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ABSTRACT

This paper explores the concept of metamemory, generally defined as the individual's knowledge of and awareness of memory. The concept of metamemory is compared to three other categories of memory and a model of what the growing child could conceivably acquire in the domain of metamemory is presented. Brief reviews of existing research relations between metamemory and other psychological phenomena, with special reference to strategic memory behavior. Finally, some propositions about how metamemory might be acquired are offered. (Author/ED)

Metamemory[1]

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Outline

I. Overview of Memory Development

Memory development is not and could not be a unitary process of change and acquisition, progressing towards a single ontogenetic destination. It could not be because memory itself is not a homogeneous psychological domain. For the student of memory development, it may be useful to distinguish four broad, partially overlapping categories of memory-related phenomena.

The first category consists of the most basic operations and processes of the memory system. Examples include the processes by which an object is recognized, the processes of representation underlying recall of absent objects or events, and the process of cueing or associating, by which one thing calls to mind or reminds us of another, related thing. We are not conscious of the actual working of these processes, and while we may be able to set them in motion by a conscious effort to remember, we probably cannot regulate or control their operation once set into motion.

In addition, most of these processes probably undergo no significant development with age (e.g., Brown, 1973). What few may develop appear to have a strongly maturational cast to them. For instance, the ability to recall an absent object, as contrasted with the ability to recognize one that is present, must presuppose the more general capacity to have conscious internal representations. This capacity is widely believed to emerge some time during late infancy, and maturational factors likely play a large role in its development. The more typical instance of this category may undergo no real development at all, however. For example, one is not really surprised to learn that, for 2-year-olds as for their elders, recall of one item can indeed cue recall of another, semantically related item (Goldberg, Perlmutter, & Myers, 1974). In sum, we would echo Morrison, Holmes, and Haith's (1974) conclusion, deleting only the qualifier "visual": ". . . to use a computer metaphor, the basic 'hardware' of visual memory seemed to exist at all age levels" (p. 424).

The second, third, and fourth categories of memory phenomena are reminiscent of Brown's (1975) distinction between "knowing," "knowing how to know," and "knowing about knowing," respectively. They are considerably more interesting to a developmentalist than the first.

The second category has to do with relatively direct, involuntary, and usually unconscious effects of one's attained level of general cognitive development on one's memory behavior. Older individuals presumably store, retain, and retrieve a great many inputs better or differently than younger ones. They will do so simply because developmental advances in the content and structure of their semantic or conceptual systems render these inputs more familiar, meaningful, conceptually interrelated, subject to inference and gap-filling, or otherwise more memorable for them. The participation of such content and structure, "knowing" or knowledge, in the mnemonic process can and usually does take place unconsciously and automatically, as do the operations of the first category. Indeed an organism would be badly adapted to its environment if very much of its remembering required deliberate, voluntary, self-conscious activity.

The third category in this taxonomy of memory phenomena subsumes the enormous variety of potentially conscious behaviors that an individual may voluntarily elect to carry out in the service of any mnemonic end, i.e., strategies. It is sometimes distinguishable from the second by its more voluntary, strategic quality. An adult dog has basic memory "hardware" (first category) and has certainly acquired knowledge of its world that powerfully affects its mnemonic activity (second category). We are loathe to credit it with much development in the third category, however. This category includes but goes beyond what Atkinson and Shiffrin (1968) probably had in mind when they coined the term "control processes." Mentally rehearsing someone's number during the brief journey from telephone book to telephone, deliberately trying to fix a name in memory by surrounding it with vivid retrieval cues, consciously attempting to reconstruct the day's events in order to remember when and where you might have mislaid your pen, and purposefully making a note on your calendar so you won't forget to call the plumber tomorrow--these are all familiar, everyday examples.

The fourth category refers to the individual's knowledge of and awareness of memory, or of anything pertinent to information storage and retrieval. One of us has christened it "metamemory" (Flavell, 1971a), in analogy with "metalanguage." A person has metamemory if he knows that some things are easier for him to remember than others, is aware that one item is on the verge of recall while another item is wholly irretrievable at present, and numerous other things we are about to catalog. Since metamemory refers to cognition about a type of human activity, it is of course a form of social cognition.

In the present chapter the focus is on developments in this fourth category. We first present a model of what the growing child could conceivably acquire in the domain of metamemory, accompanied by brief reviews of existing research evidence on metamnemonic acquisitions (Section II). There follows a discussion of possible relations between metamemory and other psychological phenomena, especially the third area discussed above, strategic memory behavior (Section III). We conclude with some guesses about how metamemory might be acquired (Section IV). We do not attempt to define metamemory very precisely in this chapter, cleanly distinguishing it from processes in the other three categories (the third, especially). We also do not propose a systematic developmental ordering or timetable for the myriad forms of metamemory, indicating which forms might normally be expected to precede which in ontogeny. Such an ordering has been roughly outlined by Kreutzer, Leonard, and Flavell (1975, chap. IV). Anything more than a rough outline would be premature, in our judgment, given the newness of the area and the relative paucity of solid research evidence concerning it.

II. Varieties of Metamemory: A Classification Scheme and a Survey of Relevant Literature

The present scheme is an attempt to answer what appears to be a central question concerning metamemory: <u>What might a person</u>

conceivably come to know, or know how to find out, concerning memory, as a function of cognitive growth and learning experience? We want to be able to classify, in other words, everything of this sort that might develop. The insertion of the phrase, "know how to find out," allows for the likely possibility that some knowledge about memory may be constructed by a subject for the very first time in response to an experimenter's query, e.g., by mentally testing out various mnemonic activities appropriate to the query and formulating his response on the basis of feedback from these covert "dry runs." Other knowledge may of course already exist in implicit or explicit form on the basis of previous memory experiences. The assumption, then, is that both mnemonic knowledge and skill at acquiring mnemonic knowledge are likely outcomes of cognitive growth and learning experience. Finally, we do not assume that all such acquired knowledge must be veridical, although most of it probably is.

In brief, the taxonomy we propose is this. First, some situations call for planful memory-related exertions and some do not. A person no doubt comes to know this fact. Second, performance in a memory situation or task is influenced by a number of factors the nature of which a person might know. We see three main classes of such factors: (a) memory relevant characteristics of the person himself, (b) memory relevant characteristics of the task, and (c) potential employable strategies.

A. Sensitivity to the Objective Need for Efforts at Present Retrieval or at Preparation for Future Retrieval

Among the important things a growing person may learn is to be attuned to and responsive to those occasions when it is adaptive either to try to retrieve something right now, or to prepare himself and/or his environment for effective future retrieval. It goes without saying that, like all of us, the young child is constantly learning and recalling things incidentally, i.e., without any deliberate intention to learn or recall. But what about intentional retrieval or preparation for future retrieval? Will he do either when explicitly asked to by someone else (elicited activity)? Will he do either without explicitly being asked to if an "objective need" is present (spontaneous activity)?

We shall take up these two questions presently, but first, some comments about terminology are in order. The expression "preparation for retrieval" is preferable here to "storage," "study," or "memorization" because it is more general. Marking one's calendar is preparing the external environment so that it will facilitate future retrieval of something. Rehearsal or verbal elaboration is preparing oneself, or one's "internal environment," for exactly the same purpose. Terms like "storage" and "memorization" primarily connote the latter, internal type of activity and consequently are too limited to cover the wide range of intelligent activities adults routinely use to optimize future retrieval.

Similarly, "retrieval" is used instead of, say, "recall," because it subsumes recognition memory, paraphrase versus rote reproduction of the original input, inspecting one's calendar, and any other form of data recovery not clearly connoted by "recall." More importantly, it permits, even though it may not immediately suggest, the interpretation that the search process and the item searched for may themselves also be external as well as internal.

In real, everyday, extralaboratory life our search and "retrieval" activities often alternate unpredictably between the inner world and the outer world. For example, we may first try unsuccessfully to remember exactly where we left that missing pen (internal search), then look for it in various likely places (external search based on internal retrieval), perhaps get cued by what we encounter there to think of still other likely places (more internal search and retrieval), and may finally search for and find the pen in one of them (external search and retrieval). Thus, not all preparation for future retrieval entails internal-storage or memorization processes, and not all subroutines of all retrieval sequences entail internal-retrieval or remembering processes. In fact, what we are calling "knowledge about memory" may itself be too narrow a designation, since some of the "knowledge" one might wish to talk about in this connection may not be about "memory" as conventionally understood. It might, for example, consist of knowledge about how to search the external world intelligently, a form of knowledge that also undergoes a marked development with age (Drozdal & Flavell, 1975).

<u>Elicited Activities</u>

Let us begin with the question about activities elicited by explicit retrieval and preparation-for-retrieval directives from others. Children will, from a very early age, search the internal and external world in response to another's retrieval directive. For instance, they will try to answer questions like "Where's your dolly?" and "What did you see at the zoo today?" However, we know of no formal studies dealing with the very young child's knowledge, abilities, and dispositions as regards such elicited retrieval. In the case of mnemonic, in-the-head retrieval, for instance, when does the child come to learn that what is not immediately remembered may come to mind with a little more thought and sustained concentration? Our guess is that early in development he automatically gives up if he cannot find the requested item immediately, and only subsequently learns that staying with the retrieval problem a little longer sometimes pays off. We are of course talking here only about simple persistence at this early level in attending to another person's request for retrieval, not about the use of clever retrieval strategies to supplement this nonstrategic retrieval effort.

There does exist some research evidence concerning young children's reactions to explicit instructions to prepare for future retrieval, as contrasted with instructions to retrieve right now. Most of this evidence centers on a developmental hypothesis initially proposed by Russian investigators (e.g., Istomina, cited in Smirnov, 1973; Smirnov & Zinchenko, 1969; Yendovitskaya, 1971) and first tested in this country by Appel, Cooper, McCarrell, Sims-Knight, Yussen, and Flavell (1972). According to this "differentiation hypothesis," as Appel et al. (1972) called it, the young child does not really understand that an explicit request to memorize a set of items for future recall is an implicit request to do something special with those items. It is an implicit request to scrutinize them very carefully and at length, or to name or rehearse them--in other words, to engage in some sort of intensive intellectual commerce with those items that might facilitate later retrieval. The young child has to acquire the recognition that a memorization instruction is a tacit invitation to be planful and goal-directed, to do something now that will only come to fruition later. In particular, he must learn to differentiate a future-oriented memorization instruction from a present-oriented perception instruction. Early in development, both might be treated as requests merely to perceive the items in an idle, essentially purposeless fashion.

Appel et al. (1972) obtained initial support for the differentiation hypothesis in two experiments with 4-, 7-, and 11-year-old children. Comparisons were made between children's study behavior and subsequent recall performance under instructions to memorize items for future recall versus instructions just to look carefully at the items. The 11-year-olds clearly differentiated between the two instructions, both conceptually and behaviorally. They seemed to know that the memorization task called for special study activities (e.g., spontaneous categorization, rehearsal), were more likely to engage in such activities under the memorization instruction than under the look instruction, and consequently achieved better recall results in the memorization condition. Appel et al. (1972) concluded that the 7-year-olds probably differentiated more clearly conceptually than behaviorally. That is, they likely grasped the general meaning and implications of the memorization instructions but typically did not command the study techniques that would behaviorally testify to the presence of that understanding. Finally, it was concluded that the 4-year-olds probably failed to differentiate both conceptually and behaviorally, and had yet to acquire a clear notion of deliberate, intentional memorization.

This picture of the development of intentional preparation for future retrieval has been revised in subsequent research (Wellman, Ritter, & Flavell, 1976; Yussen, 1975). The key idea turns out to have been Appel et al.'s (1972) distinction between conceptual and behavioral differentiation, as used in their characterization of what the 7-year-olds in their study knew versus what they did. First of all, it is now becoming very clear that many 7-year-olds in our society will indeed process items differently and recall them better under a memorization versus look instruction if they "can," i.e., if they can think of anything mnemonically beneficial to do with those particular items (Salatas & Flavell, 1975a; Yussen, Gagné, Gargiulo, & Kunen, 1974). For instance, they may carefully inspect and name items under a memorization instruction, and that may benefit recall in some task situations. That is, children of this age do seem to distinguish conceptually between an instruction to memorize and a nonmnemonic cognitive processing instruction.

Secondly, some conception of intentional memorization is detectable in even younger children, according to recent evidence. Yussen (1974) found that 4½- to 5½-year-olds will look at a model more, under conditions of perceptual distraction, if explicitly told to remember the model's behavior in order to reproduce it later. Unlike more sophisticated mnemonics (e.g., cumulative rehearsal, categorical grouping), "looking more" is a simple study behavior that a preschooler is likely to have under good control.

Even 3-year-olds seem to understand something of what it means to remember intentionally a spatial location, according to two recent series of studies (Acredelo, Pick, & Olsen, 1975; Wellman, Ritter, & Flavell, 1976). In the Acredelo et al. (1975) experiment, children were taken on strolls, exposed to an event, and later asked to find the spot where the event had taken place. On one trial the child was told at the time he would later have to find it; on another trial he was not. Recall was a great deal better when foreknowledge was provided.

In the Wellman et al. (1976) investigation, 3-year-olds experienced a series of trials of this kind: The child saw the experimenter hide a toy under one of a number of identical cups; the experimenter used a pretext to leave the room for 40 to 45 seconds; he asked the child to find the toy as soon as he returned. The toys were central figures in a story narrative that extended over the trials, and different toys were hidden under different identical cups on different trials. Some children were told to "<u>wait</u> here with the X (hidden toy)" and others to "<u>remember</u> where the X is." In two of Wellman et al.'s (1976) studies, the children asked to remember the location of the toys exhibited more behaviors during the delay period that looked like deliberate or semideliberate preparation for future retrieval than did children who merely waited with the toy; examples included touching or looking at the baited box, and making the baited box distinctive early in the delay. In one of these studies, it was easy for almost all the children to remember where the toy was. In another, the recall task was made harder by adding more cups. The children in the Remember condition recalled better than the children in the Wait condition in the latter study, and memory-relevant delay period behavior was correlated with recall in the Remember group.

Wellman et al. (1976) suggested two possible explanations for such precocious-looking intentional storage. One is the availability of simple but task-appropriate strategies in that particular situation, such as looking and touching. This factor is emerging as an important consideration in interpreting data on memory development generally, we believe. The second is the fact that what had to be remembered, in both the Wellman et al. (1976) and Acredolo et al. (1975) studies, was the spatial location of a concrete object, not a series of object names. The young child may get a good deal of reinforced practice at trying to remember where things are in everyday life. Adults often encourage or demand this kind of memory, e.g., exhort him to keep track of his toys and clothing. Also, memory for object locations is often a useful means to his own objectives.

Spontaneous Activities

Very little is known about the development of spontaneous, as contrasted with elicited or instructed, intentional activities in response to an objective need. Moreover, what little is known concerns preparation for future retrieval rather than present retrieval. Suppose that an adult has just retrieved certain items on a recall test and failed to retrieve others. He will likely be aware that, with a second recall test of those same items imminent, the situation tacitly calls for further study of the latter, missed items in preference to the former, successfully retrieved ones. It turns out that 7-year-olds are considerably less sensitive than adults to the differential-study implications of this particular situation (Masur, McIntyre, & Flavell, 1973).

A study by Siegler and Liebert (1975) entailed the planful use of an external rather than internal memory store. Ten- and 13-year-olds were given the task of setting four switches into all possible different up-down positions, in order to find the unique combination that would make an electric train run. They were supplied with paper and pencil and told, "There are many possibilities and you don't want to repeat the same choices you already made, so you might want to keep a record of which choices you have tried and found not to work." They found that keeping written records was quite strongly associated with number of distinct combinations generated, and also that many more 13-year-olds than 10-year-olds elected to keep such records. Siegler and Liebert (1975) suggest that the younger children may simply not have anticipated the need or utility of doing so.

On the retrieval side, it has been shown in several studies that providing children with external memory aids, such as visible records of past solution attempts, may facilitate solution of problems (e.g., Eimas, 1970; Roodin & Gruen, 1970; Sieber, Kameya, & Paulson, 1970). Lipsitt and Eimas (1972) conclude from such evidence that ". . . deficiencies in complex problem-solving situations may often be a function of the unavailability of relevant information and not of the absence of the necessary rules or operations, as has often been assumed" (p. 31). While we agree with this conclusion, there is an interesting ambiguity in their term, "unavailability." First, the child might do poorly without the external memory provided by the experimenter because he is simply incapable of recalling the pertinent information at the appropriate moment or, recalling it, cannot hold it in working memory long enough to use it in solving the problem. Either could of course happen to any problem solver, however sophisticated, under conditions of memory or attentional overload. A second possibility, however, is that the child might be quite capable of recalling the information if he thought to try, but might simply not think to try. There may, in other words, be no spontaneous self-instruction to try to retrieve pertinent information, i.e., the retrieval counterpart of the spontaneous preparation-for-retrieval shortcoming seen by Siegler and Liebert (1975) and Masur et al. (1973).

The term "production deficiency" was initially coined to describe a child's failure to use any particular memorization strategy spontaneously when the situation called for it, even though he could and would use that strategy effectively if explicitly directed to do so by someone else (Flavell, 1970). The sense of the present discussion is that the young child may have a far more general and pervasive "production deficiency" than that: He may seldom think of deliberately trying to retrieve at all, or of deliberately trying to prepare for future retrieval at all, in response to situations that commonly elicit precisely these sorts of cognitive efforts in more mature individuals. Part of metamemory development, then, may consist of coming to know when and why one should intentionally store and retrieve information.

B. Knowing What Variables Interact in What Ways to Affect the Quality of Performance on a Retrieval Problem

Person Variables

Person variables include all temporary and enduring personal attributes and states that are relevant to data retrieval. There is a great deal that a developing individual could potentially learn, and learn how to find out, about himself as a mnemonic organism. First, he could develop a "mnemonic self concept" that becomes increasingly elaborated and differentiated with respect to different retrieval tasks and different retrievers. For instance, experience may have taught him that he is only fair at remembering places and dates, but quite good at remembering people. He could also form impressions about how his skills at doing such things compare with those of other people: specific individuals and generalized others of similar and different ages, backgrounds, abilities, and personalities.

There is, moreover, much to learn about the capacities, limitations, and idiosyncracies of the human memory system. The growing person could discover that immediate memory is of small span and limited duration, and that additional processing may be needed to optimize subsequent retrieval. He could also induce from experience the related, sad fact that one cannot always count on retrieving later what was stored earlier, plus the happy fact that what cannot be remembered right now will often be remembered eventually. There is the further knowledge that the memory system can be untrustworthy as well as porous: It is possible to remember what did not happen and to misremember what did, in addition to outright forgetting.

The growing child may gradually learn how to read his own memory states and statuses with fair accuracy, and also to understand the behavioral implications of being in this as opposed to that state. As he becomes more attuned to internal "mnemonic sensations," he might intuit that one datum was never stored and another is in memory somewhere, but absolutely unrecoverable right now. The behavioral implication in both cases is to forego or abandon efforts at retrieval. In contrast, a third datum might be experienced as right on the threshold of recall (the "tip of the tongue" feeling), and the child could have learned to be more optimistic when he senses his memory to be in that particular state. He may also have discovered that, when learning something, the clear implication of a feeling of poor or uncertain retrievability is to keep on studying until some more satisfactory state of recall readiness is experienced.

A distinction between two related types of metamemory within this general category is suggested by this account. The first two paragraphs above refer mainly to general, previously-acquired knowledge about the properties of self and others. The third paragraph speaks instead about the ability to monitor and interpret concrete experiences in the here and now. Thus, the one type of metamemory concerns enduring abilities and traits, the other refers to transient processes and states. Needless to say, present monitoring and interpreting of specific states is informed by acquired knowledge of general properties, and knowledge of these properties must be acquired in part by monitoring and interpreting states.

In the case of general properties, it has been shown in three investigations that older children may have a clearer and more accurate conception of their own memory abilities and limitations than do younger children. Flavell, Friedrichs, and Hoyt (1970) asked children to predict how many depicted objects they would be able to recall in correct serial order, and subsequently assessed the children's actual ability to do so. The predictions were secured by briefly exposing successively longer sequences of pictures, either until the child thought that the series had now become too long for him to recall, or until a series of 10 pictures had been presented. Over one-half of the younger children (4-6 years of age) predicted "unrealistically" (the maximum, 10-object series), whereas fewer than one-fourth of the older ones (7-10 years) did so. Moreover, considering only the remaining, "realistic" children, the older ones predicted significantly more accurately than the younger ones.

Markman (1973) essentially replicated this part of Flavell et al.'s (1970) study, using only a 5-year-old sample. The children in her study proved to be just about as inaccurate in predicting their own recall as the younger children in Flavell et al.'s study. By using additional procedures she was also able to show that children of this age: (a) can predict their ability to perform certain motor tasks (e.g., the distance they can jump) much more accurately than they can predict their ability to recall, (b) predict others' ability to recall at about the same mean level of accuracy as they do their own, with the two accuracy scores also being positively correlated within individual subjects, and (c) believe that older people can recall more than younger ones (teen-agers > peers > 2-year-olds).

Finally, Yussen and Levy (1975) obtained age trends in accuracy of memory span prediction congruent with those found by Flavell et al. (1970), with 4-, 8-, and 20-year-olds. Mean predicted versus mean actual spans, reading from youngest to oldest groups, were: 8.18 versus 3.34, 6.60 versus 4.71, and a very accurate 5.89 versus 5.52. In a second study, Yussen and Levy (1975) gave 8- and 20-year-old subjects falsely low norm information, i.e., indicating that people of the subject's age have smaller spans than is actually the case. The provision of this information reduced the 8-year-olds' predicted spans to their actual spans and reduced the 20-year-olds' to below their actual spans. It seems to us that the adults in Yussen and Levy's study, especially, demonstrated an impressive amount of metamemory. They could predict their memory spans accurately; they were sensibly uncertain about their ability to predict them, in view of the novelty of the task situation; they believed that information about peers' performance on a novel memory task might provide a useful clue.

Preliminary developmental evidence on a number of aspects of metamemory, including Person variables, has been presented in a recent monograph by Kreutzer, Leonard, and Flavell (1975). Twenty children at each of grades K, 1, 3, and 5 were interviewed individually (approximate ages: 6, 7, 9, and 11 years, respectively). The 14 interview items in the battery each contained one or more questions or problems dealing with information retrieval or preparation for future retrieval. The older children in this study seemed to have a more differentiated self concept in this area than younger ones. For example, they appear more attuned to the fact that memory ability varies from occasion to occasion within the same individual, and differs from individual to individual within the same age group. In addition, while 5-year-olds may believe that older children can recall better than younger ones (Markman, 1973), Kreutzer et al. (1975) found that 9- and 11-year-olds may further believe that older children will also study differently in preparation for future recall.

At the same time, Kreutzer et al.'s younger subjects did seem to use everyday mnemonic terminology such as "remember," "forget," etc. fairly appropriately. A number of them also sensed that briefly presented rote information is subject to rapid memory loss: If just told a phone number to dial, one had better dial it right away rather than get a drink of water first. They also believed that a child who learned bird names in school last year "and then forgot them" would nonetheless find them "easier to learn" this year than a classmate who had not had them last year.

In the case of here-and-now memory monitoring, there is evidence that young children are liable to have at least some awareness of how well they have just done on a retrieval test. They may be aware, for instance, that they have or have not completed recall of all the items just presented for learning (Moynahan, 1970; Neimark, Slotnick, & Ulrich, 1971), although older children are liable to be better at this than younger ones (Geis & Lange, 1975). They can also easily recognize which items they had just recalled and which they had not, when shown the entire set afterwards (Masur et al., 1973). Finally, they show some ability to estimate the accuracy of their own recognition-memory judgments (Berch & Evans, 1973). If a 5-year-old child feels certain that an item has been presented previously or has not been presented previously, he is more likely to be correct in fact than if he feels uncertain about his judgment; this relationship between certainty and accuracy is considerably stronger in 8-year-olds, however.

In contrast, younger children do not seem to be as able as older ones to assess or predict their readiness to retrieve in advance, i.e., prior to the actual recall test. The children in Flavell et al.'s (1970) study were carefully instructed to study a set of items until they were absolutely sure they could recall them all without error. The size of each child's item set was determined by his previous recall performance. In each of three successive trials he first studied the items, then signaled his readiness to recall them, and immediately thereafter attempted to do so. Children of 4-6 years of age were much less proficient at estimating their readiness for recall than children of 7-10 years. The latter's recall was usually perfect on all three trials. The former's was not, and did not improve significantly over trials. Markman (1973) also repeated and extended this portion of the Flavell et al. investigation. She concluded that Flavell et al.'s experimental procedures may have actually led them to overestimate a 5-year-old's ability to monitor his own preparedness for retrieval. Neimark et al. (1971) also found that a number of their 6-year-old subjects were rather poor at assessing their own readiness to recall. Indeed, there is recent evidence (Denhière, 1974) that adults are by no means perfect at such assessment.

Ongoing or recent mnemonic experiences can sometimes provide clues for other mnemonic judgments and predictions, but the young child's use of them is variable. Immediately prior experience in actually recalling strongly categorized lists may heighten a 6- or 7-year-old's awareness of the greater ease of learning and recall of such lists, but the evidence is not altogether unequivocal on this point (Moynahan, 1973; Salatas & Flavell, 1975a). Markman (1973) found that some of the 5-year-olds in her study improved in their ability to predict their own memory span with practice in such prediction, even if given no feedback as to prediction accuracy; others did not, however, even with such feedback. Some of the children in Yussen and Levy's (1975) study tried (and, of course, failed) to recall sequences of 9 and 10 items before being asked to predict their ability to recall sequences of this length and shorter. Such actual recall experience had no effect on their predicted spans, even in the 8-year-old group. As to the 4-year-olds:

> The authors were amazed by the several preschoolers who actually predicted that they could recall 10 or 9 items after just being shown that they could not recall this many in the . . . practice sequence. The preschoolers were aware of their failure but said things like: "If you gave me a different list like that, I could do it." (Yussen & Levy, 1975, p. 507)

Finally, one further study has dealt with here-and-now memory monitoring in children (Wellman, 1975). In adults one of the most intriguing examples of memory monitoring is the everyday tip of the tongue experience (Brown & McNeill, 1967) or the related feeling of knowing experience (Hart, 1965). In both of these phenomena a person is in the position of failing to recall something but still knowing that he knows it. In such experiences the person not only monitors the state of an item in his own memory, but monitors it even in the item's "absence." In making a feeling of knowing judgment, for example, subjects who cannot recall an answer to a question, predict whether or not they could recognize the answer among a set of alternatives. Adults can make this kind of prediction accurately (Hart, 1965, 1967), in spite of the fact that, when they make it, the answer cannot be retrieved and there is no present opportunity for it to be recognized.

Wellman (1975) studied feeling of knowing and tip of the tongue experiences and their concomitants in 5-, 7-, and 9-year-old children. Each child was presented with a series of depicted items and asked to name them. If he could not name an item he was asked (a) if he felt he knew the name anyway, and would therefore later recognize it among a set of alternatives, (b) if he had ever seen the item before. He was subsequently tested for actual recognition of the name, as indicated in (a). Accuracy of predicted recognition/ nonrecognition increased with age, indicating an increase in the ability to monitor the states of unrecalled items. More interestingly, for the 5-year-olds judgments of whether an item had been seen before proved to be much more accurate predictors of subsequent name recognition than were judgments about recognizability, while judgments of the latter type were the better predictors for the 9-year-olds. Obviously, knowing if you have seen an item before is an important clue to knowing if you will recognize its name. Apparently the younger children were poor at assessing what was in memory not because the relevant subjective clues were inaccessible to them--accurate feelings of having seen the item before in the present case--but because they may not recognize that they _are_ clues. In addition, there was a definite increase with age in overt expressions of apparent tip of the tongue states, e.g., "Oh, I _know_ that, I just can't remember the name," and related states of incipient recall.

Task Variables

There is much to learn about the factors that make some retrieval tasks harder than others. First, some bodies of information (data, items) are harder to store and retrieve than others; and second, for any given body of stored information, some retrieval demands are more taxing than others.

For the first, considerable knowledge could be acquired as to the different properties of the input information that have effects on its subsequent retrievability. A few of these properties can characterize individual units of information considered in isolation from other units (but not, of course, in isolation from the experiential history and cognitive capabilities of the learner). For example, units which are easily encoded (labelled, imaged), meaningful, and familiar will normally be easier to remember than units which are not.

The majority of retrieval-relevant properties, however, have to do with relations among units, and hence with the structure and organization of whole sets or subsets of information units. Like the above-mentioned properties of individual units, these relations are familiar to all students of human learning and memory. One piece of information may facilitate the recall of another if they are related for the learner in any of a wide variety of ways. The two may frequently co-occur in experience, be members of the same class or parts of the same whole, occupy adjacent positions in some familiar serial structure, or be related by some logical or causal connection. Any meaningful link may make one a retrieval cue for the other, and mature learners may have become aware of this fact about memory. They are virtually certain to have become aware of the influence of a more banal property of the data set, namely, its size. Retrieval is more likely to be incomplete as the list of words, prose passage, or whatever body of information the person is supposed to learn becomes longer or more extensive.

People may also acquire the ability to make complex judgments about retrieval difficulty, weighing the probable influence of one property against that of another. They might recognize, for example, that a list of 16 words could be much easier to recall than a list of 10, provided that the latter consisted of randomly selected words and the former consisted of the series "north," "north-northeast," "northeast," "east-northeast" . . . "north-northwest." Finally, not all properties of individual information units or groups of units have substantial effects on retrievability. For example, a list of words should not be appreciably easier to remember if double spaced rather than single spaced, or if written in red rather than blue ink. Mature learners may also have acquired some ability to distinguish retrieval-irrelevant properties from retrieval-relevant ones.

As to retrieval demands, an experienced learner could come to understand that different retrieval problems make different demands upon the retriever, even when the input data remain the same. He could know, for example, that it is normally much easier to recognize something he has previously experienced than to recall it outright, with no external stimulus present to help his retrieval. Similarly, there is the learnable generalization that it is easier to recall the gist of a prose passage or a complex visual stimulus than to reproduce it exactly, word for word or line by line. The individual may also discover that items of information are harder to recall or recognize accurately if subject to the interfering effects of similar, confusable items. Retrieval situations differ considerably, both quantitatively and qualitatively, in the demands they place upon the retriever. A level or type of data recovery perfectly suitable for one situation may not be at all appropriate for another. This, too, is part of what the developing person could come to know about memory.

At least some developmental evidence exists concerning most of these task variables. Some of the 6- and 7-year-olds in Kreutzer et al.'s (1975) study seemed to believe that such properties of individual items as familiarity and perceptual salience can make them easier to remember. Similarly, 7-year-olds in Moynahan's (1973) study often said that items which are easy to name or identify are easier to remember. Most of the younger children in Kreutzer et al.'s (1975) investigation seemed very much aware that increasing the number of items in a set increases recall difficulty. Of 16 kindergarteners who initially judged one set of items to be easier to learn than another, equal-sized set, 10 reversed their judgment as soon as even one item was added to the easier set.

As to relationships among items, metamemory development regarding categorical structure has received the most study so far. In a study by Moynahan (1973), 7-, 9-, and 10-year-old children were asked to predict the relative difficulty of remembering sets of strongly categorized items versus equal-sized and otherwise comparable sets of conceptually unrelated items. The two older groups were significantly more likely than the youngest to predict that the categorized sets would be easier to recall. Moynahan was also able to show that this developmental difference could not be explained away by any correlated age differences in children's ability to detect the categories or to remember categorized sets better than noncategorized ones. Similarly, Salatas and Flavell (1975a) found that a number of 6-year-olds were not immediately cognizant of the mnemonic advantages of categorical organization, even when explicitly made aware of its presence. As indicated earlier, there is evidence from both studies that actual experience in learning categorized lists may make some children in this age range more conscious of its advantages.

In a related study by Tenney (1975), children of ages 5, 8, and 11 years were given one word by the experimenter, and were asked to generate three others, given a second word, again asked to produce three others, etc. For one group at each age level, the child's three words were in each case to be free associates of the experimenter's word. For a second group, they were to be members of the same category, e.g., "three other colors," if the experimenter's word were "blue." For a third group, they were to be "three other words that would be very easy for you to remember along with the word 'blue.'" Recall and clustering for the resulting lists were assessed in a second session. Tenney's findings were reminiscent of Moynahan's (1973). Five-year-olds had no difficulty in providing other category members on request (subjects in the second group) and showed high clustering and recall for the lists so generated. However, the first and third groups at this age level behaved very similarly in the first session, and showed low clustering and recall in the second session:

> The discrepancy between the types of structure which the kindergarteners would have found useful [i.e., categorical structures] and the relationships which they actually incorporated into their lists was striking. They made up essentially the same kind of list whether they were asked to free associate or to make up lists for recall. (Tenney, 1975, p. 112)

In contrast, when older children were asked to compose an easy-to-remember quartet of words that included "blue," they were very likely to spontaneously provide three more color words, just like subjects who were actually given categorization instructions.

Finally, Danner (1974) assessed children's metamemory for categorization at the sentence rather than single-word level. Children of ages 8, 10, and 12 years listened to and then tried to recall two 12-sentence passages, each containing four sentences on each of three topics. A polar bear was the subject of one passage, for instance, and 4 of the 12 sentences dealt with the topic of the bear's appearance. In one passage, the sentences were grouped or clustered together by topic, e.g., all four "bear-appearance" sentences adjacent to one another. In the other passage, no two sentences from a given topic ever followed one another. The former, grouped passage was better recalled and showed higher recall clustering than the unorganized one at all age levels. When subsequently shown all the sentences written out on separate cards and spatially organized as originally presented, older children were better able to detect the organizational differences between the passages than younger ones. Children were also tested for their ability to "take good notes" in preparation for future retrieval of the stories. In Danner's task situation, that meant making an adequately-rationalized selection of one sentence card from each topic, if only allowed to "keep" a total of three cards as "notes" to aid future recall of the entire passage. Of the 24 children at each age level, 5 8-year-olds, 15 10-year-olds, and 21 12-year-olds made such rationalized choices.

As for other kinds of organization, Moynahan (1973) found that her 7-year-olds seemed to understand that serial recall of a linear sequence of colored blocks is likely to be easier when blocks of the same colors are adjacent rather than randomly placed in the series. Thus, while they may not have sensed that categorizable objects portrayed in pictures are easier to recall than unrelated ones, they were likely to believe that a red-red-blue-blue-yellow-yellow block sequence would be easier to reproduce from memory than, say, a red-red-blue-yellow-blue-yellow one. Kreutzer et al. (1975) presented a set of object pictures in two ways: in list form, and woven together into a story ("A man gets up out of <u>bed</u>, and gets dressed, putting on his best <u>tie</u> and <u>shoes</u> . . ."). The child was then asked if the story presentation would make it easier or harder for an imaginary child of his age to remember the pictures, and why. The investigators found significant increases with age in selection of the story mode of presentation as the "easier" choice and in fairly intelligible, appropriate-sounding justifications of this choice.

In another interview item, Kreutzer et al. (1975) first acquainted the child with paired-associate learning task procedures, and then asked if one of two sets of four word pairs on cards would be "easier for you to learn" than the other, and if so, why. The experimenter explained that "these words are opposites, 'boy' goes with 'girl,' 'hard' goes with 'easy,' 'cry' goes with 'laugh,' and 'black' goes with 'white,' and these words are people and things they might do, so 'Mary' goes with 'walk,' 'Charley' goes with 'jump,' 'Joe' goes with 'climb,' and 'Anne' goes with 'sit.'" The experimenter then added pairs of words one by one to the set initially judged easier to learn until the child said the other set was now easier. The developmental trends were dramatic. Most 6- and 7-year-olds apparently failed to recognize the enormously greater ease of learning of the pairs of opposites. In contrast, the 9- and 11-year-olds did recognize it and, in many cases, could also explain why.

Yet the younger children clearly understood that at least one variable does <u>not</u> affect ease of learning and recall: They were almost unanimous in asserting that spreading out a set of pictures does not make them any easier or harder to remember than before.

Two items from the Kreutzer et al. (1975) study were devised to test children's sensitivity to differences in retrieval demands and difficulties with respect to a single set of input items. A number of the 9- and 11-year-olds, but almost none of the 6- and 7-year-olds, seemed to understand that it might be harder to recall a set of people's names if you had learned another, potentially confusable set of people's names right afterwards than if you had not.

That is, they showed some intuitive understanding of the classical phenomenon of retroactive interference. There were also marked age trends in the recognition that rote, word-for-word retrieval of a story is harder than free, tell-it-in-your-own-words retrieval. Almost all of the older children but only about one-fourth of the younger ones knew both that a requirement of rote as opposed to paraphrased recall would make the retrieval task harder, and also that it would call for more intensive preparation or study prior to retrieval time.

Finally, temporal aspects of memory tasks have been considered in two studies. Kreutzer et al. presented 20 object pictures and asked which of two children would remember the most, and why--a child who studied them for 1 minute or a child who studied them for 5 minutes. About half the 6-year-olds and almost all the 7-year-olds seemed to sense that more study time was likely to result in more objects recalled. In a study by Rogoff, Newcomb, and Kagan (1974) groups of 4-, 6-, and 8-year-olds were first given concrete experience with one of three temporal delays: a few minutes, 1 day or 7 days. Each child was then shown a pile of 40 pictures and told he had to remember them for a length of time equal to the delay he had experienced previously. The child inspected the pictures at his own pace, and his inspection time was recorded. Children in the 1- or 7-day condition studied longer than those in the few-minutes condition at 8 but not at 6 or 4 years of age. Somewhere in the early elementary school years, then, children apparently come to understand that more items to recall and longer retention intervals both call for more study time.

Strategy Variables

There is much to say about the development of knowledge of storage and retrieval strategies, but most of it is taken up in other chapters. Thus, we will only mention a few conceptual points and research findings not likely to be described elsewhere in this volume. It is once again convenient to distinguish between strategies which may serve as preparation for future retrieval and strategies which may facilitate present retrieval.

As Reitman (1970) has pointed out, the variety of specific moves a cognitively mature individual might think to do in preparing for future retrieval is virtually limitless. Change the nature of the task, or the state of the person with respect to it, and such an individual is likely to respond with a spontaneous and often adaptive change in preparation strategy. Butterfield and Belmont (1975) posit an "executive function" that initiates these strategic adaptations, selecting new "control processes" to suit new task conditions. It is reasonable to suppose that this executive function is informed by a considerable amount of metamemory.

We would underscore once again the fact that most retrieval problems in real life are in the nature of open-book rather than closed-book exams: The retriever is free to search external sources as well as his memory, and usually does when he can. Correspondingly, the mature information processor is likely to know that preparations for future retrieval can be made in the outer world as well as the inner one. He may mentally rehearse, cluster, or elaborate upon the material to be retrieved, but may also store it by making notes, photocopies, photographs, or tape recordings. He may try to assimilate an item into several different semantic networks in hopes of increasing its retrievability, but he also may sow his life space with written reminders, nonverbal prompts, and other external retrieval cues. Some of the internal and external retrieval cues a person may construct intentionally might better be regarded as indirect reminders to retrieve certain information, rather than as direct elicitors of the information itself. A person may write some key words on his calendar as direct retrieval cues to a whole complex of information. If the recovery of that information on a certain day is especially important, however, he may also think it prudent to make a mental or physical note to look at his calendar that day. Deliberate preparation for future retrieval is a form of planning (Flavell, 1970), and could conceivably be as elaborate and variegated as any other form.

Kreutzer et al. (1975) devised two preparation-for-retrieval and two present-retrieval items of the everyday life, "open-book-exam" sort. In one of the preparation tasks, the child was asked to imagine that he was going ice skating with a friend after school tomorrow, and hence wanted to be sure to remember to take his skates with him the next morning. He was asked how many ways he could think of, all the things he could do, to be really certain not to forget them. Two major findings emerged: First, older children could think of more different mnemonics than the younger children could, and generally showed a greater sense of planfulness in their answers. Second, "in-the-world" mnemonics were proposed far more often than "in-the-child" mnemonics by children at all grade levels. A child would frequently think of putting his skates where he would be sure to encounter them in the morning, writing himself a note, or asking his mother to remind him. He would much less frequently speak of thinking about the skates the night before, making mental checks of things to do that morning, etc.

In the other preparation task, the child was asked to think of as many things as possible to do to make sure he would remember a birthday party to which he had been invited. Once again, younger as well as older children tended to favor external physical and social resources over internal ones. They talked about writing notes, marking their calendars, putting the party invitation up on the bulletin board, and asking a parent to remind them. No fewer than 19 of the 20 7-year-olds, for example, mentioned an external-to-self information store as their first or only response in both preparation tasks.

Retrieval strategies can be as elaborate and "intelligent" as preparation strategies and can likewise, of course, involve external as well as internal procedures and retrieval targets. The individual's retrieval activities have something of the quality of a Sherlock Holmes tour de force at their most intricate and sophisticated levels (cf. Lindsay & Norman, 1972). Whether the object of his search (X) is in memory, in the external world, or both, the retriever tries to zero in on it by skillfully integrating specific memories, general knowledge, and logical reasoning. When he realizes that X probably will not come to mind by just sitting and waiting (the latter is always a good <u>first</u> move), he deliberately searches his memory for related data, in hopes that something recalled will bring him closer to X. In the most elaborate cases of this sort of intelligent, highly indirect and circumlocutious retrieving, the process is virtually one of rational reconstruction of "what must have been," in the light of remembered data, general knowledge, and logical reasoning. As with the most exotic cases of preparation for retrieval, the amount and quality of voluntary, self-initiated intellectual activity involved can be very substantial.

Kreutzer et al. (1975) tested children's knowledge of retrieval strategies in one interview item by asking them to think of all the things they could do to try to find a jacket they had lost while at school. As expected, the older children could think of a greater number of different retrieval strategies than the younger ones. While almost all of the younger children could indeed think of at least one sensible thing to do, such as look in likely places, try the school's Lost and Found, and enlist the help of others, the two most sophisticated strategies were largely confined to the two oldest groups. One strategy consisted of either trying to think of the last place the child remembered having his jacket and searching forward from there or retracing his whole day's activities step by step (11 of the 40 9- and 11-year-olds). The other strategy was an explicit temporal ordering of several search plans, presumably from most to least promising, e.g., "First I'd do X, and if I didn't find it there, then I'd look in Y" (18 of 40 9- and 11-year-olds. Knowledge about external search akin to the first of these two strategies was investigated in a study by Drozdal and Flavell (1975). If A is the last point in your itinerary where you are sure you possessed a lost item, and if B is the first point where you discovered it is missing, then the A-B segment of your itinerary is the only plausible area to search for it, assuming it could not move or be moved. Children of 9 to 10 years understand and articulate this line of reasoning very well, according to Drozdal and Flavell's data, but children of 5 to 6 years do neither.

In the other Kreutzer et al. (1975) retrieval-strategy item the interviewer said to the child:

> Suppose your friend has a dog and you ask him how old his dog is. He tells you he got his dog as a puppy one Christmas but can't remember <u>which</u> Christmas. What things could he do to help him remember <u>which</u> Christmas he got his dog? Anything else he could do? (p. 36)

The 6-year-olds probably did not understand this rather complex item very well, but the older children generally did. Asking the help of others was a common suggestion at age 7 and older. Especially at age 11, however, other interesting strategies were proposed. Five 11-year-olds suggested looking for naturally occurring external records, e.g., the dog's papers or a dog tag. Four proposed searching backwards in memory in a highly methodical, Christmas-by-Christmas fashion, somewhat analogous to searching for the lost jacket by retracing one's steps in the previously-mentioned retrieval item. Nine suggested trying to remember things that were temporally associated with the dog's arrival, usually other presents received that Christmas. In one child's words: "Maybe he could remember some of his toys that he got the same Christmas he got his dog and he could tell from the Christmas he got his toys."

This last strategy has that indirect, circumlocutious quality which seems to be the hallmark of much deliberate, strategic remembering. Marked increases with age in the use of an indirect retrieval procedure were also revealed in a study by Salatas and Flavell (1975b). The subjects were 6-, 9-, and 21-year-olds. They first acquired a good strategy (A) for remembering all of the items in a set. Their task (C) was then to name all of the items in that set that had a certain property, e.g., all of the items that were articles of clothing. A good strategy (B) to be sure not to miss any items possessing that property would be to recall all of the items in the set, reporting out clothing items as they were encountered. Many of the 21-year-olds but few of the children spontaneously used A to implement B, and thereby achieve C.

Interaction Among Variables

It seems certain that an individual who is sophisticated metamnemonically would not think of these previous classes of memory variables as independent of one another, but rather would think of them in complex interaction. He would know, for instance, that a given body of information would be more or less retrievable depending on who was storing it (Person x Task). He would know that the amount and kinds of strategic preparation he undertakes should be varied in accord with the mnemonic characteristics of the task

(Strategy x Task). That certain strategies are better suited to him than are other strategies might also be evident (Person x Strategy). And it is also reasonable to expect the knowledgeable metamnemonic subject to appreciate that the fancier, if not the plainer, forms of strategic behavior need to be closely adapted to relevant properties of both Person and Task (Strategy x Person x Task). Indeed, the adult's ability to generate a seemingly infinite variety of strategies, explicitly tailored to an enormous array of situations and demands (cf. Reitman, 1970), implicates just this interactive sort of knowledge.

It seems to us that much of this interactive mnemonic knowledge is captured by the diagram in Figure 1. On the one hand, task

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Figure 1 about here

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variables are represented in this diagram by two subclasses of variables--differences in item characteristics and differences in task demands--and these two sets of variables interact to determine the difficulty of the memory task. On the other hand, personal attributes and employable strategies interact together to determine a person's memory skill on the task. A person whose memory knowledge conformed to this diagram would know, for example, that difficult items offset easy demands, that efficient strategies offset poor memory attributes, and that high ability is needed to insure adequate performance on difficult tasks.

The knowledge that a person's memory performance is influenced by an interaction of a number of psychological and environmental factors is probably directly related to the more general knowledge that performance of any action is influenced by many similar factors. In fact, Figure 1 owes its ancestry to discussions by Heider (1958) of what he called the Naive Analysis of Action. The latter describes a social cognitive understanding of human actions in terms of such common sense conceptualizations as "ability" and "difficulty."

A reasonable test of children's metamnemonic understanding of the interactions in Figure 1 would be to have subjects rate the ease and difficulty of tasks that differ on a combination of variables. For example, a series of memory situations would be presented: (a) some with difficult items and difficult demands, (b) some with difficult items but easy demands (or the reverse), and (c) some with easy items and easy demands. The sophisticated subject should know that (c) is easier than (b), and (b) is easier than (a). The second author is preparing to conduct just such a study.

However, even in advance of precise data, some tentative evidence about children's developing knowledge of the interaction of memory variables is available. This evidence stems from the spontaneous mention of interaction of variables in the protocols, especially of older children, in the Kreutzer et al. (1975) study. For example, in one item children were shown a list of words and asked if they would choose to study them for 1 minute or for 5. The response "There's quite a lot of words here, you know, and it would be kind of hard to learn in just 1 minute," was given by an older subject in that study. This response indicates understanding that one task feature, number of words, could offset another, study time.

On this item, 16 out of 40 9- and 11-year-olds, but only 3 of 40 6- and 7-year-olds spontaneously commented on the number of pictures, as a factor justifying their choice of the 5-minute study interval.

One other type of memory knowledge seems both developmentally important and also indicates an understanding of the interaction of memory variables. This type of metamemory knowledge encompasses an understanding of various memory factors in means-end interaction. That is, it consists of knowing that the variables that form a memory problem can be related in a representational scheme consisting of initial state, goal state, and means for transforming the initial state into the goal state. It strikes us that this scheme is a description of a subject's knowledge of, and appropriate use of, what Newell and Simon (1972) would call a means-end problem space.

In this type of representation parts of what we have called Person and Task variables go together to characterize the subject's initial state. For example, his initial state might consist of his knowledge of the item characteristics plus knowledge of his own present memory state in relation to those items. Certain aspects of Person and Strategy variables would then characterize possible transformations that are means to the subject's memory goal or end. These might include, for instance, the subject's knowledge of alternative strategic routes to the goal and his knowledge of his current memory states as related to the desired goal state. Finally, aspects of Task and Person variables would characterize his knowledge of the goal or end. Examples would be his awareness of task demands and his knowledge of the degree of match between his present memory state and the goal state.

Kreutzer et al. (1975) suggested that children in the middle or late grades of elementary school are much more likely than younger children to represent presented memory information in means-end interaction. They speculated that:

> . . . the late elementary school child is much more inclined than the kindergartener to: listen to and comprehend the mnemonic problem we present to him; to feel or imagine his way into its various solution steps, including the goal situation where retrieval is finally required . . . ; and then to arrive at one or more adequate-looking means, perhaps after discarding others through feedback from some sort of inner vicarious try-out. (p. 53)

Data to support this description are currently only suggestive. For example, Kreutzer et al. (1975) analyzed some of their tasks by tabulating the explicit use of means-end connectives in the children's responses. That is, they looked for statements connected by "so that," "and then," "next," etc. In one task only 3 of 20 6-year-olds but 17 of 20 11-year-olds used such obvious signs of means-end organization of their answers. On another task none of the 6-year-olds but 9 of the 20 11-year-olds proposed a sequence of explicitly connected strategies in response to a posed memory problem.

We have attempted in Section II to categorize the sorts of things the developing child could gradually discover about memory, and to cite research evidence pertinent to each category. According to this classification scheme, the child could learn to identify situations in which it is adaptive to retrieve information or to prepare for future information retrieval. There is also a very great deal that might be learned about the variables that influence mnemonic outcomes: person variables, task variables, strategy variables, and their interactions. We think of this categorization scheme as a preliminary mapping of a new and little-explored area of memory and memory development.

III. Relations Between Metamemory and Other Psychological Phenomena

In this section we would like to consider metamemory and its development in relation to possible "associated items." One set of associated items is the various other "metas" that also emerge in childhood, and that have been receiving recent study. These "metas" include the child's verbalizable conceptions about language, perception, social interaction, emotions, motor skills, or other domains of interest. Some of these "metas" have been studied under such pseudonyms as "percept inference," "role-taking skills," and "social cognition." In the previous section we talked of the child's metamemory of the factors affecting memory actions and alluded to the conceptual relationship apparent between that and a social cognitive understanding of human actions in general. In fact, much of what was said with regard to Person Variables and Interaction Among Variables has obvious overlaps with social cognition in its attribution theory and self-attribution forms.

The area of metalanguage has been dealt with in a recent article by Gleitman, Gleitman, and Shipley (1972). They speculate that the various "metas" may be functionally related and emerge more or less synchronously in the child's development. Our own suspicion (see also Markman, 1973) is, first, that any such development of synchronies and functional interrelationships would be extremely difficult to verify, even if they should exist, because of certain very stubborn conceptual and methodological problems that beset all efforts at uncovering developmental synchronies or "stages" (Flavell, 1971b).

Even if a valid reading could be achieved, however, we doubt if all "metas" would in fact prove to emerge synchronously. Rather, it seems plausible that those psychological processes of self and others which tend to be relatively more external and therefore more accessible to perceptual inspection ought to become objects of knowledge earlier than those which are relatively less overt. Recall in this connection Markman's (1973) finding that 5-year-olds are better able to predict their motor performance than their memory performance. Under this argument, knowledge of, say, internal memorization and retrieval ("memory" in the narrower, conventional sense) ought in general to develop later than, say, metalanguage, since speech and writing are external and perceptible. This is, of course, only one variable among the many that may affect the development of all "metas."

A related question has to do with the potential unity or diversity of the various judgments and conceptualizations making up metamemory itself. As we have discussed it, a wide variety of knowledge makes up the domain of metamemory and, empirically, different aspects of this knowledge have been shown to develop at different ages. However, the consistencies and interrelationships that might exist between different pieces of metamnemonic knowledge remain as an interesting and unresearched question. Is the child who is relatively knowledgeable about clustering also relatively knowledgeable about verbal or imaginal elaboration? Does a child who knows something about the interaction of Task and Strategy variables, also usually know something of other interactions, say Person and Strategy variables? Few interindividual consistencies in children's metamemory responses were found in the one study in which they have been investigated (Kreutzer et al., 1975). However, as Kreutzer et al. cautioned, their data were not collected with such questions in mind, and their findings in this realm only indicate the need for more careful studies in the future. Very probably, certain classes of metamnemonic knowledge are related, both conceptually and empirically. Discovery of these relationships would certainly add to our knowledge of metamemory and metamemory development.

Finally, the most important question in this section, what can be said of the relationship between metamemory and memory behavior itself? Much of the interest in metamemory has stemmed from the assumption that knowledge of memory plays an important role in the generation and modification of memory-related behavior (Flavell, 1971a; Markman, 1973; Moynahan, 1974). We also endorse the importance of this role, but believe that the metamemory-memory behavior relationship is likely to be quite complex and variable.

Consider any potential memory outcome as reflecting the interrelationship of three factors: the situation, possible behaviors, and the subject's awareness or knowledge--his metamemory. Just this very rough division of factors makes it obvious that any of the following combinations might occur. (a) The situation leads to memory behavior, with no attendant awareness. A case in point would be the incidental, nonintentional storing of some item. (b) The situation leads to memory knowledge, with no attendant memory behavior. An example would be seeing a relationship between items that was not known before and recognizing that it would indeed be mnemonically relevant, but not on that occasion storing or retrieving anything on the basis of that relationship. (c) The situation leads to memory behavior, and the subject also becomes aware of the situation-behavior-outcome link. This might occur if a subject incidentally clustered items, say, and then realized that this had had an effect on memory outcome. (This relationship seems reminiscent of Piaget's concept of reflective abstraction, as described in the next section.) (d) The situation leads to awareness, and on the basis of this awareness some memory behavior is generated to deal with the situation. The many examples of planful strategic memory behavior would fall here.

Some existing results empirically flesh out these conceptual possibilities. In relation to (a) above, for example, consider a study of verbal rehearsal by Flavell, Beach, and Chinsky (1966). In that study 31 children in three grades were observed to have verbalized the stimulus names as a mnemonic strategy. Of that number only 23 reported, when questioned, that they had verbalized the items. Fully 25% of the sample were observed to engage in an effective memory behavior but were unable to report that they had.

A study by Salatas and Flavell (1975a) is pertinent to (c) above. Two groups of 6-year-olds were shown a set of categorizable pictures. One group was told to do whatever they wanted to help themselves remember; the other group was instructed merely to inspect the pictures. Both groups were given a recall task after a short interval. Those children instructed to remember were more likely to group the pictures spatially by category during the study interval. Further, children instructed to remember were more likely to subsequently judge that a categorized rather than an uncategorized set of items would be easier to remember. It is possible that practice at studying the items facilitated the metamemory judgment. An observation by Ryan, Hegion, and Flavell (1970) in their study of memory behavior in preschool children is also pertinent here. They required children to match a picture of a toy with the appropriate real toy as a strategy for effective recall. Ryan et al. thought that a number of their younger subjects may have engaged in this picture-object matching simply because picture-object matching is a high probability response and because they were asked to "use the pictures" in some way. Of interest here is the suggestion that some of the children did seem to engage in the strategy in just this mindless, unaware fashion early in the session, but during the course of the testing, enactment of the strategy in this unknowledgeable manner appeared to lead:

> to the insight that what had just been done constituted an effective mnemonic procedure. Some Ss undoubtedly first enacted the sequence under the aegis of an already formed

mediational strategy; but others, we are arguing, may at first only have been engaging in a "false positive" type, mediation-mimicking activity, driven by a low-level matching tendency, and only later have formed this mediational strategy on the basis of feedback from that activity and its mnemonic consequences. (p. 548)

Finally, let us consider the possible executive, generation-of-behavior role described for metamemory in (d) above. In discussions of memory behavior in adults it has become apparent that an individual's knowledge of his own memory processes can play an important role in his formulation and employment of strategies for memorization and retrieval (Reitman, 1970; Tulving & Madigan, 1970). Developmentally, it has been shown that children become more and more able to act in an intelligent, planful, task-adaptive manner in an ever increasing array of tasks (cf. Flavell, 1970; Meacham, 1972; Brown, 1975).

Obviously, this description asserts a (d) type relation between metamemory and behavior. Given this description, we could expect that a person who intelligently uses a particular memory strategy ought to have some metamemory knowledge of that strategy, and a person who does not use the strategy should be shown to be less knowledgeable. In other words, there ought to be a correlation between appropriate pieces of memory knowledge and pieces of memory behavior.

Having made this prediction, we hasten to point out that any number of factors may attenuate the empirical presence of such an ideal relation. For example, how deterministic, or probable, a link should we expect between a particular metamemory judgment and use of a particular strategy? Suppose a person judges that categorized stimuli are easier to recall than noncategorized ones. Would he inevitably use categorization as a storage strategy, given obviously categorizable stimuli? Not at all. He may know about categorization but think that something else might be better yet in this situation. He may think the list easy enough to use simple inspection for storage. He may have enough knowledge to judge that categorization would be a good strategy, if asked about it, but not enough to think to utilize such a strategy on his own. Lastly, there are undoubtedly gaps between metamemory and memory behavior that have to be chalked up to Original Sin. Moral action does not always accord with moral beliefs, and similarly, we do not always try to retrieve information or prepare for future retrieval in what we believe to be the most effective ways. For example, older children and adults know perfectly well that one "should" concentrate most of one's learning efforts on the least well mastered segments of whatever is to be acquired (recall Masur et al., 1973). Yet, every music student must have at least occasionally succumbed to the temptation to practice those parts he can already play best, for the excellent psychological reasons that it is easier, more fun to do, better for the ego, and less painful to the ears.

Diagnostic factors may also cloud any empirical results. Harking back to our discussion of the Ryan et al. (1970) study, we can ask of any study: Did the subject really use the strategy in an intelligent and informed manner or merely in a low-level, habitual manner? Similarly, did the subject really answer the metamemory question in an informed way? Lastly, highlighting problems must be accounted for. What are the effects of making an explicit metamemory judgment on subsequent memory behavior, or vice versa?

Given all these problems, we can now indicate some preliminary data in the literature showing a correlation between metamemory judgments and memory behavior. Wellman, Drozdal, Flavell, Salatas, and Ritter (1975) showed in three different instances that children who possessed a particular piece of metamemory knowledge were more likely to engage in a related strategy than those who did not. Two different developmental patterns of metamemory-memory behavior coordination were apparent in these data. In one pattern, even the youngest children tested who could make the metamemory judgment were likely to engage in the related strategic behavior. That is, at all ages if the child understood certain aspects of the task, then that was reflected in his task-related memory behavior. In the second pattern, metamemory judgments were not related to memory behavior at the younger ages, but were at the older ages. That is, there was a development of metamemory judgment, of memory behavior, and a developing coordination between the two.

The second pattern discussed above implies that the causal chain may be more clearly and exclusively metamemory→memory behavior later in development than it is earlier. At the same time and paradoxically, metamemory in the sense of present, conscious monitoring of mnemonic means, goals, and variables, may actually diminish, as effective storage and retrieval behaviors become progressively automatized and quasi-reflexive through repeated use and overlearning. The metamemory-memory behavior link of the older child does not thereby extinguish, of course. However, the need for it to become clearly conscious may well diminish as the behaviors it once mediated become more self-starting. Clearly, the relationship of knowledge about memory to actual mnemonic behavior, and developmental changes in this relationship are complicated subjects, but subjects worthy of future research.

IV. How Metamemory Might Develop: Possible Formative Experiences and Processes

An important question under this heading would be: What sorts of cognitive skills and concepts might be needed to make possible the attainment of different sorts of knowledge about memory? Each aspect of metamemory undoubtedly has its own list, but a few acquisitions might be important for a wide range of metamemory knowledge. More sophisticated forms of metamemory seem to rely on a multiplication-of-relations type thinking, for example. Especially, what we have spoken of as the knowledge of the interaction of memory variables implies this type of general cognitive ability, where differing amounts of one factor are systematically related to differing amounts of another. Conceptual developments regarding time and psychological causality should also be generally important. The older child's intentional, means-end view of a variety of memory facts seems to imply some command of temporal order and duration, and also an appreciation of the self's own deliberate actions as effective causes of future effects (see Hagen, 1971, on this point). The child's increasing precision in memory-relevant calculations is probably related to a general ability of older but not younger children to rely on quantitative, metric, and more mathematical-looking cognitive structures.

Assuming, for the moment, the presence of all necessary cognitive prerequisites for any given metamemory acquisition, how is the latter actually acquired? A great deal of what the child comes to know about memory could be acquired through feedback from his own self-initiated experiences, as was suggested in the discussion of the Ryan et al. study in the previous section. A child could learn a great deal by repeatedly noting, for example, interdependencies among the original input data, his own storage and retrieval activities, and what and how much of the original input gets retrieved (Smirnov, 1973). Somewhat like block tower building and somewhat unlike, say, reasoning, mnemonic activities have concrete, semitangible "products" (what is actually remembered) which can be compared to ideal or possible "products" (what had originally been experienced), and variations in the discrepancy between the two are potentially relatable to one's own intervening activities. Much of metamemory development may therefore develop through something analogous to Piaget's "reflective abstraction" process. As we interpret this process, the child abstracts and permanently incorporates into his cognitive structure generalizations or regularities concerning the properties of his own actions vis-à-vis the environment, as contrasted with knowledge about the environment itself which derives from "physical abstraction" (e.g., Piaget, 1970, p. 728). Since metamemory and all other "metas" primarily entail generalizations about people and their actions vis-à-vis objects, a reflective abstraction-like process may play an important role in their acquisition.

The child's formation of abstractions about his own behavior is likely to be influenced in a number of ways. As discussed before, from the Russian point of view (Yendovitskaya, 1971), the parents' interaction with the child may greatly influence what the child attends to, and so what abstractions are formed. Parents, teachers, and others may frequently set various types of storage and retrieval tasks to the child, or engage in such efforts themselves, under the child's watchful eyes. At times, these significant others may actually provide a model of various memory behaviors, but probably more often they are simply providing "aliments" and demands that shape the child's own thoughts. Along these lines, it seems obvious that a child's experiences in school and with school tasks provide an important set of occasions as well as important "aliments" related to memorizing and retrieving. Cross-cultural studies of the effects of schooling (see chapter by Cole & Scribner in this volume) provide some indications that the school experience, and its demands, are potent shapers of certain cognitions independent of what subject matter is explicitly and intentionally taught in school. All of this section is of course quite speculative, at this point. It is always much harder to specify plausible acquisitional processes than to describe and developmentally order the acquisitions which they generate.

References

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

Appel, L. F., Cooper, R. G., McCarrell, N., Sims-Knight, J., Yussen, S. R., & Flavell, J. H. The development of the distinction between perceiving and memorizing. Child Development, 1972, 43, 1365-1381.

Atkinson, R. C., & Shiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory (Vol. 2). New York: Academic Press, 1968.

Berch, D. B., & Evans, R. C. Decision processes in children's recognition memory. Journal of Experimental Child Psychology, 1973, 16, 148-164.

Brown, A. L. Judgments of recency for long sequences of pictures: The absence of a developmental trend. Journal of Experimental Child Psychology, 1973, 15, 473-480.

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.

Brown, R., & McNeill, D. The "tip of the tongue" phenomenon. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 325-337.

Butterfield, E. C., & Belmont, J. M. Assessing and improving the executive cognitive functions of mentally retarded people. In I. Bialer & M. Sternlicht (Eds.), Psychological issues in mentally retarded people. Chicago: Aldine, 1975.

Danner, F. W. Children's understanding of intersentence organization in the recall of short descriptive passages. Unpublished doctoral dissertation, University of Minnesota, 1974.

Denhière, G. Apprentissages intentionnels à allure libre: Etude comparative d'enfants normaux et débiles mentaux. Enfance, 1974, September-December (3-5), 149-174.

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

Eimas, P. D. Effects of memory aids on hypothesis behavior and focusing in young children and adults. Journal of Experimental Child Psychology, 1970, 10, 319-336.

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.

Flavell, J. H. First discussant's comments: What is memory development the development of? Human Development, 1971, 14, 272-278. (a)

Flavell, J. H. Stage-related properties of cognitive development. Cognitive Psychology, 1971, 2, 421-453. (b)

Flavell, J. H., Beach, D. R., & Chinsky, J. M. Spontaneous verbal rehearsal in a memory task as a function of age. Child Development, 1966, 37, 283-299.

Flavell, J. H., Friedrichs, A. G., & Hoyt, J. D. Developmental changes in memorization processes. Cognitive Psychology, 1970, 1, 324-340.

Geis, M. F., & Lange, G. Planful storage for planful retrieval: A developmental study of cue utilization in school-aged children.

Paper presented at the meeting of the Society for Research in Child Development, Denver, April, 1975.

Gleitman, L. R., Gleitman, H., & Shipley, E. F. The emergence of the child as grammarian. Cognition, 1972, 1, 137-164.

Goldberg, S., Perlmutter, M., & Myers, N. Recall of related and unrelated lists by 2-year-olds. Journal of Experimental Child Psychology, 1974, 18, 1-8.

Hagen, J. W. Some thoughts on how children learn to remember. Human Development, 1971, 14, 262-271.

Hart, J. T. Memory and the feeling of knowing experience. Journal of Educational Psychology, 1965, 56, 208-216.

Hart, J. T. Memory and the memory monitoring process. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 685-691.

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 No. 159).

Lindsay, P. H., & Norman, D. A. Human information processing: An introduction to psychology. New York: Academic Press, 1972.

Lipsitt, L. P., & Eimas, P. D. Developmental Psychology. Annual Review of Psychology, 1972, 23, 1-50.

Markman, E. Factors affecting the young child's ability to monitor his memory. Unpublished doctoral dissertation, University of Pennsylvania, 1973.

Masur, E. F., McIntyre, C. W., & Flavell, J. H. Developmental changes in apportionment of study time among items in a multitrial free recall task. Journal of Experimental Child Psychology, 1973, 15, 237-246.

Meacham, J. A. The development of memory abilities in the individual and in society. Human Development, 1972, 15, 205-228.

Morrison, F. J., Holmes, D. L., & Haith, M. M. A developmental study of the effect of familiarity on short-term visual memory. Journal of Experimental Child Psychology, 1974, 18, 412-425.

Moynahan, E. D. The development of knowledge concerning the effect of categorization upon free recall. Child Development, 1973, 44, 238-246.

Neimark, E., Slotnick, N. S., & Ulrich, T. The development of memorization strategies. Developmental Psychology, 1971, 5, 427-432.

Newell, A., & Simon, H. A. Human problem solving. Englewood Cliffs, N.J.: Prentice-Hall, 1972.

Piaget, J. Piaget's theory. In P. H. Mussen (Ed.), Carmichael's manual of child psychology (Vol. 1). New York: Wiley, 1970.

Reitman, W. What does it take to remember? In D. A. Norman (Ed.), Models of human memory. New York: Academic Press, 1970.

Rogoff, B., Newcombe, N., & Kagan, J. Planfulness and recognition memory. Child Development, 1974, 45, 972-977.

Roedin, M.L., & Gruen, G. E. The role of memory in making transitive judgments. Journal of Experimental Child Psychology, 1970, 10, 264-275.

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

Salatas, H., & Flavell, J. H. Behavioral and metamnemonic indicators of strategic behaviors under remember instructions in first grade. Unpublished manuscript, 1975. (a)

Salatas, H., & Flavell, J. H. Retrieval of recently learned information: Development of strategies and control skills. Unpublished manuscript, 1975. (b)

Sieber, J. E., Kameya, L. I., & Paulson, F. L. Effect of memory support on the problem-solving ability of test-anxious children. Journal of Educational Psychology, 1970, 61, 159-168.

Siegler, R. S., & Liebert, R. M. Acquisition of formal scientific reasoning by 10- and 13-year-olds: Designing a factorial experiment. Developmental Psychology, 1975, 11, 401-402.

Smirnov, A. A. Problems of the psychology of memory. New York: Plenum Press, 1973.

Smirnov, A. A., & Zinchenko, P. I. Problems in the psychology of memory. In M. Cole & L. Maltzman (Eds.), A handbook of contemporary Soviet psychology. New York: Basic Books, 1969.

Tenney, Y. J. The child's conception of organization and recall. Journal of Experimental Child Psychology, 1975, 19, 100-114.

Tulving, E., & Madigan, S. A. Memory and verbal learning. Annual Review of Psychology, 1970, 21, 437-484.

Wellman, H. M. The development of memory monitoring: The feeling of knowing experience. Unpublished doctoral dissertation, University of Minnesota, 1975.

Wellman, H. M., Drozdal, J. G., Jr., Flavell, J. H., Salatas, H., & Ritter, K. Metamemory development and its possible role in the selection of behavior. In G. A. Hale (Chair), Development of selective processes in cognition. Symposium presented at the meeting of the Society for Research in Child Development, Denver, 1975.

Wellman, H. M., Ritter, K., & Flavell, J. H. Delibe e memory behavior in the delayed reactions of very young children. Developmental Psychology, 1976, in press.

Yendovitskaya, T. V. Development of memory. In A. V. Zaporozhets & D. B. Elkonin (Eds.), The psychology of preschool children. Cambridge, Mass.: M.I.T. Press, 1971.

Yussen, S. R. Determinants of visual attention and recall in observational learning by preschoolers and second graders. Developmental Psychology, 1974, 10, 93-100.

Yussen, S. R. Some reflections on strategic remembering in young children. In G. H. Hale (Chair), Development of selective processes in cognition. Symposium presented at the meeting of the Society for Research in Child Development, Denver, 1975.

Yussen, S. R., Gagné, E., Gargiulo, R., & Kunen, S. The distinction between perceiving and memorizing in elementary school children. Child Development, 1974, 45, 547-551.

Yussen, S. R., & Levy, V. M., Jr. Developmental changes in predicting one's own span of short-term memory. Journal of Experimental Child Psychology, 1975, 19, 502-508.

Footnotes

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Figure Caption

Figure 1. Metamemory schema of memory variables in interaction.