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The Challenges of Teaching Good Information Processing to Learning Disabled Students

A MODEL of good information processing is sketched, describing how metacognitive knowledge influences strategy selection and use. Three factors pose particular problems for learning disabled students as they attempt to acquire metacognitive knowledge and to use study strategies productively: neurological impairments; deficiencies in general world knowledge; and negative beliefs, attitudes, and styles that limit self-efficacy. Creating an educational atmosphere that explicitly builds conceptual (domain-specific) knowledge and teaches positive beliefs about learning potential is essential in promoting metacognitively-oriented instruction.

We have advanced a theory of strategy-based instruction based on a number of interactive components (cf., Borkowski, Carr, & Pressley, 1987; Pressley, Borkowski, & Schneider, 1987). The origin and rationale for our theory are based in part on the results of laboratory and classroom studies documenting that learning impaired children are more passive, lower in self-efficacy, and less strategic than their average achieving counterparts (Borkowski & Cavanaugh, 1979). Some of these deficiencies are due to home, school, and cultural-environmental factors: Parents are often inconsistent in teaching their children to be strategic, organized, and planful during critical stages of early development. Teachers focus on content rather than processes (Carr & Borkowski, in press). Society rewards success rather than effort, goal achievement rather than progress. Hence, it is not surprising that many students, both learning impaired and average-achieving, fail to demonstrate a broad repertoire of general and domain-specific learning strategies and study skills. In short, children often exist in environments that do little to encourage sophisticated cognition.

The components of our model of metacognitively-based information processing are summarized in Table 1. The model's dynamics and salient components can best be understood in terms of how children acquire and use *strategies*. Initially, a child is taught by a teacher or parent to use an elementary study strategy. With repetition and guided practice, including re-explanations tailored to specific difficulties encountered during early instruction (e.g., Duffy & Roehler, 1989), the child has opportunities to learn about a strategy's attributes and characteristics, such as when and where it can be used most profitably (i.e., *Specific Strategy Knowledge* begins to develop). Knowledge about the appropriate use of a strategy is essential for its maintenance and transfer. Its development is especially likely when there is frequent and explicit feedback about the performance changes that follow strategy use (Borkowski & Cavanaugh, 1979; Pressley, Ross, Levin, & Ghatala, 1984). If the child's home and school environments are stimulating and include extensive strategy instruction, the child will come to know a number of procedures for mediating the learning of important tasks as well as when to apply them.

Over time, the child will acquire a belief in the general utility of being strategic (i.e., *General Strategy Knowledge* accumulates), including an understanding that effort expended in identifying the best strategy to use in a situation and executing that strategy often pays off in improved performance. These beliefs develop as the child learns to attribute successful (and unsuccessful) learning outcomes to effort expended (or lack of effort) in strategy deployment rather than to ability or good fortune. Future strategy selection decision are determined by General Strategy Knowledge, combined with specific strategy knowledge that specifies which strategies are appropriate for various occasions. Once a selection occurs, General Strategy Knowledge, and the belief that execution-effort is worthwhile, can motivate the actual carrying out of the activated strategies. In short, General and Specific Strategy Knowledge account for much of the executive activity in the cognitive system.

Although these main components of the metacognitive model have been of use in understanding cognitive development and the dynamics of complex thinking, their translation to classroom learning contexts is just beginning to be understood. It has already become apparent, however, that some of the less central components of the good information processing model (see Table 1) are relevant to the development of learning skills that flow from explicit instruction. Unfortunately, when these components are considered, it becomes obvious that not all students can become efficient information processors. By devoting most of this article to components that may preclude the education of good information processing, our aim is to offer a balanced perspective on the potential for transforming poor information processors into good information processors. The challenges associated with educating learning disabled students in metacognitive and information processing skills will become clear as our discussion proceeds.

Table 1. Components of Good Information Processing†

Main Components††

Strategies

Cognitive operations over and above the processes that are a natural consequence of carrying out the task, ranging from a single operation to a sequence of interdependent operations. Strategies achieve cognitive purposes (e.g., comprehending, memorizing) and are potentially conscious and controllable activities. In this model, cognitive strategies are broadly conceiving, capturing most of the procedural knowledge a person possesses. This is knowledge of how to do things.

Examples: Intentionally creating mental images representing the contents of stories that are read.
Reorganizing to-be-learned materials into conceptually related groups.
Planning-translation-revision cyclical approach to writing.

Specific Strategy Knowledge

Metacognitive information specifying how, when, and where to carry out the strategies a person knows. Although not considered in this article, this information includes memory of where the strategy was acquired and who taught it, whether the strategy is fun to execute, and other pieces of information unique to a strategy. A good information processor possesses a unique set of metacognitive knowledge for each strategy they know. This information is used to guide application of the strategy (e.g., making possible recognition of appropriate situations for using the strategy).

General Strategy Knowledge

Metacognitive knowledge relevant to many strategies possessed by a learner. This knowledge motivates and directs the use of specific strategies.

Examples: Understanding that personal effort increases the likelihood of success.
Realizing that although effort per se is important, effort channeled through strategic activity is better than working hard.
Understanding that specific strategies are not tied to one task, but can be matched to new situations, with some modifications possible to accommodate these new tasks.
Recognition that strategies are most likely to be successful if their execution is shielded from competing behaviours, distractions, and emotions.

Additional Components

Neurological Integrity

Central nervous system components supporting short-term and long-term memory; perceptual systems.

Conceptual Knowledge

Important literary, scientific, historical, and cultural knowledge. Used in conjunction with strategies to process new information efficiently. Sometimes this knowledge makes the use of strategies unnecessary, such as when prior knowledge produces automatic associations in the knowledge base that are closely linked with the new content.

Table 1. Continued

Beliefs, Attitudes, and Styles

Habitual feelings about, and approaches to, cognitive tasks. Beliefs and attitudes influence motivation to use strategies and to make cognitive efforts in general. A person's habitual style can either support the use of strategies and cognitive processing or undermine it (e.g., habitual impulsivity precludes the use of strategies requiring "time to execute").

Examples: Beliefs and attitudes supportive of good information processing (low fear of failure).

An attitude supportive of good information processing: Self-efficacious (i.e., appropriately confident about ability to do tasks that are near to one's current level of competence).

Styles supportive of good information processing: Planful, reflective, low anxious, and deep information processing (looking for meaning).

†Additional components covered in detail in previous articles about the model (e.g., Pressley, Borkowski, & Schneider, 1987, in press).

††Main components in that they have been emphasized more than others in our previous descriptions of Good Information Processing.

Boundary Conditions on the Teaching of Good Information Processing

Although we often have reported success in training various aspects of good information processing, it has become apparent during the conduct of our research that instructional benefits do not always transpire. For instance, strategy instruction generally does not produce large performance gains, even when task analyses suggest it should. Three of the more important student characteristics that limit the effectiveness of strategy instruction are neurological integrity; conceptual knowledge; and cognitive beliefs, attitudes, and styles. These characteristics typically differentiate learning disabled students from their average- and high-achieving classmates.

Neurological integrity

Major psychological processes, such as learning, cognition, and perception, depend on neurological integrity. These processes are reflected in tasks that measure reaction speed, iconic memory, short-term memory, and word decoding efficiency (see Borkowski, 1985). Biologically-based processes enable the organism to sense, perceive, and apprehend reality. Many complex behaviours, including the execution of strategies, are not possible in the absence of neurological integrity. To illustrate, we draw on research using short-term memory and word decoding skills as indices of neurological functioning. These processes - which are difficult to modify - appear to predict a child's propensity to carry out study strategies.

Functional short-term memory capacity. Pressley, Cariglia-Bull, Deane and Schneider (1987) analyzed the relationship between children's use of an imagery strategy following instruction and their short-term memory capacity.

In this study, memory capacity was determined in large part by the structural and functional adequacy of the central nervous system. Children, ages 6 to 13 years, were presented 20 sentences to learn. The sentences depicted concrete events and hence were compatible with imaginal encoding (e.g., "The fat boy ran with the grey balloon"). Children in the imagery condition were told to make a picture in their head for each sentence, whereas control children were instructed to try hard to learn the material.

The most important finding was that children with greater short-term memory capacity (as assessed by an independent battery of tests) were more successful in the imagery condition than were children with less capacity. In fact, students with low short-term capacity did not benefit at all from strategy instruction. Regression analyses, as well as structural equation modeling, supported the contention that imagery generation was causally linked to short-term capacity.

Word identification, comprehension, and summarization. A large body of empirical evidence (see Perfetti & Lesgold, 1979), supported by the central processing theory of reading (LaBerge & Samuels, 1974), suggests that *word identification* is a prerequisite for good comprehension. Persistent failure at word identification leads to difficulties in many aspects of reading comprehension, especially strategic functioning. For instance, if a great deal of processing capacity must be devoted to word identification (as is the case for many learning disabled children), little processing capacity remains for the execution of comprehension strategies. Thus, the central focus of a study by Rebek (1987) was to determine whether the effectiveness of a particular form of reading strategy instruction, reciprocal teaching (Palincsar & Brown, 1984), would be limited by students' word identification competencies.

Learning impaired children, ranging in ages from 10 to 14 years and at least two years behind in reading level, served as subjects. Prior to training, word identification competencies were assessed. Next reading comprehension strategies were taught using traditional reciprocal teaching in one of two experimental conditions. In another condition, reciprocal teaching was combined with attribution retraining. Traditional reciprocal teaching consisted of teachers and students taking turns executing strategies (such as paraphrasing, predicting, and summarizing), with the instructions occurring in a dialogue context. Children presumably "discover" metacognitive information about the strategies, such as when and where to employ them, as the teacher cedes control of strategy implementation to the students. The attribution retraining supplement consisted of short lectures and dialogues about the importance of being consistent and trying hard to deploy comprehension strategies. An attributional control group received strategy and attribution training on two basic memory tasks not closely related to reading (paired associates and sort recall). Control students were tested on the same passages as the students in the two main experimental conditions.

Post-tests assessed reading comprehension at three levels: Metacognition was measured using the Paris and Jacobs (1984) scale of reading awareness; changes in attributional beliefs were evaluated; use of summarization strategies was assessed. One month following training, a final in-class generalization test was given during which students were asked to summarize and comprehend paragraphs. Grades for the semesters preceding and following training were also obtained.

Since few differences emerged in the analyses of the reciprocal teaching and reciprocal teaching plus attribution training condition, these data were collapsed over the two treatment conditions for all subsequent analyses. As predicted, the effectiveness of reciprocal teaching was influenced by the word identification ability of poor readers. Learning impaired students with average decoding abilities profited from reciprocal teaching. In contrast, students with poor decoding skills showed little or no comprehension gains. In short, a measure of word identification, determined in part by neurological functioning (e.g., Petrauskas & Rourke, 1979), predicted the potential success of strategy-based reciprocal teaching. These data suggest that neurological factors are important to consider in designing and executing strategy instructions in classroom contexts.

Summary. Although an important paper by Campione and Brown (1978) pointed to the complex interplay of the neurologically-based architecture of the cognitive system and the use of cognitive strategies, few psychologists or educators have taken this interaction into account in building their theories or carrying out their research programs. The reason the issue is important, especially in the area of learning disabilities, is threefold: (a) Many learning disabled children suffer from neurological impairments that are difficult to modify (e.g., Selz & Wilson, 1989); (b) theories about strategy acquisition and transfer in learning disabled students will likely remain incomplete if the concept of neurological integrity is ignored; (c) research programs may rush too quickly to the clarion call of cognitively-oriented training programs, without recognizing that many of these programs are most appropriate for students possessing more intact neurological integrity. An example of one such program may be reciprocal instruction of reading comprehension strategies.

Conceptual knowledge

The Good Information Processing model proposed by Pressley, Borkowski and Schneider (in press) assumes that mature thinkers possess more than procedural knowledge in the form of strategies (e.g., Anderson, 1983). They also have an enormous amount of declarative information in their long-term memories that represent factual knowledge about the world (Anderson, 1983), including concepts and knowledge about relationships between concepts. This declarative information can be used to mediate performance in various problem solving tasks.

Although knowledge can be defined very broadly, many conceptualizations assume that each item in semantic memory is represented by nodes that are connected to each other by means of links (Anderson, 1983). According to semantic network models, each node is not only connected with other items but has distinctive features associated with it. In development, the number of nodes increases as do the number and strength of connections among items. Also, the number of features associated with an item changes with increasing age (cf., Bjorklund, 1987; Bjorklund, Muir, & Schneider, in press; Schneider & Pressley, 1989).

In addition, many types of knowledge are organized as schema and scripts in which event-related knowledge is packaged, including procedural and declarative information relevant to particular situations (e.g., Mandler, 1984). A famous example is the restaurant script (Schank & Abelson, 1977). Even very young children know much about negotiating restaurants, or at least fast food establishments (e.g., Nelson, Fivush, Hudson, & Lucariello, 1983). We assume that the knowledge base of Good Information Processors is particularly well-structured and elaborated with many nodes and schemas interrelated in semantically sensible ways, thus enabling them to "chunk" information into large meaningful units. In contrast, children with learning impairments need special help in enlarging and enriching their conceptual knowledge of the world, since a history of learning deficiencies results in less knowledge than possessed by more intellectually adept peers. There are at least three ways that a well-developed knowledge base can support strategy use and performance on cognitive tasks (Pressley, Borkowski, & Schneider, 1987), with the importance of each of these mechanisms considered briefly in the remainder of this subsection.

Knowledge facilitates the use of specific strategies. During the 1970s, the development of learning strategies was hypothesized to be the basic source of individual and developmental differences in cognitive performance. The fact that the knowledge base can have a considerable impact on the efficiency of strategies was neglected (cf., Chi & Ceci, 1987). Today, most researchers agree that having detailed knowledge in a particular domain permits a person to process information more efficiently (cf., Bjorklund & Harnishfeger, 1989; Ornstein & Naus, 1985; Schneider & Pressley, 1989). The basic theoretical assumption is that fewer mental resources are required to perform a cognitive task when the person is highly familiar with the task's items. By expending less cognitive capacity to activate relevant task information, more cognitive resources can be allocated to the selection and execution of strategies as well as coordination of strategy use with other strategies.

Most of the developmental research on knowledge as an enabling condition for strategy use has been carried out in the area of memory. For example, Peter Ornstein and his associates (e.g., Ornstein, Baker-Ward, & Naus, 1988) have documented that some forms of strategy use depend largely on the state of the knowledge base. In one experiment 8-year-old children rehearsed to-be-learned word lists aloud. Although all of the words were known to the children, some participants were given items that elicited many associations with prior knowledge, whereas others studied words prompting fewer associations (Ornstein & Naus, 1985). Rehearsal characteristics differed as a function of word type. Children rehearsing low associates repeated fewer than two different items during each study opportunity, whereas those learning high associates included more than three items in each rehearsal set. Ornstein and Naus (1985) concluded that highly meaningful materials facilitate rehearsal and recall because of associations with prior relevant knowledge.

Studies contrasting experts and novices have provided additional demonstrations of the effects of knowledge on memory performance. For example, Chi (1978) recruited experienced and inexperienced chess players, assigning them the task of recalling various chess positions. The most interesting aspect of this research was that subjects' knowledge correlated negatively with age since children (10 years of age) were the chess experts and adults were chess novices. Although children performed worse on traditional memory span tests than adults, they reproduced the chess configurations more accurately. This study provided evidence supporting the idea that domain-specific knowledge enables a child expert to perform like an adult expert and better than an adult novice, thus showing a reversal of the usual developmental pattern.

Chi assumed that the superiority of child experts could be due to the use of "chunking" or grouping strategies. Indeed, a closer analysis revealed that children recalled more chunks and more pieces per chunk than the adults, at least during the first trials of the repeated recall tasks. Similar findings were reported by Gold, Gruber, Opwis and Schneider (1989) who replicated and extended the design used by Chi (1978) by adding child novice and adult expert groups to the sample. It appears, then, that a rich knowledge base facilitates the use of sophisticated chunking strategies, which in turn lead to superior recall.

Knowledge prompts strategy use. Studies of children's use of organizational strategies have contributed to our understanding of the relationship between the knowledge base and the initiation of strategy use. Although young elementary school children do not fully understand the advantages of organizational strategies, there is evidence that they organize highly related materials according to semantic categories (Bjorklund & Jacobs, 1985). This activity is not due to intentional strategies but rather because activation of one item elicits its associate in an automatic fashion (Frankel & Rollins, 1985; Lange, 1978; Rabinowitz, 1984; Schneider, 1986). As they automatically process highly related items in a categorical fashion, some children realize that categorization is a good learning technique, prompting them to continue using organizational strategies even when materials are not highly related. For example, Best and Ornstein (1986) asked third graders to learn a list of items with obvious categorical interrelationships. After learning this list of highly related materials, the transfer of categorization to materials not containing obvious semantic relationships was tested. Automatic categorization during the processing of the first list induced organizational strategy use with less strongly related materials. Thus, there was an intimate relationship between domain-specific knowledge and understanding when particular strategies can be useful (i.e., the acquisition of Specific Strategy Knowledge about when to use specific strategies was enhanced).

Bjorklund and Jacobs (1985) also presented data consistent with the interpretation that processing of highly related categorizable materials can lead to more systematic semantic processing of nonassociated categorizable materials. In their study, third, fifth, seventh, and ninth graders were presented a list of 20 categorizable items. Within categories, some of the items were highly related, whereas others were not associated with other category members. The items were presented either in a random order, in a blocked fashion with inter-item associations minimized, or in a blocked fashion emphasizing inter-item associations. When associative relations were designed to prompt use of organizational strategies, the recall of highly associated items should occur first, followed by recall of nonassociated category members. This pattern was obtained for the two older age groups. Third and fifth graders failed to use nonassociative categorical relations to mediate recall.

Both Best and Ornstein's (1986) and Bjorklund and Jacobs' (1985) data support the assumption that young children's categorization activities are often stimulus driven. When materials relate to the knowledge base, there is automatic (or semi-automatic) organization of to-be-learned items. There is also carryover of organizational tendencies to materials that are not so obviously consistent with prior knowledge.

Knowledge can minimize the need for strategy activation. Many instances of efficient learning occur without strategic assistance. The knowledge base can affect cognitive performance directly – that is, performance is mediated predominantly by the knowledge base rather than strategies. For instance, Siegler (1988, in press; Siegler & Shrager, 1984) studied children solving math problems by retrieving math facts from their knowledge base rather than relying on computational strategies. Strategies were used only if the child had not previously stored a relevant math fact in long-term memory or if the child wanted to make sure that the fact stored in long-term memory was correct.

Work by Paris and his colleagues (e.g., Paris, 1978; Paris & Lindauer, 1982) is also relevant here. They studied the role of constructive, inferential processes (i.e., processes driven by prior knowledge of relationships in the world) in remembering texts. There were clear developmental trends in inference skills, indicating that older children are more likely than younger children to use their world knowledge automatically to go beyond the facts presented in text. In a similar vein, Anderson and his associates (e.g., Anderson & Pearson, 1984) demonstrated that people often automatically interpret and comprehend texts they are reading in light of prior knowledge, often to the point that their later recall of contents is distorted by the knowledge they bring to the learning task.

Studies contrasting experts and novices provided even more impressive illustrations of direct knowledge effects on text recall and comprehension. For instance, Pearson, Hansen and Gordon (1979) recruited second graders who could be categorized as snake experts or novices. Questions about a short text on the subject of snakes dealt with both information explicitly presented in the text and facts that were only implied but could be inferred based on prior knowledge. Not surprisingly, the experts answered the questions much better than the novices. According to Pearson et al. (1979), the relatively greater superiority of experts on text-implicit questions was due to the operation of snake-content schema possessed by the experts but not the novices.

In a more recent study by Schneider, Körkel and Weinert (in press), third, fifth, and seventh grade children were presented a story about a soccer game, with the subjects classifiable as soccer experts and novices. The children could further be classified with respect to general ability, either as poor learners or good learners. The results were generally consistent across a variety of measures that tapped both exact memory of the text and memory for appropriate inferences. Regardless of age, experts outperformed novices. Third grade experts performed better than seventh grade novices, thus demonstrating a reversal of typical developmental trends. Even more striking, the expertise classification was much more predictive of performance than was the general ability classification. Low ability experts outperformed high ability novices on every memory and comprehension measure used in the study.

Summary. A child's knowledge base has a direct effect on cognitive performance. While we assume that good information processors use their extensive prior knowledge appropriately on many occasions, there is ample evidence that most people fail to make the most of their prior knowledge, failing to activate stored information that could mediate learning (Pressley, Symons, McDaniel, Snyder, & Turnure, 1988; Schmeck, 1988; Woloshyn, Willoughby, Wood, & Pressley, in press; Wood, Pressley, & Winne, in press). Strategies can come to the rescue in such cases, at least with average-ability learners. Such students can be taught methods to prompt activation and search of their knowledge bases (see Pressley, Symons et al., 1988; Woloshyn et al., in press; Wood et al., in press). More troubling, students who lack well developed knowledge bases, some of whom are learning disabled, are probably not going to benefit from the carryover effect discussed earlier in this section and will be unable to perform tasks that other children perform easily, simply by relating the current situation to prior knowledge. Most troubling, these same children may find difficulty in using strategies that require extensive prior knowledge. In short, a poorly developed knowledge base will frustrate and restrict many strategy instructional effects with learning impaired students.

Cognitive beliefs, attitudes and styles

Strategies, knowledge about those strategies, and other conceptual forms of knowledge are not enough to guarantee good information processing. General tendencies that are shaped by beliefs and attitudes about self-efficacy play an important role in motivating appropriate strategy use as well as the application of conceptual information. These stylistic tendencies can do much to promote, or subvert, capable information processing.

Beliefs and attitudes. Good information processors are not afraid to tackle appropriately challenging academic tasks, largely because they believe they can complete such tasks successfully. In this sense, they are self-efficacious (Bandura, 1986). They assume that problems can be accomplished by analyzing the demands of challenging tasks head-on, with the relevant skills and knowledge they already possess. On the other hand, good information processors are not overconfident, recognizing they have a lot to learn. Yet they believe they can learn most tasks given the time and appropriate educational opportunities. This duality means that good information processors see themselves as continually evolving, with their cognitive growth largely under their own control. They believe they will advance cognitively by working hard, mastering important academic strategies and acquiring important conceptual knowledge. In contrast, poor information processors generally believe their performance is out of their control, attributing it to innate and immutable ability-related factors.

Although the origins of attributional beliefs are deeply embedded within cultural and familial contexts and are often reinforced by parents' and teachers' interpretations of the causes of academic successes and failures, Borkowski and his colleagues hypothesized that it might be possible to devise short-term interventions to reduce dysfunctional attributions, replacing them with attributions that explicitly link success to the use of appropriate strategies. For example, Carr and Borkowski (in press) suggested that attributional beliefs are strongly related to development of self-esteem and other motivational components necessary for academic achievement. If this scenario is correct, altering attributional beliefs might affect both self-esteem and academic achievement. Some ten years earlier, Dweck (1975) taught helpless children to attribute failure to controllable causes such as insufficient effort; her training resulted in increased motivation and improved performance. Moreover, metacognitive knowledge and general strategy knowledge can also be modified by retraining attributions as part of strategy instruction. See Reid and Borkowski (1987) for supporting evidence with hyperactive children, and Borkowski, Weyhing, and Carr (1988) for data pertaining to learning disabled children.

In a recent study on the importance of modifying attributional styles prior to strategy training, Carr and Borkowski (1989) randomly assigned 52 underachieving students to one of three conditions. All participants were taught each of three reading comprehension strategies (topic sentence, summarization, and questioning), over the course of six sessions. In a strategy-plus-attribution condition, underachieving students were given direct instructions about reading strategies as well as attribution retraining. Children were taught the steps to each strategy (e.g., "first read the entire paragraph, then make sure you understand what you read"). The instructor also reinforced the need for effort ("searching for meaning requires considerable effort but this extra effort is necessary for successful recall of the passage"); these instructions constituted the attributional retraining component of the manipulation. Children in the strategy-only condition received strategy training through direct instruction without attributional retraining. Those in the control group received the same tasks as the treatment groups without training.

Three weeks following the final training session, students were posttested on measures of reading awareness, self-esteem, and attributions about the causes of performance. Use of comprehension strategies and prose recall were also tested. The addition of the attributional component to this training program produced significant gains in strategy use, recall performance, reading grades, and attributional beliefs. Not only did the strategy-plus-attribution condition promote the maintenance of the trained strategies, it also facilitated the generalization of those strategies to the classroom. Attributional training had a sizable impact on the effects produced by strategy training per se, although admittedly it does not always do so (e.g. see the discussion of Rebek, 1987, presented earlier). Surprisingly, given the promising pilot data, no type of strategy training increased self-esteem. More intensive, long-term, and multi-faceted instructions may be necessary for changes in self-esteem to occur.

Style. People differ in the ways they habitually relate to tasks, with some differences promoting good information processing and others preventing it. For instance, reflecting before responding usually improves performance compared to impulsive responding (i.e., acting quickly without thinking through a problem or task); see Baron (1981, 1985) and Messer (1976) for examples. Emotionally-based self-control permits rational cognitive processing, whereas emotions out of control, such as high anxiety, can completely disrupt performance (e.g., Tobias, 1979).

Some people process information they are studying at a deep level, trying to fully comprehend it; others process it superficially, such as by learning through rote methods. Not surprisingly, deep processors tend to do better at many academic tasks than do surface processors (Entwisle & Ramsden, 1982). Although most of the evidence supporting the conclusion that some learning styles promote good information whereas others undermine it is correlational in nature, there is a growing experimental literature documenting that styles can be altered in ways that encourage other aspects of information processing. For example, Meichenbaum (1977) has demonstrated how hyperactive children can be taught to inhibit their impulsive tendencies. The combined correlational and experimental evidence suggests that learning styles play an important part in determining the quality of information processing (see, Pressley, Woloshyn et al., in press).

Summary. Overanxious people consume much of their short-term capacity with worry, using cognitive resources that could be put to better use in the application of strategies and other knowledge. For instance, impulsive children do not take the time even to identify task-relevant strategies; moreover, their pace of responding precludes the completion of potential strategies they might select. Other students routinely process material in a rote fashion, exerting a great deal of effort to do so, yet never understanding the content they are learning at the deep level required for long-term retention to occur. Still others are governed by beliefs that reduce or eliminate their motivation to use strategies. Conversely, believing that good performance is possible by using viable strategies and executing them properly can do much to fuel conscious, cognitively-oriented actions. The educational community is beginning to understand how to encourage such beliefs as well as stimulate reflective (Meichenbaum, 1977), deep (e.g., Hounsell, 1984), and nonanxious (Morris, Kratochwill, & Aldridge, 1988) information processing.

Closing Comments

An intact nervous system is essential for good information processing. For instance, the "hardware" that comprises long-term memory stores strategies, motivational beliefs, and conceptual knowledge. The "hardware" that is short-term memory permits conscious activation and use of the components in long-term memory as part of the processing of external stimulation. The functioning of short-term memory, which is limited in capacity, is more efficient the greater the knowledge base. An extensive knowledge base permits efficient chunking of information, and the fewer the chunks, the greater the likelihood short-term capacity will not be exceeded. In addition, if strategies are stored in a long-term memory system, that permits reorganization of material into more manageable units, the number of chunks can be reduced further, again increasing the odds that short-term capacity will not be exceeded.

In addition to possessing an extensive knowledge base that includes strategies and conceptual information, the good information processor know when, where and how to use the procedural and declarative information in long-term memory. The motivation to use this knowledge is high because the student is confident that success is made possible by applying what is already known to current tasks. A reflective, nonanxious style support this cognitive belief, which is aimed producing at a deep and rich level of understanding.

Good information processors are planful, aware of their cognitive activities, and informed. As they process new information efficiently, they become even more proficient information processors because their knowledge base increases due to their efficient use of strategies and their semi-automatic interpretation of new information in light of existing knowledge. This new knowledge makes them ever more competent, fueling additionally their belief they can tackle novel problems with likely success. With increasing competence there are few reasons to be anxious about academic challenges. New knowledge acquired using efficient strategies to accomplish a current assignment makes it easier for deeper processing to occur on future assignments (i.e., an expanded knowledge base facilitates the interpretation of new, related input).

Creating good information processors through education is challenging even in the case of normal and high achieving learners, requiring long-term exposure to important procedural and conceptual information and extensive direct teaching of that information. With learning impaired children, the challenges are ever greater. Neurological deficiencies can undermine metacognitively-oriented training. Long-term learning deficiencies result in a knowledge base that may not be developed sufficiently to mediate new learning. Children who experience academic difficulties often have built up pessimistic beliefs about their own abilities, ones capable of destroying academic motivation. Thus, even when they are motivated to succeed, their extant cognitive styles may not support good information processing.

The special educator needs to confront realistically all of these possible constraints on the educability of learning disabled children. Despite the challenge, there is considerable evidence that even if it is not possible to produce "good" information processing in academically delayed students, "better" information processing is an attainable goal (see Mastropieri & Scruggs, 1987, for an important accumulation of evidence relevant to this point). Although realistic about the challenges that lie ahead, we remain optimistic that education can do much to improve the functioning of learning disabled children by attempting to train, *on all fronts*, good information processing. That is, strategies, knowledge, and styles must be focused on simultaneously in the classroom in order for metacognitively-oriented instructions to succeed. Perhaps the most constructive way to view the constraints highlighted in this review is to consider them as factors that must be taken into account, and overcome, in designing strategy-based classroom instructions.

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