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ABSTRACT

The first section of this report reviews traditional memory studies, which have provided much of our information concerning memory development. Major strengths and weaknesses of memory-development studies are illustrated by comparison with recent research into children's problem-solving skills. The report concentrates on one area of general concern to both the problem-solving and memory-development literatures, that of self-regulation and control, which may be the area of the most fundamental difference between the experienced and the naive learner. A final section considers alternative methods and problems in studying developmental change in this area. (AA)

CENTER FOR THE STUDY OF READING

Technical Report No. 48

SKILLS, PLANS, AND SELF-REGULATION

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I. Introduction

In thinking about memory development, we have rarely questioned the essential similarity of the processes studied under the rubrics problem solving skills and memory strategies (Brown, 1975a, 1977a, 1977b). A general class of information processing models, with their emphasis on routines which are controlled and regulated by an executive, seem suitable for describing the major psychological processes of interest in both domains. However, as our charge at this symposium was to function under the memory development heading we decided to refocus our thinking from our usual position of regarding the problem-solving and memory people as those who study the same processes but on different tasks. Instead, we began by looking for any interesting differences between the major emphasis and accomplishments in one field which could intelligently inform the development of the other. There do appear to be some psychologically interesting differences, not only in the tasks and skills studied, but in the depth of analysis devoted to those tasks and skills and in the commitment to addressing instructional goals. In the first part of this paper we will highlight some of these differences between the two approaches and try to illustrate a weakness in the current mainstream of memory development research. In the second part we will concentrate on one area of general concern to both the problem solving and memory development literatures, that of self-regulation and control, our candidate for the most fundamental difference between the experienced and the naive. In the final section we will indicate new problem areas and new ways of considering what it is that develops with age and experience.

II. Differences Between the Memory Development and Problem Solving Approaches to Cognitive Development

As our task is to consider what memory theorists have to say concerning development, we will approach the issue from the perspective of the memory development literature. Studies concerned with some aspect of memory dominate the field of cognitive development at this time, at least in number if not in content. Before we address the issues central to such research, a brief history of the way developmental psychologists interested in memory have approached the question of what develops might prove illustrative.

A. Early Studies

Prior to the 1960s the question, "what develops," would not have been raised. Obviously, memory develops. Lacking a fine grained analysis of memory processes, early researchers selected tasks and age groups somewhat randomly. They found that on most tasks, older children remembered more than younger ones, and slow learners had more difficulty remembering than those of average ability! The predominant explanation, when one was offered at all, was that immature learners have a limited memory "capacity"; and as they mature this capacity increases, allowing them to retain more. The underlying metaphor, whether implicitly or explicitly stated, was the mind as a container: little people have little boxes or jars in their heads, and bigger people have bigger containers. Any demonstration of inferior performance on the part of the smaller person proved the capacity limitation "theory", not surprisingly, as such a theory was merely a restatement of the data (Chi, 1976). The same general state of affairs also characterized the problem solving literature, where early studies also illustrated poor performance by young children on a variety of tasks. Explanations of why the young do poorly were either not forthcoming or involved a circular argument--little people have little problem solving capacity, a restatement of the data masquerading as a theoretical explanation.

More sophisticated, or simply more adventurous, theorizers subdivided the metaphorical containers. They attributed the deficits in memory or problem solving performance to a limitation in the space available in one of the main architectural structures of the information processing system, with space defined in terms of the number of slots, spaces, or buffer units available to the system at any one time. It was thought that as a child matured, his available space increased. The correlation of digit span with age, intelligence, and general problem solving efficiency was taken as firm support for this notion of increasing space with increasing age, and short-term memory was cited as the most likely culprit in the young child's mental overpopulation problem. With Chi and Case as the other speakers in this session, and Simon as a participant in another, we can leave discussion of the pitfalls of a simple capacity notion to the more experienced (Chi, 1976). Historically, most developmental psychologists also avoided the issue of architectural systems and capacity limitations thanks to two important influences on the field, the pioneering work of John Flavell (1970) on memory strategies in the young, and the widespread dissemination of levels of processing approaches to memory (Craik & Lockhart, 1972) with their de-emphasis on capacity, coding, and flow in and between containers.

B. The Production Deficiency Hypothesis

The guiding hypothesis of developmental memory research, initiated by Flavell in the 1960s and still popular today, is that the main difference between young children and mature memorizers is the tendency to employ a variety of mnemonic strategies whenever feasible. Borrowing from mediational theories of learning, Flavell introduced the terminology of production and mediational deficiencies to describe this difference. A production deficiency is said to exist when the child does not spontaneously produce a task-suitable mnemonic; however, if trained to do so, the child can use the mnemonic and his performance improves as a result. A mediational deficiency exists when a child produces a necessary mnemonic either spontaneously or under instruction, but it fails to enhance performance. Probably due to the paucity of strategies selected for study, mediational deficiencies have rarely been documented, and therefore the central issue in the memory development research has been the spontaneous production of appropriate mediation.

Simply stated, the theory consists of three propositions: (1) young children do poorly on a variety of memory tasks, because they fail to introduce the necessary mnemonic intervention; (2) if they are trained to use a suitable strategy, their performance improves, at least temporarily; (3) if the memory task does not demand mnemonic intervention, developmental differences will be minimal. To prove or disprove one or the other of these hypotheses is still the goal of the majority of developmental memory studies.

It is also reasonable to characterize the field as remarkably limited in the tasks selected for examination. When seeking to prove or disprove proposition 1 or 2, investigators almost invariably choose some rote memorization situation, such as list learning, where rehearsal or taxonomic categorization is the strategy of choice. When seeking to prove or disprove proposition 3, they select some sort of recognition memory task. We have objections to both approaches. We believe that the strategy-no strategy distinction served a valuable function in its time by organizing a chaotic field and by attempting to distinguish when and where the limitations of youth, lack of experience, or low IQ would be most debilitating. However, the two main lines of research now following this tradition have such severe built-in limitations that future proliferation should not be encouraged. The main problems center around the study of tasks rather than processes and the paucity of developmental information provided by the particular tasks selected.

1. Nonstrategic tasks. The first of these two lines of research currently generating a spate of studies is one for which we feel personally responsible. These studies focus on proposition 3, which we were rash enough to make explicit (Brown, 1973, 1974, 1975a) rather than implicit as Flavell had done (1970). The proposition asserts that if a situation exists where deliberate mnemonic intervention is not a prerequisite for efficient performance, developmental differences will be minimized. Obviously, it would be futile to seek tasks where no developmental differences occur; for not only must the tasks selected be impervious to mnemonics efforts, but they must also be uncontaminated by any other developmentally sensitive factor. The point of the original statement was not to prove the absence of developmental trends, but merely to demonstrate that the magnitude of any developmental effect is sensitive to the degree that sophisticated plans and strategies can interface the subject-task interaction. In general, the hypothesis is well supported whether the comparison involves intentional versus incidental learning instructions in adults or cross-age comparisons (Brown & Smiley, 1977b). Situations do differ in the degree to which intentional mnemonic action can enhance performance, and some recognition memory and recency tasks are less sensitive to strategic intervention than are many other memory tasks that require rote recall (Brown, 1975a).

This does not seem to be the point that the current set of studies seeks to prove. Interest has shifted from processes to tasks per se, and the game has become one of trying to show developmental differences in recognition memory tasks.

In general, such attempts are successful, but their success is not surprising. Recognition memory as a task is clearly not impervious to developmental differences. True, with distinct target and distractor items, excellent levels of performance have been found for very young children as well as adults, a ceiling effect which often clouds interpretation of age effects. However, with careful choice of distractors, one could easily produce a floor effect across all ages. Matching-to-sample tests have been devised so that choice of the correct alternative is extremely difficult even without any memory load. Floor or ceiling effects can completely obscure developmental differences, and it was for this reason that we selected variants of a recency problem for our earlier studies of the strategy-no strategy distinction (Brown, 1973a, 1973b, 1973c).

If the question of interest is whether or not age differences will be found in a recognition memory task, the distractor items are crucial. Even the simple manipulation of increasing the number of distractors on a choice trial increases the likelihood of finding a developmental trend, as young children's performance is disrupted by this manipulation (Brown, 1975b). If, however, one would like to show that young children perform better than older children, then a more subtle manipulation might be needed, but in principle, such a demonstration is possible. For example, one could vary the similarity of the distractor and target items along some scale of physical or semantic similarity not yet salient to the young, but distracting to the old. The less mature child would not be snared by the "related" distractor and should outperform the confused older participant. If we knew enough about the development of conceptual systems, we should be able to produce any possible pattern of age effects in recognition tasks by varying the target-distractor similarity on dimensions differentially salient to the ages under investigation.

Such an endeavor, however useful for testing hypotheses concerning conceptual development, is not relevant to the original discussion of whether some situations exist where young children perform well on memory tasks. The importance of understanding that the magnitude of developmental differences varies as a function of task demands should not be lost in this argument. The dramatic differences between even college students trained in some exotic mnemonic and those not so trained is enormous (Bower, 1970; Crovitz, 1970), and the problem faced by the young child who fails to introduce even simple aids must be seen in this light. We would still defend the position that in order to understand what memory development is, it is essential to identify areas of strength as well as areas of weakness (Brown, 1974, 1975a). Furthermore, if we wish to devise remedial help for the inexperienced we need both to capitalize on naturally-occurring strengths and to identify major areas of deficiencies. Finally, as Chi (1976) has argued persuasively, it is only by eliminating candidates for what does not develop that we can identify the true areas of developmental deficiencies.

2. <u>The modal memory strategy experiment</u>. The second line of research currently dominating the field is a proliferation of replication studies demonstrating the developmental sensitivity of strategy susceptible tasks. One problem with these studies is overkill--they long ago provided ample documentation of young children's mnemonic ineptitude. Further, they have been designed in such a way that they provide a surprising dearth of information concerning memory development, even if by that we restrict ourselves to the emergence of common mnemonic strategies.

The main problems again stem from undue concentration on a limited subset of tasks and strategies. Almost all studies concerned with the mnemonic production deficiency hypothesis have centered on list learning tasks and the strategies of taxonomic categorization and rehearsal. Apart from the obvious undesirability of any restricted focus if we wish to gain an overview of developmental processes, and the now oft-lamented lack of ecological validity of such tasks (Brown, 1977b), there are some interesting limitations imposed by this particular focus. First, these two strategies tend to emerge between the ages of five and seven years and, under the conditions usually studied, do not undergo much refinement after the grade school years. Thus, we are left with an almost total lack of information concerning what develops before five and after eight or nine years of age. The second problem is that we lack detailed models of the gradual emergence of even these simple strategies, and indeed they may not be susceptible to detailed task analyses.

The typical experiment in this area consists of crude assessments of the presence or absence of strategic intervention. Children are then divided into those who produce and those who do not; those who produce outperform those who do not. We rarely have evidence of intermediate stages of production. Consequently, we are usually unable to describe the developmental progression of the skill or to diagnose the current state of the learner so that instructional programs can be tailored to fit individual needs.

Probably the most important deficiency is that the tasks are set up in such a way that we cannot say anything about nonproducers. If children are not rehearsing on our task, we have no way of knowing what it is that they are doing. From the standard production deficiency experiment we receive no information concerning the younger or less efficient child, and it is often this information that we really need. This criticism is true of other areas of cognitive development, which also reflect the pervasive influence of the production deficiency paradigm in developmental research. Imprinted early on the five to seven age period as one of important cognitive change (White, 1965), developmental psychologists as diverse as those with behavioristic (Kendler & Kendler, 1962) or Piagetian (Kuhn, 1974) leanings have followed a modal experimental design with the following characteristics. The age range of the children studied is usually kindergarten to fourth grade, although occasionally four-year-olds and fifth graders are included. Typically no more than two or three ages are studied, and age, not pretest competency, is the developmental variable. Performance on one standard task is assessed. The main metric is presence or absence of a strategy or rule; and the inevitable finding is that younger children do not have it, older children do, and occasionally there is an intermediate stage. The inclusion of the youngest group ensures that a reliable developmental trend can be reported, as they usually perform abysmally. Even a cursory review of developmental journals will show an amazingly large number of studies meeting these criteria of the modal production deficiency experiment.

Apart from providing a baseline from which improvement with age can be measured, the inclusion of the younger or less efficient group in these enterprises provides little information. They perform poorly, and therefore highlight the improvement with age we wish to demonstrate. But we know nothing about their state of understanding. They are characterized as <u>not</u> being at a certain level, of <u>not</u> having a certain attribute; they are nonproducers, nonconservers, nonmediators; they are not strategic or not planful; they lack number concepts, reversible operations, or transitivity. They are sometimes described as passive, even though the tasks are designed so that the only way to be characterized as active is to produce the desired strategy. All of these descriptions are based on what young children do not do compared with older children, rather than what they can do; for we have no way of observing this in the confines of the tasks selected for study.

In the memory development area, the dominance of the modal experimental design aimed at list-learning strategies has led to two veritable wastelands in our knowledge: we know next to nothing concerning memory development in the preschool period and even less about how the process evolves during the adolescent years. The major forays into these territories have been the attempts of clever investigators to push down the age at which production of common strategies occurs (Wellman, 1977). There have been very few attempts to look at the emergence of more ingenious strategies in the high school population (Brown & Smiley, 1977b).

This description of the modal production deficiency experiment is overly harsh, but it is intended to indict the pedestrian nature of most of the current literature rather than the creativity of the original investigations in the area. And we should not ignore a major strength of this research area; the sheer bulk of data does provide impressive support for the generality of the strategic deficit hypothesis. But there are also the attendant weaknesses we have mentioned: (1) an undue concentration on a few standard tasks of limited ecological validity; (2) the lack of precise developmental models of emergent skills; (3) the concentration on a very narrow age range; and (4) the lack of information concerning nonproducers.

C. Task Analyses.

Many of the major investigators in the problem-solving area share a common approach, that of providing detailed task analyses of the processes they study. They also share a common location, Carnegie-Mellon and Pittsburgh, so, not surprisingly, their approach is well represented at this symposium. Therefore, we will concentrate on just a few main facets of this work, which contrasts sharply with the modal production deficiency experiment of developmental memory research.

The main emphasis is on providing detailed explicit models of cognitive development within a limited task domain. The aim is to provide precise descriptions of the initial and final form of the cognitive process under investigation and to delineate important intermediate stages. The area is characterized by Klahr and Wallace's (1970) principle of developmental tractability, i.e., the charge that developmental models should "allow us to state both early and later forms of competence and provide an easy interpretation of each model as both a precursor and successor of other models in a developmental sequence" (Klahr & Siegler, in press, p.). With a well-designed task analysis, it should be possible to detect not only the presence or absence of a desired piece of knowledge or skill, but starting and intermediate stages as well. One important feature of the typical experimental design in this area is that the problems selected are sensitive to the gradual emergence of the knowledge studied. Errors produced by the novice are as informative as correct responses produced by the proficient, thus providing as rich a picture of the "non-producer's" strategy as of the producer's end state rules.

One of our main criticisms of developmental memory research is that such detailed task analyses have rarely been performed. Notable exceptions are the work of Ornstein and Naus (1977) and Butterfield and Belmont (1977) on the emergence of sophisticated rehearsal strategies. Ornstein and Naus have shown an interesting developmental progression from no production, to an intermediary stage of repeating single items, to an efficient strategy of cumulative rehearsal. The cumulative rehearsal stage is also subject to gradual refinement as the size and stability of the chunks selected become more uniform. Butterfield, Wambold, and Belmont (1973) have shown that adequate encoding, retrieval, and a coordination of both are necessary for efficient performance on their circular recall task. Immature memorizers perform inadequately due to a failure of any one or all of these activities. Such attention to intermediate stages of competence is rare. Although interesting production inefficiencies were documented in the early Minnesota studies (Corsini, Pick & Flavell, 1966), in general, memory tasks have not been designed so that systematic stages in an emergent strategy could be detected.

In contrast to the memory research, consider two experimental programs from the problem-solving literature--Gelman's (this volume) analysis of the emergence of counting principles in very young children, and Siegler's (1976, and this volume) detailed developmental description of children's strategies for solving the balance scale problem. As these programs are also represented at the conference, we will not give a detailed description here. Note, however, that both programs do share two important features that are not commonly found in studies of memory strategy development. First, the knowledge under investigation emerges gradually with several readily identifiable substages. This is particularly true of Siegler's work, for the balance task has provided interesting information concerning the levels of competence of children from five to seventeen years. Gelman's impressive success at uncovering the richness, rather than the poverty, of numerical reasoning in preschool children has attenuated the age range over which the skills she investigates develops. Second, both programs provide detailed specification of feasible rules for solution, and the tasks are engineered so that the particular rule used (or not used) by the child can be detected. Thus, both programs provide information which is optimal for those who would attempt instructional intervention. Systematic error patterns can be used to diagnose the child's pretraining competencies and areas of weakness, so that instructional routines can be tailored to fit the diagnosis.

To illustrate, we will use the balance scale problem because of the detailed description of stages and because the instructional relevance of the task analysis has already been demonstrated (Klahr & Siegler, in press; Siegler, 1976). The apparatus is a balance scale with four equidistant pegs on each side of a fulcrum. Small circular discs, all of equal weight, can be placed on the pegs in various configurations. The arm of the balance can tip left or right or remain level, depending on how the weights are arranged. The arm is prevented from tilting, however, until the child predicts which side (if either) will go down. Siegler identified four systematic rules that children can employ to solve this task, rules which fall into a nice hierarchy of increasing maturity. A child using rule 1 attends only to weight, the number of circular discs on each side of the fulcrum. If they are the same, the child predicts balance; otherwise he predicts that the side with the greater weight will go down. A child following rule 2 is more advanced, for he considers both distance from the fulcrum and amount of weight whenever the weight (number of discs) on the two sides is equal. When they are unequal, weight alone dominates. Children using rule 3 always consider both weight and distance, but when the cues conflict they lack a rule for conflict resolutions and must guess. Rule 4 represents "mature" knowledge or the "end state," and solution is based on the sum-of-products calculation. While some five-year-olds can operate systematically with rule 1, some 16-year-olds still have problems with rule 4, a nice developmental spectrum for description.

Siegler's task analysis is successful because he can detect not only when mature knowledge of the torque principle is reached, but also significant milestones along the route. Similarly, by considering the errors produced by two- to four-year-olds in a counting task, Gelman can diagnose which counting principle the child lacks--that of one-to-one correspondence, stable ordering, cardinality, etc. In both cases the key word is diagnosis, not only of end state activity, but of starting and intermediate levels as well.

D. Instructional Relevance and Training Studies

Training studies have become a characteristic feature of both the memory development and problem solving literatures, although such endeavors are initiated for different reasons. Training studies in the memory development literature are by-products of the production deficiency modal experiment and are usually designed to answer a question of theoretical rather than practical interest. Having demonstrated that, on their own volition, young children do not use a particular strategy effectively, the researcher moves on to the next step in the modal experiment--determining whether the deficiency is one of production or mediation. Training is instigated. If performance now improves, the original problem is deemed one of production; if not, a deficit in mediation is inferred. These studies are, in general, successful in providing answers to the original question of whether production or mediation deficits underlie poor performance. That the matter rests here, and the modal experiment is judged complete, is justifiable given the original reason for conducting the experiment.

Since instructional relevance was not a guiding concern of the area, the proponents can scarcely be blamed for falling short of some criteria of accountability. The outcomes of such studies, however, have little practical utility. The fact that five-year-olds can be trained to rote rehearse like seven-year-olds may answer a theoretical question, but is of questionable practical significance. Indeed, it is interesting that the only programs in the area of memory development where practical application has been a major issue are those aimed at inducing strategic behavior in aberrant populations (Brown, 1974; Brown & Campione, 1977b; Butterfield & Belmont, 1977; Campione & Brown, 1977). The question of practical outcomes of training is of critical concern when the subject population is educationally delayed.

One must doubt the practical utility of training memory strategies because, at best, the result is durable improvement on the training task itself, but there is little evidence for general improvement in performance on similar tasks (Brown, 1974, 1977b). To borrow from Greeno (1976), we can satisfy behavioral objectives in that the subjects do perform the trained behaviors, but we certainly have not satisfied cognitive objectives of changing the subject's underlying cognitive processes or the way he views memory problems in the future. Without evidence of transfer, of a genuine improvement in the subject's understanding of the processes involved, one must ask whether improvement on the training task itself is a desirable end product. As the majority of memory training studies have focused on inculcating specialized skills of rote learning lists, the instructional relevance of these outcomes is questionable.

Given the undoubted cost of the detailed task analyses needed before informed instruction can be initiated (Brown, 1977b; Butterfield & Belmont, 1977; Klahr & Siegler, in press), it seems reasonable to suggest that instructional relevance be the guiding force in the initial choice of training tasks (Resnick, 1976). We should consider tasks where improvement would be a desirable outcome even without generalization from the training situation. For example, severely retarded institutionalized people can be trained to perform complex industrial assembly jobs if the seemingly complex tasks are broken into easily manageable subunits (Gold, 1972; Wade & Gold, 1977). The goal of the training procedure is to achieve quick errorless performance on the training task itself, because armed with this skill the hitherto unemployable individual can earn a living wage. Generalization of the training is not a prerequisite for a substantial practical improvement in the trainee's situation. Most training attempts in the problem-solving literature have focused on elementary arithmetic, counting, reading subprocesses, scientific reasoning, etc. The major investigators in this area have taken the instructional relevance principle seriously, while this has not been a main purpose of memory training studies.

A second feature of memory training studies is that the training itself is somewhat cursory. Some of the better procedures consist of the experimenter modelling briefly what he determines (intuitively) to be the desired strategy. Some of the worst procedures consist of the experimenter restructuring the to-be-remembered material (e.g., by blocking categories), presumably in the hope that the trainee will derive the implicit strategy for himself. The superiority of explicit intervention has been amply documented (Brown & Campione, 1977a, 1977b; Butterfield & Belmont, 1977; Campione & Brown, 1977). However, even the better attempts at explicit instruction are not based on sophisticated task analysis and do not take into consideration the particular needs of the trainee. The one notable exception to this rule is the program of Butterfield and Belmont (1977).

In contrast, detailed task analysis is a characteristic feature of training studies in the problem solving area, and the benefits of this approach for tailoring individual instruction can be illustrated by again considering the balance scale problem. Having established the psychological reality of the four-rule hierarchy, Siegler (1976) proceeded to provide training relative to the starting level of the trainee. Groups of five- and eight-year-old children who were operating with rule 1 were presented with two types of training, distance problems and conflict problems. Distance problems provide the child with experience with rule 2, while conflict problems provide experience necessary for rule 3. Thus, training with distance problems was geared one level above the child's original starting point, and conflict training was aimed at two (or more) steps ahead.

The stage was set to test a widespread assumption concerning training, that the distance between the child's existing knowledge and new information is a critical determinant of how successful that training will be (Brown, 1975a, 1978; Inhelder, Sinclair & Bovet, 1974; Kuhn, 1974; Piaget, 1971). This was confirmed, as both age groups benefitted from training only one level beyond their initial competence. When training was geared two levels beyond pretest levels, only the older children showed improvement. In subsequent studies it was determined that the five-year-olds' difficulty was one of encoding; they failed to encode distance information, concentrating their attention solely on weight. After training in encoding distance, they too could receive some benefit from the conflict problems. As expected, near training was found to be more effective, although training aimed two levels above pretest competency provided some help. Presumably, training on rule 4 would not improve the lot of rule 1 subjects. Of main interest here is that detailed task analyses informed intelligent instruction. As a result of his task decomposition, Siegler was able to determine the initial level of the trainee and what would constitute near or far training for him. Training could therefore be aimed at the child's present level, and entering ability was the determinant of what type of training was needed, rather than age or pretest failure as is the case in memory studies.

In this section we have emphasized differences in the current approaches taken in the mainstream of the memory development and problem solving areas. These differences are most apparent when one considers task analyses and instructional relevance. Note, however, that although there is a clear difference in emphasis, both literatures have followed a similar evolution. Both have progressed from a concentration on demonstration studies, through a period of production deficiency examinations, to a concern with training (Kuhn, 1974). By emphasizing recent advances in the problem-solving literature, we hoped to illustrate a weakness in the current state of the art concerning memory development.

III. Commonalities Between Memory Development and Problem-Solving Literature

In the previous sections we have emphasized divergence between investigators in the mainstream of memory development research and those classified as cognitive psychologists interested in problem solving. Here we will emphasize an area of convergence, for investigators in both areas are becoming increasingly concerned with the child's knowledge about the rules, strategies, or goals needed for efficient performance. Klahr (1974) distinguished between knowledge and the understanding of that knowledge. For memory theorists the division is between memory skills and capacities, and metamemory, the knowledge one has concerning them (Flavell & Wellman, 1977). Most theories of human cognition and artificial intelligence also make a distinction between the knowledge and routines available to the system and the executive that monitors and controls the use of these data. Although we appreciate that there are serious problems with this simple dichotomy (Brown, 1977a, 1977b; Klahr, 1974; Winograd, 1975; Woods, 1977), in the interest of brevity we will accept the division here and ignore the theoretical complications. Also in the interest of brevity, we will not review the literature concerning metacognitive development, as there are now available several reviews of the gradual emergence of self-interrogation and regulation over a wide range of situations (Brown, 1977a, 1977b, 1977c; Flavell, 1976; Flavell & Wellman, 1977).

A. Self-Interrogation and Self-Regulation

The main premise we would like to discuss is that when faced with a new type of problem, anyone is a novice to a certain extent. Novices often fail to perform efficiently not only because they may lack certain skills but because they are deficient in terms of self-conscious participation and intelligent self-regulation of their actions. The novice tends not to know much about either his capabilities on a new task or the techniques necessary to perform efficiently; he may even have difficulty determining what goals are desirable, let alone what steps are required to get there. Note that this innocence is not necessarily age related (Chi, this volume), but is more a function of inexperience in a new problem situation. Adults and children display similar confusion when confronted with a new problem: a novice chess player (Chi, 1977) has many of the same problems of metacognition that the very small card player experiences (Markman, 1977). For both, the situation is relatively new and difficult. Barring significant transfer from prior experience, the beginner in any problem-solving situation has not developed the necessary knowledge about how and what to think under the new circumstances.

The point we wish to emphasize is that children find themselves so situated more often than adults, and very young children may be neophytes in almost all problem situations. Thus an explanation of why young children have such generalized metacognitive deficits (Brown, 1977b; Flavell & Wellman, 1977) is that most of our experimental tasks are both new and difficult for them. It is this lack of familiarity with the game at hand that leads to a concomitant lack of self-interrogation concerning the current state of knowledge and to inadequate selection and monitoring of necessary steps to decrease the distance between starting levels and desired goals. The child's initial "passivity" in many memory and problem solving tasks, his failure to check and monitor his ongoing activities, his failure to make his own task analysis, could be the direct result of gross inexperience on such tasks. This does not mean that young children are incapable of self-regulation, only that they tend not to bring such procedures to bear immediately on new problems. Children are universal novices, it takes experience before they build up the knowledge and confidence which would enable them to adopt routinely the self-interrogation mode of the expert (Bransford, Nitsch & Franks, 1977).

Although absolute novices tend not to incorporate effective metacognitive activities into their initial attempts to solve problems, it is not simply the case that experts do and novices do not engage in effective self-regulation. As Simon and Simon (this volume) have pointed out in their study of physics problem solvers, the expert engaged in less observable self-questioning than did the relative novice, for the processes of problem solving in this domain had become relatively automatized for the expert. The relative novice, however, provided many instances of overt self-questioning and checking. Note that Simon and Simon's novice had received sufficient background instruction so that the basic rules for solution were known to her. We would characterize her state of knowing as typical of the learner, acquainted with the rules of the game and beginning to acquire expertise.

We would not be surprised to find that there is a relatively typical pattern of activity characterizing the process of becoming an expert. First, the absolute novices would show little or no intelligent self-regulation due to complete unfamiliarity with the task. This would be followed by an increasingly active period of deliberate self-regulation as the problem solver becomes familiar with the necessary rules and subprocesses, and attempts to orchestrate these activities which are deliberate and demand effort. Finally, the performance of the expert would run off smoothly as the necessary subprocesses and their coordination have all been overlearned to the point where they can be coordinated relatively automatically.

We have as yet little developmental data to suggest that such a pattern is a characteristic feature of growth during problem solving, but we would like to predict that such a progression would be a relatively stable feature of learning in many domains. Furthermore, although age and experience are obviously intimately related, we do not believe that the growth pattern is necessarily age related. Young children may show the same progression of naivety to competence within simpler task domains. Evidence such as that provided by Child (this volume) young chess experts is exactly the kind needed to support this conjecture. If we wish to understand how much of the young child's ineptitude is due to lack of expertise, rather than age per se, we must look at behavior in areas where the child is competent as well as those where he is inefficient.

There is one other factor that might contribute to the young child's general metacognitive problem. In addition to being hampered by the novelty of most experimental situations, young children may simply not realize that there are certain metacognitive operations which will be useful in practically any situation. These general metacognitive skills are discussed at length in another paper (Brown, 1977b), and we will only briefly summarize them here. The basic skills of metacognition which the child must acquire include predicting the consequences of an action or event, checking the results of one's own actions (did it work), monitoring one's ongoing activity (how am I doing), reality testing (does this make sense), and a variety of other behaviors for coordinating and controlling deliberate attempts to learn and solve problems. These skills are the basic characteristics of efficient thought, and one of their most important properties is that they are transsituational. They apply to the whole range of problem-solving activities, from artificially structured experimental settings to what we psychologists defensively refer to as "real world, everyday life" situations. It is equally important to check the results of an operation against some criterion of acceptability, whether one is memorizing a prose passage or reading a textbook, following instructions in a laboratory experiment, a classroom, or on the street. A child has to learn these various skills, but perhaps of equal importance, he has to learn that they are almost universally applicable, that whenever he is faced with a new task, it will be to his advantage to attempt to apply his general knowledge about how to learn and solve problems.

Not only does interest in metacognition characterize both the problem-solving and memory development literatures of American developmental psychology, but traditionally this has been a prime concern of Soviet studies of cognitive development. Vygotsky (1962) was one of the first to describe the two phases in the development of knowledge: first its automatic unconscious acquisition, followed by a gradual increase in active, conscious control over that knowledge. Recent translations of previously unknown work of Vygotsky's attests to his life-long interest in what we now call metacognition (Wertsch, personal communication). The ingenious studies of Istomina in tracing the goal-directed, conscious control of early memory strategies (Istomina, 1975) and later study skills (Smirnov, Istomina, Mal'tseva and Samokhvalova, 1971) are notable exceptions to the wastelands discussed above. Thus, there is considerable agreement among American and Soviet psychologists that what develops in a variety of problem-solving situations is the increasing conscious control and regulation of goal-oriented strategies.

B. Invention and Generalization

Given their common interests in training strategies or rules and in meta-cognitive development, it is not surprising that in both the problem-solving and memory development fields, there is a growing interest in whether metacognitive development can be fostered or accelerated by direct intervention. The position has been nicely stated by Norman, Gentner and Stevens:

> The skills of debugging are clearly important ones. Papert believes it is perhaps even more important to teach a child how to debug his own knowledge than to teach him the knowledge itself. The implication is that if a child knows how to learn, then he can get the knowledge by himself. We find that this philosophy strikes a sympathetic chord: Why do we not attempt to teach some basic cognitive skills such as how to organize one's knowledge, how to learn, how to solve problems, how to correct errors in understanding. These strike us as basic components which ought to be taught along with the content matter (Norman et al., 1976, p. 194).

The same philosophy has been stated recently in both the memory training and problem-solving literatures (Brown, 1977b); and of course it is the essence of the distinction between cognitive and behavioral objectives of training (Greeno, 1976). The central question is how do we foster the development of generalized knowledge concerning one's own cognitive actions and, to go even further, how do we induce invention of new and more efficient skills for problem solution? Facile generalization and invention are traditional signs of intelligent activity and are prime candidates for "what develops". Young and slow-learning children are not efficient at: (1) going beyond the information given, (2) inventing new solutions, or (3) transporting old solutions across task boundaries. These problems distinguish their behavior over a wide variety of tasks.

The question of whether direct intervention can bring about improvement in metacognitive functions is only just beginning to be the subject of intensive research activity. It is easy to suggest that training should be aimed at showing children "how to organize their knowledge," "how to learn," and "how to solve problems"; but it is considerably more difficult to instantiate these suggestions in concrete training programs. Some advances have been made, however. Resnick has had some success in the area of elementary mathematical reasoning in instructing "routines that put the learner in a good position to discover or invent strategies for themselves" (Resnick, 1976, p. 72). Similarly, our initial attempts at inculcating simple checking and monitoring strategies have been quite successful and, indeed, represent our only evidence of generalization in educable retarded children (Brown & Campione, 1977b). For example, children trained to estimate their recall readiness prior to a test of ordered rote recall of a list of picture names, became more efficient and maintained their efficiency for at least a year. Furthermore, the effects of training generalized to a somewhat different task where the children were required to indicate their readiness to reproduce the gist of simple stories. Training children to stop, check, and self-question before responding does seem to be effective.

As a further illustration of the convergence of the problem-solving and memory development fields, both Resnick (Resnick & Beck, 1977) and Brown (1977c) have independently extended the notion of self-regulation as a general characteristic of successful learning to the problem of reading comprehension. Both suggest that instruction in conscious use of self-interrogation and self-monitoring strategies might prove effective in enhancing comprehension skills of poor readers.

These preliminary successes with training self-monitoring in children are most encouraging. Equally encouraging for the prognosis of successful training of metacognitive insights is the outcome of an intensive course in problem-solving skills provided for college students (Hayes, 1976). Self-reports at the end of the semester-long training program indicated that the main areas of improvement were ones we would term metacognitive. The students reported increased awareness of their own cognitive processes, improvement in planning and organizing, increased diagnostic skills (or personal task analyses), and improvement in generalized problem-solving skills. Attempts to develop intensive training programs aimed at young and slow-learning children are currently underway in our laboratory (Brown, 1977b).

As we have seen, it is primarily in the area of metacognitive development that the areas of problem solving and memory development converge. It is also here that current interest and activity is being generated, and we are optimistic that from such approaches we will gain considerable insight into "what develops" in normal children and what can be induced in the less proficient.

C. Strengths and Weakness of Both Approaches

The two major bodies of knowledge concerning cognitive development, the problem-solving and memory development literatures, have been compared and contrasted. We have emphasized the major differences in approach and indicated that the one topic of current concern in both areas is that of metacognition. This merging of interest from two distinct fields of inquiry is exciting, and it is because of this convergence that we select the metacognitive skills of self-interrogation and self-regulation as prime candidates for what develops.

In contrasting the differences rather than the similarities of evolution in the two research areas, we have also highlighted the strengths and weaknesses of each approach, for the strengths of one are the weaknesses of the other. The large body of literature in the memory development area has provided us with impressive evidence of the generality of the strategy deficit problem in young children's thinking. There are literally hundreds of examples of the young child's failure to employ common mnemonics on laboratory rote-learning tasks.

We know a considerable amount about how the child comes to employ deliberate skills of remembering, first in the realm of real-world activities (Istomina, 1975), and then as a deliberate goal of laboratory tasks. We also know a considerable amount about what does not develop (Brown, 1975; Chi, 1976). We can predict fairly accurately not only that the young will perform poorly on memory tasks, but where or when their difficulties will be most apparent. We also are beginning to make progress in identifying the underlying processes responsible for inadequate performance (Chi, 1976; Huttenlocher & Burke, 1976). These are real and important advances. Researchers in the problem-solving areas, because of the need for expensive, detailed task analyses, do not have a similar mass of data to support their conclusion. Their concentration on a very limited set of problems with fortunate properties of easy decomposition into steps is inevitable.

The major weaknesses in the memory development literature are the strengths of the problem-solving area. Whereas the memory studies can be characterized by a general lack of detailed explicit models of varying states of competence, the problem-solving literature has several good examples of detailed models. Similarly, a concern for instructional relevance is a notable feature of the problem-solving area, but memory-training studies have not been designed to answer questions of instructional relevance.

What is needed at this point is a merging of the two disciplines, a convergence which can most readily be achieved by considering new tasks and processes where a dichotomization between strictly memory versus problem-solving tasks would not be made. In the next section we will introduce some of our favorite candidates.

IV. Alternate Methods for Asking What Develops

In order to answer the pertinent question concerning cognitive development, what develops, it may be necessary for us to expand the repertoire of tasks and strategies we select for intensive examination. If such an expansion is warranted, it might be wise, before embarking, to consider critically the criteria by which we select new tasks. Ideally, we would like to harness the strengths of both the traditional memory and problem-solving literatures. In this section we will (a) indulge in speculation concerning ideal criteria for task selection, (b) introduce a subset of tasks where we have some initial data and which we believe tap important psychological processes, and (c) suggest alternate methods of observing cognitive growth.

A. Criteria for Selecting Tasks and Strategies

Extrapolating from the previous sections, we believe that an ideal strategy to study would be one that is within the repertoire of the child across a wide age range and one that can fairly be said to represent an important cognitive activity. Furthermore, starting, intermediate, and ending states should all be traceable. Ideally, the process under examination should be susceptible to description by means of detailed, explicit models which can map its developmental progression. The type of activity we have been looking for, therefore, are those that show interesting early precursors and are activities engaged in during problem solving by both young and old.

In addition to a broad age range where the processes of interest are undergoing change, a broad task range should also be a selection criterion. By this we mean that the process under investigation should be a useful activity across a wide variety of tasks. If we are to invest considerable effort in mapping a developmental progression in some cognitive domain, we should focus on a cognitive process of widespread generality. And, in the same vein, if we are prepared to embark on training attempts, whether for basic or applied raasons, the process we wish to inculcate should have reasonable instructional relevance. Furthermore, training preferably should result in cognitive gains as well as behavioral gains (Greeno, 1976).

Finally, we should select a task where we can consider not only the activity of interest but the growing knowledge that the child has concerning that activity. This knowledge should be measurable by means other than just self-report, i.e., there should be some method of externalizing the flexibility with which the child controls and governs his own behavioral repertoire.

Of course, various criteria become differentially important depending on the particular goal of a research program. For example, for those interested in training, the criteria of instructional relevance and a broad range of applicability are paramount. But these criteria would not be so important for those concerned with, for example, the earliest signs of strategic planning. We have included the set of criteria here merely to illustrate some of the general concerns which should be considered when embarking on a program of developmental research. The ones we have chosen are no doubt important but there are no doubt others we have overlooked. In addition, we would not pretend that the tasks we have selected successfully meet even our own criteria. Rather, we have introduced a few idiosyncratic candidates which we favor and which we believe have the potential of eventually satisfying a subset of the criteria.

B. Selected Tasks and Strategies

1. Extracting the main idea. Getting the gist of a message, whether oral or written, is an essential communicative as well as information-gathering activity. Without this ability, children would never learn a language and would certainly never come to use that language as a vehicle for communication. The ability to extract the main idea, to the exclusion of nonessential detail, may be a naturally-occurring proclivity, given of course a reasonable match between the complexity of the message and the receiver's current cognitive status (Brown, 1975a).

In a recent series of studies (Brown & Smiley, 1977a, 1977b), we have been considering the limited case where children must extract the main theme of a prose passage, a story. Our subject population has ranged from preschoolers as young as three years of age to college students, and the stories are adapted to suit the different age groups. We find the same pattern across age: with or without conscious intent to do so, subjects extract the main theme of a story and ignore trivia. Even the youngest child's recall favors the essential action sequences of the story. Preschool children provide less detailed recall of stories or events, but they do favor the main theme. Older children have more highly-developed scripts (Nelson, 1977; Nelson & Brown, 1977) for storytelling, but even very young children apprehend the essential gist of a story plot (Brown, 1976).

Children are misled in their comprehension of stories by the same snares that trap adults (Brown, Smiley, Day, Townsend & Lawton, 1977). Led to believe certain "facts" concerning a main character or the location of an action, facts which never appear in the original story, children disambiguate and elaborate in the same way as adults. They false recognize theme-congruent distractors in recognition tests, and introduce importations from their preexisting knowledge when recalling. In addition, they have difficulty distinguishing between their own elaborations and the actual story content.

If there is such essential similarity across ages in how children construct a message from prose passages, what then is the interesting developmental trend? Not surprisingly, given the theme of this chapter, we believe that what develops is increasing conscious control of the naturally-occurring tendency, a control which allows more efficient gathering of information.

As children mature they become able to predict in advance what are the essential organizing features and crucial elements of texts (Brown & Smiley, 1977a, 1977b). Thanks to this foreknowledge, they make better use of extended study time. If given an extra period for study (equal to three times their reading rate), children from seventh grade up improve their recall considerably for important elements of text; recall of less important details does not improve. Children below seventh grade do not usually show such effective use of additional study time; their recall improves, if at all, evenly across all levels of importance. As a result, older students' recall protocols following study include all the essential elements and little trivia. Younger children's recall, though still favoring important elements, has many such elements missing.

We believe that older students benefit from increased study time as a direct result of their metacognitive insights and their ability to predict ahead of time what are the important elements. Younger students, not so prescient, cannot be expected to distribute extra time intelligently; they do not concentrate on only the important elements of text, since they do not know in advance what they are.

To substantiate our belief that metacognitive control governs this developmental trend we have observed the study actions of our subjects. In particular, we have examined the physical records they provide, records that can be scored objectively--notes and underlining of texts. A certain proportion of children from fifth grade and up spontaneously underline or take notes during study. At all ages, the physical records of spontaneous subjects favored the important elements; i.e., the notes or underlined sections concentrated on elements of the text previously rated as crucial to the theme.

Students induced to adopt one of these strategies did not show a similar sensitivity to importance; they took notes or underlined more randomly. Some of the very young children underlined all the text when told to underline. Although the efficiency of physical record keeping in induced subjects did improve with age, it never reached the standard set by spontaneous users of the strategy. Furthermore, the recall scores of spontaneous producers were much superior. Even fifth graders who spontaneously underlined showed an adult-like pattern and used extra study to differentially improve their recall of important elements. When we combined all fifth graders, the few spontaneous producers and the rest, the efficient pattern of the spontaneous children was masked.

It should be pointed out that we do not believe there is a magical age at which children become able to indicate the important elements of a text. This is obviously a case of headfitting (Brown, 1975a, 1978), i.e., the intimate relation of the child's current knowledge and the complexity of the stimulus materials. We have found that with much simpler texts children can pick out the main ideas at a much earlier age. We are currently examining whether they show a concomitant decrease in the age of onset of simple strategies given this foresight.

In short, knowledge about texts (or any message source for that matter) must consist of general knowledge about consistent features of all texts and specific knowledge about the particular exemplar at hand, a specific knowledge which must be influenced by the idiosyncratic characteristics such as complexity. Similarly, we would expect that strategies for learning from text would depend on general strategic knowledge about suitable activities but these would have to be triggered by certain specific features of the text now being studied. Quite simply, if the text is so complicated that the reader cannot identify the main points, he can scarcely be expected to select them for extra study, even if he possesses the prerequisite strategic knowledge that this would be a good study ploy. Thus, we would predict that even the sophisticated college student may behave immaturely when studying a difficult text.

This brief summary of some of our ongoing research (for details see Brown & Smiley, 1977b), illustrates what we believe to be a repetitive pattern in cognitive development. What develops is often increasing conscious control over an early emerging process. Even young children extract the essential gist of messages if they are not misled by red herrings, such as artificially increased salience of nonessential detail (Brown, 1977b). All our subjects have shown this ability to a lesser or greater extent--even preschool children (Brown, 1976), poor readers (Smiley, Oakley, Worthen, Campione & Brown, 1977), and slow learners (Brown & Campione, 1977b). What develops with age is strategies to assist this process and enhanced sophistication and control over these strategies; a sophistication embedded in increasing metacognitive insights. Using his knowledge about elements of texts, his knowledge concerning how to study, and the interface of these two factors, the older student can become much more efficient when processing information presented in texts.

2. Visual scanning. Our next selection of a naturally-occurring ability which shows interesting refinement and developing conscious control with age and experience is the behavior of visual scanning, the process by which one

"actively, selectively, and sequentially acquires information from the visual environment" (Day, 1975). Effective and efficient visual scanning requires a high degree of executive control, directing fixations and sequencing eye movements from one point of the visual array to another.

The process of visual scanning begins in the first hours of life. Even newborn infants scan visual stimuli (Salapatek, 1975), but in a very restricted fashion: the young infant is likely to limit his fixations to only one corner of a simple geometric figure (Salapatek, 1968), or to just one feature of a face (Maurer & Salapatek, 1976). The young infant's attention is drawn, almost compelled, to small areas of high contrast. He seems to have very limited voluntary control over his looking and has been characterized as "captured" by visual stimuli (Ames & Silfen, 1966; Stechler & Latz, 1966).

This involuntary looking gradually gives way during the first few months to much more voluntary control. By three or four months a baby scans the entire pattern, not just a single feature (Gibson, 1969), and thus becomes capable of extracting more, higher-level information. In addition, active stimulus comparison is performed (Ruff, 1975): when presented with two visual patterns, a baby looks back and forth between the two. The degree of shifting increases with age. The more similar the stimuli, the more looking back and forth the infant does, suggesting that even for infants the deployment of a strategy depends on the difficulty of the task. Thus, in the first few months of life we can see important refinements in visual scanning. The behavior comes more and more under voluntary control and gains the infant an ever-increasing amount of information, and rudimentary strategies for gathering information can be identified.

The later developmental course of visual scanning parallels the changes occurring during infancy. Many aspects of development can be attributed to the expanding role of internal, planful, self-regulation of scanning and the concomitant decreasing importance of external variables. Although the young infant gradually stops being "captured" by simple stimuli, we see repeated examples of this same problem in older children attempting to cope with more complex tasks. The exact manifestation varies according to the situation. For example, when studying an unfamiliar irregular shape, three-year-old subjects make fewer eye movements than six-year-olds (Zinchenko, Chzhi-tsin, & Tarakanov, 1963). Furthermore, the younger children fixated primarily in the center of the figure, while the older children's fixations cover its more informative contours.

Although six-year-olds in the Zinchenko et al. study showed relatively mature scanning, if a more complex stimulus were presented, they might display immature scanning. Mackworth and Bruner (1970) showed adults and six-year-old children sharply focussed photographs with a great deal of detail information. The six-year-olds often became "so hooked by the details" that they failed to scan broadly over the rest of the stimulus: "Having arrived at a 'good place' on which to rest their gaze; they seem to feel 'disinclined' to leap into the unknown areas of the sharp pictures" (p. 165). Mackworth and Bruner concluded that adults possess an effective visual search program, which enables them to coordinate central and peripheral vision together, but that children do not. Children can extract detail information centrally, and they can detect peripheral stimuli. However, they cannot execute the two operations simultaneously. Thus, the main problem is one of coordination and control, not the presence or absence of specific skills.

Increased cognitive control is also reflected in other important developmental changes in visual scanning. For example, children's scanning gradually becomes more systematic, indicating the presence of higher-order organization of the behavior. Vurpillot (1968) filmed the eye movements of four- to nine-year-old children as they decided if two houses were identical. Unlike the older subjects, the youngest children rarely made the systematic paired comparisons of comparably located windows that are necessary for successful performance. Furthermore, the young children's scanning was less exhaustive. When two identical houses were shown, they often failed to look at all the windows before pronouncing the houses the same.

Another important developmental change in visual scanning is that with age children focus on the more informative areas of a visual stimulus. The older the child, the more likely he is to fixate those distinctive features that give him the greatest amount of relevant information for the task at hand (Mackworth & Bruner, 1970; Olson, 1970; Zinchenko et al., 1963). Conversely, young children find it more difficult to ignore irrelevant information. Just as in incidental memory studies and in prose studying experiments, the younger the child the more attention he is likely to devote to stimuli that are irrelevant to the task he is performing (Pushkina, 1971).

Although we have mentioned several general developmental trends in visual scanning, it is extremely important to recognize that scanning behavior at any age will vary greatly depending on the nature of the task and situation. Our estimate of children's capabilities will always, necessarily, be a function of the task we use to make the estimate, and we will probably err any time we characterize the child as being either strategic or not strategic at a given age, as being deficient at one point and productive at another. For example, consider the question of whether preschool children can employ a strategy of scanning systematically. The answer will depend very much on the stimulus presented. A child might scan quite systematically around a group of figures arranged in a circle, in which case, as Day (1975) notes, the strategy is essentially "given" by the stimulus. However, the same child might scan randomly the same number of figures in a more complex arrangement. Thus, it will be crucially important to what extent the child must generate and impose his own strategy on a visual array.

Similarly, the degree of difficulty children have attending to informative and ignoring irrelevant aspects depends on the stimuli. The clearer the stimuli, the more likely children are to locate informative areas. The less organized the stimulus and the greater the number of distracting elements it contains, the harder it will be for the child to ignore those irrelevant elements. Although by adulthood scanning has usually developed into quite an efficient, individualized process (Noton & Stark, 1971), adults are by no means immune to the metacognitive problems children experience so frequently. If required to perform a difficult scanning task, such as inspecting chest x-rays for signs of pathology (Thomas, 1968), adults (relative novices) often suffer some of the same deficiencies seen in children, e.g., failing to scan as exhaustively as necessary or failing to focus on the most informative areas.

Scanning tasks thus reveal the same general pattern illustrated by the gist recall procedure. Scanning a visual array, like extracting the main idea, is a naturally-occurring response necessary for a wide variety of tasks, and for survival. As the child matures he develops the ability to control and coordinate scanning, to make scanning a strategic action tailored finely to changing task demands.

3. Retrieval processes. For our third example we have selected retrieval, considered broadly to encompass finding objects hidden in the external environment as well as retrieving information temporarily lost in memory. In both cases the subject often must use some other information to help him track down the desired object or thought. Although children can use external cues to search the environment before they use internal cues to search their own memories, many of the same strategies are relevant to both activities. Furthermore, in both these activities an important aspect of what develops is that the child is increasingly able to direct and control his search procedures, i.e., he achieves increasing metacognitive control, including planning ahead to facilitate later

retrieval and executing a search according to a logical plan. Our discussion here will draw heavily on the work of John Flavell and his colleagues, for they have been by far the most active and creative investigators in this area.

Retrieval activities occur naturally at an early age and continue to develop over a long period of time. Even infants are capable of organizing a sequence of behaviors into a search, but their initial efforts are very limited. The earliest information we have concerning the development of retrieval comes from object permanence tasks. When six- or seven-month-old infants first start searching for hidden objects, they often do something very interesting from the point of view of self-regulation. A child may initiate what appears to be an attempt to remove the cloth concealing a desired object, only to become distracted by the cloth itself. We can characterize this as a failure to maintain executive control: in the midst of conducting a search, the child appears to forget the goal of the search, and subsequently ceases those behaviors originally directed toward achieving the goal. A minimal requirement for the coordination and control of retrieval efforts is the ability to keep the goal in mind for a sufficient period of time and in the face of distractions.

Another interesting aspect of early retrieval activities is that even toddlers employ rudimentary strategies in their search efforts, as revealed by the perseverative search errors they make in object permanence tasks (the Stage IV error). Beginning at about eight months, an infant who has previously found an object hidden at one place (A) is likely to search for it again at A, even though he has just witnessed the object being hidden at a second location (B). We would say, with Harris (1973), that the infant seems to be employing a strategy of looking for an object in the place where he found it before. Although this strategy has obvious limitations and often causes the infant to fail in object permanence tasks, it seems reasonable that looking for an object where he found it before would serve the child relatively well in his everyday interactions with objects. Interestingly, children as old as two have been found to rely on this same strategy (Loughlin & Daehler, 1973; Webb, Masur, & Nadolny, 1972).

We have characterized the toddler's search as strategic, because it suggests the systematic execution of a plan. The degree of self-conscious participation involved, however, is probably minimal. As with the other areas we have reviewed, children achieve increasing sophistication at retrieval processes as conscious, voluntary control over them intensifies. In the case of retrieval, this sophistication is clearly reflected in at least two characteristics of performance: children become more likely to do something deliberate at the time of storage to facilitate later retrieval, and their attempts at retrieval become more systematic and efficient.

Even very young children engage in relatively simple behaviors whose sole function is to help them remember where something is for later retrieval. Children as young as three years old who have been instructed that they will later have to recall the location of an object (Wellman, Ritter, & Flavell, 1975), or an event (Acredolo, Pick, & Olsen, 1975), show better memory than children not informed about a subsequent recall test. Thus, the children must do something to help them remember during the delay. Wellman et al. (1975) observed their subjects and reported that while they waited, the children in the instructed memory condition looked at and touched the location they were supposed to remember. Preschool children are also able to use a specific cue provided for them; when an external cue marking the location of an object is made available, they can use it to help retrieve the object (Ritter, Kaprove, Fitch, & Flavell, 1973). In addition, they are sometimes capable of arranging a cue themselves to aid their later retrieval (Ryan, Hegion, & Flavell, 1970).

Not surprisingly, the tendency to use such cues increments with age. However, even when they think to use a retrieval cue, younger children may fail to use it as effectively as an older child. In a study by Kobasigawa (1974) first grade children who spontaneously used an available category cue still recalled fewer items per category than did third graders. In other words, even when they thought to use the retrieval cues, the younger children failed to conduct an exhaustive search for the items associated with each cue. Istomina (1975) also noted the tendency of younger children not to execute an exhaustive search of their memories. Although some of her four- and five-year-old subjects actively attempted to recall a list of items, they still did not try to retrieve items not immediately recalled. Older children, however, often showed signs of conducting an active internal search: "In some cases the child recalled what he had forgotten only with long pauses, during which he would try not to look at those around him, i.e., he would direct his gaze downward, to the side, or screw up his eyes" (p. 31). The non-exhaustive search of the younger subject could result from several possible factors. The child may not check his output against a criterion of acceptability, or, alternatively, he may have a different criterion from the experimenter's (Kobasigawa, 1974). Or his monitoring of his own memory may be inadequate to inform him that there are items yet to be recalled. In any case, these all represent problems of metacognition of one sort or another. The essential similarity of the problem of non-exhaustiveness in both visual scanning and retrieval is obvious.

We have argued that there are some essential similarities between the retrieval of objects from the environment and the retrieval of information from memory and that many of the same strategies will be relevant in both cases, e.g., conducting an exhuastive search. However, it is clear that external retrieval is an easier task than is memory scanning. Object retrieval studies show evidence of intentional efforts to remember and the use of strategies in children as young as three, which is a much younger age than Istomina (1975) found that children could deliberately adopt the goal of remembering and recalling a list of words. In object retrieval situations the cues available to aid memory are external and physically present; all the child must do is think to use them or orient to them. Thus, the problem is much simpler than one in which the child must initiate and maintain a purely internal, cognitive orientation to information in memory. The latter requires a greater degree of metacognitive control; the child must use internal processes, cognitions, to control other internal processes.

There is again some similarity between another crucial variable in visual scanning, retrieval, and story recall. When structure is provided by the external environment, a young child will perform much better than when he must provide that structure for himself (Day, 1975). In story recall a similar dependence on structure has been reported by Mandler and DeForest (1977). Young children are even more dependent than their elders on the fact that the structure of stories conforms to an idealized schema. Disturb this familiar structure and the young child is lost but the older learner can use strategies to recover to some extent from the violation of the normal story structure.

Another interesting aspect of the development of retrieval processes concerns the growing knowledge children have about this process. Although young children can use an external cue provided for them to set up such a cue themselves, they have at best very limited knowledge about why such cues are useful or what types of cues would be most effective (Gordon & Flavell, in press; Kreutzer, Leonard, & Flavell, 1975). Such metamnemonic knowledge, which permits intelligent direction of memory activities develops gradually. For example, not until the age of seven or eight do most children understand that the search for a lost object should be limited to the area in which the object could logically be, i.e., the area between where one first discovers its absence and where one last remembers having it (Drozdal & Flavell, 1975). Nine to 14-year-old children realize one of the points we have emphasized in this section, that an external retrieval task, finding a jacket lost at school, would be easier than a purely internal one, remembering a great idea one had for a birthday present but then forgot (Yussen & Levy, 1977). Better informed about retrieval processes in general, the older child can become more flexible in generating strategies appropriate to the solution of a given problem.

Our three selected tasks, extracting the gist, visual scanning and retrieval, cannot be claimed to satisfy all the criteria set out at the beginning of this section, but they approach this goal. The processes examined clearly are important cognitive activities, relevant to a broad range of tasks. And they develop over a wide age range, during which starting, intermediate, and end states can be identified, and reidentified at several developmental stages depending on the difficulty of the task and the match between the task demands and the child's extant cognitive status. We know that extracting the gist and retrieval have reasonable instructional relevance; this has already been demonstrated and, indeed, is obvious. Visual scanning has received little attention from the perspective of relevance for instructive purposes, although training in scanning strategies has been found to modify the behavior of impulsive children who tend not to focus on the more important areas of a stimulus (Egeland, 1974). Finally, the knowledge that children possess has been shown to augment with experiences in the domains of retrieval and getting the gist; both self-reports and observed behaviors confirm the notion of increasing self-regulation. Although scanning also shows increasing self-regulation, we know of no investigations aimed at the child's conscious knowledge of his own visual scanning behavior. This would be an interesting area of inquiry, although we hope it will not be dubbed meta-scanning.

The main criterion left unsatisfied by all our tasks is that none of the processes have been described by detailed, explicit developmental models of the type formulated by Klahr & Siegler (in press). This unfortunately does not distinguish them from most other processes under investigation by developmental psychologists, and suggests what our future goals should be. The possibility of formulating such models, we believe, depends on first selecting a task meeting at least the criteria of development over a broad age range with identifiable states.

In summary, we believe that one main aspect of what develops is metacognition --the voluntary control an individual has over his own cognitive processes. This is certainly not to say that metacognition is the only thing that develops; however, we have tried to illustrate our belief that the growth of metacognitive abilities underlies many of the behavioral changes that take place with development. When we examine a naturally occurring behavior, a behavior which begins very early in the child's life without tutelage, what develops is often not so much the process itself, but increasing sophistication and refinement in its exercise. We have seen various aspects of this gradual refinement in all three processes examined. Children become increasingly efficient at extracting information, whether from a story, a picture, or their own memories. They come to rely less on externally provided structure for they become able to generate their own structure internally. This efficiency seems in part traceable to the development of more efficient and effective strategies to help organize the extraction process and a growing tendency to monitor them. These strategies include making more exhaustive attempts, whether at recalling or scanning; the spontaneous adoption of skills, such as note-taking and underlining texts or using a cue for retrieval; and greater reliance on internal versus external control, whether scanning a picture, comprehending a story, or retrieving ideas. By examining a variety of apparently unrelated processes which develop over a wide age range, these commonalities in what develops become quite striking.

C. Methods for Observing Developmental Change

As our last general point, we would like to emphasize that in order to construct a realistic picture of the child's competencies, it is sometimes necessary to use methods other than traditional experimentation. We sometimes gain our most interesting information from informally observing, questioning, and playing with children, particularly the very young. Indeed, without these methods we would have even less information about cognitive development below five than we now do. We do not wish to denigrate experimentation. In fact, it is our bias that in order to confirm a hypothesized developmental trend, it is almost always necessary to devise a tightly-controlled experimental test. But we plead for other approaches because of the predominance of laboratory experimental methods in our field.

Although we realize that calls for an increased concern with the ecological validity of our research enterprises are becoming commonplace, and to some wearisome, we would support the movement in the area of the development of cognitive skills. For it is true that our estimate of a child's competencies are sometimes dramatically changed if we consider his behavior in naturally-occurring situations. If, therefore, we are in the business of delineating the cognitive competencies of the four-year-old, we will gain a distorted picture if we only see the four-year-old in a laboratory setting. Of course, the four-year-old's laboratory performance is informative but it is only one side of the picture, and it is the side we tend to concentrate on. To fill in the picture we need to consider the other side, how our four-year-old functions in the world around him, outside the confines of the laboratory. This argument probably holds for any population including the rat, but gains more credence the younger and less compliant the laboratory game player.

For these reasons we would like to advocate a three-prong research plan similar to that described by Cole and Scribner (1975) for cross-cultural research comparisons. The basic theme is an interweaving of experimental and ethnographic research to investigate a particular activity in a range of situations, from the naturally occurring to the experimental. Such a strategy seems ideally suited for comparative research with groups that differ not in terms of national origin or degree of formal schooling, but in terms of age or school success within our society.

First, one should investigate the subject's understanding of the experiment or task and his role as subject. Before reaching any conclusions concerning competency one should become thoroughly familiar with the task demands and how these appear to the child as well as the experimenter. We must know whether the child is familiar with the materials and the response demands, whether he can understand the instructions, and whether the point of the experiment seems reasonable to him. In short, is the leading activity (Meacham, 1977) envisaged by the experimenter (e.g., deliberate retention as goal) also countenanced by the child? As a second approach, Cole and Scribner (1975) suggest that we should "experiment with the experiment." Instead of repeating one fixed paradigm across ages, we should work with many different variations of a paradigm, variations suited to the interests and abilities of the children studied. The third strategy is to investigate the same process in a range of situations, including the naturally-occurring context of the culture, e.g., early childhood.

Cole and Scribner's plea is similar to that made by Soviet developmental psychologists (Brown, 1978; Meacham, 1977). They emphasize that cognitive activities develop and change within a socio-historical cultural context and the nature of these acculturation processes influence the activities, motives, focus, and types of cognitive competence displayed by the individual. Therefore, it must be profitable to view the memory abilities of the developing child in relation to the ecology of childhood.

We know of few studies that exemplify this approach; in fact, to illustrate it we will turn to some research conducted "long ago and far away." Almost thirty years ago Istomina (1975) published a study in the Soviet Union on the development of voluntary memory in children between three and seven years. We would like to describe this experiment in some detail, because it provides such an excellent example of our argument that assessment of children's memory capacity and metacognitive skills is influenced by the artificiality of many laboratory tasks, which the child may not fully understand or be fully engaged in.

One of the most interesting features of Istomina's experiment was a comparison between children's memory for lists of words in a relatively standard list-learning situation versus their memory for comparable lists embedded in a meaningful (to the child) activity. Istomina's reasoning for contrasting these two conditions was "that the development of retention and recall as internal, purposeful acts takes place initially as part of a broader, articulated, and meaningful activity (since it is only within the context of such activity that the specific acts of remembering and recall can have any meaning for a child)" (pp. 8-9). A game that made sense to the child and aroused a desire to participate should provide motivation for the child to set memory goals for himself and to discover various mnemonic means for remembering. The child should be more likely to adopt the goal of remembering and to seek strategies to help him remember if he is highly motivated to perform some task in which memory plays an essential role.

Istomina set children the task of remembering a list of items to be bought at a play store. The store was set up in their preschool and equipped with a cash register, scale, play money, and a variety of items "for sale," including toys, food, clothing, etc. One at a time, the children were recruited to go on a shopping errand. The teacher would slowly name five items for the child to buy and send him to the store in the next room. An assistant at the store recorded how many items the child recalled and observed the accompanying activity.

The children were also tested for memory of comparable lists of words presented in a traditional learning situation. The experimenter called each child for a "lesson", and instructed the child to listen attentively so he could later recall all the words. The list of words was of comparable length, meaning, and difficulty to the list of store items. In both the game and learning situations, the experimenter prompted the child to remember as much as he could, asking if he could remember any more if he had forgotten anything.

Recall was clearly superior in the game situation, indeed almost twice as high at the younger ages. When remembering is an intrinsic part of some meaningful activity, we obtain a higher estimate of young children's memory capabilities (Murphy & Brown, 1975).

We do not know exactly why recall is higher in a meaningful activity, but Istomina suggests several possibilities. For one thing, the children are more motivated to remember: they want to play the game properly, and at some point most of the older children realize that this means they must remember their shopping lists. Istomina argues that although the youngest children know what it means to remember, this is not enough: "they must not only know what remembering is by itself, but also be able to see it as an end result, an objective to which activity must be directed, i.e., to grasp it as a goal" (Istomina, 1975, p. 59). The goal of remembering is more salient in the game situation and children are more likely to adopt it as their own goal in that task. This is in contrast to the typical learning situation in which, however clear it seems to the experimenter that the goal is to remember, we are often uncertain that the child shares that goal.

Once the child can set remembering as a conscious goal for himself, he then starts searching for more effective ways to carry it out. Istomina's naturalistic situation produced a delightful set of protocols detailing individual children's emergent procedures for remembering. Many of her subjects seem to have discovered spontaneously most of the mnemonic strategies developmental psychologists have identified. The strategies adopted and the way in which they are used become increasingly complex and sophisticated with age.

Three-year-old Valerik barely waited for the list of items to be read before rushing off to the store. The three-year-old's view of the game seems to be limited to assuming the role of going to the store and returning with items, but does not seem to include the notion of bringing back the specific items on the list. Four-year-old Igor listened attentively to the shopping list, and then tried to carry out his errand as quickly as possible. He even seemed to try to avoid distraction, refusing to stop and talk when on his way to the store. Very few four-year-olds showed more specific mnemonic behaviors, but between four and five a qualitative shift seemed to occur, and all the older subjects seemed to make active attempts to remember. Many five-and six-year-olds actively rehearsed: they were often observed moving their lips, repeating the words over to themselves as the experimenter read them and as they walked to the store.

Many of the older children showed strong evidence of executive control, and seemed to be monitoring their own memory states and even checking themselves to determine how well they remember:

> Slava M. (five years, six months) listened silently as the list was read, looking at the experimenter tensely, and after a slight pause asked him to repeat the list one more time. He did not recall the list immediately, frowning, shrugging his shoulders, and saying: "Wait a minute, I'll get it, hold on . . ." (p. 26).

> Dima F. (six years, six months) listened to the list, muttering silently, and then repeated it almost as if to himself. At the store, he quickly recalled three items, then paused, screwed up his eyes, and said, with concern: "Oh! What else was there? Nope, I can't remember what else I have to buy . . ." (p. 26).

"Alik K. (five years, eight months) listened to the message to the end and then quickly went off to the store. However, halfway there he turned back. 'I can only remember endive. What else was there?' he asked the experimenter" (p. 27). Alochka also returned from the store to ask the experimenter for the items she had forgotten. Clearly, these children must have been testing themselves on their way to the store. Finally, the oldest children (six-seven years old) displayed more sophisticated strategies of trying to form logical connections between the items on their lists, often rearranging the order of the words based on their meaning.

Istomina's (1975) work is fascinating not just for the information it provides about young children's memory processes, but also for the methodological point it emphasizes. The best situation in which to study very early memory development is in a natural context in which the child is likely to understand the task and be motivated to perform it. The young child's performance on laboratory tasks is often markedly inferior to his performance in a game setting. Although this variable is crucially important when studying very young children, the same general point is applicable to other ages as well. Subjects of any age, even adults, are likely to perform better in a meaningful task in which they are actively engaged. Thus, if we want accurate, generalizable information about development, we should extend the realm of our investigations from the laboratory into the real world. However, a vital aspect of this approach is that we must investigate the same process in both these situations; we must look at the process in a natural activity that is meaningful to the subject and suited to his abilities, and we must also use well-controlled experiments to test particular hypotheses about the process. Experiments themselves can be engineered to provide controlled observations, and exciting activities for children.

V. Summary

The first section of this chapter was devoted to a consideration of traditional memory studies which have provided us with much of our information concerning what develops. Major strengths and weaknesses of memory development studies were illustrated by means of a comparison with recent research into children's problem-solving skills. In the second part we concentrated on alternate methods and procedures for attacking the problem of important developments in the ability to think, reason, and solve problems.

A common theme throughout was the gradual emergence of finely tailored skills adapted to meet specialized task demands. We attributed the heightened sensitivity to fine gradations of the task and strategy interface to enhanced metacognitive insights, i.e., the thinker's knowledge, control, and coordination of his own cognitions. This accumulation of knowledge about how to think in an increasing array of problem situations is an outcome of experience with more and more complex problems. Young children's insensitivity to their problem-solving potential is the result of lack of exposure to such situations, rather than age per se, for the same problems that beset the very small problem solver can often impede effective thinking in the adult novice.

To illustrate the emergence of increasingly strategic action we concentrated on three main tasks: extracting the gist of a message, scanning the visual environment, and retrieving lost information from the external world or from the mind. These three tasks share several interesting similarities in development. A consideration of cognitive growth in these domains, from infancy to maturity, provided the principal support for our conceptualization of what develops. Our candidate for a primary developmental agent is an expanding knowledge concerning how to think and the ability to monitor and coordinate the activities displayed in effective thinking.

As a final point, we have concentrated in this chapter on "what develops" in keeping with the title of the volume. However, we would like to point out that an equally important question is how development occurs (Brown, 1978). It seems to be fairly representative of the developmental literature that considerable progress has been made in mapping what develops but there has been far less attention paid to what mechanisms underlie this progression. The problems of growth and change are quintessential developmental questions and are of fundamental importance no less to the instructional psychologist who wishes to accelerate growth, than to the theorists who seek to understand development. Therefore, in conjunction with descriptions of the steps along the route from naivety to expertise, we would like to see extended discussion of the conditions fostering this growth in competence.

References

Acredolo, L. P., Pick, H. L., & Olsen, M. G. Environmental differentiation and familiarity as determinants of children's memory for spatial location. Developmental Psychology, 1975, 11, 495-501.

Ames, E. W., & Silfen, C. K. Methodological issues in the study of age differences in infants' attention to stimuli varying in movement and complexity. Paper presented at the meeting of the Society for Research in Child Development, Minneapolis, 1966.

Bower, G. H. Analysis of a mnemonic device. American Scientist, 1970, 58, 496-510.

Bransford, J. D., Nitsch, K. W., & Franks, J. J. Schooling and the facilitation of knowing. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Broudy, H. S. Types of knowledge and the purposes of schooling. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Brown, A. L. Judgments of recency for long sequences of pictures: The absence of a developmental trend. Journal of Experimental Child Psychology, 1973, 15, 473-481. (a)

Brown, A. L. Mnemonic elaboration and recency judgments in children. Cognitive Psychology, 1973, 5, 233-248. (b)

Brown, A. L. Temporal and contextual cues as discriminative attributes in retardates' recognition memory. Journal of Experimental Psychology, 1973, 98, 1-13. (c)

Brown, A. L. The role of strategic behavior in retardate memory. In N. R. Ellis (Ed.), International review of research in mental retardation (Vol. 1). New York: Academic Press, 1974. Pp. 55-111.

Brown, A. L. The development of memory: Knowing, knowing about knowing, and knowing how to know. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 10). New York: Academic Press, 1975. Pp. 103-152. (a)

Brown, A. L. Recognition, reconstruction, and recall of narrative sequences by preoperational children. Child Development, 1975, 46, 156-166. (b)

Brown, A. L. The construction of temporal succession by preoperational children. In A. D. Pick (Ed.), Minnesota symposia on child psychology (Vol. 10). Minneapolis: University of Minnesota, 1976. Pp. 28-83.

Brown, A. L. Development, schooling and the acquisition of knowledge about knowledge. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press. (a)

Brown, A. L. Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), Advances in instructional psychology. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press. (b)

Brown, A. L. Metacognitive development and reading. In R. J. Spiro, B. Bruce, & W. F. Brewer (Eds.), Theoretical issues in reading comprehension. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press. (c)

Brown, A. L. Theories of memory and the problem of development: Growth, activity, and knowledge. In F. I. M. Craik & L. Cermak (Eds.), Levels of analysis approaches to cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1978, in press.

Brown, A. L., & Campione, J. C. Training strategic study time apportionment in educable retarded children. Intelligence, 1977, 1, 94-107. (a)

Brown, A. L., & Campione, J. C. Memory strategies in learning: Training children to study strategically. In H. Pick, H. Leibowitz, J. Singer, A. Steinschneider, & H. Stevenson (Eds.), Application of basic research in psychology. New York: Plenum Press, 1977, in press. (b)

Brown, A. L., & Smiley, S. S. Rating the importance of structural units of prose passages: A problem of metacognitive development. Child Development, 1977, 48, 1-8. (a)

Brown, A. L., & Smiley, S. S. The Development of Strategies for Studying Prose Passages. Unpublished manuscript. University of Illinois 1977. (b)

Brown, A. L., Smiley, S. S., Day, J. D., Townsend, M. A. R., & Lawton, S. C. Intrusion of a thematic idea in children's comprehension and retention of stories. Child Development, 1977, in press.

Butterfield, E. C., & Belmont, J. M. Assessing and improving the cognitive functions of mentally retarded people. In I. Bailer & M. Steinlicht (Eds.), Psychological issues in mental retardation. Chicago: Aldine Press, 1977.

Butterfield, E. C., Wambold, C., & Belmont, J. M. On the theory and practice of improving short-term memory. American Journal of Mental Deficiency, 1973, 77, 654-669.

Campione, J. C., & Brown, A. L. Memory and metamemory development in educable retarded children. In R. V. Kail, Jr., & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Chi, M. T. H. Short-term memory limitations in children: Capacity or processing deficits? Memory and Cognition, 1976, 4, 559-572.

Chi, M. T. H. Metamemory and chess skill. Unpublished manuscript, University of Pittsburgh, 1977.

Cole, M., & Scribner, S. Theorizing about socialization of cognition. Ethos, 1975, 3, 249-268.

Corsini, D. A., Pick, A. D., & Flavell, J. H. Production deficiency of nonverbal mediators in young children. Child Development, 1968, 39, 53-58.

Craik, F. I. M., & Lockhart, R. S. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 1972, 11, 671-684.

Crovitz, H. F. Galton's walk. New York: Harper & Row, 1970.

Day, M. C. Developmental trends in visual scanning. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 10). New York: Academic Press, 1975. Pp. 153-193.

Drozdal, J. G., & Flavell, J. H. A developmental study of logical search behavior. Child Development, 1975, 46, 389-393.

Egeland, B. Training impulsive children in the use of more efficient scanning techniques. Child Development, 1974, 45, 165-171.

Flavell, J. H. Developmental studies of mediated memory. In H. W. Reese & L. P. Lipsitt (Eds.), Advances in child development and behavior (Vol. 5). New York: Academic Press, 1970. Pp. 181-211.

Flavell, J. H. Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Flavell, J. H., & Wellman, H. M. Metamemory. In R. V. Kail, Jr., & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N. J.: Lawrence Erlbaum Associates, 1977, in press.

Gibson, E. J. Principles of perceptual learning and development. New York: Appleton-Century-Crofts, 1969.

Gold, M. Stimulus factors in skill training of the retarded on a complex assembly task: Acquisition, transfer and retention. American Journal of Mental Deficiency, 1972, 76, 517-526.

Gordon, F. R., & Flavell, J. H. The development of intuitions about cognitive cueing. Child Development, 1977, 48, in press.

Greeno, J. G. Cognitive objectives of instruction: Theory of knowledge for solving problems and answering questions. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976. Pp. 123-161.

Harris, P. L. Perseverative errors in search by young infants. Child Development, 1973, 44, 28-33.

Hayes, J. R. It's the thought that counts: New approaches to educational theory. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Huttenlocher, J., & Burke, D. Why does memory span increase with age. Cognitive Psychology, 1976, 8, 1-31.

Inhelder, B., Sinclair, H., & Bovet, M. Learning and the development of cognition. Cambridge, Mass.: Harvard University Press, 1974.

Istomina, Z. M. The development of voluntary memory in preschool-age children. Soviet Psychology, Summer 1975, 13, 5-64.

Kendler, H. H., & Kendler, T. S. Vertical and horizontal processes in problem solving. Psychological Review, 1962, 69, 1-16.

Klahr, D. Understanding understanding systems. In L. W. Gregg (Ed.), Knowledge and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1974. Pp. 295-300.

Klahr, D., & Siegler, R. S. The representation of children's knowledge. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 12). New York: Academic Press, 1977, in press.

Klahr, D., & Wallace, J. G. Development of serial completion strategies: An information processing analysis. British Journal of Psychology, 1970, 61, 243-257.

Kobasigawa, A. Utilization of retrieval cues by children in recall. Child Development, 1974, 45, 127-134.

Kreutzer, M. A., Leonard, C., & Flavell, J. H. An interview study of children's knowledge about memory. Monographs of the Society for Research in Child Development, 1975, 40(1, Serial Number 159).

Kuhn, D. Inducing development experimentally: Comments on a research paradigm. Developmental Psychology, 1974, 10, 590-600.

Loughlin, K. A., & Daehler, M. A. The effects of distraction and added perceptual cues on the delayed reaction of very young children. Child Development, 1973, 44, 384-388.

Mackworth, N. H., & Bruner, J. S. How adults and children search and recognize pictures. Human Development, 1970, 13, 149-177.

Mandler, J. M., & DeForest, M. The code in the node: Developmental differences in the use of a story schema. Paper presented at the Society for Research in Child Development Meetings, New Orleans, 1977.

Markman, E. M. Realizing that you don't understand: A preliminary investigation. Child Development, 1977, in press.

Maurer, D., & Salapatek, P. Developmental changes in the scanning of faces by young infants. Child Development, 1976, 47, 523-527.

Meacham, J. A. Soviet investigations of memory development. In R. V. Kail, Jr., & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Murphy, M. D., & Brown, A. L. Incidental learning in preschool children as a function of level of cognitive analysis. Journal of Experimental Child Psychology, 1975, 19, 509-523.

Nelson, K. Cognitive development and the acquisition of concepts. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Nelson, K., & Brown, A. L. The semantic-episodic distinction in memory development. In P. Ornstein (Ed.), Memory development. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Norman, D. A., Gentner, D. R., & Stevens, A. L. Comments on learning schemata and memory representation. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Noton, D., & Stark, L. Eye movements and visual perception. Scientific American, 1971, 224, 34-43.

Olson, D. R. Cognitive development: The child's acquisition of diagonality. New York: Academic Press, 1970.

Ornstein, P., & Naus, M. The development of rehearsal. In P. Ornstein (Ed.), Memory development. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Piaget, J. The child's conception of time. New York: Ballantine Books, 1971.

Pushkina, A. G. Mechanisms of transposition of relations in preschool-age children. Soviet Psychology, 1971, 9, 213-234.

Resnick, L. B. Task analysis in instructional design: Some cases from mathematics. In D. Klahr (Ed.), Cognition and instruction. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Resnick, L. B., & Beck, I. L. Designing instruction in reading: Interaction of theory and practice. In J. T. Guthrie (Ed.), Aspects of reading acquisition. Baltimore, Md.: Johns Hopkins Press, 1977, in press.

Resnick, L. B., & Glaser, R. Problem solving and intelligence. In L. B. Resnick (Ed.), The nature of intelligence. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, Pp. 205-230.

Ritter, K., Kaprove, B. H., Fitch, J. P., & Flavell, J. H. Cognitive Psychology, 1973, 5, 310-321.

Ruff, H. A. The function of shifting fixations in the visual perception of infants. Child Development, 1975, 46, 857-865.

Ryan, S. M., Hegion, A. G., & Flavell, J. H. Nonverbal mnemonic mediation in preschool children. Child Development, 1970, 41, 539-550.

Salapatek, P. Visual scanning of geometric figures by the human newborn. Journal of Comparative and Physiological Psychology, 1968, 66, 247-258.

Salapatek, P. Pattern perception in early infancy. In L. B. Cohen & P. Salapatek (Eds.), Infant perception (Vol. 1). New York: Academic Press, 1975. Pp. 133-248.

Salapatek, P., & Kessen, W. Visual scanning of triangles by the human newborn. Journal of Experimental Child Psychology, 1966, 3, 155-167.

Siegler, R. S. Three aspects of cognitive development. Cognitive Psychology, 1976, 8, 481-520.

Smiley, S. S., Oakley, D. D., Worthen, D., Campione, J. C., & Brown, A. L. Recall of thematically relevant material by adolescent good and poor readers as a function of written versus oral presentation. Educational Psychology, 1977, in press.

Smirnov, A. A., Istomina, Z. M., Mal'tseva, K. P., & Samokhvalova, V. I. The development of logical memorization techniques in the preschool and young school child. Soviet Psychology, Winter 1971-1972, 10, 178-195.

Stechler, G., & Latz, E. Some observations on attention and arousal in the human infant. Journal of the American Academy of Child Psychiatry, 1966, 5, 517-525.

Thomas, E. L. Movements of the eye. Scientific American, 1968, 219(2), 88-95.

Vurpillot, E. The development of scanning strategies and their relation to visual differentiation. Journal of Experimental Child Psychology, 1968, 6, 632-650.

Vygotsky, L. S. Thought and language. Cambridge, Mass.: MIT Press, 1962.

Wade, M. G., & Gold, M. W. Limitations of the retarded worker when maximizing the man-machine interface. Human Factors, 1977, in press.

Webb, R. A., Massar, B., & Nadolny, T. Information and strategy in the young child's search for hidden objects. Child Development, 1972, 43, 91-104.

Wellman, H. M. The early development of intentional memory behavior. Human Development, 1977, 20, 86-101.

Wellman, H. M., Ritter, R., & Flavell, J. H. Deliberate memory behavior in the delayed reactions of very young children. Developmental Psychology, 1975, 11, 780-787.

White, S. H. Evidence for a hierarchical arrangement of learning processes. In L. P. Lipsitt & C. C. Spiker (Eds.), Advances in child development and behavior. New York: Academic Press, 1965. Pp. 187-220.

Winograd, T. Frame representations and the declarative/procedural controversy. In D. G. Bobrow & A. Collines (Eds.), Representation and understanding: Studies in cognitive science. New York: Academic Press, 1975. Pp. 185-210.

Woods, W. A. Modeling comprehension: Multiple theory formation in high-level perception. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), Theoretical issues in reading comprehension. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Yussen, S. R., & Levy, V. M., Jr. Developmental changes in knowledge about different retrieval problems. Developmental Psychology, 1977, 13, 114-120.

Zinchenko, V. P., Chzhi-tsin, B., & Tarakanov, V. V. The formation and development of perceptual activity. Soviet Psychology and Psychiatry, 1963, 2, 3-12.

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