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Memory Development

Since the 1970s, a new interest in the development of memory has stimulated numerous research activities. These have led to a complex pattern of findings. Although the majority of studies address memory development in children, use of a life-span perspective has also attracted much attention. This entry will present the most important outcomes of research on memory processes, in both children and adults.

1. Sources of Memory Development in Children

According to most researchers, changes in basic capacities, memory strategies, metacognitive knowledge, and domain knowledge all contribute to children's memory development (Björklund 1990, Schneider and Pressley 1989, Siegler 1991). There is also broad agreement that some of these sources of development contribute more than others, and that some play an important role in certain periods of childhood but not in others.

1.1 The Role of Basic Capacities

One of the earliest views of memory development relied heavily on the concept of "capacity". In its simplified version, memory development was exclusively seen as a function of memory capacity: according to this model, what develops in memory is the hardware of the memory system conceptualized as absolute capacity, rather than its software, that is, specific processes or procedures to memorize materials. Of course, such a simplified view is incompatible with the memory data.

Dempster (1985) reviewed in detail potential sources of development for short-term capacity. Taken together, the data from numerous studies show that age-correlated performance increases in memory span should not be interpreted as enlargement of some biologically determined capacity, particularly when memory development during the preschool years and thereafter is considered. It is only during early infancy that the effects of structural changes and basic processes seem to be large and direct contributors to memory performance (Siegler 1991). Factors that may contribute to developmental increases in memory span from the preschool years onward include: (a) speed of information processing; (b) automatic item processing.

In sum, then, it appears that *intra-individual* changes in children's memory capacity contribute little to memory development. As was pointed out by Siegler (1991), these basic processes are present at a very early age and function well even in very young children. Although basic processes are essential for memory, they do not contribute much to improvements in memory with age.

1.2 Effects of Memory Strategies

"Memory strategies" have been defined as mental or behavioral activities that achieve cognitive purposes and are effort-consuming, potentially conscious and controllable (Flavell 1985).

Since the early 1970s numerous studies have investigated the role of strategies in memory development. Particularly in the 1970s individual differences in the use of memory strategies were conceived of as the major source of developmental differences in memory development (Weinert and Perlmutter 1988). The majority of studies on the development of strat-

egies investigated children's use of rehearsal, organization, and elaboration strategies in laboratory tasks. Typically, these strategies were not observed in children younger than 6 or 7. This absence of strategic behavior was attributed to a "production deficiency" (Flavell 1985). That is, young children do not engage in memory strategies because they simply do not know how and when to do so. However, more recent research has shown that the ages of strategy acquisition are relative, and variable between and within strategies. Even preschoolers and kindergarten children are able to use intentional strategies, both in ecologically valid settings such as hide-and-seek tasks, and in the traditional context of a laboratory task (see Schneider and Pressley 1989).

In general, the use of creative, natural-tasks settings in studies conducted mainly in the 1980s and early 1990s has clearly shown that young children's strategic competencies have been underestimated for a long time. Despite this recent change in perspective, there seems little doubt that the most dramatic developmental changes in children's strategy use can be observed during the elementary school years.

Taken together, the findings from studies demonstrate that strategy development in children is more continuous than was originally assumed. They also show that use of encoding and retrieval strategies must be considered in interaction. New methodologies (e.g., mathematical modeling) permit sophisticated analyses of encoding versus retrieval (for a review see Brainerd 1985). Even more importantly, there is now an increasing realization that the use of encoding and retrieval strategies largely depends on children's strategic as well as nonstrategic knowledge. There is impressive evidence that individual differences in metacognitive and domain-specific knowledge may have a strong impact on how well strategies are executed, and on how much children recall in a memory task. Given these findings, the earlier belief that individual differences in memory strategies represent the most important source of memory development no longer seems tenable. There is now broad consensus that the narrow focus on developmental changes in strategy use should be replaced by an approach that takes into account the effects of various forms of knowledge on strategy execution.

1.3 The Role of Metacognitive Knowledge

One knowledge component that has been systematically explored since the early 1970s concerns children's knowledge about memory. Flavell and Wellman (1977) coined the term "metamemory" to refer to a person's potentially verbalizable knowledge about memory storage and retrieval, and developed a taxonomy that parsed metamemory into two main categories, "sensitivity" and "variables." The sensitivity category included knowledge of when memory activity is necessary (i.e., memory monitoring). The variables category included a person's mnemonic self-concept, characteristics of a task relevant to memory, and knowledge about potentially applicable memory strategies (see Schneider and Pressley 1989 for an overview of conceptualizations of metacognitive knowledge).

Empirical research exploring the development of different aspects of metacognitive knowledge revealed that children's knowledge of facts about memory increases considerably over the primary-grade years, but is incomplete by the end of childhood. Most studies showed impressive increases in knowledge about strategies with increasing age, a finding that was paralleled by the development of strategic skills. Thus an important aim of most empirical studies was to demonstrate that there are close relationships between metamemory and memory behavior.

Evaluating the outcomes of research dealing with metamemory–memory behavior relationships is a complicated task. Whereas the first generation of studies found only weak relationships between knowledge about strategies and strategy use, a second generation of studies indicated a more positive pattern of results. In a meta-analysis of studies containing metamemory–memory relationship data, Schneider and Pressley (1989) reported an overall correlation of 0.41 based on a large set of studies. Accordingly, a significant statistical association between metamemory and memory was found, particularly when the relationship between knowledge about strategies and the use of memory strategies was concerned. What children know about their memory obviously influences how they attempt to remember. Given the diversity of findings, however, much more needs to be known about the interplay between metacognitive knowledge and strategic behavior in various memory situations.

1.4 The Impact of Domain Knowledge

Since the late 1970s, there has been increasing evidence for the striking effects of domain knowledge on performance in many memory tasks. In numerous studies, it has been shown that domain knowledge influences how much as well as what children recall (Chi and Ceci 1987). Research on the interaction of domain knowledge and specific memory strategies indicates that there are at least three ways in which the knowledge base relates to strategy use (Pressley et al. 1987): knowledge can (a) facilitate the use of particular strategies, (b) generalize strategy use to related domains, or (c) even diminish the need for strategy activation.

1.4.1 Knowledge and the use of particular strategies. The assumption that rich knowledge enables competent strategy use has been confirmed in numerous studies. Most of these studies focused on the effects of conceptual or semantic knowledge

on the use of organizational strategies in sort–recall tasks. Experimental manipulations concerned children's knowledge of categorical relationships among items in terms of "category typicality" or "interitem associativity." Taken together, this research clearly showed that differences in the meaningfulness of words considerably influences strategic processing, particularly in young school children. Strategic effects of the knowledge base are not restricted to categorization tasks but have been observed in other memory paradigms as well (Pressley et al. 1987).

1.4.2 Knowledge strategy use and related domain. Several researchers (e.g., Best and Ornstein 1986, Björklund 1987) have proposed that semantic organization initially seen in the recall of young school children is mediated not by a deliberately imposed strategy but by the relatively automatic activation of well-established semantic memory relations. As they automatically process highly related items in a categorical fashion, children may notice categorical relations in their recall. They may then realize that categorization is a good learning strategy.

1.4.3 Nonstrategic effects of the knowledge base. Evidence that rich domain knowledge can diminish the need for strategy activation has been convincingly demonstrated in developmental studies using the expert–novice paradigm. Studies comparing experts and novices in a given domain (e.g., chess or soccer) on a memory task related to that domain provided evidence that rich domain knowledge enables a child expert to perform much like an adult expert and better than an adult novice—thus showing a reversal of usual developmental trends. Moreover, these studies also confirmed the assumption that rich domain knowledge can compensate for low overall aptitude on domain-related cognitive tasks, as no differences were found between high- and low- aptitude experts on the various recall and comprehension measures.

Taken together, these findings indicate that domain knowledge increases greatly with age, and is clearly related to how well children remember. Domain knowledge also contributes to the development of other competencies that have been proposed as sources of memory development, namely basic capacities, memory strategies, and metacognitive knowledge. Accordingly, it seems evident that changes in domain knowledge play a large role in memory development.

2. Memory Development in Adults and the Elderly

Assessments of memory development between late adolescence and late adulthood have not revealed any substantial changes in memory performance as a function of capacity, strategies, or knowledge. Obviously, interindividual performance differences remain stable, and intra-individual changes over time seem negligible during this time period. On the other hand, numerous studies have identified declines in memory performance in the elderly. Attempts to locate the sources of memory losses in old age have relied on the four components already outlined above.

2.1 The Influence of Basic Capacities

Study of memory in the elderly is made difficult by the problem of recruiting representative subjects. This makes it difficult to judge the importance of cognitive capacity as an explanatory factor. However, even studies that used healthy and intelligent old people as subjects found that information-processing speed was generally reduced in the elderly (see reviews by Knopf 1987, Light 1991). Training studies focusing on "developmental reserve capacity" (e.g., Baltes and Kliegl 1992, Kliegl et al. 1989) revealed that although elderly persons could considerably increase their memory performance as a function of cognitive training, none of the older adults reached a level of performance approaching the average of (trained) young adults. There is reason to assume that the negative age difference found in these studies is due to neurobiological constraints leading to a reduction of mental capacity.

2.2 The Impact of Memory Strategies

According to the often invoked "disuse hypothesis," older people should use memory strategies less frequently than young adults because they are no longer capable of complex memory tasks. By and large, however, there is little evidence to support this assumption. For example, Knopf (1987) did not find any differences between young adults and the elderly in the use of grouping strategies. Regardless of age, most subjects were able to use organizational strategies facilitating the recall of long wordlists. On the other hand, effects of strategy use on memory performance seemed to decrease with increasing age. Whereas these and many other findings provide strong evidence against the "disuse hypothesis," they are in accord with the assumption that memory loss in old age is related to decreases in mental capacity and information-processing speed.

2.3 The Role of Knowledge Components

The results of most studies assessing age differences in metacognitive and domain-specific knowledge do not indicate any decline in these knowledge components as a function of age. Although metacognitive knowledge seems to remain stable in old age, its relation to memory performance decreases with increasing age (see Knopf 1987). Regarding the impact of domain-specific knowledge, several findings support a "compensation hypothesis" in that older subjects can use their particularly rich knowl-

edge in many domains to compensate for deficiencies resulting from slower information-processing (Salthouse 1991).

3. Conclusion

Generalizations in the field of memory research are difficult given the great variability of memory phenomena, attributes, modalities, and contents. Given the evidence of several studies, however, it appears that the knowledge base and metacognitive knowledge are major sources of interindividual differences in memory performance, regardless of chronological age. Remarkable intra-individual changes in memory development are apparent during the elementary school years and in old age. Young children's memory gains can be attributed to the joint development of strategies and knowledge. Decreases in memory functions observable in very old adults point to neurobiological constraints that could be due to both a genetically determined program of biological aging as well as to a neurophysiological substrate resulting from a lifetime of experience and cognitive activity (Baltes and Kliegl 1992).

See also: Cognition and Learning; Cognitive Development: Overview

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Memory, Teaching and Testing for

Students are required to remember great amounts of material in school. Sometimes the demand is explicit, resulting in students intentionally attempting to memorize material; at other times memory is incidental, as when students remember information in text that was read for some other purpose or recall information related to a science or mathematics problem that was solved as part of school work. In general, two factors are cited most frequently as affecting memory of new material: whether the new information is consistent with or can be related to prior knowledge, and how the new information is processed (e.g., whether and which cognitive strategies are applied to the material). Information that is consistent with or can be related to prior knowledge is more easily remembered than information that is not consistent with or relatable to prior knowledge. With respect to information processing, both encoding processes (i.e., activities during study) and retrieval processes (i.e., activities during testing) are known to be critical determinants of how information is organized in long-term memory and how much of it is remembered.

In short, "what the head knows . . . [and does] has an enormous effect on what the head learns and