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CONTENTS

Section 6. PIAGET AND DEVELOPMENT

Section 7. COGNITIVE PSYCHOLOGICAL ANALYSES

Section 8. INTELLIGENCE AND COGNITIVE PROCESSES

Section 9. READING PROCESSES

KNOWLEDGE DEVELOPMENT AND MEMORY PERFORMANCE

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Abstract

It is commonly accepted that memory development is accompanied by the acquisition of strategies such as rehearsal. This paper argues for focusing on children's content knowledge base as a locus of development of strategic knowledge. The paper cites some direct and indirect evidence in favor of the view that cognitive development is largely the increment of content knowledge, both declarative and procedural, and further suggests that strategies might be generalized forms of specific content-related procedural knowledge.

To understand learning, one must make a detailed examination of the structure and development of children's knowledge bases. The intention of this paper is to propose that the structure and growth of a child's knowledge base are important components in the study of learning. The paper begins with a definition of the knowledge base, followed by theoretical and empirical rationale for focusing on the knowledge base, and closes with an illustration of the interaction of the use of processing strategies with the structure, content, and representation of a child's knowledge in memory tasks.

Knowledge Base

It is trivial to assert that a child's knowledge base grows with age. To be more specific, it is this growth that accounts for learning and improved memory performance. But it is not trivial to describe the structure of a child's knowledge base at each stage of development, or to explain how this structure accounts for learning and memory performance. The latter is the goal of this research.

For pragmatic reasons, a distinction will be made between three types of knowledge: procedural, declarative, and strategic. Procedural knowledge can be characterized as knowledge of rules; knowing how to multiply two digit numbers, for example. Declarative knowledge may be viewed as lexical knowledge or the knowledge of facts. For example, factual knowledge about animals can be thought of as declarative knowledge. The game of chess provides an excellent illustration of the dfiferences between procedural and declarative knowledge. Knowledge about the chess pieces, games and players corresponds to declarative knowledge, while knowledge about which move to make corresponds to procedural knowledge. Both procedural and declarative knowledge are domain-specific. In this paper, they will be referred to as content knowledge.

In contrast, strategic knowledge may be viewed as knowledge of heuristic rules that are presumably applicable across several domains. For example, the process of rehearsal may be seen as a heuristic rule, and it can be used with digits, letters, or words, etc.

Although the distinction among procedural, declarative, and strategic knowledge may be artificial in the sense that a single formalism such as a production system may be able to capture all three types of knowledge, it provides a useful framework for the discussion of developmental research at the present time.

Developmental researchers in the past have centered their attention primarily on the acquisition, production, and mediation of strategies as a major component of cognitive development, because the evidence has consistently shown that the use of strategies increases with age, and that the increasing use of these strategies is accompanied by an improvement in memory performance. Developmentalists now are faced with the problem of accounting for the acquisition of these strategies. It is proposed here that the increasing use of strategies may be the result of a complex set of processes involving the acquisition and perfection of the strategies themselves, coupled with the development of content knowledge to which these strategies are to be applied. Hence, one initial research goal is to explore the extent to which the richness, structure, and representation of content knowledge affect and influence the use of processing strategies. Before doing so, both the theoretical and empirical rationale for focusing on content knowledge are discussed.

Theoretical Rationale for the Study of Content Knowledge

The prevailing assumption of a major aspect of developmental research is that adults possess a small set of strategies. In memory tasks, for example, a set of strategies might include rehearsal, recoding, grouping, labeling, imaging, elaboration, and so on. Development is thus seen as the acquisition of a limited set of strategies that have been identified in the adult literature as essential to the successful performance of a task. In order to understand how these strategies are acquired with development, however, one may need to examine how the development of content knowledge can facilitate the acquisition of strategic knowledge.

There are basically two theoretical positions that can be taken. The weaker position is to accept the prevailing hypothesis, but with the stipulation that beyond strategic development, memory development is also accompanied by the development of the content knowledge. Hence, whenever the use of deliberate processing strategies cannot account for all the age differences in memory performance, any remaining variance can perhaps be explained by differences in content knowledge. A stronger position is to state that development is the growth of content knowledge, both procedural and declarative, and that strategies are initially domain-specific procedural knowledge that eventually become more generalizable. This view necessitates studying the representation and nature of the content knowledge that children possess, and how domain-specific procedural knowledge might evolve into general strategies.

To summarize, the weaker hypothesis states that development is mainly the acquisition of strategic knowledge, with incremental content knowledge contributing only to a small portion of performance improvement. The stronger hypothesis assumes that development is mainly the increment of more content knowledge, both declarative and procedural. The greater use of strategies with increasing age is a byproduct of greater content knowledge, in the sense that strategies are a generalized form of specific procedural knowledge.

Either hypothesis is consistent with the observation that there is a correlation between age, content knowledge in general, strategy usage, and performance, as shown in Matrix 1 of Figure 1. What Matrix 1 shows is that memory performance generally improves with age, and it also improves with strategy usage and greater general knowledge. Hence, it seems difficult to attribute all performance deficits to processing deficits when performance is also correlated with knowledge deficits. The goal is thus to assess the extent of the knowledge effects.

Empirical Support for the Study of Content Knowledge

Theoretical arguments have been made for the study of content knowledge. Is there any empirical evidence to further

Matrix 1

Age	Content Knowledge	Strategic Knowledge	Memory Performance
Children	Less	Less	Less
Adults	More	More	More

Matrix 2

Age	Content Knowledge	Strategic Knowledge	Memory Performance
Same	Same	Less	Less
Same	Same	More (Training)	More

Matrix 3

Age	Content Knowledge	Strategic Knowledge	Memory Performance
Children	More	Less	More
Adults	Less	More	Less

Matrix 4

Age	Content Knowledge	Strategic Knowledge	Memory Performance
Same Child	More	Same	More
Same Child	Less	Same	Less

Figure 1. The Relationship among age, knowledge, strategy usage, and performance outcome of designs used in developmental research.

suggest such an investigation? Although not explicitly designed to test this hypothesis, several studies have produced results which can be interpreted as support for the weaker hypothesis.

One domain of empirical support arises from training studies that attempt to improve children's memory performance. A limitation is often found in these training studies in their ability to elevate young children's performance to the level of adults or older children. For example, training a rehearsal strategy can generally elevate children's memory performance so that their recall is superior to those of other children of the same age who did not get such training (see Matrix 2, Figure 1). However, training the use of a strategy often cannot elevate recall to the level of older children (Belmont & Butterfield, 1971); some other factor, such as the knowledge base, may be limiting performance.

The limitation of strategy training shows up in another way. When children of all age groups are trained to use a strategy such as grouping, the recall level of all age groups improves, which means that the initial age differences still remain, and must be explained by some other factor (Hutterlocher & Burke, 1976). The same observation also holds for individual differences within an age group. That is, if all the individuals are provided with the same training, whether they need it or not, the initial individual differences will remain after training (Lyon, 1978).

A third limitation of training studies is that they often fail to generalize (Brown, 1974). That is, if children are trained to use rehearsal processes with digits, they may not necessarily be able to generalize the application of such a strategy to words. The failure of generalization can be interpreted in at least three ways: (a) the definition of a strategy as being general is faulty (i.e., strategy usage is necessarily tied to content domain, which supports the stronger hypothesis); (b) training was ineffective in some way, or (c) the role of a strategy in affecting performance is not as powerful as one might think. However interpreted, lack of generalization suggests that an examination of content knowledge is crucial.

Finally, if adults are inhibited from using strategies that have been identified a priori as critical to the performance of a given task, the level of performance of the adults does not drop to the level of the child (Chi, 1977). This again suggests that strategy usage is not entirely responsible for the observed age differences in recall.

Although training studies as a set are difficult to interpret when they fail, the studies cited above collectively point to the possibility that the weaker hypothesis is supported. That is, it appears that beyond deliberate strategy usage, a portion of age differences in memory performance can be attributed to some other factor, such as knowledge differences.

In order to seek evidence in support of the stronger hypothesis, a situation analogous to Matrix 3 of Figure 1 can be created, where the correlation between age and knowledge is disrupted by manipulating knowledge independently of age. In a study using this design (Chi, 1978), adults with limited knowledge of chess were unable to memorize as many chess pieces as 10-year-old children who had some knowledge of chess. The adults also took longer (required a greater number of trials) to memorize the entire chessboard positions than children. For this same group of subjects, children could memorize fewer digits on a given trial, and required a greater number of trials to learn 10 digits than adults. For the first time, it has been shown that age need not correlate with memory performance when it does not correlate with knowledge. For the same group of subjects, the strategic knowledge necessary to perform in a memory task presumably did not change when the stimulus material was changed from digits to chess. What did change was the amount of content knowledge. The reversal in the outcome of the performance measures (comparing Matrix 1 and 3) suggests that children who possess more knowledge in a content domain can overcome whatever limitation is imposed by more limited strategic knowledge.

Although it is not clear from the chess study whether children's superior performance arises from more developed declarative or procedural chess knowledge, either assumption is consistent with the stronger hypothesis, if we want to maintain a distinction between procedural and strategic knowledge. That is, if we assume that better memory performance on chess arises from greater chess-related procedural knowledge, then it suggests that domain-specific procedural knowledge may serve the function that strategies serve in mediating performance. Hence, it may only be fruitful to study domain-specific procedural knowledge.

Another source of data which also supports the stronger hypothesis comes from Myers and Perlmutter's (1978) research on 2- to 5-year-olds. They found that memory performance in that age range improved, but they observed no evidence of an increase in the application of processing strategies. These results tend to put more emphasis on general knowledge growth as a major focus for development in that age range, although other less straightforward interpretations are possible.

A final piece of evidence in support of the stronger hypothesis comes from a study in which a situation analogous to Matrix 4 (Figure 1) is created. The approach here was to study intensively an individual child so that age and general strategic knowledge are constant, but to vary how much the child knows about a particular domain of knowledge (Chi, 1979). The subject in this case study was a four-year-old child who is an expert on the topic of dinosaurs. It was possible to partition the child's repertoire of 40 dinosaurs into two sets: One with which he was very familiar and another with which he was less familiar. Using a link-node semantic network structure, the representation of the greater-knowledge set of 20 dinosaurs was shown to be much denser and more complexly organized than the representation of the lesser-knowledge set of 20 dinosaurs. In comparing memory performance on the two sets of dinosaurs, it was not surprising to find that the child's recall, retention, and clustering performance was superior in the more knowledgable set. Hence, the design of this study is essentially the counterpart of a training study. In the one case (Matrix 4), content knowledge was manipulated, and in the other case (Matrix 2), strategic knowledge was manipulated. Both types of manipulations produced superior memory performance under conditions where there was more knowledge, suggesting that both types of knowledge--strategic and content--have powerful influences on memory performance.

Interaction of Content Knowledge and Processing Strategies

Up to this point, the research goal has been to seek evidence of the importance of content knowledge on memory development. Since both content and strategic knowledge have been shown to be important, one needs to examine the interaction of the two.

A study is currently in progress where we describe a five-year-old girl's representation of her 22 classmates. We found that her basic representation was organized according to the seating arrangement of her class, taking the form of a spatial hierarchical structure, in which the 22 children were divided into four sections, with five to six children attached to each section. Associated with each child is additional information, such as the sex, race, and grade levels of the child. In other words, the 22 classmates were not organized hierarchically according to dimensions such as the sex of the child. We know this because when we asked her to recall all the boys' names (or girls' names), she did so by using the spatial seating arrangement.

When we obtained a "stable" representation, (stable means that the same representation was manifested using multiple procedures), we explored how well she could use a retrieval strategy, in this case, recalling the names in alphabetical order. The child easily learned to apply such a strategy when the knowledge was very stable and overlearned, even though the strategy was fairly new to her repertoire. However, she had difficulty applying the same strategy to a learned set of names of people she did not know.[7] Hence, it appears that when and how well a strategy can be used depends a great deal on the structure of the content