18	2.7	2.52	3.03	2.50
4. Mean Z score	—	4.44	—	5.0	—	2.62	—	3.27
5. Total number of repeated items	2	15	1	21	0	6	1	8
Total number of intrusive errors	1	2	1	1	9	4	10	3

	Exp. 7 Phase 5	Exp. 6	Exp. 7 Phase 5	Exp. 6
Mean number of cards recalled	18.15		9.0	
Mean number of categories recalled	4.85		3.15	
Mean number of cards recalled per recalled category	3.75		2.85	
Total number of repeated items	3		4	
Total number of intrusive errors	3		6	

a) Pw vs Wp - Significantly more cards were recalled in both the cued and free recall conditions by the Pw group (Cued recall T = 8.544, Free Recall T = 3.24, both $>$ 2.797 $p < 0.005$ 1 tail with 24 df). The children in the Pw condition recalled on average 4 more cards in both cued and free recall than those in the Wp condition.

b) Comparisons with Exp.6 (Pw vs Pp)(Wp v. Ww) - With the Picture display, slightly more Picture cards were recalled with the Words as category cues than with the Pictures as category cues, although this difference, (one card in the cued recall only), was not significant.

With the Words display the children using the Word category cues recalled, on average two cards more than those using the Picture category cues although this difference was only deemed significant for the cued recall. (Cued recall T = 2.257 $>$ 2.064 $p < 0.05$ 2 tail; Free recall T = 1.739 $>$ 1.711 $p < 0.1$ 2 tail both with 24 df).

2) Mean number of categories recalled

As was the case in Exp.6 it was only with the Words that a child could not recall any items from one of the categories in cued recall.

a) Pw vs Wp - On average only 4½ categories were recalled by those in the Wp group whilst the Pw group recalled on average 5½ categories. This difference was significant (T = 3.862 $>$ 2.797 $p < 0.01$ 2 tail with 24 df).

b) (Pw vs Pp) (Wp vs Ww) - With the Picture display material the children using the Word category cues recalled slightly more categories than those using the Picture category cues. These differences were not significant.

With the Words material the children using the Words category cues recalled on average one more category than those using the Picture category cues and this difference was significant. (T = 4.093 $>$ 2.797 $p < 0.01$, 2 tail test with 24 df).

3) Mean number of cards recalled per recalled category.

In both cued and free recall more cards were recalled per category with the Picture display material than the Word display material, but a curious and most interesting interaction took place between the type of categorycues used and the drop in performance between cued and free recall.

In cued recall going from highest to lowest performance the order of conditions was Pw, Pp, Ww, Wp, whereas in free recall the order was

Pp, Pw, Wp, Ww.

Whilst the Word category cues certainly increased the number of categories recalled in free recall over that of the Picture category cues the children recalled more from each recalled category with the Picture category cues. Clearly, Word category cues were efficient at allowing children to recall categories, but this efficiency was gained at the cost of reducing the number of items recalled from each category.

a) Pw vs Wp - The difference between the free recall of these two conditions was almost significant ($T = 1.96 > 1.711$ $p < 0.1$ 2 tail test with 24 df) the Pw children recalling on average half a card more per recalled category than the Wp children.

b) (Pw vs Pp) (Wp vs Ww)- Whilst the differences between cued and free recall led to the effects discussed earlier, in neither the Pictures display condition nor the Words display condition were there significant differences between the two types of category cues in free recall.

4) Z Scores

a) Pw vs Wp - The children in the Pw group showed almost twice as much clustering in their recall as those in the Wp group although this difference fell just short of significance. ($T = 2.002 < 2.064$ for $p < 0.05$ 2 tailed test with 24 df).

b) (Pw vs Pp) (Wp vs Ww) - Although no differences were significant the children in the Pictures display condition group clustered their free recall more with the picture category cues, whereas the opposite was true in the Words display condition group where more clustering was obtained with the Word category cues.

c) TAB (6, 2) The Size of each category cluster.

Size of category cluster

	1	2	3	4	Total
Pw	46	30	13	17	215
Pp	31	21	29	14	216
Wp	33	29	13	4	146
Ww	52	26	17	5	175

TAB (6, 2) shows that the discriminating factor separating the performance of the Pw and Wp groups was that the Pw children recalled over four times as many complete categories as the Wp children.

In terms of the conditions producing the largest clusters of category recall the order was clearly Pw, Pp, Ww, Wp - a trend reflected many times throughout this experiment.

5) Total number of repeated items and intrusive errors.

a) Pw vs Wp - More cards were repeated in the Pw condition whilst more intrusive errors occurred in the Wp condition. This seems to be in keeping with the nature of the material to be recalled rather than the effect of the various category cues, children repeating more Pictures and inventing more possible category members with the Words, a trend borne out in Experiment 6.

THE MEMORABILITY OF EACH CATEGORY.

TAB (6, 3) shows that, as in Experiment 6, the Fruit were easily the best remembered category of items in each display whilst the Animals were the least well remembered. Of great interest is the comparison between the Phase 5 conditions.

TAB 6, 3) The number of items recalled from each category (maximum 52) and, in brackets, the number of children recalling all 4 items from each category (maximum 13 children).

Category	Pw			Wp			Total		
	cued recall	free recall	Phase 5	cued recall	free recall	Phase 5	Pw	Wp	Grand Total
Men	49(10)	36(5)	42(10)	28(0)	20(1)	13(0)	98(25)	90(1)	188(26)
Clothes	48(10)	32(4)	39(9)	32(0)	9(0)	12(0)	92(23)	80(0)	172(23)
Fruit	52(13)	44(7)	47(11)	46(8)	40(5)	35(5)	131(31)	133(18)	264(49)
Buildings	46(8)	41(6)	36(7)	36(4)	26(1)	16(2)	103(21)	98(7)	201(28)
Animals	46(5)	28(2)	30(6)	31(0)	23(0)	10(0)	84(13)	84(0)	168(13)
Vehicles	46(7)	34(Ø)	42(6)	35(2)	28(1)	31(1)	111(13)	105(4)	216(17)
	287	215	236	208	146	118			

THE EFFECTS OF CATEGORY CUEING ON PHASE 5 RECALL.

Perhaps the acid test of any cueing technique is how much the subject will be able to use it without the assistance of the experimenter.

The results, shown in TABs (6, 1) and (6, 3) indicate that telling children to use category cueing themselves significantly increased the recall in the Pw group whilst the children in the Wp group were unable to use it as effectively ($T = 5.226 > 2.797$ $p < 0.01$ 2 tail test with 24 df).

The children in the Pw group recalled exactly twice as many cards as those in the Wp group (recalling both more categories and more from each recalled category): in fact, they not only exceeded their free recall, they virtually repeated (and in the case of the Animals category, exceeded) their performance in cued recall.

Quite clearly the structure of the Pw material gave the necessary "props" to the 9 year olds, whilst the Wp material emphasised their production deficiency.

In summary, this experiment has shown that not only are Pictures much better remembered than Words but the optimum arrangement for recall is to use Word category cues organising pictorial material, whilst the worst configuration is using pictorial category cues with Word material the exact order being, from best to worst Pw, Pp, Ww, Wp.

This result ties with the point made in Exp.4 where children using the word display experienced the most difficulty executing a spatial (pictorial) task. The greater memorability of the Picture material also explains why the greatest age differences in any of the 20 Questions experiments occurred with the Pictures, the progressively older children being better able to produce more categories with regard to the visual display while, at the same time, being better able to keep track of the questions they asked.

CHAPTER NINE

GENERAL CONCLUSIONS

CHAPTER NINE

GENERAL CONCLUSIONS

This thesis has been concerned with 9 to 15 year olds who are English school pupils of average scholastic attainments, and with age-related changes in how these pupils deal with two types of problem-solving task. One type is the Twenty Questions game, the use of which in psychological inquiry was pioneered by Bruner et al (1966) in their book Studies in Cognitive Growth. The other type of task is the attempted recall of an array of presented items: as used in this thesis, the psychological study of this type of task was pioneered mainly by Flavell (1970) in a chapter entitled 'Developmental studies of mediated memory'. In dealing with each type of problem it is open to children to increase their problem-solving efficiency by making planful use of categorisation. And the main question to which this thesis has been devoted is whether there is, in the pupils concerned, a spontaneous increase with age in the planful use of categorisation.

The purpose of this concluding chapter is to relate the empirical findings of the thesis to the wider study of cognitive development and, in particular, to four traditions of such study. These four traditions are as follows.

First, there is the structuralist tradition of Piaget (see Flavell, 1963). Piaget regards cognitive development throughout childhood in terms of the emergence of progressively more powerful forms of intelligence which mark the child's transition from dependence on narrow perceptual-motor co-ordinations to the use of comprehensively organised systems of formal operations and logical structures. Secondly, there is the tradition of Bruner (See Bruner, 1973). Bruner, like Piaget, is concerned mainly with the development of children and, again like Piaget, distinguishes broad stages of development which he characterises in terms of the child's dependence on enactive, iconic, and symbolic systems of representation.

Bruner differs from Piaget in his greater emphasis on skill acquisition and on the roles played by language and by cultural context in shaping development.

Thirdly, there is the tradition of Luria (see Luria, 1976 and Luria, 1979). Luria emphasises the development of adaptive skill systems as a result of social interaction, and the dependence of such skill development, not only on biological constitution, but also on their cultural and social adaptiveness. For example, he worked with non-literate Uzbek adults whose cultural context had never induced them to deal with verbal syllogisms in the abstract manner which is sometimes supposed to be typical of literate Western adults but who dealt with syllogisms, not in terms of any abstract argument form, but in situational terms, that is, in terms of concretely familiar practical situations which the syllogism suggested. Fourthly, there is what might be called the Carnegie-Melon tradition (see Simon, 1979, and Anderson, 1981) which is centred on Carnegie-Melon University, draws upon long-established studies of skilled performance and more recent innovations in computer-based cognitive science, and is mainly concerned with the development of complex skills in adults. The emphasis lies in the acquisition, through prolonged experience and practice, of the skills and bodies of knowledge which lead people to become experts in, say, chess, algebra, computation, geographical route-finding. In so far as this tradition considers children's cognitive development, the tendency is to view that development in the same skill-building terms as the development of adult expertise and not to view children in terms of age-related stages of cognitive functioning.

With these four traditions in mind, consider three of the main empirical findings to emerge from the present thesis.

(1) Regarding Twenty Questions, when the children are presented with 24-item displays comprising either numbers or words or pictures, there

is, with increasing age, a large and highly significant increase in the use of categorical questions at the expense of particular questions but, at the same time, there is no significant increase in problem-solving efficiency as measured by the number of questions asked prior to locating the target item. The use of a clear-cut half-split strategy is virtually absent and is not readily evoked by verbal instructions and demonstrations.

(2) Regarding the recall task, when the children study a 24-item display and are later asked to recall as many of the items as they can, there is, with increasing age, a significantly increasing use of categorisation as a memory-aiding device, and an associated increase in the number of items successfully recalled.

(3) With both types of task, there is a striking descrepancy between the problem-solving efficiency which the children spontaneously achieve and the greater efficiency which these same children achieve under appropriate conditions of pressure or guidance.

How do these three findings relate to the four traditions of viewing cognitive development ? Consider the first finding about Twenty Questions. All four traditions would expect that, with increasing age from 9 to 15 years, there would be an increasing disposition to categorise the items, to do so in a greater variety of ways, and to ask categorical rather than particular questions. However Piaget and Bruner might well be vexed that the increasing use of categorical questions is unaccompanied by any increase in problem-solving efficiency. Although Piaget did not explicitly study Twenty Questions, it seems likely that he might view the half-split strategy as a predestined idea which somehow matures as an aspect of formal operational intelligence. Whether or not it is correct to attribute such a view to Piaget, it is certain that such a view gets no support from the present findings: in the average English school pupil there is, up to the age of 15 years (and beyond), no spontaneous appearance of the half-split strategy. Bruner's expectations about the development of the half-split

strategy are easy to state because they are given in Bruner et al (1966) who depict children as developing progressively increasing competence in "constraint-seeking" abilities and who, furthermore, support this developmental picture with what appears to be convincing evidence.

Why should the evidence reported by Bruner et al. be in disagreement with the evidence obtained in this thesis ? There are four possible explanations, each of which is amenable to experimental test. First, Bruner's subjects were of high I.Q. and probably came from schools and homes which were above average in their provision of intellectual stimulation and challenge: by contrast, the present subjects were of average scholastic ability and came from average backgrounds. Secondly, Bruner used a 42-item display whereas the present writer used a 24-item display. The larger number of display items might have provoked more planful questioning, although this seems doubtful in view of the findings of Denney (see Chapter 1 of this thesis) who used the same display as did Bruner. Thirdly, and probably much more importantly, Bruner's subjects were given considerable prior acquaintance with the display. The subjects took part in an earlier experiment in which the display was presented and the children required repeatedly to categorise and recategorise the items in the display. This earlier experiment not only emphasised categorisation but provided the children with opportunities to explore various ways of categorising the items and to discover relationships among various category groupings. This prior opportunity to explore, and become familiar with, the categorical properties of the display may well have influenced the children's subsequent dealings with the Twenty Questions task. In the writer's experiments the children had no such prior experience with the array and, indeed, some of the children gave the impression that they were more preoccupied by exploring the categorical potentials of the display than with playing the Twenty Questions game efficiently. Fourthly, there is the format in which Bruner et al reported the results of their Twenty

Questions study. They presented a general account of a progressive developmental increase in "constraint-seeking" ability and supported their account with selected illustrative data and protocols. It is not impossible that, in doing this, they gave an exaggerated impression of the extent to which their empirical findings were in line with their general developmental picture. Nor should it be overlooked that the general developmental account was in line with Bruner's theoretical expectations: his reason for studying the Twenty Questions game was to cast light on how children made the transition from the iconic to the symbolic mode of thinking. Whatever the explanation for the disagreement between the findings of Bruner at al. and of the present writer with regard to the spontaneous development with age of an increasing problem-solving efficiency in dealing with Twenty Questions, the report by Bruner et al caused subsequent investigators to assume that such a progressive development had been established and, in some instances, to assume further and incorrectly that such a progressive efficiency was indicated by the frequently-repeated finding that older children ask more categorical questions than do younger children. Notice that this latter erroneous assumption is easy to fall into. Optimally efficient questioning, as exemplified by the half-split strategy, demands the predominant, almost exclusive, use of categorical questions. But the converse does not follow: it is possible to use categorical questions inefficiently.

The developmental picture which emerges from the writer's findings, and from the bulk of the literature about Twenty Questions, is that, with increasing age during the pre-adult years, there is an increasing disposition to ask categorical questions but that the efficient use of categorical questions requires higher-order skills of planning which depend, for their development, on the special provision from outside of appropriate pressures, opportunities, and incentives. This picture is most obviously in harmony with the traditions of Luria and of the work centred on Carnegie-Melon,

i.e. traditions which emphasise the acquisition of repertoires of skill which can, under appropriate circumstances, be used as components in higher-order skills. This picture accepts that the half-split strategy is a complex performance which involves the selection and co-ordination of a great variety of component skills. The picture accepts that, in the course of normal everyday life, children are likely to acquire skills which equip them better to understand and apply the half-split strategy; but also asserts that the strategy does not emerge spontaneously and requires to be provoked by circumstances which, in one way or another, emphasise the objective and the means of economical questioning. Precisely what such circumstances might be is, at present, an open question. They must occur in the lives of the many people who nowadays work with computer systems and use the binary-chop with facility when dealing with familiarly computerised subject matters. But whatever these circumstances are, they do not appear to have occurred in the lives of the school pupils who took part in the present investigations.

It has just been emphasised that, in studying the cognitive development of children, there is need to take into account the real-life social and biographical circumstances of the children concerned and not merely to view the child as an isolated entity. The role of real-life social and biographical circumstances seem also to be implicated by the second and third main findings of the present thesis.

The second main finding concerns the recall type of task. The finding confirms the well-established role of categorisation as a memory-aiding device (see Hunter, 1976). The finding also shows a spontaneous increase with age in the effective use of this device. This spontaneous, age-related increase in the effective use of categorisation contrasts with the absence of such an increase in relation to Twenty Questions. Why should there be this developmental difference between the two types of task ? The answer probably lies in the functional characteristics which

are, for the children, manifest in the two tasks. The recall task has its counterpart in many real-life situations where children must often have occasion to try to recall an assembly of items or of people. In this sense, the recall task is relatively well practiced. In the task, working by categories is a procedure which facilitates successful recall and does so in a relatively immediate and noticeable way: the use of categorisation is thereby favoured by the circumstances surrounding the task of recall. By contrast, the economical use of questions in a Twenty Questions game has no obvious counterpart in real-life situations. Furthermore, in guessing games, as carried out by children in their everyday life, there are probably very few costs or penalties for asking a large number of piece-meal questions, and probably very little conspicuous stress on economical questioning. If such is the case, it is to be expected that, faced with Twenty Questions games, progressively older children show little or no spontaneous increase in the economical use of questions until such time as special pressures are introduced into the situation.

The third main finding is that, in both types of task, there is a discrepancy between the problem-solving efficiency which the children spontaneously achieve and the greater efficiency which they achieve under appropriate pressure or guidance. This confirms the well-established phenomenon called production deficiency (see Hunter, 1976). Thus, when Twenty Questions is played under conditions which heavily stress the importance of economical questioning and which provide some illustrations of how such questioning can be done, children often make more effectively planful use of categorisation. Yet their spontaneous approach to the game is cognitively more lax, less foresightful, more reliant on piece-meal impressions and impulses. Likewise in the recall task, children who make effective use of categorisation when they are told to do so, adopt as their spontaneous approach a more lax procedure which relies more on haphazard recall. This discrepancy between spontaneous performance

and pressured/guided performance typically involves higher-order procedures such as surveying the longer-range properties of the task, planning an overall programme for dealing with the task, and sticking to this programme in the face of moment-by-moment distractions. The third main finding shows that such higher-order procedures can be within the reach of children who may, nevertheless, not bring them to bear in their spontaneous dealings with a task. The use, and consequent practice of, such higher-order procedures can depend on the pressures of the task situation.

The above discussions of three main findings of the thesis have dwelt on a very general point, namely, that developments of human accomplishments arise from individual biological constitution in interaction with the opportunities, pressures, and incentives afforded by the individual's social and biographical circumstances. In the four psychological traditions mentioned earlier, this general point receives increasing emphasis as we pass from Piaget to Bruner to Luria and to the Carnegie-Melon psychologists.

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APPENDICES

APPENDIX A

Exp.1 - The total distribution of question types asked by each 9 year old over the 4 games played with the Number Display

	PQ					CQ										Grand Totals				
	Direct	Connected by location	Connected by category	Hypothesis	PCQ	Perceptual	Functional	Nominal	N in display (Above N / Below N)	N not in display (Above N / Below N)	N in display (Between N and N)	N not in display (Between N and N)	Row/Column	Half-split	Fragment	Repeated	Illicit	PCQ	CQ	Total
Jonathan	8	0	0	3	0	15	0	2	0	0	0	0	0	0	0	0	0	11	17	28
Robert	1	0	0	4	6	11	0	0	0	0	0	0	0	0	0	0	0	5	11	22
Craig	24	28	0	0	0	0	0	4	0	0	0	0	0	0	0	3	1	52	4	56
Colin	20	37	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	57	0	57
Paul	0	0	0	16	1	10	0	0	0	0	0	0	5	0	0	0	0	16	15	32
Roger	1	0	0	10	0	0	0	12	0	0	0	1	0	0	0	0	0	11	13	24
Robert	3	0	0	6	4	8	0	0	0	0	0	0	0	0	0	0	2	9	8	21
Samantha	0	0	0	4	9	0	0	0	0	0	0	0	5	0	0	0	0	4	5	18
Louise	0	0	0	8	3	4	0	0	0	0	0	0	7	0	0	0	0	8	11	22
Sharon	3	0	0	9	0	0	0	0	0	0	0	0	10	0	0	0	0	12	10	22
Judith	0	0	0	11	0	0	0	0	0	0	0	0	8	0	0	0	0	11	8	19
Jane	69	50	0	0	0	0	0	0	0	0	0	0	0	0	0	23	2	119	0	119
	129	115	0	71	23	48	0	18	0	0	0	1	35	0	0	46	5	315	102	440

APPENDIX B

Exp. 1 - The total distribution of question types asked by each 12 year old over the 4 games played with the Number Display

	← PQ →					← CQ →											Grand Totals				
	Direct	Connected by location	Connected by category	Hypothesis	PCQ	Perceptual	Functional	Nominal	Above N Below N N in display	Above N Below N N not in display	Between N and N N in display	Between N and N N not in display	Row/Column	Half-split	Fragment	Repeated	Illicit	PCQ	CQ	Totals
Ian	0	0	0	4	8	0	0	4	0	0	0	0	13	0	0	0	0	4	17	29
Darren	0	0	0	7	0	2	0	4	0	10	0	2	0	0	0	0	2	7	18	25
Andrew	0	0	0	4	4	5	0	4	0	0	0	0	8	0	0	0	0	4	17	25
Richard	0	0	0	7	2	1	0	9	0	3	0	0	0	0	0	0	0	7	13	22
Julian	0	0	0	10	3	21	0	0	0	0	0	0	0	0	0	3	1	10	21	34
Nicholas	0	0	0	6	8	14	0	0	0	0	0	0	0	0	0	0	0	6	14	28
Debbie	0	0	0	20	0	0	5	4	0	0	0	0	6	0	0	2	0	20	15	35
Julie	1	0	0	5	3	0	0	14	0	1	0	1	1	5	0	2	0	6	22	31
Susan	6	0	0	8	0	1	0	22	0	0	0	1	0	0	0	2	0	14	24	38
Tina	0	0	0	7	1	0	0	1	0	18	0	0	0	0	0	0	3	7	19	27
Morishka	0	0	0	4	0	0	0	0	0	0	0	0	1	10	6	0	0	4	17	21
Fiona	0	0	0	5	0	0	0	4	0	2	0	12	0	0	0	0	0	5	18	23
	7	0	0	87	29	44	5	66	0	34	0	16	29	15	6	9	6	94	215	338

APPENDIX C

Exp. 1 - The total distribution of question types asked by each 15 year old over the 4 games played with the Number Display

	PQ					CQ										Grand Totals				
	Direct location	connected by category	connected by	Hypothesis	PCQ	Perceptual	Functional	Nominal	Above N / Below N N in Display	Above N / Below N N not in Display	Between N and N N in Display	Between N and N N not in Display	Row/Column	Half-split	Fragment	Repeated	Illicit	PCQ	CQ	Total
Howard	0	0	0	7	0	0	0	4	0	5	0	2	5	0	0	0	0	7	16	23
Mark	15	1	0	18	0	0	12	0	0	0	0	0	0	0	0	0	0	33	12	45
Ian	0	0	0	7	0	2	0	4	3	7	0	0	0	0	0	0	0	7	16	23
Kevin	0	0	0	5	0	0	0	4	0	0	7	0	22	0	0	0	0	5	33	38
Stephen	0	0	0	6	0	0	0	4	2	13	0	0	0	0	0	1	0	6	19	25
Fiona	3	0	0	8	0	0	1	9	0	18	0	1	0	0	0	1	0	11	29	40
Lynn	8	0	0	13	0	1	0	4	0	25	0	0	0	0	0	2	5	21	30	51
Julie	0	0	0	5	0	0	0	7	0	1	9	0	0	0	0	0	0	5	17	22
Deborah	0	0	0	5	18	0	0	0	0	0	0	0	8	0	0	1	0	5	8	31
Caroline	0	0	0	6	13	19	0	1	0	0	0	0	0	0	0	2	6	6	20	39
Louise	0	0	0	5	0	16	0	0	0	0	0	0	0	0	0	0	0	5	16	21
Sandra	5	0	0	9	0	0	0	17	0	11	0	4	0	0	0	0	0	14	32	46
	31	1	0	88	31	38	13	54	5	80	16	7	35	0	0	7	11	125	248	404

APPENDIX D

Exp. 2 - The total distribution of question types asked by each 9 year old over the 4 games played with the Picture Display

	PQ					CQ						Grand Totals				
	Direct	Connected by location	Connected by category	Hypothesis	PCQ	Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment	Illicit	Repeated	PQ	CQ	Total
Raymond	13	17	2	0	0	0	0	0	0	0	0	0	1	32	0	32
Jeff	0	0	0	11	0	0	8	3	0	0	0	0	0	11	11	22
Paul	2	1	5	11	1	0	5	3	0	0	0	1	0	19	8	28
Richard	28	19	4	0	0	0	0	0	0	0	0	1	3	51	0	51
Gary	14	18	8	13	0	3	2	5	0	0	0	2	5	53	10	63
Dominic	23	17	2	0	0	0	0	0	0	0	0	0	1	42	0	42
Sharon	4	2	3	9	4	0	11	2	0	0	0	2	1	18	13	35
Colette	0	0	0	7	5	2	17	0	0	0	0	0	1	7	19	31
Paula	0	0	0	7	2	0	0	0	7	0	0	0	0	7	7	16
Julie	31	13	6	0	0	0	0	0	0	0	0	0	11	50	0	50
Gill	17	5	4	0	0	4	0	0	0	0	0	0	0	26	4	30
Karen	0	0	0	9	4	3	6	8	0	0	0	0	0	9	17	30
	132	92	34	67	16	12	49	21	7	0	0	6	23	325	89	430

APPENDIX E

Exp. 2 - The total distribution of question types asked by each 12 year old over the 6 games played with the Picture Display

	PQ				PCQ	CQ					Grand Totals				
	Direct	Connected by location	Connected by category	Hypothesis		Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment	Illicit	Repeated	PQ	CQ	Total
Stephen	1	0	0	3	5	8	1	0	0	0	0	0	0	4	9	18
Richard	1	0	0	6	15	0	7	3	0	0	0	0	0	7	10	33
Gavin	13	6	15	3	0	9	0	4	0	0	0	0	5	37	13	50
Michael	1	0	0	7	2	15	2	0	0	0	0	0	0	8	17	27
Gerald	8	0	1	13	11	0	8	4	0	0	0	0	1	22	12	45
Paul	44	11	13	0	0	0	0	0	0	0	0	0	13	68	0	68
Paula	2	0	0	7	0	0	1	8	0	0	0	0	0	9	9	18
Jane	0	0	0	9	1	3	3	12	0	0	0	0	0	9	18	28
Sheena	6	2	0	13	2	4	8	6	0	0	0	0	1	21	18	41
Diane	1	0	1	11	0	0	2	8	0	0	0	0	0	13	10	23
Michelle	0	0	0	5	2	0	10	7	0	0	0	1	0	5	17	24
Mandy	0	0	0	9	3	0	5	2	0	0	0	0	0	9	7	19
	77	19	30	86	41	39	47	54	0	0	0	1	20	212	140	393

APPENDIX F

Exp. 2 - The total distribution of question types asked by each 15 year old over the 4 games played with the Picture Display

	PQ				PCQ	CQ						Illicit	Repeated	Grand Totals		
	Direct	Connected by location	Connected by category	Hypothesis		Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment			PQ	CQ	Total
Kevin	0	0	0	4	2	1	5	16	0	0	0	0	0	4	22	28
Andrew	2	0	0	4	3	0	2	16	0	0	0	0	0	6	18	27
Philip	13	0	0	13	0	16	0	0	0	0	0	0	0	26	16	42
Philip	1	0	0	5	1	0	4	12	0	0	0	0	0	6	16	23
Paul	0	0	0	5	3	6	5	5	0	0	0	0	0	5	16	24
Sharon	2	0	0	8	2	9	0	13	0	0	0	0	0	10	22	34
Judith	0	0	0	6	3	0	2	10	0	0	0	0	0	6	12	21
Jacky	0	0	0	5	0	0	4	17	0	0	0	0	0	5	21	26
Christine	3	0	0	7	7	1	12	8	0	0	0	0	0	10	21	38
Tracy	0	0	0	8	0	2	0	10	0	0	0	0	0	8	12	20
Sally	0	0	0	7	0	1	7	1	0	0	0	0	0	7	9	16
Mandy	1	0	0	8	2	3	9	9	0	0	0	0	0	9	21	32
	22	0	0	80	23	39	50	117	0	0	0	0	0	102	206	331

APPENDIX G

Exp.3 - The total distribution of question types asked by each 9 year old over the 4 games played with the Word Display

	← PQ →					← CQ →						Grand Totals				
	Direct	Connected by location	Connected by catetory	Hypothesis	PCQ	Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment	Illicit	Repeated	PQ	CQ	Total
Kevin	23	12	6	0	0	0	0	0	0	0	0	0	2	41	0	41
Gary	0	0	0	5	10	0	0	0	8	0	0	0	0	5	8	23
Warren	2	0	0	10	1	6	5	1	0	0	0	0	0	12	12	25
Darren	10	39	5	0	0	0	0	0	0	0	0	0	6	54	0	54
Frank	0	0	0	9	8	1	14	0	0	0	0	0	0	9	15	32
Christopher	7	0	3	10	0	0	3	9	0	0	0	0	0	20	12	32
Sharon	18	11	2	0	0	0	0	0	0	0	0	0	0	31	0	31
Pat	2	0	0	11	0	0	0	0	2	3	0	0	0	13	5	18
Elaine	22	5	3	0	0	4	0	0	0	0	0	0	0	30	4	34
Lynn	20	18	4	0	0	0	0	0	0	0	0	0	4	42	0	42
Lisa	1	0	0	9	0	0	3	4	0	0	0	0	0	10	7	17
Sharon	0	0	0	8	3	0	13	0	0	0	0	0	0	8	13	24
	105	85	23	62	22	11	38	14	10	3	0	0	12	275	76	373

APPENDIX H

Exp. 3 - The total distribution of question types asked by each 12 year old over the 4 games played with the Word Display

	PQ					CQ						Illicit	Repeated	Grand Totals PQ	CQ	Total
	Direct	Connected by location	Connected by category	Hypothesis	PCQ	Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment					
Paul	0	0	0	8	5	3	11	0	0	0	0	0	0	8	14	27
Chris.A	3	2	0	7	1	1	0	0	5	0	0	0	0	12	6	19
Mark	5	0	2	5	1	2	19	5	0	0	0	0	2	12	26	39
Chris.B	0	0	0	7	3	7	7	10	0	0	0	0	1	7	24	34
Thomas	5	0	1	4	2	5	7	3	0	0	0	1	0	10	15	27
David	0	0	0	10	7	3	14	4	0	0	0	0	0	10	21	38
Janette	1	0	0	7	9	0	10	7	0	0	0	0	1	8	17	34
Mandy	0	0	0	6	0	0	12	7	0	0	0	0	0	6	19	25
Julie	0	0	0	13	0	1	11	1	0	0	0	0	0	13	13	26
Diane	0	0	2	5	4	11	3	4	0	0	0	0	0	7	18	29
Hayley	0	0	0	8	0	0	0	12	0	0	0	0	0	8	12	20
Christine	0	0	0	4	7	0	0	11	0	0	0	0	0	4	11	22
	14	2	5	84	39	33	94	64	5	0	0	1	4	105	196	340

APPENDIX I

Exp. 3 - The total distribution of question types asked by each 15 year old over the 4 games played with the Word Display

	PQ					CQ							Grand Totals			
	Direct	Connected by location	Connected by category	Hypothesis	PCQ	Perceptual	Functional	Nominal	Row/Column	Half-split	Fragment	Illicit	Repeated	PQ	CQ	Total
Helen	0	0	0	12	0	0	12	6	0	0	0	0	0	12	18	30
Gill	2	0	0	2	8	0	2	2	0	0	0	0	0	4	4	16
Christine	0	0	0	4	6	2	1	14	0	0	0	0	0	4	17	27
Jane	3	0	5	3	0	3	0	10	0	0	0	0	0	11	13	24
Judy	1	0	1	11	0	2	1	15	0	0	0	0	0	13	18	31
Joanne	0	0	0	7	0	0	0	10	0	0	0	0	0	7	10	17
Maxine	0	0	0	7	5	0	1	22	0	0	0	0	0	7	23	35
Michael	0	0	0	5	5	2	1	8	0	0	0	0	0	5	11	21
Paul	0	0	0	14	4	8	18	6	0	0	0	0	0	14	32	50
William	0	0	0	6	4	0	4	15	0	0	0	0	0	6	19	29
Anthony	0	0	0	8	5	0	3	7	0	0	0	0	0	8	10	23
Karl	0	0	0	9	1	0	15	0	0	0	0	0	0	9	15	25
	6	0	6	88	38	17	58	115	0	0	0	0	0	100	190	328

APPENDIX J

Exp. 4 - The total distribution of question types asked and the number of games concluded successfully or partially using the SSH method by the 9 year olds in the 4 games of Phase II and the 1 game of Phase IV in each Display condition.

NUMBER DISPLAY	PHASE II					PHASE IV					
	PQ	CQ			Total	PQ	CQ			Total	
		Spatial Content					Spatial Content				
		Half	Other				Half	Other			
Simon	30	3	2	0	35	1	0	10	0	11	
Mark	14	8	1	0	23	2	2	2	0	6	
Colin	12	0	6	0	18	3	3	0	0	6	
Linda	64	0	0	0	64	1	1	3	0	5	
Dawn	26	4	2	0	32	1	4	0	0	5	*
Tracy	17	1	5	0	24	1	3	3	0	7	
Total	163	16	16	0	196	9	13	18	0	40	
PICTURE DISPLAY											
Jason	40	0	0	0	40	2	2	4	0	8	
Ian	40	0	0	0	40	3	1	2	0	6	
Mark	8	3	12	0	23	1	3	0	0	4	ρ
Jane	17	4	7	0	28	3	3	1	0	7	
Jasmine	40	0	0	0	40	1	4	1	0	5	ρ
Rebecca	68	0	0	0	68	0	3	3	0	1	
Total	213	7	19	0	239	10	16	11	0	31	
WORD DISPLAY											
Christopher	6	0	12	0	18	1	4	0	0	5	*
Craig	9	9	8	0	26	3	2	2	0	7	
Andrew	19	4	5	0	28	2	0	5	0	7	
Melany	7	8	12	0	27	2	3	2	0	7	ρ
Julia	5	16	7	0	28	1	4	1	0	6	ρ
Lisa	18	0	10	0	28	2	4	2	0	8	ρ
Total	64	37	54	0	155	11	17	12	0	40	

ρ = Partially successful SSH game

* = Completely successful SSH game

APPENDIX K

Exp.4 - The total distribution of question types asked and the number of games concluded successfully or partially using the SSH method by the 12 year olds in the 4 games of Phase II and the 1 game of Phase IV in each Display condition.

	PHASE II						PHASE IV					
	PQ	CQ			Total		PQ	CQ			Total	
		Spatial Content						Spatial Content				
NUMBERS DISPLAY		Half	Other					Half	Other			
David	7	7	9	0	23		1	4	1	0	6	P
Mathew	6	10	0	7	23	*	1	4	0	0	5	*
Anthony	11	0	23	0	34		2	3	2	0	7	P
Jane	8	9	12	0	29		1	4	2	0	7	P
Christine	8	10	8	0	26		10	4	0	0	5	*
Denise	6	1	43	0	50		1	2	4	0	7	
Total	46	37	95	7	185		7	21	9	1	37	
PICTURE DISPLAY												
David	15	4	0	9	28		1	3	2	0	6	
Nigel	10	0	7	6	23		1	4	0	0	5	*
Andrew	6	9	4	0	19	*P	1	4	0	0	5	*
Mandy	26	2	3	0	31		1	2	5	0	8	
Jane	5	10	8	0	23		2	3	1	0	6	
Julie	9	3	1	19	32		2	4	1	0	7	P
Total	71	28	23	34	156		8	20	9	0	37	
WORDS DISPLAY												
Gareth	13	4	0	0	17		2	1	2	0	5	
Andrew	8	4	0	19	31		0	3	0	1	4	P
Stephen	11	2	7	0	20		3	2	2	0	7	
Tracy	12	2	7	0	21		1	1	7	0	9	
Susan	18	0	0	12	30		1	3	4	0	8	
Paula	7	12	5	0	24	P	3	3	1	0	7	
Total	69	24	19	31	143		10	13	16	1	40	

P = Partially successful SSH games

* = Completely successful SSH games

APPENDIX L

Exp. 4 - The total distribution of question types asked and the number of games concluded successfully or partially using the SSH method by the 15 year olds in the 4 games of Phase II and the 1 game of Phase IV in each Display condition.

	PHASE II						PHASE IV					
	PQ	CQ			Total		PQ	CQ			Total	
		Spatial	Content					Spatial	Content			
NUMBERS DISPLAY		Half	Other					Half	Other			
Shaun	8	12	1	0	21	ppppp	2	4	0	0	6	*
Mark	13	8	0	4	25		1	4	0	0	5	*
Paul	9	3	9	0	21		1	4	1	0	6	p
Alexia	21	0	11	0	32		1	2	1	0	4	p
Andrea	8	7	7	13	35		1	4	0	0	5	*
Christine	6	16	1	0	23	*ppp	2	4	0	0	6	p
Total	65	46	29	17	157		8	22	2	0	32	
PICTURE DISPLAY												
Paul	5	15	0	0	20	****	2	4	0	0	6	*
Kevin	5	8	0	4	17		1	4	0	0	5	*
Ian	8	13	0	0	21		1	4	0	0	5	*
Alan	15	5	9	0	29	*	2	4	0	0	6	*
Deborah A	7	12	4	0	23		2	3	2	0	7	p
Deborah B	6	16	0	0	22	p***	1	4	0	0	5	*
Total	46	69	13	4	132		9	23	2	0	34	
WORD DISPLAY												
Stuart	6	10	2	0	18	ppp	3	3	2	0	8	
Mark	8	10	9	0	27		2	3	2	0	7	p
David	8	4	3	12	27		2	4	2	0	8	p
Elaine	35	0	0	0	35		1	1	4	0	6	
Julie	16	1	14	0	31		2	4	1	0	7	p
Tracy	11	9	8	0	28		3	3	2	0	8	
Total	84	34	36	12	166		13	18	13	0	44	

p = Partially successful SSH games

* = Completely successful SSH games

APPENDIX M

Exp.4 - The number of questions asked in each Phase II game by each 9 year old in each Display condition.

	Game Number	1	2	3	4	Total
NUMBER DISPLAY	Simon	5	19	9	2	35
	Mark	6	4	7	6	23
	Colin	3	3	5	7	18
	Linda	1	50	6	7	64
	Dawn	10	8	7	7	32
	Tracy	2	9	6	6	24
	Jason	8	1	26	5	40
	Ian	10	13	16	1	40
PICTURE DISPLAY	Mark	5	5	5	8	23
	Jane	5	5	11	7	28
	Jasmine	24	7	7	2	40
	Rebecca	33	10	24	1	68
	Chris.	7	3	3	5	18
	Craig	6	6	6	8	26
	Andy	6	7	8	7	28
WORD DISPLAY	Melany	6	6	7	8	27
	Julia	7	8	7	6	28
	Lisa	9	6	8	5	28

APPENDIX N

Exp. 4 - The number of questions asked in each Phase II game by each 12 year old in each Display condition.

	Game Number	1	2	3	4	Total
NUMBER DISPLAY	David	7	6	4	6	23
	Mathew	4	5	5	4	23
	Anthony	7	11	7	9	34
	Jane	7	9	7	6	29
	Christine	7	6	7	6	26
	Denise	11	12	23	4	50
PICTURE DISPLAY	David	7	7	7	7	28
	Nigel	6	6	5	6	23
	Andrew	5	6	4	5	19
	Mandy	5	14	3	9	31
	Jane	6	5	6	6	23
	Julie	16	7	5	4	32
WORD DISPLAY	Gareth	4	4	6	3	17
	Andrew	10	8	7	6	31
	Stephen	4	2	5	9	20
	Tracy	5	4	4	8	21
	Susan	8	5	3	14	30
	Paula	8	7	4	5	24

APPENDIX O

Exp. 4 - The number of questions asked in each Phase II game by each 15 year old in each Display condition.

	Game Number	1	2	3	4	Total
NUMBER DISPLAY	Shaun	7	5	4	5	21
	Mark	6	10	5	5	25
	Paul	5	6	5	5	21
	Alexia	7	11	9	5	32
	Andrea	7	10	9	10	35
	Christine	6	5	6	6	23
PICTURE DISPLAY	Paul	5	5	6	5	20
	Kevin	4	4	4	5	17
	Ian	5	6	6	4	21
	Alan	10	11	4	4	29
	Deborah A	6	6	5	6	23
	Deborah B	6	5	6	5	22
WORD DISPLAY	Stuart	4	5	4	5	18
	Mark	8	6	5	8	27
	David	7	8	4	8	27
	Elaine	4	14	11	6	35
	Julie	8	6	6	11	31
	Tracy	7	7	9	6	28

APPENDIX P

Exp. 6 The distribution of items recalled in Cued and Free recall from each category in the Picture Display with picture cues by the 9 and 12 year olds. (R = repeats and I = intrusive errors).

9 yr. olds	CUED RECALL							FREE RECALL						
	Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total	Men	Clothes	Fruit	Buildings	Animals	Vehicles	Total
Stephen	4	2	4	4	3^{I}	2	19	4	2	4	3^{I}	0	2	15
Simon	4	3	4	4	3	4	21	3	2	3	3	2	3	16
Kevin	4	4	4	3	4	3	22	4	0	3	3	0	3	13
Timothy	4	4	4	4	4	4	24	4	1	4	4^{R}	3	4	20
Stuart	4	4	4	4	4	3	23	4	0	4	4	4	3	19
Dominic	3	3	4	4	4	3	21	3	0	4	4	4	3	18
Mathew	3	3	4	4	3	2	19	2^{2R}	0	3	4	1	0	10
Sasha	4	4	4	3	3	3	17	4	4	3	2	1	3^{R}	21
Jane	4	3	4	4	2	3	18	3^{R}	3	4^{R}	3	2	2	17
Edwina	3^{R}	4	4	4	4	4	23	3^{R}	4	4^{2R}	3	3	1	18
Sarah	4	4	4	4	4	4	24	4	4	4^{2R}	3	4	4^{R}	23
Samantha	4	4	4	3	4	4	23	4^{R}	0	4^{R}	3^{R}	3^{2R}	3^{3R}	17
Jasmine	2	3	4	3	0	3	15	2	0	3	3	3	2^{R}	13
Total	47	45	52	48	41	42	273	44	20	47	42	30	33	216
12 yr. olds														
Darren	4	3	4	3	3	4	21	3	3	4^{4R}	3	0	4^{R}	17
Ian	2	3	4	4	3	4	20	2	3	4	3	2^{R}	4	18
Glen	3	4	4	4	2	3	20	3^{2R}	0	3^{R}	4^{2R}	2	3	15
Andrew	4	3	4	4	2	3	20	3	3	4	4	2	3	19
Thomas	3	4	4	4	4	2	21	3^{R}	4^{2R}	4	2^{R}	2	2	17
Robert	4	4	4	3	4	4	23	4	4	4	3	0	3^{2R}	18
Amanda	4	4	4	4	3	3	22	3	4	4	4	0	3^{2R}	18
Claire	4	4	4	3	3	4	22	4	4	0	4	3	3	18
Susan	4	4	4	4	3	3	22	4	4	4	4	3^{I}	3	22
Andrea	4	4	4	4	4	4	24	4	4	4	4	4	4	24
Patricia	4	4	4	3	4	3	22	4^{3R}	4^{4R}	4I^{4R}	3^{R}	4^{4R}	3^{I}4^{R}	22
Marie	4	3	4	3	3	3	20	4	4	4	2	2	1	17
Janet	4	4	3	3	3	3	20	3	4^{R}	3	3	3	2	18
Total	48	48	51	46	41	43	277	44	45	46	43	27	38	243

APPENDIX Q

Exp. 6 The distribution of items recalled in Cued and Free recall from each category in the Word Display with word cues by the 9 and 12 year olds (R = repeats and I = intrusive errors).

9 yr. olds	CUED RECALL Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total	FREE RECALL Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total
Mark	3	3	3	4	0	3	16	2	2	3^{I}_{R}	2	3	2	14
Robert	2	2^{I}	2^{I}	4	3	3^{I}	16	2	2	0	1	2	3	10
Robert	3	2	3	3	3	2	16	2	0	3	2	2^{R}	2	11
Simon	3^{I}	4	4	3	3	3	20	0	4	4	3	3	2	16
Richard	2	3	4	3	3	3	18	2	3	4	3^{R}	3	2	17
James	3	4	4	3	4	1	19	3	2	3	2	4	1	15
Damian	3	4	4	3	3	2	19	2	0	4	2^{R}	0	2	10
Dominic	3^{I}	2	2	1	2	3	13	3^{I}_{R}	0	2	0	2	3	10
Rosemary	2^{I}	3	3^{I}	3	4	1	16	1	3	4	2	3^{R}	1	14
Fiona	4	4	4	2	4	2	20	2	1	2	2	3	2	12
Petra	2^{I}	4	4	4	4	3^{R}	21	2	2	3	3	4	3	17
Charlotte	3	3	3	3	4	2	18	4	0	2	3	4^{R}	3	14
Shavourne	4	4	3^{I}	4	4	2^{I}	21	4^{R}	4	2	2	1	2^{I}	15
	37	42	43	40	41	30	233	29	23	36	27	34	28	175
12 yr. olds.														
David	3^{I}	4	4	2^{2I}	3	3^{I}	19	2	4	1	2	2^{R}	3	14
Anthony	2^{I}	4	3^{I}	3	3^{I}	2^{2I}	17	2	3^{RR}	3	2^{I}_{R}	2^{R}_{I}	3^{R}	15
Peter	3	4	2	3	2^{I}	3^{I}	17	2	2	2	0	1	2^{R}	9
David	3	1^{2I}	3^{I}	3^{I}	4	3^{I}	17	3	0	2^{I}	2^{I}	3^{I}	2^{I}	12
Kiernan	3	4	4	4	3	3^{I}	21	1	3^{R}_{R}	2	3^{R}	0	2^{R}	11
Mark	4	4	4	4	4	3^{I}	23	4	0	4	3	4^{3R}	3^{I}	18
Salvinder	4	3	4	3	3	3^{I}	20	4	3	3	4^{RR}	0	3	17
Alexia	4	4	4	4	3	4	23	4	3	4	1	3	0	15
Denise	4	4	4	3	4	3	22	3	3	4	4	3^{R}	2	19
Helenfedorwicz	2	4	4	2	4	3	19	3	4	3	2	4^{R}	3	19
Rosemary	3	4	4	3^{I}	4	4	22	3^{2R}	4	4	2	4	1	18
Claire	4	3	3	3	3	3	19	0	3	3	3	3	3	15
Julie	3	4	2	3	3^{R}	3	18	0	4	2	3	4	3	16
	42	47	45	40	43	40	257	31	36	37	31	33	30	198

APPENDIX R

Exp. 7 The distribution of items recalled in Cued and Free recall from each category in the Pictures Display with word cues (Pw) and from each category in the Word Display with picture cues (Wp) by the 9 year olds. (R = repeats and I = intrusive errors).

	CUED RECALL							FREE RECALL						
9 yrs. Pw	Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total	Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total
Michael	4	4	4	4	3	4	23	4	4	4	4	3	3	22
John	4	4	4	4	3	3	22	4R	4	4RR	4	3R	3	22
Chris	4	4	4	4	4	4	24	1	4	4	4R	0	3	16
Alan	4	4	4	4	4	4	24	4RR	4	4	4	4	3	23
Bridget	3	4	4	3	3	3	20	2	0	2	3	1	2	10
Bernadette	4	4	4	2	4	3	21	4RI	3	2R	2	3	3	17
Julia	4	4	4	3	4	4	23	4	4	4	3	4	2	21
Anita	3R	3R	4	4	3I	3	20	3	3R	4	4	0	2	16
Jane	4	3	4	3	3	4	21	1	0	3R	3	3R	2	12
Tracy	4	4	4	4	3	4	23	3R	3	4	2	0	3R	15
Sean	4	4	4	4	4	3	23	1	0	3R	2	3	3	12
Stephen	4	4	4	4	4	4	24	3	3	3	4	3	3	19
Andrew	3	2	4	3	4	3	19	2I	0	3	2	1	2	10
Totals	49	48	52	46	46	46	287	36	32	44	41	28	34	215
9 yrs Wp														
Keith	1I	2	4	2	2	2	13	0	2	4	1	0	2	9
Catherine	3	2	3	4	2	3	17	2	0	4	4	3	1	14
Kerstein	3	3I	4	2	3I	3	18	4	3	4	2	1	3	17
Penelope	0	3	4	3	2	3	15	0	0	3	2	2	0	7
Allison	2	3	3	4	2	2	16	2	0	3	3	2	2R	12
Dermott	3	2	4	3	3	3	18	2	0	2	3	3	3	13
Christopher	2I	2	4	4	3	3	18	1I	0	4	3	1	2	11
David	3	2	2I	2	3I	2	14	2	0	1	0	1	2	6
Trevor	2	2	3	2	1	4	14	2	0	3	0	2	4	11
Sean	3	3	3	1	1	3	14	0	2	3RI	2	0	3R	10
Anthony	1	2	4	4	3	2	16	2	0	2	2	2R	3	11
Mark	3	3	4	2	3	1I	16	3R	2	3	2RR	3I	0	13
Julie	2I	3I	4	3	3	4	19	0	0	4	2	3	3	12
Totals	28	32	46	36	31	35	208	20	9	40	26	23	28	146

APPENDIX S

Exp. 7 The distribution of items recalled in Phase V recall from each category in the Pw and Wp groups of 9 yr. olds.

Wp

	Men	Clothes	Fruits	Buildings	Animals	Vehicles	Total
Keith	0	2	4	0	0	2	8
Catherine	0	0	3	0	2^{I}	3	8
Kerstein	3	3^{I}	4	3	0	3^{I}	16
Penelope	0	3^{I}	4	0	0	3	10
Alison	2	2	3^{I}	4	2	2	15
Dermot	3	0	3	0	0	2	8
Chris	0	0	0	0	0	3	3
David	0	0	0	0	1	0	1
Trevor	2	0	3	2	0	3^{I}	10
Sean	0	2^{I}	3	0	0	3	8
Anthony	0	0	4	4	2^{2I}	3^{R}	13
Mark	3	0	0	0	0	0	3
Julie	0	0	4	3	3	4	14
	13	12	35	16	10	31	117

Pw

Michael	4	4	4	4	0	4	20
John	0	4	4	4	4	3^{I}	19
Chris	4	4	4	4	4	4	24
Alan	4	4	4	4	4	3	23
Bridget	0	4	3	4	0	0	11
Bernadette	4	4	4	2	0	4	18
Julie	4	4	4	3	4	3	22
Anita	4	3^{I}	4	0	3^{I}	3^{3R}	17
Jane	4	0	4	0	3	4	15
Tracy	4	4	4	4	0	4	20
Sean	4	0	4	0	4	3	15
Stephen	4	4	0	4	4	4	20
Andrew	2	0	4	3	0	3	12
	42	39	47	36	30	42	236

APPENDIX T

The questions asked by those children who located the target in 4 questions or less

Name	Game No	Hypotheses	PCQ	CQ	Total	
9 years						
Robert (A)	2	1	0	2	3	Got a 6 in? ✓ Got a 3? ✓ 36? ✓
Robert (B)	3	1	0	2	3	Has it got a 1 in? X 5 in? ✓ [all the 5s, not 51] 52 ✓
Robert (B)	4	2	0	1	3	Has it a 7 in? ✓ 47? X [not 47, try all 7s] 67? ✓
Samantha	2	1	1	1	3	Is it that one up [col.4]? ✓ That one across [row 4]? ✓ 36? ✓
Samantha	4	1	2	1	4	That line? [col.1] ✓ That line across? [row 2] X That one [row 1] ✓ 67? ✓
Louise	2	1	0	3	4	First column down? X 4th? ✓ end in 6? ✓ 36? ✓
Sharon	4	1	0	1	2	That line? (col.1) ✓ 67? ✓
Judith	1	1	0	3	4	On this row? (col.2) X 4th column? X 3rd? [col.] ✓ 13? [unlucky number] ✓
Judith	3	2	0	1	3	In this row? (col.2) ✓ is it 63? X 52? ✓
12 years						
Richard	3	1	0	2	3	Is it above 50? ✓ it's in the 60s column? X 52? ✓
Richard	4	2	0	2	4	above the 40s? ✓ in the 60s column? ✓ 68? X 67? ✓
Julian	4	1	1	2	4	1 in it? X 7 in it? ✓ 6 in it? ✓ 67? ✓
Nicholas	1	1	2	1	4	second number a 3? ✓ in the 60s? X 50s? X 13? ✓
Nicholas	2	1	2	1	4	second number a 6? ✓ in the 40s? X in the 30s? ✓ 36? ✓
Susan	4	1	0	3	4	is it odd? ✓ in the teens? X in the 60s? ✓ 67? ✓
15 years						
Stephen	1	1	0	3	4	is it above 50? X above 20? X is it odd? ✓ 13? ✓
Louise	1	1	0	3	4	is the first digit below 3? ✓ is the first digit above 1? X is the second digit above 2? ✓ 13? ✓