

Developmental Trends in the Metamemory–Memory Behavior Relationship: An Integrative Review*

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Introduction

Since the beginning of the 1970s, increasing attention has been directed toward the development of children's awareness of their own memory. This phenomenon has been termed *metamemory* by John Flavell (1971), who broadly defined it as the individual's potentially verbalizable knowledge concerning any aspect of information storage and retrieval. Whereas the interest in metamemory development has been growing rapidly since then, documenting the construct's general usefulness in a wide area of different memory situations, there are at least two critical points that deserve special consideration: (1) the conceptualization of the construct and (2) its status as a predictor of actual memory behavior. While the latter is the topic of the present chapter and is discussed in more detail, we first concentrate on some problems related to the definition of metamemory.

The first taxonomy of classes of memory knowledge was provided in the metamemory interview study by Kreutzer, Leonard, and Flavell (1975).

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Subsequently, Flavell and Wellman (1977) offered a more systematic and elaborated attempt to classify different types or contents of metamemory. Although alternative conceptualizations have been presented (see Chi, 1983), and more extended and general models of metacognition have been developed since (see Flavell, 1978, 1979, 1981; Kluwe, 1982), the classification scheme of Flavell and Wellman has been used in the majority of empirical studies concerned with the development of metamemory. According to this taxonomy, a distinction between two types of memory knowledge can be made: (1) the *sensitivity* category refers to the child's knowledge that some situations require intentional mnemonic behavior and others not; (2) the *variable* category refers to the knowledge that performance in a memory situation is influenced by a number of factors or variables. Within the latter type of metamemory, the person, task, and strategy variables are differentiated. In brief, the *person category* concerns the knowledge about one's own general memory limitations and capacities as well as the ability to monitor concrete experiences in a memory task (here-and-now-memory monitoring). *Task variables* refer to the awareness that task demands or properties of input information can influence memory performance. *Strategy variables* correspond to the individual's knowledge of storage and retrieval strategies.

It should be noted that this taxonomy of metamemory was not intended to be exhaustive, and the authors pointed out that they did not attempt to define the concept precisely. In their review articles, Cavanaugh and Perlmutter (1982) and Wellman (1983) emphasized that the vagueness of the metamemory conceptualization seems to be responsible for some of the inherent problems: as is typical of ill-defined concepts, there is agreement with regard to the central instances, but the underlying disagreement of current approaches to metamemory becomes obvious when more detailed analyses of the phenomenon are considered. Thus, while most definitions of metamemory include long-term knowledge about task demands, strategy, and person variables (as well as knowledge about one's own current memory states), it is uncertain and questionable (see Cavanaugh & Perlmutter, 1982) whether the conceptualization should also include the use of memory knowledge (i.e., the translation of memory knowledge into efficient executive processes). With other words, the problem is if metamemory should be considered a mixture of what Chi (1983) has called *declarative* knowledge (i.e., factual and verbalizable knowledge about memory) and *procedural* knowledge (i.e., knowledge about production rules). As a consequence, investigators should state explicitly and in more detail the instances they subsume under the concept of metamemory in order to eliminate possible sources of confusion.

A second problem in connection with metamemory, and the one of

primary interest in the present article, concerns the role it plays in the determination of actual memory behavior. As Brown (1978) stated, one of the most convincing arguments in favor of studying metamemory was that there must be a close relationship between the individual's knowledge of memory and her or his performance in different memory tasks. Similarly, Hagen (1975) in his commentary on the Kreutzer et al. (1975) interview study emphasized the need for research demonstrating the applicability, generality, and validity of the metamemory interview data. The possibility of predicting and explaining memory behavior attracted most investigators of metamemory and stimulated empirical research.

On the other hand, Flavell and Wellman (1977; Flavell, 1978; Wellman, 1983) pointed out that although conceptual analysis of the problem is necessary to understand whether, when, and how metamemory and memory behavior *might* be related, they argued that one cannot expect to find a strong connection between memory knowledge and memory activity. That is, there is no reason to assume that a strong metamemory-memory behavior relationship should be found regardless of subjects' age or task demands. On the contrary, various examples were given demonstrating that under certain circumstances (e.g., lack of motivation, problems with effort allocation) a strong relationship is rather unlikely. Although the authors do believe that metamemory will have a substantial impact on memory behavior when the motivational factors are favorable, their analyses indicate that this relationship and its developmental changes are complicated subjects.

In view of this theoretical complexity, it should be interesting to look at the existing empirical evidence of the metamemory-memory behavior relationship. At first glance, the results seem discouraging. Mainly relying on the negative findings of the often-cited studies by Kelly, Scholnick, Travers, and Johnson (1976) and by Salatas and Flavell (1976), several more recent articles have concluded that the empirical evidence for a close tie between metamemory and memory behavior is notably lacking (e.g., Brown, Bransford, Ferrara, & Campione, 1983; Chi, in press). In a more extended evaluation including about a dozen empirical studies, Cavanaugh and Perlmutter (1982) also found that the majority of these have yielded moderate or low correlations between children's declarable knowledge of memory and their performance on certain memory tasks.

In contrast, Wellman (1983) cited several investigations reporting more substantial links between metamemory and memory behavior. A closer examination of the possible reasons for this discrepancy reveals that while Wellman concentrates on the memory *monitoring* literature, Cavanaugh and Perlmutter focus mainly on investigations concerned with the development of *organizational strategies*. Thus, the strength of the relationship

between memory knowledge and memory behavior may partly depend on the type of knowledge and behavior studied. Studies referring to the dynamic aspect of the person variable of the Flavell and Wellman taxonomy (here-and-now memory monitoring) appear to show a more positive relationship, whereas those concentrating on the task or strategy variable (importance of organizational strategies) in most cases fail to show a metamemory-memory behavior connection. This conclusion is tentative, however, because these two reviews are clearly not exhaustive, as indicated by their surprisingly small overlap in cited research. These articles mainly concentrated on conceptual problems, and the metamemory-memory behavior relation was only one of several interesting points they discussed. Thus, a more exhaustive review appears to be necessary to get a more reliable answer to the question how metamemory and memory behavior are related.

From a theoretical point of view, there is no reason to expect to find a single, uniform relation between memory knowledge and memory behavior. Most of the empirical investigations have been developmental in nature, assessing the connection between memory knowledge and actual memory performance in different age groups and for different tasks. Consequently, it is the purpose of the present article to evaluate both the developmental pattern of the metamemory to memory behavior link and the dependence of this link on selected task variables.

As noted earlier, the somewhat fuzzy conceptualization of metamemory makes it necessary to give an explicit description of the measures accepted as characteristics of the construct in the present review. In the present review, studies were judged to empirically assess the metamemory-memory behavior relationship when they include either verbal or non-verbal measures of memory knowledge and related them to separate measures of memory activity. Data from interviews and questionnaires are typical verbal measures of metamemory found in studies concerned with organizational strategies, whereas different kinds of judgment (e.g., feeling of knowing, performance prediction, judgment of recall readiness) are typically used in studies analyzing memory monitoring. In addition to these verbal reports, more indirect nonverbal measures are also accepted when they appeared to indicate metamnemonic activities. Examples include the underlining of text units judged as important for understanding and reproducing prose and reaction time measures indicating memory search processes, the latter showing a high correlation with (verbal) feeling of knowing judgments (cf. Moore & Haith, 1979; for a more detailed discussion see Cavanaugh & Perlmutter, 1982).

Interestingly, the selection of measures used to assess metamemory appears to depend on the category of metamemory (e.g., knowledge of person variables versus knowledge of task demands) under investigation.

Memory monitoring studies generally used more indirect, derived metamemory indicators, compared with the verbal measures found in studies concerned with knowledge of task variables. Furthermore, the latter allows a more differential assessment of the metamemory-memory behavior relationship, because different forms of memory behavior (e.g., strategy use during information storage and information retrieval as well as amount of recall) could be related to memory knowledge. In contrast, memory monitoring studies simply assessed the correspondence between knowledge and memory performance. In view of these apparent differences between the two major types of metamemory-memory behavior relations, an attempt will be made in the present study to describe the different task requirements in terms of the complexity of skills or cognitive processes involved. It is hypothesized that the main differences in developmental patterns found for different types of metamemory-memory behavior relationship are due to different levels of memory tasks difficulty. Consequently, as a variety of experimental settings are encountered in investigations into both major types of relationship, it is further assumed that within-type differences in developmental patterns will be larger than between-type differences.

According to the preceding selection criteria, approximately 50 studies were found assessing the metamemory-memory behavior relation. Our classification of the research is evident in the organization of the review. In the first major section, studies analyzing memory monitoring are considered. Although alternative categorizations seem possible, two types of studies are distinguished with regard to the kind of memory monitoring process analyzed. In investigations assessing performance prediction, judgments were made *prior* to study. Thus, estimations of performance are required in advance of the actual memory task (mostly in the span prediction paradigm).

The second type of studies focused on what Brown et al. (1983) and Wellman (1983) have labeled *effort and attention allocation strategies*. While these studies investigate different memory situations (e.g., retrieval vs study effort) and differ with respect to the degree of complexity of the judgment required, in all the studies of the second type the knowledge of the *current* state of one's own memory determines memory performance.

The second section is devoted to studies concerned with the child's knowledge of organizational and elaborational strategies and their use in actual memory tasks. While most of these studies focused on the use of clustering strategies, a few studies assessed children's knowledge of various elaborational strategies that could be used in paired associate tasks.

The third major section covers studies that include a training period. These training and intervention studies were first developed to establish memory strategies and test metamnemonic activities in educable mentally

retarded children (see Brown, 1978). But in later studies, this experimental design was found to be useful in the analysis of the metamemory-memory behavior relationship in normal populations. As Borkowski, Reid, and Kurtz (1984) pointed out, the somewhat unsatisfying empirical evidence for this relationship from studies employing the free-recall learning paradigm might be due to the fact that preexisting and well-established organizational strategies can be used. These function automatically, so there may be no need to activate metamnemonic knowledge in this type of situation. Training studies normally include a strategy transfer task, which requires a decision about whether to use, to modify, or to abandon a previously learned strategy. This transfer paradigm may provide a more favorable context for the appearance of a connection between metamemory and memory performance.

Finally, a statistical procedure for summarizing research findings is presented in the fourth section. The traditional method of literature review has been repeatedly criticized for lack of analytical precision as a result of the idiosyncracies of the reviewer's perspective or neglect of important information in the primary data (see Cooper, 1979; Cooper & Rosenthal, 1980). Procedures of numerically combining the results of independent studies, labeled *meta-analysis* by Glass (1976, 1978; Glass, McGaw & Smith, 1981), were used to provide a quality control for the literary review presented in the first three sections. Although these statistical procedures have been suggested as an alternative to the narrative review, it should be noted that the present metaanalysis of correlational studies faced some problems that seem to restrict its general value. Although the guidelines given by Glass (1978) helped to overcome the difficulty of converting a variety of summary statistics (e.g., phi coefficients, contingency coefficients, *t* values) into product-moment correlation coefficients, there remained several studies that did not contain statistical information of the kind that could be used for this type of transformation. As a consequence, the intended quality control could not be secured for all parts of the literary review. Thus, the metaanalysis was considered to supplement and not to replace the traditional procedure.

The Use of Memory Knowledge in Memory Monitoring Tasks

Performance Prediction

Studies concerning the metamemory-memory behavior relationship have been confined to a limited number of experimental tasks and procedures. A considerable proportion of these studies concentrated on the

performance prediction paradigm, particularly the memory span prediction task. Recall that the metamemory-memory behavior relationship usually has been assessed by comparing children's judgments with their actual memory performance. But here, the relationship between these two measures (i.e., prediction accuracy) is regarded as a measure of *metamemory*. Consequently, no independent measure of memory is available in these studies. Nevertheless, several investigators tried to connect children's metamemory with selected indicators of memory behavior by comparing prediction accuracy with the amount of recall. Interestingly, only a few authors explained why these two variables should be expected to be highly correlated; but generally, it was speculated that proficient memorizers should also be more aware of their memory capacities and limitations. Before these attempts are discussed in more detail, a short survey of the numerous developmental studies of memory-span prediction is given to determine the developmental pattern of metamemory for this type of task.

Memory Span in Serial Recall Tasks

In the classical study of span prediction, Flavell, Friedrichs, and Hoyt (1970) asked preschool children, kindergarteners, second and fourth graders to predict their immediate memory span. Successively longer sequences of pictures showing familiar objects were briefly presented to the child, who had to indicate whether she or he could recall them in correct serial order. The prediction process continued until the subject judged the series of pictures too long to reproduce or until a series of 10 pictures had been presented. Next, the child's actual memory span was assessed using the same procedure. The main result was that the two youngest groups tended to considerably overestimate their memory ability: more than half of them predicted a span of 10 items, while fewer than one fourth of the older children did so. Although mean predicted span was higher than mean actual span at each grade level, the difference was considerably smaller for the two older groups as a result of both an increase in actual span and a decrease in their predicted span. According to these results, only children of about 7 years and older seem to be able to assess their memory span limitations accurately. It is worth noting, however, that about one third of the younger children could predict their own span with surprising skill. In a replication of this part of Flavell et al.'s (1970) study with kindergarteners, Markman (1973) got results very similar to those of Flavell et al.: about one half of the 5-year-old children made unrealistic predictions, judging that they could recall all 10 items in serial order.

Subsequent investigations attempted to discover why young children have difficulties in monitoring their memory by either using additional procedures or modifying the original one. According to one hypothesis,

the abstractness of the memory task might have caused the inaccurate predictions of young children. Indeed, a series of experiments have shown that preschoolers and kindergarteners can accurately predict their performance on simple motor tasks (see Markman, 1973). Similarly, young children benefited considerably when the prediction task was presented in a meaningful context such as a board game (see Justice & Bray, 1974) or a simulated shopping situation (Wippich, 1981).

A second hypothesis assumed that young children's difficulties in predicting memory span were due to their lack of experience in thinking about their own memory. But here, the empirical evidence is somewhat equivocal. While some studies demonstrated that kindergarteners could benefit from training trials (Markman, 1973) or feedback and experience with the memory task (Chi, 1978; Justice & Bray, 1979; Moynahan, 1976; Wippich, 1981), the results of other studies do not support the conclusion that lack of experience causes young children's difficulties. For example, Yussen and Levy (1975) and Wippich (1980) replicated the findings of Flavell et al. (1970), despite the fact that they provided opportunity for the children to experience the difficulty of the memory task either by reversing the sequence of the estimation procedure (Yussen & Levy, 1975) or by assessing the actual memory span first (Wippich, 1980).

All in all, these findings indicate that preschoolers have enormous difficulties with the unfamiliar-span prediction task. They apparently do not benefit from actual experience with serial recall unless specific prompts are given. On the other hand, there exists some empirical evidence indicating that preschoolers do possess the metamnemonic abilities to handle this problem when task conditions are favorable.

Another series of investigations focused on predictions of the *content* of future recall rather than the amount of recallable stimuli. It was assumed that predictions on an item-by-item basis could provide a more sensitive measure of developmental differences in children's awareness of their own retrieval limitations. In particular, it seemed possible that the unrealistic overpredictions of young children obtained in the span prediction task were due to their difficulties in discriminating memorizable from non-memorizable stimulus items. This hypothesis can easily be tested by using signal detection analysis, especially its parameter d' , which indicates the distinctiveness in the distributions of memorizable and nonmemorizable items (the greater the ability to correctly predict which stimuli will or will not be remembered, the greater d').

While Kelly, Scholnick, Travers, and Johnson (1976) and Monroe and Lange (1977) found that the rate of correct predictions of recall (i.e., hits) was rather high even for preschoolers and kindergarteners, Worden and Sladewski-Awig (1982) pointed out that neither of these two studies ex-

amined response bias as a second possible source of estimation inaccuracy, varying independently of d' . The author's assumption was that sensitivity for memorizable and nonmemorizable items may be as good in preschool children as in older children, but that their poorer performance in prediction of future recall could be due to a more liberal response bias (i.e., a greater proportion of hits and false alarms). In their study, kindergarteners, second, fourth, and sixth graders were nearly equally accurate in discriminating between recallable and nonrecallable picture stimuli. Additional analyses of response bias, however, supported the authors' hypothesis that younger children responded more liberally, obviously using weak signals to predict correct recall. Thus, the younger children's aforementioned overprediction of serial recall seemed to be mainly due to their increased false alarm rates, a result also found in the Kelly et al. study.

Taken together, these findings from studies investigating children's predictions of the content of recallable stimuli can explain the reasons for young children's bad metamemory in this task. They indicate that preschooler's metamemory concerning the prediction of serial recall is generally not well developed. On the other hand, young elementary school children demonstrate accurate memory knowledge independent of the type of span-prediction procedure.

But how does metamemory influence the amount of recall in this memory task? One of the most-cited studies (Kelly et al., 1976) concluded that no relationship between prediction accuracy and memory performance could be found. A closer examination of the experimental design, however, showed that it differed in several aspects from the aforementioned traditional span prediction tasks. In this study, the subjects (kindergarteners, first, and fourth graders) did not have to retrieve the items themselves, only their spatial locations. Because the recall test was nonverbal (children had to replace the items in serial order) and the list-estimation procedure included feedback, the prediction task was considerably simplified, providing optimal conditions for the younger children. Consequently, the authors failed to detect age differences in prediction accuracy, which was rather high at each grade level (.75 in average). On the other hand, fourth graders recalled significantly more than the younger children. As metamemory was nearly equally high across all age groups regardless of the number of items actually recalled, the correlation between metamemory and recall was necessarily nonsignificant. There seems to be reason to believe that the nonsignificant relation between metamemory and memory performance was due to a ceiling effect in the prediction task. The connection between knowledge and behavior may be different when analyzed separately for each age group, instead of across age groups as done by Kelly et al. (1976).

Empirical support for this possibility comes from two investigations that compared the prediction of serial recall versus recognition (Levin, Yussen, DeRose, & Pressley, 1977; Yussen & Berman, 1981). As Levin et al. (1977) emphasized, it has been demonstrated in several studies that recognition memory is high for both children and adults (see Brown, 1975). Older children and even adults, however, do not seem to be aware of the enormous capacity of their recognition memory. Thus, the authors assumed that, in contrast to the prediction for serial recall, no significant age differences should be expected on the recognition task; the usually high predictions of younger children should correspond more closely with their actual recognition performance, while the incomplete awareness of the older subjects might result in an underestimation of their recognition capacity. This hypothesis was empirically confirmed for all groups of subjects (first graders, third graders, and college students) in their sample. More important, while in the recall condition, high correlations between prediction accuracy and actual performance were obtained even for the youngest children, this relationship turned out to be rather weak for all groups in the recognition condition. Yussen and Berman (1981) were able to replicate and generalize these findings for groups of first, third, and fifth graders. Again, the correlations between metamemory and memory performance were high for both recall problems (i.e., recall for word lists and sentence lists), but only weak for the two corresponding recognition tasks, regardless of age. Similarly, Wippich (1981) reported significant negative correlations between the amount of overestimation and the amount of recall when memory span prediction was assessed in the simulated shopping situation. Interestingly, no relationship could be found when the kindergarteners in this study were presented with the traditional (laboratory) type of span-prediction task.

In sum, these results confirm the speculation that proficient memorizers are more aware of their memory and its limitations when prediction of serial recall is considered. This is true even for very young children (kindergarteners) provided that the task is presented in a meaningful context. On the other hand, it also has been shown that these conclusions cannot be generalized to different classes of memory problems. There is strong evidence that the relationship between metamemory and memory performance in a recognition task is generally modest even for adolescents and adults.

Prediction of Recall for Differently Structured Lists

Many studies have demonstrated that even young children usually show an increase in recall when they are asked to learn items from cate-

gorizable word lists, compared with their performance on lists with unrelated items (see Tenney, 1975). Several studies investigated children's spontaneous awareness of this fact by using the memory prediction paradigm. In a study by Moynahan (1973), first, third, and fifth graders were required to predict the relative ease of free recall for pairs of categorized and noncategorized picture lists. Children were first asked why they thought the chosen list was easier to remember and then asked to recall the lists. Here, metamemory (i.e., awareness of the facilitative effect of categorization) was assumed to particularly improve children's recall of categorizable lists, compared with their performance on unrelated lists. Thus, the difference between subjects' recall of clusterable and nonclusterable lists was chosen as the performance measure and related to prediction accuracy. Moynahan found that subjects generally recalled more from categorized lists than from noncategorized lists, and that recall increased with age. When asked to explain their choice, third and fifth graders more frequently referred to the categorical characteristics than first graders. A similar age trend was found for prediction accuracy, but it must be emphasized that first graders' scores still were significantly above chance expectation. But, although the correlations between prediction accuracy and recall performance were positive for all tasks and grades, none reached significance.

Yussen, Levin, Berman, and Palm (1979), using a similar design, included picture lists organized according to physical (shape) categories, in addition to lists containing semantic or random categories. On the metamemory task, first, third, and fifth graders had to predict which of the three lists would be easiest to remember. For recall, subjects were first asked to sort the items according to one of the three categories, and then were required to name the pictures after they had been covered. Children at all grade levels judged the semantic organization to be significantly easier than random organization, but only the oldest subjects also rated semantic organization more effective than physical categorization. With regard to recall, children in the semantic sorting condition were superior to all other subjects. Similar to the findings of Moynahan (1973), no significant correlations between metamemory (i.e., prediction) and actual memory performance were detected, although several of these were highly positive.

The results of these two studies are consistent with those usually reported in span prediction studies. Spontaneous awareness of the impact of different list organizations on ease of retrieval is found even in the youngest age groups. The metamemory-memory behavior relationship, however, is considerably more modest than that found in the span-prediction tasks. Although this might be partly due to the rather crude meta-

memory measures used in the studies of Moynahan (1973) and Yussen et al. (1979), the requirements (i.e., the identification of list properties combined with the awareness of their implications for recall) appear to be more difficult for younger children, compared with the requirements of the span prediction tasks. Empirical support for this assumption comes from the observation that first graders usually did well in the span-prediction tasks, but had considerable problems when required to predict recall for differently structured lists.

Effort and Attention Allocation Strategies for Rote Memory Tasks

All studies discussed up to this point have assessed children's general knowledge about the properties of their own memory, its capacities, and its limitations. In contrast, a considerable body of research concentrated on what Flavell and Wellman (1977) have called "here-and-now memory monitoring"—that is, the ability to assess the transient processes and to interpret the current state of memory.

Allocation of Study Effort

In the study-time apportionment task introduced by Masur, McIntyre, and Flavell (1973), first and third graders, together with college students, were given lists of pictures to learn in a multitrial, free-recall task. In all trials but the first, subjects were allowed to select half of the items for extra study. Planfulness in this task was defined as (1) *attention* allocation—that is, awareness of the current state of the to-be-retrieved items, and more important, (2) *study effort* allocation—that is, the distribution of study time in such a way that the previously not-recalled difficult items got the most attention. Both third graders and college students did select previously missed items for further study, whereas first graders appeared to select randomly, thus demonstrating poor metamemory. When the metamemory-memory behavior relationship was considered, it turned out that use of the appropriate strategy increased memory performance only for college students. Third graders seemed to benefit only slightly from the more sophisticated strategy.

Bisanz, Vesonder, and Voss (1978) used paired-associate lists to study the development of what they called the "two-state discrimination-utilization strategy." According to their hypothesis, an effective acquisition strategy based on memory monitoring consists of (1) discrimination of recalled and missed items, and (2) the effective distribution of study time

and/or effort—that is, greater processing effort for the previously missed items. The authors found that the discrimination-utilization strategy used by fifth graders and college students could not be detected in their youngest subjects (first and third graders). While the studies of Masur et al. (1973) and Bisanz et al. (1978) corroborated the findings of Berch and Evans (1973) that younger children are capable of distinguishing recalled from missed items, their results indicated a time lag between when children are able to identify missed items correctly and when they select these items for additional study. According to Brown (1978), the major difficulty of the study-time apportionment task has to do with the problem that the previously recalled items have to be maintained in memory while the previously missed items are selected for further study. As the subject is likely to forget the items already recalled if she or he does not work with them during the extra study time period, two activities have to be coordinated to cope with the task demands: (1) concentrating on the previously missed items, and (2) repeating the previously remembered items. Thus, the poor memory performance of first graders and also third graders in this task could be partly due to their difficulties in using appropriate rehearsal strategies. In contrast, fifth graders apparently not only know what activities have to be selected for this kind of task, but also do use these strategies efficiently.

On the other hand, Rogoff, Newcombe, and Kagan (1974) demonstrated that effort-allocation strategies of young elementary school children can be effective when recognition memory tasks are used. When asked to study pictures for a memory task, 8-year-old children adjusted their inspection times according to the length of the delay period (a few minutes, a day, or a week) between inspection and test. In contrast, 4- and 6-year-olds did not show longer inspection times when longer delays were announced. Furthermore, a significant negative correlation between the number of recognition errors and inspection time was detected, indicating the efficiency of strategic behavior.

In sum, knowledge about the successful use of effort-allocation strategies in the study-time apportionment paradigm seems to develop rather late in childhood. In case of free recall or paired-associate learning tasks, successful performance apparently results only if a discrimination-utilization strategy is combined with continuous rehearsal activities. It has been shown that children at age 10 years and above are able to master this complex problem, but for younger children a close relationship between metamemory (i.e., strategy awareness) and memory performance has not been found. When an easier recognition task is used instead, 8-year-old children also can show some planfulness, but younger subjects in general fail to understand the task demands.

Allocation of Retrieval Effort: Feeling-of-Knowing Experiences

A different set of investigations concentrated on children's knowledge of retrieval effort allocation strategies. Most of them dealt with the well-known everyday tip-of-the-tongue experience and the related feeling-of-knowing state. In both of these phenomena the subject fails to recall something, but still knows that she or he knows it. The tip-of-the-tongue experience reflects the subject's knowledge that an item not currently recalled is imminently recallable, while the feeling-of-knowing experience reflects the knowledge that an unrecalled item is recognizable. In two studies by Wellman (1977; 1979) it was assumed that metamemory (i.e., knowledge about the recallability or recognizability of items) is likely to influence the subject's strategic memory search behavior (i.e., increased retrieval effort), which in turn should positively affect memory performance.

Wellman (1977) studied both phenomena in kindergarteners, first, and third grade children. Each subject was presented with three sets of pictures varying in ease of naming. If the child could not name a stimulus the child was asked if (1) she or he had ever seen the item before ("seen" judgment), or if (2) she or he could recognize the item among a set of alternatives (feeling-of-knowing judgment). Subsequently, a recognition test was given, and the child rated her or his confidence in the choice. The results indicated that the ability to monitor the states of unrecalled items significantly increased with age. The accuracy of "seen" judgments was greater than feeling-of-knowing accuracy in the two youngest age groups, but for the third graders, feeling-of-knowing judgments were the better predictors of subsequent name recognition. Thus, in this age group a rather close connection between metamemory and memory performance could be found. Although the younger children had relevant information in their memories, they obviously did not use it when making the feeling-of-knowing judgments. On the other hand, older subjects were more frequently found to experience the tip-of-the-tongue phenomenon, demonstrating some of the emotional reactions (e.g., agitation or frustration) well-known from similar experiments with adults.

In an attempt to analyze these data more exhaustively, Wellman (1979) additionally examined the relationship between children's feeling-of-knowing judgments and their actual retrieval effort. Indications of retrieval effort were inferred from transcriptions of tape recordings of the children's comments and vocalizations like attempting to name the items, asking for retrieval time, affirming retrieval possibility, and so forth. The hypothesis was that judging an item as known should lead to an increased retrieval effort; judging it as not known, however, should result in less effort. This assumption was confirmed for all age groups: although the correspon-

dence between metamemory and this type of memory behavior was closer for the older children, kindergarteners also significantly related retrieval effort to feeling-of-knowing judgments in the predicted manner. Thus, apparently, children's often inaccurate perception of their knowledge seemed to determine their search behavior more than what they actually knew.

Similar results were found in a study by Posnansky (1978). Here, kindergarteners and third graders were asked to remember picture stimuli grouped in categories of different size. Children were either given category size information, were required to estimate category size, or did not get any information about the true category size. The interval between the last word produced in a given category and the first word produced in the next category during recall was considered an indicator of systematic search behavior guided by the knowledge about the actual category size. Posnansky found that those kindergarteners and third graders who had estimated the category size first used their estimates to guide recall. That is, significant negative correlations between intercategory pause time and percentage of category recalled were found for both age groups. Even more important, length of intercategory interval correlated more highly with children's estimates of category size than with true category size. Thus it was the child's own estimate of category size (i.e., metamemory) that closely corresponded with search efforts for kindergarteners as well as for third graders.

Finally, Brown and Lawton (1977) analyzed the feeling-of-knowing experience in educable retarded (EMR) children of three varying ability levels (mental ages [MA] = 6, 8, and 10 years). Younger children were not able to predict the accessibility of items in memory, but could judge the correctness of their recognition response *after* it had been made (see the corresponding findings for very young children by Berch & Evans, 1973). In contrast, educable retarded children with MAs of 8 years and above were able to predict recognition accuracy when recall failed.

In sum, the results obtained using the feeling-of-knowing paradigm indicate that children at age 8 years and above are accurate when asked to estimate the retrievability of items that are not recallable at the moment. For these subjects, metamemory (i.e., awareness of the current state of information in memory) was closely related both to retrieval effort and memory performance. Although the evidence for younger children is not so clear-cut, it appears that they do possess information relevant for the solution of this task. Thus, although in the two studies by Wellman (1977; 1979) kindergarteners' metamemory (i.e., feeling-of-knowing experience) did not strongly affect their memory performance, it was closely related to their retrieval effort. According to Brown and Lawton (1977), monitoring of retrieval effort seems to be somewhat easier than monitoring of

attention allocation of study effort: their EMR children with MAs of 8 years were capable of correctly estimating the current state of items in the feeling-of-knowing task, but failed when asked to predict recall readiness or to apportion their study time efficiently.

Effort and Attention Allocation Strategies for Prose Materials

The studies described so far have in common that they investigated children's memory monitoring skills by using rote-learning laboratory materials. This procedure has been criticized by several researchers who emphasized that such knowledge has only a limited range of applicability (see Brown, 1978). As a consequence, a number of more recent studies assessed children's knowledge of skills extremely useful in their everyday school life experiences, namely, study-monitoring abilities when text processing (memory for prose) was required. According to Baker and Brown (1981), this area of research deals with "reading for remembering," as opposed to the comprehension monitoring literature focusing on "reading for meaning." Reading for remembering not only involves all activities necessary for comprehension monitoring, but also includes several study-monitoring skills. The research concerning the development of study-monitoring abilities particularly concentrated on skills such as (1) focusing on the main ideas of texts, and (2) making use of the logical structure of the material (or prose organization).

Sensitivity to the Main Idea of Text Passages

Most of the investigations in this field have been carried out by Ann Brown and her colleagues (Brown & Smiley, 1977, 1978; Brown, Smiley, Day, Townsend, & Lawton, 1977; Brown, Smiley, & Lawton, 1978). The authors used rather complicated procedures to assess children's knowledge about central issues of text passages. Prior to the outset of the studies, the verbal materials (Japanese folk stories) were divided into linguistic sub-units, and independent groups of college students rated the structural importance of these idea units for the main theme of the stories using a 4-point scale. The resulting four levels of importance of information were regarded as a quasi-objective measure that was compared with the ratings of the experimental subjects. Thus, children's sensitivity to the constituent units of texts was chosen as a measure of metamemory. It was hypothesized that those children concentrating on the main events of a story during study should also show the same organization in recall, that is, they should reproduce the most important events but exclude nonessential de-

tails. Metamemory here was inferred from a behavioral measure; subjects had to indicate (i.e., cross out with pencils of different colors) successively higher levels of importance. With regard to recall, a rating procedure was used to determine the number of idea units reproduced by the subjects.

By comparing the importance ratings of their subjects with the quasi-objective measure, Brown and Smiley (1977) found that metamemory (i.e., sensitivity to importance units) developed gradually over the entire age range studied. While third graders made no distinction among levels of importance, fifth graders differentiated the most important units from the remaining three categories. Seventh graders showed greater sensitivity, distinguishing the two upper and the two lower levels, but had difficulties in distinguishing the medium levels. In contrast, college students could distinguish every level of importance, thus demonstrating the reliability of the measurement procedure. Importance level was highly significant in determining recall. Interesting enough, recall was determined by the structural importance of the text units for all age groups (see also Brown et al., 1977), but only children at age 12 years and above showed some awareness of the essential organizing features of texts. As these children also recalled significantly more idea units of the story, a rather close metamemory-memory behavior relationship for this task was assumed to develop by Grade 7. In contrast to the results obtained for the development of monitoring skills in rote-memory tasks, here the development of metamemory lagged behind memory performance. That is, although younger children were not aware of the important structural units of the texts, they still favored these important units in recall.

In a subsequent study (Brown & Smiley, 1978), the authors tested the hypothesis that the more mature readers would use their better knowledge about the crucial elements of texts when extra study time was provided. As in the aforementioned study by Masur et al. (1973), strategic effort-allocation was chosen here as a measure of metamemory. It was assumed that the older students should benefit from increased study time because they were aware of the fact that selective attention should be given to the central ideas of the story. As expected, most fifth-grade children did not improve their recall with the extra study time, but children from seventh grade up benefitted considerably, improving their recall particularly on the two most important levels of information. A closer examination of children's study activities showed that spontaneous underliners represented the superior group at each age level. But while fifth graders isolated only the most important units and consequently improved their recall of these units only, spontaneous underliners in the seventh- and eighth-grade samples showed a greater sensitivity to the two most important levels; their recall patterns resembled those of adults. Thus, Brown and Smiley (1978)

concluded that most of the younger children in their sample could not use extra time efficiently because they did not know the important elements of texts. On the other hand, older students tended to show more strategic behavior, paying attention to the main ideas of the stories. Here again, a close connection between metamemory and recall was not found before Grade 7. But, as already mentioned, it should not be overlooked that also a certain proportion of fifth graders spontaneously used adequate strategies favoring the important elements of the stories.

In another related study, Brown et al. (1978) modified the procedure used by Brown and Smiley (1977, 1978), in that half of the subjects were asked to select retrieval cues they judged important to recall the stories instead of rating the importance of text units. Fifth graders did not differentiate between these two task demands, but older children (seventh and eighth graders) tended to choose lower importance levels when selecting retrieval cues, compared with their selection of main ideas. According to Brown et al. (1978), the latter finding proves the existence of a rather sophisticated retrieval plan in older children, who seem to anticipate that the less central facts will provide most difficulties when recall is attempted. Not surprisingly, this fine sensitivity to the demands of gist-recall tasks is a skill that develops very late in childhood, and even older high school students have problems using a flexible retrieval strategy. Although these results appear to indicate that the ability to select the main ideas of a text passage (i.e., sufficient metamemory) cannot be found in elementary school children, Brown and her colleagues repeatedly emphasized that the problems experienced by their younger subjects could be the result either of the length of the passage to be rated, the complexity of the material or the difficulty of the rating procedure itself, which might have masked young children's sensitivity to the task.

Some support for this assumption comes from a study by Yussen, Matthews, Buss, and Kane (1980), who examined children's metacognitive awareness of important text units in rather simple and short prose passages, compared with the stories used by Brown and her co-workers. Perhaps more important, the authors referred to an explicit theory of story structure (i.e., the formal story grammar used by Stein & Glenn, 1979) to test their hypothesis that children's knowledge of text units relevant for recall develops during the elementary school years. According to this grammar, the initiating event, the character's action, and the result of the action can be considered basic categories of simple stories, and there is a greater probability of them being recalled than all others. As predicted, these key categories of the stories were recalled significantly better than other categories regardless of age, but it turned out that the youngest children (second graders) were not aware of the salience of the basic cate-

gories. When asked to select the most critical elements in the stories, they randomly chose among basic and unimportant categories. In contrast, fourth graders were more likely to identify the parts of the stories that were most important. Furthermore, modest support for a significant metamemory-memory behavior relationship was only found for the older children, indicating that the more knowledgeable children were also better at recalling the stories.

Knowledge about the Effect of Prose Organization

Finally, several further studies concentrated on another aspect of metamemory, namely, children's sensitivity to different text structures. Danner (1976) investigated children's understanding of prose organization and its effect on their recall by using short descriptive passages differing in logical structure. In topically well-organized passages, each paragraph dealt with one topic, whereas in disorganized versions, sentences from different topics were mixed together. Children in Grades 2, 4, and 6 were required to recall both types of passages. In addition, they were asked which task was the more difficult one and why. It turned out that passage organization affected the amount of recall and its structure (clustering) in children from all age groups, but only the older subjects (fourth and sixth graders) could explain how the passages differed. The younger children were able to detect that the disorganized passages were more difficult, and they also did quite well when asked to describe the main topics of the paragraphs, but they obviously were not aware of the relationship between organization and recall. Again, these findings suggest that the awareness of the facilitative effects of topical organization on recall considerably lags behind the age at which the organization itself has a significant effect. This result also illustrates the effects of task difficulty. Although the prose material used by Danner consisted of very short and simple sentences, the task to judge the difficulty of differently organized prose passages seems to be more complex, compared with the task to judge the difficulty of categorized or uncategorized word lists (cf. Moynahan, 1973). Thus, as Brown (1978) stated, a child knowing a lot about organization, when the basis of that organization is taxonomic categorization, may know little or nothing about the organizational principles underlying text materials.

On the other hand, knowledge about the impact of the logical structure of prose passages appears to be well developed by Grade 6, as Elliott (1980) demonstrated. In his study, the effects of two types of textual organization called "adversative" and "attribution" were examined. While in an adversative top-level structure, a favored view is related to an opposing view; in an attribution passage, the ideas are all related to a su-

perordinate topic, but not necessarily to each other. It is assumed that the more loose organization of ideas in an attribution structure can explain the fact that in earlier studies, recall for this type of organization was reported to be more difficult. The two short passages used by Elliott covered the same content but differed in top-level structure. Sixth graders and college students were required to read and immediately recall the passages and, in addition, were given a metacognitive questionnaire focusing on a comparison of the two versions of experimental passages. Furthermore, subjects were individually interviewed about their awareness of more general characteristics of texts, learners, and study situations. Highly significant relationships between metamemory scores and recall were found for both age groups. Although the adversative structure facilitated college students' recall more than that of sixth graders, the younger subjects, too, seemed to be aware of the effect of organization.

In sum, investigations of effort and attention allocation when studying texts have shown that this skill develops rather late in childhood. As Brown et al. (1983) point out, adequately judging one's mastery of the gist of texts requires that one first distinguish between important and unimportant segments of the passage, then concentrate on the central elements of texts and, as they become well known, shift to less important segments. The research done by Brown and her colleagues shows that young school children are not aware of this complex strategy. Although older elementary school children and even high school students had some problems using strategy knowledge in the experimental paradigm developed by Brown et al., further investigations with easier tasks and procedures showed that advanced elementary school children do possess efficient study-monitoring abilities. In contrast, children younger than 10 years of age appear to be unaware of the organizational principles underlying text materials, irrespective of their task difficulty.

This survey of the memory-monitoring literature has shown that a wide variety of experimental tasks have been used to analyze the relationship between children's memory knowledge and their memory performance. As expected, the results do not represent a uniform developmental pattern of the relationship, but strongly suggest that different levels of task difficulty seem to be mainly responsible for the heterogeneous findings. The results differ systematically according to the complexity of skills-processes involved in the tasks. A rather close connection between metamemory and memory behavior is found even in kindergarteners and young elementary school children when task requirements do not overload working memory—that is, when either the recallability or the recognizability of single items or limited item sets is tested. This seems to be true for most studies concerning the prediction of amount and composition of fu-

ture recall as well as for studies assessing children's retrieval-effort allocation strategies (e.g., feeling-of-knowing experiences). On the other hand, when either supraspan lists are presented, or a combination of complex strategies (e.g., self-testing, rehearsal) is required to cope with the task demands, significant relationships between metamemory and memory performance are only found in advanced elementary school children. Examples of these more difficult task requirements include attention-allocation strategies and study-effort allocation strategies (e.g., study-time apportionment) for rote-memory tasks as well as for prose materials.

Memory Knowledge and the Use of Organizational Strategies

With regard to the task variable of metamemory in the taxonomy of Flavell and Wellman (1977), most investigations into the metamemory-memory behavior relationship dealt with children's knowledge of the importance for recallability of the relationship among stimulus items, thereby assessing the impact of children's knowledge about the categorical structure of item lists on subsequent recall. Thus, here metamemory was defined as children's verbalizable knowledge of the role of organization in recall. Most of these studies had in common that subjects were provided with a sort-recall task: they usually were first encouraged or forced to establish input organization by sorting the items into personally meaningful or predefined groupings, and then were asked to freely recall the items. Thus, metamemory could be related to different forms of memory behavior: (1) strategic sorting behavior as a measure of input organization, (2) clustering or categorization during recall as a measure of output organization, and (3) the amount of recall as an indicator of memory performance.

It should be noted that the relationships among children's input organization, output organization, and memory performance has been analyzed in many developmental studies during the 1970s (cf., e.g., Kobasigawa, 1977; Lange, 1978; Moely, 1977), but only a few of them also assessed children's verbalization knowledge of the role of organization recall. In brief, the majority of these previous studies demonstrated that younger subjects (6- to 8-year-old children) did not spontaneously engage in sorting activities, but could increase their recall when required to do so. In contrast, most children at Grade 4 and above spontaneously used their abilities to sort items into categories when asked to prepare for future recall. In view of these "production deficiencies" in the use of category

organization among young children, it is worth noting that they apparently do know about the impact of organizational principles on recall, as can be concluded from the interview data obtained by Kreutzer et al. (1975) and Moynahan (1973). Similarly, even the majority of the mentally retarded children in the sample of Eyde and Altman (1978) were able to recognize adaptive behavior (i.e., the categorization of items) in this task, but here again only the older and higher-ability children spontaneously used the categorization strategy in preparing for recall.

More recent investigations into the metamemory-memory behavior relationship are characterized by their common attempt to analyze the sources of children's organization failures. Consequently, most of them have concentrated on the effects of task manipulation that might increase children's spontaneous use of recall organization. Modifications of the aforementioned traditional sort-recall task mainly included variations of (1) the kind of instructions given before or during the presentation of the item lists, and (2) the interrelationship among stimuli to be recalled. Further, some more-recent investigations focused specifically on the connection between domain-specific knowledge and the awareness of the functional relationship between the means and goals in this kind of memory task.

The Impact of Instruction

In the often-cited study by Salatas and Flavell (1976), a sort-recall task including three study-test trials was used to analyze the ability to distinguish between perceiving and memorizing in first-grade children. Subjects in the experimental condition were instructed to remember a set of clusterable picture stimuli in a free-recall task, whereas control subjects were asked to look at the items and received an unexpected recall test. As expected, recall was significantly higher for the remember condition, compared to the look group. The attempt at trying to remember in the experimental group also led to significantly more correct answers in a subsequent metamemory test, which addressed children's knowledge of the facilitative effect of categorization. But surprisingly, metamemory was not related to sorting behavior during the study trials, and it also could not predict children's strategic behavior in a retest given 6 weeks later. Subjects who had not categorized during study were as likely as categorizers to say that grouping of the items would facilitate recall. Thus, the authors concluded that there was no evidence that memory knowledge was a necessary condition for actual strategy use.

This assumption was tested in a study by Wimmer and Tornquist

(1980), who also used a sort-recall task to compare the metamemory-memory behavior relationship for first graders, fourth graders, and high school students. The metamemory questions corresponded to those given by Salatas and Flavell (1976), but were presented either before (i.e., awareness condition) or after the memory task (control condition). Metamemory turned out to be a necessary condition for strategic behavior in this study, as almost all subjects showing strategic behavior also explicitly stated their knowledge about the efficiency of categorical item grouping. Further, metamemory was significantly related to strategy use when the data were aggregated across age and experimental conditions. But a closer examination of the data reveals that this effect is primarily due to the inclusion of the 10- and 17-year-old subjects, who generally were aware of the facilitative effect of clustering and did use it efficiently in the memory task. In contrast, only about 50% of the first graders (the same proportion as found by Salatas & Flavell) showed adequate memory knowledge, and fewer than half of these knowledgeable children also used the clustering strategy *after* the metamemory interview had been presented. On the other hand, no strategy users could be found in this age group when the memory task was given *prior* to the metamemory interview. This result sharply contrasts with the findings of Salatas and Flavell (1976) showing that about half of the first graders spontaneously used clustering sorting strategies in this experimental condition. Although differences in task materials (27 items from 9 categories in the Wimmer & Tornquist study, 16 items from 4 categories in the study by Salatas & Flavell) might have contributed to the discrepant findings, they certainly cannot totally explain the different patterns of results. Nevertheless, both studies demonstrated that (1) knowledge of the facilitative effect of stimulus grouping is not well developed in first graders, and (2) metamemory does not relate to strategy use in this age group. In addition, the results obtained by Wimmer and Tornquist suggest that a rather close relationship between knowledge and behavior in this type of memory task does exist for children of age 10 years and above, given that categorizable items are used in the task. Corsale and Ornstein (1980) have shown that when semantically unrelated stimuli are chosen instead, a stable metamemory-memory behavior relationship emerges even later in childhood. In their study, third and seventh graders were assigned to one of three instructional conditions. Meaning-instructed subjects were told to sort the picture stimuli into groups that "go together," but were not informed of a subsequent recall test, while recall-instructed subjects were asked to sort the items in a way that would help to remember them. A third group received a combination of both instructions. As predicted, instructional manipulations had no effect on the recall of seventh graders, showing that these older children had learned to ad-

equately use active organizational strategies when the goal was to remember. On the other hand, the recall-instructed third graders remembered significantly less than all other experimental groups. Apparently, these younger children did not know what it means to prepare for recall when the relationship among stimuli is not as obvious as in the usual sort-recall task with highly familiar, clusterable items. Further, although a subsequent metamemory interview indicated that all subjects were aware of the fact that organized materials are easier to remember, the third graders obviously did not know *when* an organizational strategy should be used (i.e., if it is appropriate when a few or many things have to be remembered).

Effects of Task Properties

The preceding three studies have in common that they examined the relationship between metamemory and memory behavior by using a single task and only two or three *task-specific* metamemory questions. Flavell and Wellman (1977) have suggested that *general* memory knowledge should be a crucial factor in understanding how metamemory is related to memory behavior. If it is true that metamemory is necessary for effective memory behavior, a similar relation between knowledge and strategic behavior should be obtained across several related memory tasks.

These problems were addressed in a study by Cavanaugh and Borkowski (1980), which is undoubtedly one of the most comprehensive investigations ever done in this area. Kindergarteners, first, third, and fifth graders were presented with all 14 metamemory subtests of the extensive interview developed by Kreuzer et al. (1975), before they received three related memory tasks (sort-recall, cognitive cueing, alphabet search). While in the traditional sort-recall task the children were told to do anything with the items that might be useful to remember them, in the cognitive cueing task children were required to sort the stimuli into boxes with the cue pictures that remained visible during recall. Finally, an alphabet-search task required subjects to write down randomly presented letters before they were presented with an unexpected recall task. Partial correlations controlling for age revealed rather modest but consistent correlations between metamemory and measures of recall, input organization, and output organization. Thus, it appeared that the metamemory-memory behavior relationship seemed to be broadly based across several domains of memory knowledge and several memory tasks. But when the data were analyzed for developmental trends, the number of significant correlations dropped considerably; specific memory knowledge was significantly re-

lated to memory behavior only for the oldest age group (fifth graders). In contrast, strong developmental trends could be found for the degree of consistency of memory behavior in the three recall tasks. While none of the intercorrelations for the kindergarteners reached significance, all were significant for the fifth graders. By using a contingency analysis similar to that of Salatas and Flavell (1976) and Wimmer and Tornquist (1980), the authors further tested the hypothesis that metamemory is a necessary condition for efficient memory behavior. In contrast to the findings of Wimmer and Tornquist, subjects with low metamemory and high strategy-use scores were frequently observed regardless of the metamemory subtest actually chosen. Similarly, no support was found for the assumption that a close metamemory-memory behavior relationship can only be detected if task-specific and general knowledge components are considered simultaneously. The metamemory subtests involving task-specific knowledge proved to be the best predictors of memory behavior. In view of their failure to find predictable patterns among the significant metamemory-memory behavior correlations, Cavanaugh and Borkowski (1980) concluded that "it appears that fresh conceptual analysis of the metamemory side of the metamemory-memory relationship is needed, especially as regards the aspects of knowledge that *ought* to be involved. Such reanalysis must be accompanied by further refinement of metamemory assessment methods" (p. 450).

With regard to the metamemory assessment problem, interesting results were obtained in a study by Best and Ornstein (1979). The authors examined the hypothesis that experience with taxonomic materials facilitates and enhances (in a learning-set sense) memory performance in sort-recall tasks with semantically unrelated items. Third and sixth graders were first either given three trials of sort-recall with semantically associated stimuli or presented with semantically unrelated picture lists. In the test phase, subjects in both conditions were given two sort-recall tasks with unrelated items to find out if the different previous experiences could influence children's strategic behavior. After the memory tasks, metamemory was assessed with a comprehensive battery of questions derived from previous investigations. In addition to this traditional procedure, a behavioral measure of metamemory was used: subjects had to instruct first graders concerning performance on the sort-recall task, telling them the strategies most useful to remember the items. It was assumed that the subjects would be more explicit in the information provided when the "pupils" are considerably younger. With regard to memory performance, it turned out that prior experience with categorized or uncategorized material influenced sorting behavior and recall of third graders in the expected manner, but did not affect memory behavior of sixth graders, who

used adequate organizational strategies irrespective of prior experience (cf. the similar findings by Corsale & Ornstein, 1980). As in the study by Cavanaugh and Borkowski (1980), data from the metamemory interview did not significantly correlate with memory performance of third graders, and the connection was also modest for sixth graders (Best, personal communication, February 1982). Although the pattern of correlations was not consistent, it turned out that in general the behavioral metamemory measure was more closely related to recall. Interesting enough, the two metamemory measures had little relationship to each other. This finding seems to shed some doubts on the validity of the interview data, especially for younger children. Although the reliability of the metamemory interview of Kreutzer et al. (1975) has been repeatedly demonstrated (cf. Cavanaugh & Borkowski, 1980; Kurtz, Reid, Borkowski, & Cavanaugh, 1982), peer tutoring as a behavioral measure of metamemory appears to be more sensitive to children's actual knowledge. In a similar study, Best (1981) replicated the finding that categorical experience induced the children (third graders) to use organizational strategies and increased their recall of subsequently presented unrelated items lists. But it was also shown that a *simulated* peer tutoring task (children were asked to pretend that the experimenter was a first grader to whom they had to explain the strategy) turned out to be a weak indicator of children's metamemory. According to Best, children had enormous difficulties in pretending that the experimenter was a first grader.

The Impact of Children's Knowledge Base and Their Perceptions of the Task

While the preceding studies demonstrated young children's production deficiencies in a variety of experimental conditions, the question why children did not use their strategy knowledge still remains open, and there is also no satisfactory explanation of why and how children learn to overcome production deficiencies (see Paris, 1978; Paris & Lindauer, 1982). Some recent studies (Corsale, 1981; Bjorklund & Zeman, 1982) have addressed this point, either concentrating on the role of knowledge base (i.e., stimulus familiarity) or measuring children's perceived value of the strategy used in this type of task.

As for the impact of children's familiarity with the particular content area, studies have shown that sophisticated organizational strategies are spontaneously used and age differences in recall and clustering are sharply reduced when the memory task minimizes age differences in knowledge base.

For example, Corsale (1981) found that third graders spontaneously

organized stimuli in a sort-recall task with high-salient (i.e., prototypical) items regardless of the kind of instruction used, that is, they sorted the items taxonomically whether instructions emphasized meaningful groupings or only the recall of items. When low-salient items were used instead, spontaneous use of categorization (combined with better recall) was observed only for children instructed to group for meaning. In contrast, kindergarteners did not benefit from recall instructions. Thus, the level of categorical salience of items usually chosen in sort-recall tasks seems to be at least partly responsible for young elementary school children's production deficiencies. But this explanation cannot account for the problems of kindergarteners, who did not spontaneously engage in strategic behavior even when they knew the basic category structures.

Bjorklund and Zeman (1982) contrasted the traditional sort-recall task with a "class-recall" task, where children had to remember the names of their classmates. A series of experiments was conducted to test the assumption that young children's production deficiencies can be explained by developmental differences in knowledge base. Indeed, while significant age differences were obtained for recall and clustering behavior in the sort-recall task, memory performance of the first, third, and fifth graders in the study was comparably high in class-recall. When metamemory (i.e., children's awareness of the strategies they used to recall the names of their classmates) was related to memory performance, it turned out that strategy awareness was generally poor for children of all age groups despite high levels of recall. Only fifth graders showed some increase in memory performance and strategy awareness when the metamemory questions were presented prior to the memory task, provided they had some time to prepare for the task. Most of the younger children apparently entered the task without a definite retrieval plan, but occasionally discovered an effective grouping strategy (e.g., considering seating arrangements, reading groups, gender, or race) during their retrieval attempts.

Further interesting evidence concerning the nature of young children's production deficiencies came from studies investigating children's perceived value of strategies useable in the sort-recall task. Thus, Justice (1981) asked preschoolers, kindergarteners, and second graders to judge the mnemonic effectiveness of four different memory strategies (i.e., grouping, repeating, naming, and looking) for a given sort-recall task. To assess the metamemory-memory behavior relationship, strategies chosen as optimal by the children were compared with those actually adopted on the memory task. While half of the second graders adopted the strategy chosen as optimal, only 20% of the preschool and 15% of the kindergarteners did so. Furthermore, second graders preferred the more complex and sophisticated strategies (i.e., grouping and rehearsal) both in judgment and actual behavior. On the other hand, the younger subjects rated the

ineffective looking strategy as optimal and actually used naming strategies on the memory tasks. Thus, as the utility of the complex strategies was not apparent to the younger children, they chose other means they were familiar with and that they believed to be effective.

A similar phenomenon was observed in a study by Cox and Paris (1979). Here, fourth graders, young adults, and the elderly were presented with a random list of categorically related words and instructed either to recall the items after studying (the remember condition), to generate as many memory strategies as possible before the study of items (the generate condition), or to learn the lists by conceptually grouping the items (the instruct condition). After the memory task, subjects were asked to (1) report the strategies used, (2) rank order strategies in terms of perceived effectiveness, and (3) indicate which strategies would be used by them as a future study activity on similar tasks. Although correspondence between the generated strategies (metamemory) and those actually used (memory behavior) was high for all age groups, there were interesting age differences in the types of strategies preferred. While college students and elderly subjects relied on categorization, most fourth graders rather consistently used rehearsal and rated it higher than other strategies. Even those children instructed to categorize during study thought rehearsal to be the most effective strategy and also reported that they would use rehearsal as a future study activity. Thus, the brief practice with a more sophisticated strategy did not change children's belief about the effectiveness of certain mnemonic techniques in producing better memory performance. They apparently did not understand the importance of categorization as a mnemonic operation facilitating recall. Interestingly, although both fourth graders and elderly showed poorer results in the remember condition, compared with their recall in the instruct condition, only the elderly subjects benefitted from the generate condition. Thus, production deficiencies of children and elderly appear superficially similar, but reflect underlying qualitative differences in task understanding. The poorer performance of the elderly under remember instructions seem to be due to a lack of self-testing and familiarity with the task; in contrast to the fourth graders, they knew about the facilitative effect of categorization and had easy access to this strategy after a prompt was given in the generate condition. As in this study the subject's evaluations of means and goals relevant for the task were taken into account; it was possible to find out different sources of a superficially similar memory difficulty.

To summarize, a consistent and rather close connection between metamemory and memory behavior in the traditional sort-recall task with categorizable stimulus material seems to emerge rather late in childhood. Children younger than 10 years old did not systematically relate their knowledge to adequate strategic behavior in the memory task without ad-

ditional prompts or highly associated stimulus lists. Although even second graders knew that semantically organized lists are easier to remember than unrelated lists, they usually were unaware of the importance of categorization strategies for facilitation of recall and preferred to rely on familiar strategies (e.g., rehearsal) that proved to be less effective.

The Status of Output Organization in the Sort-Recall Task

The discussion of the metamemory-memory behavior relationship in the sort-recall task so far has focused on sorting behavior (input organization) as an indicator of strategy use (i.e., memory behavior). Clustering during recall (output organization) has also been considered as a possible indicator of strategic behavior (as discussed previously). Although some of the aforementioned studies reported moderate to high correlations between clustering and recall, it has been repeatedly questioned whether clustering always indicates deliberately chosen retrieval strategies. Thus Neimark, Slotnick, and Ulrich (1971) stated that in their study, clustering per se was insufficient evidence of deliberate organizing, and Corsale (1981) emphasized that for young children, use of category structure during retrieval was related neither to sorting behavior nor to level of recall, particularly when high-salient items were used. This result can be accounted for by Lange's (1978) assumption that highly associated items automatically elicit one another's recall. Thus here the associativity among items results in what seems to be a sophisticated categorization strategy. A tenuous relationship between clustering and recall was also found in a study by Kee and Bell (1981), who additionally pointed out that organization during recall was no source of developmental differences in free-recall learning. In contrast, organization at study turned out to be at least a partial source of developmental differences in the recall performance of second graders, sixth graders, and college students. All in all, these findings seem to justify the decision to focus on input organization as an indicator of strategic behavior in the sort-recall task.

Memory Knowledge and Use of Strategies in Paired-Associate Learning Tasks

The results of the few studies analyzing children's knowledge and spontaneous use of organizational strategies in a paired-associate task (Pressley and Levin, 1977; Waters, 1982) suggest that here the metamem-

ory-memory behavior relationship is much clearer, compared with the findings for the sort-recall task (see Brown et al., 1983). It should be considered, however, that both studies differed from the majority of the preceding sort-recall studies in that they used samples of advanced elementary school and high school children.

In the study by Pressley and Levin (1977), children's awareness of the strategies used in a paired-associate task was chosen as an indicator of metamemory. Subjects reported the strategies used immediately after the presentation of a list of paired-associate items, and on the basis of their reports they were classified as rehearsers, elaborators, or mixed-strategy users. As predicted, there was a change in strategy use during adolescence: the proportion of those subjects relying on at least some elaboration significantly increased between Grades 5 and 9, whereas the proportion of rehearsers decreased between these two grade levels. Perhaps more interesting, when analyzing the memory performance it turned out that the effect of the strategy used was significant, indicating that elaborators recalled most and rehearsers least at all age levels. Furthermore, fifth graders who reported elaborating outperformed ninth graders who did not report using the more sophisticated strategy. Thus, here the strategy used by the subjects was a better predictor of performance than the age of subjects, a result rarely found in studies using younger samples and different memory tasks.

Waters (1982) also analyzed the relationship between reported strategy use and memory performance in a paired-associate learning task, but additionally assessed which of four possible strategies (i.e., reading carefully, rehearsal, and visual and verbal elaboration) was judged most effective by the eighth and tenth graders of her sample. Metamemory was significantly related to both strategy use and memory performance in both age groups, and again subjects who used either verbal or visual elaboration more often tended to recall more word pairs. But even eighth and tenth graders' metamemory seemed to benefit from task experience, as shown by a comparison with control subjects who received only the metamemory questions. After the recall test, most experimental subjects identified elaboration as the most effective strategy, but only one-fourth of the eighth graders and one third of the tenth graders in the control group did so. This finding indicates that knowledge about the facilitative effect of elaboration strategies in paired-associate tasks appears to emerge later in childhood than knowledge about the effects of clustering strategies in sort-recall tasks. On the other hand, Moynahan (1978) demonstrated that even first graders can successfully be taught to effectively use some form of elaboration (i.e., physical interaction strategies) in a paired-associate task when recognition is assessed instead of recall. Here, most of the young children correctly rated this strategy as better than a rehearsal strategy, and also

spontaneously used it on another paired-associate recognition task. But apparently it takes a long time until knowledge about elaboration is spontaneously verbalizable and usable in paired-associate recall tasks.

In sum, the studies reviewed in this section indicate that as far as organizational strategies in categorization or paired-associate tasks are concerned, a close metamemory–memory behavior relationship emerges rather late in childhood. As for the sort-recall task, children younger than 10 years only spontaneously engage in sorting activities when high-salient items are presented and usually prefer to rely on familiar rote-learning strategies (e.g., rehearsal). Similar to the more complex memory-monitoring procedures the task involves learning of supraspan lists, and successful performance requires the combination of rather complex skills. As Neimark et al. (1971) stated, in order to cope with the task, an exhaustive organization for efficient encoding of each item has to be combined with the ability to keep track of “readout”—that is, to know what has been recalled and what is still missing. Younger children appear to be unaware of both requirements, and there is evidence that they sometimes discover organizational strategies only as a result of retrieval attempts (see Bjorklund & Hock, 1982). On the other hand, it appears that the traditional metamemory interview leads to an underestimation of younger children’s actual knowledge. Thus, it seems possible that the metamemory–memory behavior connection might be stronger when behavioral measures of knowledge are used.

Training of Strategy Use

As already mentioned, tests of maintenance and generalization of strategies might be contexts in which metamemory and memory behavior are closely related. Because in a transfer situation, decisions are required about whether or how to use a newly acquired strategy, in a (slightly) modified task arrangement, it was assumed that the metamemory–memory behavior connection would be more apparent in intervention studies (cf. Borkowski & Cavanaugh, 1979; Borkowski, Reid, & Kurtz, 1984). Several recent studies have concentrated on this hypothesis by training either memory monitoring skills or the use of organizational strategies in sort-recall tasks.

Training in Memory Monitoring

Brown, Campione, and their colleagues (Brown & Barclay, 1976; Brown & Campione, 1977; Brown, Campione, & Barclay, 1979; Brown,

Campione & Murphy, 1977) conducted several studies to assess the effects of specific mnemonic skills on the educable retarded children. These studies differed with respect to the trained strategies but were similar in design. They all included a pretest to assess baseline behavior, some days of strategy training, and two or three prompted or unprompted posttests assessing maintenance and (in some cases) generalization of the strategy in question. Furthermore, all studies were directly comparable in that two groups of subjects (children of MAs 6 and 8 years) were always considered in the analysis. Uniform results were obtained for maintenance—that is, a successful implementation of a mnemonic skill. In general, both groups of subjects responded to training and improved their monitoring skills during the training procedure, but only the older children showed the same level of skill on subsequent posttests, irrespective of the type of memory monitoring strategy under investigation. Interestingly enough, this was true for rather simple task requirements like span estimation (Brown, Campione, & Murphy, 1977) as well as for more complicated ones like recall readiness (Brown, Barclay, 1976; Brown, Campione, & Barclay, 1979), and study time apportionment (Brown & Campione, 1977). Although evidence of maintenance of older subjects was generally encouraging, Brown et al. (1977) did not succeed in effecting transfer of strategic behavior in the memory-span estimation task to new situations, where either the task format was slightly changed or numbers were used instead of pictures. Thus, training for one specific skill or task did not generalize to highly similar tasks. In other words, metamemory was not related to subsequent strategy use when rather task-specific strategies had been taught.

Consequently, Brown et al. (1979) concentrated their effort on the training of more general skills. Training of general self-testing strategies like rehearsal or anticipation proved to be very effective in the older age group. Improved recall readiness was detectable even 1 year after training, replicating, and extending the results obtained by Brown and Barclay (1976). But more important, training recall readiness on a list-learning task transferred to quite a different task, namely, preparing for gist recall of prose passages. Children trained in the preceding two self-testing strategies recalled significantly more idea units at each level of importance than the control subjects. Thus it was shown that even educable retarded children (MA = 8 years) are able to transfer a memory monitoring strategy to a quite dissimilar recall readiness task. Because they failed to effect generalization in much simpler tasks (e.g., memory-span prediction) when attempting to train children in task-specific mnemonics, the authors have good reason to attribute their success in this study to the fact that a more general problem-solving routine was trained. This finding corroborates Belmont, Butterfield, and Ferretti's conclusion (1980) that generalization

can be observed only when some aspect of self-monitoring strategy is taught.

Training in the Use of Organizational Strategies

Even more recently, several investigations have been conducted to assess the relationship between metamemory and maintenance as well as successful transfer of organizational strategies in paired-associate and sort-recall learning tasks. Although these training studies differed in many procedural details, they all have in common a focus on strategy training in young children between ages 7 and 9 years.

Organizational Strategies in Paired-Associate (PA) Learning Tasks

Two related studies by John Borkowski and his colleagues (Kendall, Borkowski, & Cavanaugh, 1980; Kurtz et al., 1982) analyzed the relationship between metamemory and successful strategy transfer in PA tasks.

In the study by Kendall et al. (1980), mentally retarded children (MA = 6:9 years) were trained in a four-step interrogative strategy considered as helpful for PA learning. Children were instructed to (1) associate a relationship between the PA items; (2) ask why the two items are together; (3) elaborate on characteristics of the items; and (4) use these elaborations to answer the "why" question generated in Step 2. A battery of metamemory questions (mainly from the Kreutzer et al., 1975, interview study) was given before the training procedure and after the strategy generalization task. Children in the experimental condition were taught to use the interrogative strategy during four training sessions and were tested in long-term retention of the final training list, strategy maintenance, and strategy generalization. Children in the interrogative control condition received no strategy instructions and established a baseline for training effects. A second control group participated only in the two metamemory interviews. It turned out that recall was significantly better for experimental children than for control children across all training sessions and in the tests of maintenance and generalization. Thus, the interrogative strategy was maintained and successfully transferred to the generalization task. While no significant correlations were found between metamemory pretest and recall, metamemory pretest was significantly related to quality of elaborations at generalization. On the other hand, metamemory posttest significantly correlated with recall in the later training sessions as well as with recall in the long-term retention test, maintenance, and generalization tasks. In addition, a significant relationship between metamemory posttest

and quality of elaborations (i.e., strategy use) was found. Thus, here the importance of metamemory for effective strategy use during maintenance and generalization was shown even for young educable retarded children. It should be noted, however, that strategy transfer was assessed for what Kendall et al. (1980) called a "near" generalization task, which was only slightly changed in that triads of items were used instead of pairs.

A similar study with normal second graders was conducted by Kurtz et al. (1982). Major changes in design concerned the omission of the long-term retention test and the metamemory posttest. Thus, only a (interrogative) control group was compared with the experimental children. With respect to experimental-control differences in recall, the results were similar to those of Kendall et al. (1980). But in contrast, (pretest) metamemory was significantly related to strategy use and memory performance in both maintenance and generalization. Interestingly enough, the correlation between metamemory and strategy use in maintenance remained significant even when the effect of IQ was partialled out. Furthermore, metamemory was a better predictor of strategy use during maintenance and generalization than the IQ measure. In sum, the results of both training studies showed the importance of metamemory in strategy maintenance and transfer, thus confirming the assumption of the authors that good metamemory seems to be a prerequisite for strategy generalization in PA tasks (see also Moynahan, 1978). Nevertheless, the data were not completely consistent with those of Kendall et al., in that pretest metamemory proved to be an efficient predictor of memory behavior only for the normal children in Kurtz et al. (1982). On the other hand, educable retarded children did not enter the task with appropriate knowledge but did benefit considerably from the extensive training program.

Organizational Strategies in Free-Recall Learning Tasks

Most investigations concerned with the training of organizational strategies used the aforementioned sort-recall paradigm. But before the results of these studies are discussed in more detail, two studies are considered first, which also concentrated on free recall or word lists or picture lists. Here, however, children were instructed to use simple rehearsal (Kramer & Engle, 1981) or cumulative rehearsal (Cavanaugh & Borkowski, 1979) within chunks or clusters instead of sorting items during the study phase. While metamemory and memory performance (i.e., recall) were assessed in the same way as in the sort-recall studies, memory behavior (i.e., strategy use) was inferred from exposure durations of the final stimulus within each cluster or chunk—considerably longer than that of the preceding items.

In the study by Cavanaugh and Borkowski (1979), task-specific measures of metamemory were used to find out if (1) metamemory can predict children's level of strategy use and (2) successful strategy training can in turn influence metamemory. Consequently, pre- and posttests of metamemory were used. Children in the experimental condition were provided with two training sessions and instructed to use cumulative rehearsal within clusters of items. Half of them received feedback on the value of the cumulative clustering strategy following the maintenance task, which was given 2 weeks after the last training session. While an uninstructed control group participated in all sessions, a second control group only received the two metamemory tests to control for the possible effects of noninstructed free-recall learning on metamemory. No generalization task was given in this study. As for maintenance, the results showed that correct strategy use was found for the experimental subjects but not for the control group. Children who maintained the cumulative rehearsal strategy also recalled significantly more than those experimental subjects who did not do so and the control children. More important for the present review, significant correlations were detected between pretest metamemory and both strategy use and recall in the maintenance task. Additionally, strategy use at maintenance was significantly related to metamemory assessed 3 weeks after the maintenance test. Comparisons of the pretest-posttest metamemory scores yielded a significant improvement only for the experimental children in the feedback condition, thus underlining the importance of awareness induction in this task.

While these results supported the view of Borkowski et al. (1984) that training studies provide a more favorable context for a close metamemory-memory behavior relationship, Kramer and Engle (1981) were not equally successful in demonstrating the effectiveness of rehearsal training and strategy awareness for strategy use and memory performance in their generalization tasks. In this study, normal and retarded children of equivalent developmental age ($MA = 8$ years) were trained in a rehearsal strategy in order to recall relatively unrelated picture stimuli. Two days of training were followed by an immediate and a delayed posttest, both including a maintenance free-recall task and two generalization tasks (i.e., a serial-position probe test and a picture-recognition task). Subjects were assigned to four treatment groups, according to the systematic variation of training conditions (i.e., rehearsal and strategy awareness training). While all subjects received metamemory questions following the training and posttest sessions, only subjects in the strategy-awareness condition got feedback on the value of strategy use. When recall and strategy use on the maintenance tests were analyzed, it turned out that rehearsal training (but not strategy-awareness training) improved performance on the two posttests.

With regard to the two generalization tasks, no strategy transfer was observed for the serial-recall probe, and there was only weak evidence for strategy transfer on the recognition task. Moreover, although some of the correlations were rather high, metamemory was neither significantly related to memory behavior (i.e., strategy use) nor to memory performance on the maintenance and generalization tasks. Thus, this study provided no support for the notion that a high level of metamemory is necessarily related to good memory performance in this type of task. The authors attributed their failure to induce generalization to the fact that the subjects were made aware of the utility of a particular strategy but were not trained in more general self-checking strategies (see also Brown et al., 1979). But there might still be other reasons for the negative results. It is by no means obvious that subjects should transfer the strategy of repeating stimuli in sets of four-item chunks to a task dealing with serial recall of only 8 digits, particularly when the findings concerning children's prediction of their own memory span for digits (see preceding section) are taken into account. Moreover, the recognition task seems to be inappropriate as a generalization measure because a ceiling effect was reported for all treatment groups. That is, due to the enormous capacity of recognition memory all subjects were performing almost without error. Thus, there is good reason to assume that the selection of inappropriate generalization tasks may have contributed to the negative findings in this study.

When training studies using sort-recall tasks are considered instead, the pattern of results seems to be more clear-cut. One of the first studies combining strategy training in a sort-recall task with the assessment of children's knowledge about the usefulness of mnemonic strategies was conducted by Ringel and Springer (1980). Here, first, third and fifth graders were assigned either to an uninstructed control group or to three experimental groups instructed to use a semantically based sorting strategy. Two of these experimental groups additionally received feedback telling them about their improvement and the cause-effect relationship between strategy use and improvement in performance. Following the test of strategy maintenance on a new sort-recall task, each child was presented with a variety of metamemory questions. Unfortunately, the investigation did not systematically relate metamemory to memory performance and strategy use in the maintenance task. But when the three task-specific metamemory items were considered, it turned out that third grade experimental subjects in the two feedback conditions who maintained the strategy gave more correct answers than the instruction-only and control subjects. All experimental subjects in fifth grade, however, maintained the sorting strategy *and* showed better metamemory than the control children. In contrast, first graders' metamemory scores did not vary as a function of experi-

mental condition. Thus, only for the two older age groups was there a close relationship between metamemory and memory behavior.

More direct evidence concerning the important role of metamemory in strategy acquisition, maintenance, and generalization in sort-recall tasks was reported by Borkowski, Peck, Reid, and Kurtz (1983). In their study, two similar experiments were conducted to explore the connections between young children's cognitive tempo (i.e., impulsivity-reflectivity), metamemory, and strategic behavior on multiple tasks. As in the preceding study by Cavanaugh and Borkowski (1980), sort-recall, alphabet-search, and cognitive-cuing tasks were used, but the design differed in so far as the traditional sort-recall procedure and the alphabet-search task were used to assess strategy acquisition and maintenance, while the cognitive-cuing task was chosen to assess strategy generalization. In other words, the purpose of these experiments was to assess the combined effect of clustering-rehearsal strategy training (on a sort-recall task) and an exhaustive search-strategy training (on an alphabet search task) on memory behavior and performance in a related task that required subjects to sort stimuli into boxes with cue pictures remaining visible during recall. The main differences between the two experiments concerned the position of the metamemory interview, which was given either before or after the training procedure. Moreover, two training periods instead of one were given in the second study. When metamemory was assessed after training (Study 1), significant correlations were found between metamemory and strategy use in the maintenance and generalization tasks. Both input and output strategies contributed to the significant correlations, and perhaps more important, the correlations changed only slightly when cognitive tempo (impulsivity) or verbal ability were partialled out. As the second experiment demonstrated, a different pattern of results was obtained when metamemory was assessed before the training sessions. Metamemory did not correlate with strategy use at transfer in the first generalization task, but was significantly related to transfer after the second training period had been completed. Again, the correlation remained significant when cognitive tempo was partialled out. Thus, both experiments showed that children who successfully maintained and generalized experimenter-induced strategies also had higher levels of metamemory. Moreover, although metamemory was significantly correlated with cognitive style, it proved to be a better predictor of memory behavior than impulsivity-reflectivity. These results demonstrate the importance of metamemory as a mediator or causal link in the process of strategy maintenance and generalization.

Further support for this assumption comes from a study by Paris, Newman, and McVey (1982). The authors tried to show that strategy train-

ing is a necessary but not a sufficient precondition of efficient learning. Given that a strategy is a constructed means-goals relationship (cf. Cox & Paris, 1979; Paris, 1978), metamemory in the sense of awareness about the utility and functional value of mnemonic actions should be closely related to actual memory performance. Consequently, in the study by Paris et al. (1982) first and second grade children were assigned either to a traditional (non elaborated) or to an elaborated training group, which in addition to the demonstration of chosen strategy also received a short explanation of the reasons why and how the given strategy could help to remember picture stimuli in a sort-recall task. Multiple assessments of metamemory included the traditional interview questions and the strategy-rating task used by Cox and Paris (1979), which required the subjects to estimate the general utility of 10 different mnemonic activities (e.g., rehearsal, self-testing, taxonomic grouping). The children had to perform two study-recall trials on each day, but training was restricted to the third of five sessions, and the two subsequent sessions were considered tests of strategy learning and maintenance. The authors demonstrated that this brief intervention was sufficient for the elaborated training group to show an increase in metamnemonic awareness from the second to the two last sessions, while metamemory in the nonelaborated group did not change. Furthermore, especially children in the elaborated condition chose sorting as an effective study behavior after training, and as a consequence, they also significantly improved their recall, compared with the nonelaborated group. Even more important, a causal model was constructed to test the assumption that training condition influences metamemory, which in turn predicts memory behavior and memory performance. A main result was that elaborated training had multiple direct and indirect effects on metamemory, memory behavior, and performance. As predicted, children's understanding of the value of the strategy (i.e., metamemory) proved to be a mediator coordinating means and goals, thus leading to a more frequent use of effective mnemonic actions in this type of memory task.

Additional support for the assumption that children's belief strongly influences strategy learning comes from the aforementioned study by Best (1981). When the performances of children induced to use clustering strategies were compared with those explicitly trained to organize, it turned out that although the training group recalled more items than the induction group on immediate recall tests, their performance level was not maintained as well as that of the induction group. Even more interesting, the induction group showed a higher level of metamemory, compared with the training group. According to Best, this finding seems to reflect the fact that children in the induction group had to develop their own strategies to facilitate remembering and consequently were more aware of the importance of strategy use for memory performance.

To summarize, most of the training studies described in this section confirmed the assumption that the level of metamemory predicts strategy use and memory performance in maintenance and generalization tasks when organizational strategies are under investigation. The relationship between metamemory, memory behavior, and memory performance turned out to be much stronger in the transfer paradigm than in the free-recall paradigm discussed earlier. Consequently, this pattern of results confirms the view of Borkowski, Reid, and Kurtz (1984) that the transfer paradigm provides a more favorable context for the appearance of the metamemory–memory behavior relationship because it requires a decision about whether to use or to abandon a previously learned strategy. Interesting enough, the results obtained by John Borkowski and his colleagues have also shown that metamemory proves to be a better predictor of memory behavior than related concepts like IQ and cognitive style. Furthermore, the findings reported by Borkowski et al. (1984) appear to confirm the “bidirectional hypothesis” with regard to the link between metamemory and memory behavior discussed by Brown (1978) and Flavell (1978). That is, it has been repeatedly shown that the availability of an appropriate strategy *combined with an understanding of its value* leads to successful strategy transfer, which in turn adds to metacognitive knowledge. But it should be mentioned that the demonstration of a close metamemory–memory behavior relationship has been restricted to “near” generalization tasks (see Borkowski & Cavanaugh, 1979) that are very similar to the training situation. The only “far” generalization task—that is, the serial probe recall task used by Kramer and Engle (1981), which differed in such aspects as structure and content, failed to document strategy transfer. Although this task appears to be inappropriate for the aforementioned reasons, the question of whether metamemory is also closely related to strategy transfer in “far” generalization tasks still remain open.

As Pressley, Borkowski, and O’Sullivan (Chapter 4, this volume) have pointed out, most of the training studies discussed so far did not include a self-testing component. According to their findings, the training of procedural knowledge for acquiring specific strategy knowledge—referred to as Metamemory Acquisition Procedures (MAPs) by Pressley et al.—seems to be extremely effective in facilitating transfer. MAPs include memory monitoring processes such as comparing performance after using different strategies (to detect relative strategy efficacy) or self-testing (to evaluate the usefulness of a new strategy). First empirical results given by Pressley et al. (Chapter 4, this volume) demonstrate that children as young as 7 to 8 years of age can possess memory knowledge about relative strategy efficacy *and* use this information to direct subsequent cognitive activity. Teaching MAPs obviously enhances both strategy awareness and strategy usage and may facilitate transfer in “far” generalization tasks.

Meta-analysis of the Correlational Findings

As already mentioned, a statistical procedure for summarizing research findings (i.e., meta-analysis) was additionally chosen to supplement and provide a quality control of the conclusions drawn in the traditional review of research. With regard to the preceding correlation studies, such an approach intuitively makes sense when the relationship between sample size and statistical significance of results is taken into account. For example, consider the case that due to the complex experimental design of many of the preceding studies, a correlation of about .35 between metamemory and memory behavior may fail to reach statistical significance because of small sample size. Undoubtedly, this nonsignificant finding will be taken as negative evidence for the assumed relationship. But on the other hand, when the same correlation coefficient is obtained after ten or more similar studies have been statistically integrated, the conclusion that there is no significant relationship between the two variables in question is no longer justified. As this result is now based on a rather large sample size, it has to be assumed that not only a statistically significant but also a practically relevant relationship was found.

Given the obvious advantage of this procedure of recording the findings of studies in quantitative terms, one is nevertheless confronted with several problems when attempting to extract from each study the statistics needed for combining the results (see Cooper, 1979). The main problem of the present meta-analysis was the fact that several studies had to be omitted from analysis because they did not report any statistics convertible into correlation coefficients. Many other experimental reports contained summary measures like t or F statistics, chi-square, and nonparametric statistics. But here, the guidelines given by Glass (1978) and Glass et al. (1981) proved very helpful in converting these statistics into Pearson correlation coefficients (the guidelines for converting various summary statistics into product-moment correlations used in the present meta-analysis are listed in the appendix).

A second problem faced in the meta-analysis is related to the fact that its basic unit, namely the *study*, is a vaguely specified concept. As Glass (1978) stated, it may represent "anything from an afternoon dalliance with a dozen subjects to an enormous field trial lasting months" (p. 355). As a consequence, the difficulty encountered when statistics from the various metamemory studies were collected was that some articles reported coefficients for several dependent variables (i.e., memory tasks), whereas others concentrated only on a single measure. Moreover, several studies reported results from a series of independent experiments. Although in that case,

alternative courses of action are open to the reviewer, the units of analysis chosen here were correlations between metamemory and memory behavior obtained in independent experiments.

With regard to the statistical combination (aggregation) of the correlation coefficients, analysis was carried out in the metric of $r(xy)$, that is, in terms of the familiar product-moment correlation scale. Although it is frequently recommended that the correlations should be squared, averaged, and the square root taken rather than averaged directly, Glass et al. (1981) demonstrated that this choice seldom makes a practical difference.

All in all, 47 correlations were collected or reconstructed by using the preceding strategy. Nearly 50% of the studies reported statistics that had to be converted into correlation coefficients (an overview of all studies included in the meta-analysis is presented in the appendix).¹ Taken together, the correlations between metamemory and memory behavior averaged .41 with a standard deviation of about .18. Thus, the average quantitative relationship was considerably above what was generally assumed to be the strength of association of these two variables. When the correlations were classified by the type of study-memory task and age group (see Table 1), it was shown that the pattern of correlations by and large corroborates the conclusions drawn in the narrative review. Although developmental trends were found for the correlations between metamemory and memory monitoring, the strength of association was remarkable even for preschoolers and kindergarteners. On the other hand, the connection was only modest for younger children when knowledge about organizational strategies in sort-recall tasks was considered. Furthermore, as concluded from the literary review, the association was much stronger for training studies dealing with organizational strategies. Unfortunately, only few age-specific correlations were available here because most researchers in this field collapsed their data across the different age groups to assess the relationship between the two variables. When the correlation between metamemory and strategy use was compared with that between metamemory and memory performance in the studies concerned with organizational strategies, it turned out that the strength of association was higher for the former in both sort-recall studies (.27 vs. .23) and training studies (.42 vs. .33).

In sum, the meta-analytical findings confirmed the assumption that different patterns of correlations can be found for different classes of memory tasks and strategies, and that developmental trends are demon-

¹The number of age-specific correlations does not equal the number reported for the average correlation both because of this fact and because the age-specific correlations were averaged within each study before the results of the experiments were statistically combined.

Table 1

Correlations between Metamemory and Memory Behavior-Performance Classified by Type of Study and Grade Level^a

Group	Grade					Average
	P/K ^b	1/2	3/4	5/6	7+	
Memory monitoring (rote memory tasks)	.39 (4)	.48 (6)	.52 (6)	.55 (5)	.59 (2)	.45 (11)
Memory monitoring (prose materials)	—	—	—	.55 (3)	.54 (2)	.57 (3)
Organizational strategies (clustering)	—	.21 (1)	.21 (2)	.46 (3)	—	.25 (13)
Organizational strategies (paired-associate)	—	—	—	—	.52 (2)	.64 (3)
Training studies (organizational strategies)	—	.43 (7)	.28 (7)	—	—	.38 (16)

^aNumbers in parentheses indicate the number of correlation coefficients available for the analysis.

^bP, preschool; K, kindergarten.

Given that a strategy is a constructed means-goals relationship (cf. Cox 1984) it is not surprising that the correlation between metamemory and memory behavior-performance is high within each paradigm. On the other hand, most of the numerical values obtained for the different relationships were surprisingly high. A mean correlation of .41 between metamemory and memory behavior-performance based on the data of several hundred subjects clearly contradicts the conclusion conveyed in most reviews of the field that only a weak link between the two variables has been found. Rather, the quantitative integration of the empirical findings does indicate that metamemory is substantially related to memory behavior and performance. Thus, meta-analysis of metamemory studies led to a conclusion similar to that drawn by Gage (1978) when discussing meta-analysis of empirical research on teaching: "Considered as clusters, the studies acquire sufficient power to dispel the false impression created when the statistical significance of weak single studies is taken seriously" (p. 30).

Summary and Conclusion

The detailed survey of the empirical evidence for the metamemory-memory behavior relationship presented in this article was stimulated by the apparently discrepant conclusions of the review articles by Cavanaugh

and Perlmutter (1982) and Wellman (1983). Thus, it is reasonable to ask which of the two views of the relationship proved to be more adequate. The answer is rather simple: the conclusions of both articles were correct with regard to the particular sample of metamemory studies on which they concentrated. That is, most studies assessing the link between metamemory and memory behavior in sort-recall tasks (reviewed by Cavanaugh & Perlmutter, 1982) revealed only weak to moderate relationships even in advanced elementary school children. On the contrary, the pattern of results was generally more positive when memory monitoring tasks were considered instead (as done by Wellman, 1983). Here, considerably more significant relationships between memory knowledge and memory performance were reported, and it was found that occasionally even preschoolers and kindergarteners were capable of efficiently relating metamemory to memory behavior. As a rule of thumb, positive relationships between these two variables were detected for younger children when the memory task required recall or recognition of either single items or small items sets. On the other hand, only weak relationships at best were found for younger subjects when (1) the task was to recall supraspan item lists and (2) a combination of complex strategies was necessary to cope with the task demands.

Neither of these reviews included the results of studies analyzing the metamemory-memory behavior relationship for organizational strategies in paired-associate learning tasks or for several types of intervention programs (i.e., studies investigating the maintenance and generalization of instructed strategies), all of which contributed substantially to the overall positive pattern of results. Taken together, the empirical findings support Wellman's assertion that gloom about weak relationships between metamemory and memory behavior is unwarranted. As the metanalysis of empirical results demonstrates, there is a significant and substantial relationship. Moreover, metamemory predicts memory behavior better than such related concepts as intelligence and cognitive style (cf. Borkowski et al., 1983).

This overall result is all the more impressive in view of the fact that a variety of both methodological and theoretical problems were detected in most studies. The most obvious shortcomings concerned the assessment of metamemory and the lack of explicit theoretical models dealing with the metamemory-memory behavior relationship. As the solution of both types of problems appears to be essential for future progress in metamemory research, particularly for the evaluation of the metamemory-memory behavior relationship, this point should be discussed in more detail.

First of all, as for the methodological problem the most important

point concerns the question *how* (i.e., what measures should be used) and *when* (i.e., before, during, or after memory activity) metamemory should be assessed. As already mentioned, in the studies discussed so far the type of metamemory assessment varied systematically with the category of metamemory under investigation. That is, memory monitoring studies mainly used verbal or nonverbal measures concurrent with a memory activity, whereas investigations into the use of organizational strategies relied on verbal measures (i.e., interview questions) given either before or after memory performance. At first glance, the general empirical finding that the concurrent, mainly nonverbal and high-inference metamemory measures proved to be better predictors of memory behavior than the low-inference, independent verbal reports may seem surprising. Nevertheless, it corroborates the results of the thorough, theoretical analysis of the various metamemory measures done by Cavanaugh and Perlmutter (1982), which showed that "in general, concurrent measures are preferable to independent measures, and nonverbal ones (e.g., comparative judgments) are less problematic than those based on verbal reports" (p. 20). Thus, there is good reason to assume that the weak results found in metamemory studies dealing with organizational strategies are at least partly due to the particularly poor metamemory assessment method used in this paradigm. Indeed, as Kurtz et al. (1982) demonstrated, many of these studies did not adequately address the issue of reliability, by using only two or three interview questions (mostly from the Kreutzer et al. interview study). It was shown that an acceptable level of reliability could only be obtained when scores of the various subtests of the Kreutzer et al. interview were pooled to yield a composite score. But as for the aforementioned "how" question, it does not seem to be sufficient to increase only reliability of the interview measure. Because almost all measures of metamemory have their specific limitations and drawbacks (see, for a detailed discussion, Cavanaugh & Perlmutter, 1982; Meichenbaum, Burland, Gruson, & Cameron, in press), a multimethod assessment approach providing converging measures of metamemory is needed to minimize the conceptual and methodological shortcomings of the individual techniques.

With regard to the "when" question, it is very surprising that this problem has been neglected by most metamemory researchers. Even if the often-cited problem connected with the veridicality of postexperimental verbal reports is left out for the moment (see for a more detailed discussion Brown et al., 1983; Cavanaugh & Perlmutter, 1982; Ericsson & Simon, 1980), it may be argued that the retrospective assessment of metamemory leads to an overestimation of long-term, stable memory knowledge. Given the aforementioned bidirectionality hypothesis, experience with a memory task will lead to an increase in postperformance metamemory scores, but nothing is known about the durability of the effect.

That is, we do not know how much of the knowledge acquired in the actual memory situation will actually be transferred to long-term memory. In the case of preexperimental interviews, an underestimation of the "true" metamemory capacity seems to be more probable, especially for younger subjects. As mentioned earlier, making predictions in advance of an actual memory activity appears to be a very difficult task for young children. Yet, most of the subtests of the Kreutzer et al. (1975) interview require children to imagine possible scenarios and to consider how they might act in them (see Brown et al., 1983). This hypothesis of a metamemory overestimation in postexperimental interviews and a metamemory underestimation in preexperimental verbal reports has not yet been systematically tested. Nevertheless, the metanalytical data do show that the "when" question is of empirical importance: whereas the correlation between preexperimental metamemory and memory behavior averaged .25, the relationship was considerably higher (.54) for postexperimental metamemory interviews. Again, a multimethod assessment approach should help to solve or at least minimize this problem.

A second main problem concerns the lack of sophisticated theoretical models leading to an understanding of whether, when, and how metamemory and memory behavior might be related in different age groups and for different tasks. Many of the examples given by Flavell (1978) and Wellman (1983) to describe possible settings when metamemory and memory behavior might not be related do not refer to situations typically found in the empirical investigations into the phenomenon. That is, most of the empirical situations were designed to stimulate conscious, strategic memory activities, and there was also reason to assume that metamemory would influence memory behavior if the former occurred. Consequently, the assumption of a positive relationship between metamemory and memory behavior seems plausible for a wide range of memory-monitoring tasks as well as for memory tasks dealing with organizational strategies. On the other hand, it is not equally easy to maintain that the relationship between metamemory and memory performance (e.g., number of items recalled) should be similarly tight. Although efficient strategy use may improve memory performance in many situations, here the influence of other important variables like memory capacity or information-processing speed should be taken into account and controlled to provide an adequate test of the hypothesis.

With regard to developmental trends in the metamemory-memory behavior relationship, the influence of task characteristics also has to be considered. Negative findings have usually been attributed to production deficiencies of the younger subjects. When children's deficits were on the memory behavior side (as was the case in most studies dealing with rote memory tasks), it proved very helpful to assess the children's belief about

the task-specific means-goals relationship in order to explain the empirical findings (see Cox & Paris, 1979; Wellman, 1977). Interestingly, when the identical empirical fact (i.e., no metamemory-memory behavior relationship) was found in studies dealing with prose materials, this was mainly due to deficits on the metamemory side. That is, younger subjects were not aware of the most important text units but automatically reproduced these key categories during recall. These findings seem to indicate that task-oriented theoretical models are necessary to explain developmental trends in the metamemory-memory behavior relationship. On the other hand, it also may be interesting to see if the more general and sophisticated models of knowledge behavior relationships already developed in other areas (e.g., the attitude-behavior connection in social psychology) can be used to form testable hypotheses about the nature of metamemory-memory behavior relationships (see the suggestions by Cavanaugh & Perlmutter, 1982; Wellman, 1983).

A last crucial point is the fact that empirical evidence about the metamemory-memory behavior relationship is restricted to cross-sectional studies mostly using age groups as units of analysis. Given the large within-group variances reported in several studies (see Brown & Smiley, 1978; Pressley & Levin, 1977) and the assumption that understanding of intraindividual change is necessary to truly understand interindividual differences (see Baltes, Reese, & Nesselroade, 1977), longitudinal studies are also needed. So far, there appears to be only one study that systematically analyzes the metamemory-memory behavior relationship in a (long-term) longitudinal design, combining single-case studies with the traditional age-group assessments (Knopf, Körkel, Schneider, Vogel, Weinert, & Wetzell, 1981). But mainly due to both time-consuming assessment methods and large sample size, results are not yet available.

To conclude, a comprehensive analysis of the empirical evidence of the metamemory-memory behavior relationship yields a complex but generally more positive pattern than recently assumed in the literature. Nevertheless, a variety of methodological and conceptual problems restrict both reliability and validity of the findings. But because remedial procedures seem to be available, there is hope that the metamemory concept may prove even more efficient in predicting memory behavior and will find its place in theories of cognitive development and intelligence.

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Appendix

To make the meta-analytical procedure used in this study clearer and replicable, a listing of the statistical conversions applied to the data is given in Tables A1 and A2. It should be noted that Table A1 only contains the conversion rules

Table A1

Guidelines for Converting Various Summary Statistics into Product-Moment Correlations

Reported statistic	Transformation to r_{xy}
(1) Point-biserial correlation, r_{pb}	$r_{xy} = r_{pb} \sqrt{n_1 n_2} u/n$ (u = ordinate of unit normal distribution n = total sample size)
(2) $t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$	$r_{pb} = \sqrt{\frac{t^2}{t^2 + (n_1 + n_2 - 2)}}$ then convert r_{pb} to r_{xy} via (1)
(3) $F = MS_b/MS_w$ for $J = 2$ groups	$\sqrt{F} = t $ then proceed via (2) above
(4) $F = MS_b/MS_w$ for $J > 2$ groups	Collapse J groups to 2 then proceed via (3) above
(5) χ^2 only (i.e., no frequencies reported) for a contingency table	$r_{xy} \cong P = \left(\frac{\chi^2}{\chi^2 + n} \right)^{1/2}$
(6) 2×2 contingency table	Calculate tetrachoric r_{xy} from tables

Table A2

Correlations between Metamemory and Memory Behavior-Performance Classified by Study and Grade Level^a

Studies classified by type	Grade					
	P/K	1/2	3/4	5/6	7+	Average
Memory monitoring (rote memory)						
Bisanz et al. (1978)	—	.24	.23	.39	.55	.35
Brown & Lawton (1977)	—	—	—	—	—	.65
Kelly et al. (1976)	—	—	—	—	—	.12 (2)

(Continued)

Table A2 (Continued)

Studies classified by type	Grade					
	P/K	1/2	3/4	5/6	7+	Average
Levin et al. (1977)	—	.65	—	.69	.62	.65
Posnansky (1978)	.64	—	.51	—	—	.57
Rogoff et al. (1974)	—	—	—	—	—	.34
Wellman (1977)	.19	.35	.60	—	—	.36
Wippich (1981)	.45	—	—	—	—	.45
Worden & Sladewski-Awig (1982)	.29	.33	.32	.26	—	.30
Yussen & Berman (1981)	—	.64	.73	.70	—	.69 (2)
Memory monitoring (prose materials)						
Brown & Smiley (1978)	—	—	—	.33	.53	.43
Elliott (1980)	—	—	—	.76	.54	.71
Yussen et al. (1980)	—	—	—	.57	—	.57
Organizational strategies (clustering)						
Best & Ornstein (1979)	—	—	.21	.36	—	.26
Cavanaugh & Borkowski (1980)	—	—	—	—	—	.12 (6)
Justice (1979)	—	—	—	—	—	.32
Salatas & Flavell (1976)	—	.21	—	—	—	.21
Wimmer & Tornquist (1980)	—	—	—	—	—	.44
Bjorklund & Zeman (1982)	—	—	—	.65	—	.32 (3)
Organizational strategies (paired associate)						
Waters (1982)	—	—	—	—	.52	.52
Pressley & Levin (1977)	—	—	—	—	.52	.52
Moynahan (1978)	—	—	—	—	—	.88
Training studies (organizational strategies)						
Borkowski et al. (1983)	—	—	—	—	—	.53 (2)
Cavanaugh & Borkowski (1979)	—	—	.38	—	—	.38 (4)
Kendall et al. (1980)	—	.53	—	—	—	.53 (2)
Kurtz et al. (1982)	—	.37	—	—	—	.37 (4)
Paris et al. (1982)	—	.37	—	—	—	.37
Kramer & Engle (1981)	—	—	.19	—	—	.19 (3)

*Numbers in parentheses indicate the number of correlation coefficients available for analysis.

used in this study; a more comprehensive listing of possible guidelines can be found in Glass, McGaw, & Smith (1981, pp. 149 and 150).

Furthermore, a more detailed overview of the results of meta-analysis is given in Table A2, presenting the specific correlation coefficients obtained for each study included in the meta-analysis.

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