Chapter 11

Cognition and Mental Retardation

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The purpose of this chapter is to provide an overview of some of the recent behavioral research in mental retardation that concerns cognition and its facilitation. The discussion necessarily must be limited to only a subgroup of research domains. The ones that have been selected are among those that have been most heavily researched (therefore allowing some rather firm conclusions to be drawn), and/or they are areas of research that offer particular promise for the future.

The group of cognitive psychologists studying mental retardation have a challenging task. While they join other more ''college-sophomore''-oriented researchers in trying to understand cognition in general, their task takes them further into the complicated world of trying to uncover, understand, and explain individual differences in cognitive functioning. The ultimate goal is theory construction that facilitates the understanding and remediation of deficiencies in cognitive performance. Determining which mental processes can be modified and how that can best be accomplished is a central issue that crosscuts the entire field.

It should be noted that cognitive researchers as a rule do not usually recognize etiology as a variable in their research. (Down syndrome is one notable exception.) There seem to be several reasons for this, with the principle one being that many people with mental retardation who function at the relatively higher levels intellectually are unclassifiable with respect to the origins of their mental handicap. Given the penchant of cognitive psychologists for group research designs that include only mildly retarded subjects, and the generally similar performance of so-called cultural-familial retarded persons equated for age and IQ, etiology does not seem to be a relevant variable in most cognitive studies.

The research that is reviewed in this chapter includes studies on the

representation of knowledge. language, perception, memory, attention, and problem solving. While there are no major breakthroughs to report, it can be said with certainty that progress is clearly being made in laying the groundwork for an empirically based theory of mental retardation.

REPRESENTATION AND LANGUAGE

Representation refers to the stored knowledge that we have about the world. This knowledge concerns objects, events/actions, and causal, spatial, and temporal relationships. As scientists, we infer the existence of representation from the way an individual uses certain symbol systems, particularly language—either spoken, written, signed, or otherwise coded—as in pictures, models, photos, cartoons, and stick figures. Thus, if children speak about giraffes, we assume that they have some concept of giraffes. Similarly, if a giraffe is drawn, recognized, or used in a sentence that is comprehended by children, we infer that they have some conceptual representation of the object giraffe. The manner in which individuals access these representations and how representations are organized in memory has been the subject of considerable research. The specific questions most pertinent to mental retardation are:

1. Does representation differ with intellectual level?
2. If so, can representation be influenced by modification techniques?

While representation is best reflected in an individual's linguistic output, the semantic content of that output is seen as the purest display of cognitive representation. Semantic knowledge refers to the meaning associated with words, phrases, sentences, and other units of language. This meaning is involved not only in the comprehension and expression of language, but also in the process of thinking. Because of the important role of semantics in intellectual ability, the relationship of semantic knowledge to mental retardation is a critical theoretical and practical link.

Research on Semantic Knowledge

If we assume that what children can say and comprehend is a reflection of what they know and how their knowledge is organized, then descriptions of children's spontaneous speech acts can contribute significantly to our understanding of the development of semantic knowledge. This approach was taken by Coggins (1979). He has collected two-word utterances from 3- to 6-year-old children with Down syndrome and classified these utterances on the basis of their relational meanings (e.g., agent-action, agent-object, action-object, possessor-possession, etc.). He found that the spontaneous speech of Down syndrome children did indeed contain the same categories of relational meanings as did the speech of nonretarded children matched on developmental

level. He concluded that children with Down syndrome are able to "identify underlying regularities in experience; discriminate and identify attributes of objects and people; distinguish action from the recipient of that action; discriminate self from persons and objects; and, recognize and identify change in spatial position orientation. The findings also suggest the possibility that processes and structures by which meaning is known, represented, and created in the sensorimotor period may be quite similar to that of normal children" (p. 178).

An alternative approach for studying semantic knowledge focuses on the way in which people use meaning to identify objects and events. One way to conceptualize the meaning of a linguistic event is to think of it as a node in a giant network that has a node for each word, concept, or idea that a person knows. The links in the network between the particular linguistic unit and other units specify the "meaning" of the given unit. For example, if there are links established in the network between "giraffe" and "animal" and "zoo," then, the two latter terms likely are part of the meaning of "giraffe." The organizational networks that comprise a word's meaning are not easy to study, yet such research is necessary in order to identify differences between the semantic knowledge of mentally retarded and nonretarded individuals. McCauley and Sperber and their students (McCauley, Sperber, & Roaden, 1978; Sperber, Ragain, & McCauley, 1976) have conducted a series of studies on the ability of retarded and nonretarded children and adults to categorize objects into their superordinate categories (giraffe-animal) and to identify characteristics of objects (airplane—wings, fly). The major dependent variable in many of their studies was speed (reaction time). The tasks were varied and included picture naming and sentence verification as well as other tasks prominent in the information processing literature. Their findings support the general conclusions drawn from Coggins's study. Individuals with retardation appear to form categories (e.g., dogs, cats) and to establish hierarchical relationships among categories (e.g., the categories of "dog" and "cat" are both viewed as instances of the "animal" category) in a manner similar to that of nonretarded individuals. Retarded adults are, however, consistently slower in making a superordinate judgment (i.e., that a cat is an animal) than nonretarded adults (Davies, Sperber, & McCauley, 1981). Thus, while both groups apparently have the requisite knowledge and have it stored in the same way qualitatively, persons with retardation appear to have a relatively greater difficulty in retrieving the knowledge as indexed by retrieval speed.

If asked to judge whether a particular property is associated with an object (e.g., whether a carrot is orange, whether birds can fly, whether money can be spent), retarded adults are faster at recognizing statements about what can be done to an object (e.g., "an airplane can be flown") than statements about the physical characteristics (e.g., "an airplane has wings"). This latter finding, the authors conclude, is consistent with the view that action proper-

ties are central in early concept formation. Children are known to form concepts in terms of their own action on them; retarded adults apparently organize information according to the same rules. The investigators found no evidence for qualitative differences in semantic organization between retarded and nonretarded children, other than the finding that retarded adolescents and adults appear to be more like mental age-matched nonretarded children than chronological age-matched adolescents (see Sperber & McCauley, 1984, for a comprehensive review of this work).

Modifiability

Since issues of semantic development significantly overlap with those of language development in general, the facilitation of semantic development in individuals with mental retardation is often synonymous with the more general issue of facilitating language acquisition. Actually, the question of whether language can be modified is a complex one with two answers. If the question is paraphrased as a query about whether children can be influenced to output more, or to use more and different words or small syntactic units, the answer is "yes." Behavioral techniques have repeatedly demonstrated that babies (including babies with Down syndrome) can be conditioned to make more sounds (Poulson, 1983) and children and adults can be conditioned to talk more. Furthermore, new words and constructions can be taught in a manner that enables their generalization to new contexts (Baer & Guess, 1971; Stephens, Pear, Wray, & Jackson, 1975; Welch & Pear, 1980; Wheeler & Sulzer, 1970—to name only a few). This type of facilitation certainly has an important role. Many theorists believe that increasing the single-word vocabulary is essentially teaching children to say the names of categories that they already have. Thus, increasing vocabulary at least increases communication. If, as it has been persuasively argued by Vygotsky (1978), Feuerstein, Rand, Hoffman, and Miller (1980), and their followers, much of cognition is socially mediated, a great deal of information is transmitted via parents, siblings, and other significant people in children's lives. The greater the children's understanding of the topics and relationships (vocabulary) conveyed by these educators, the more comprehensive will be their cognition.

A second interpretation of the question could be, "Can training increase the rate of language development in retarded children?" To date, there have been no successful demonstrations of enhanced progression through the stages of development. However, differences in maternal interaction style do appear to be reliably associated with differences in children's linguistic ability (Hamilton & Sherrod, in preparation; Peterson & Sherrod, 1982; Sherrod, Siewert, & Cavallaro, 1984) and differences in scores obtained on the Bayley Scales of Infant Development (Mahoney, Finger, & Powell, 1985). According to Sherrod and colleagues, mothers whose conversational style includes a high incidence of descriptions of their child's ongoing activities (activity-relevant lan-

guage) provide a richer linguistic environment than do mothers whose conversational style is not relevant to their child's activities. Similarly, Mahoney et al. have reported a positive relationship between maternal responsiveness (relative to a controlling or directive style) and scores obtained on the Bayley. These results suggest that it may be possible to teach parents to interact with their infants in such a way as to facilitate language development.

We have mentioned two lines of research that suggest that the language difficulties of individuals with mental retardation are at least partially remediable: (1) behavioral techniques that seek to teach or increase the output of specific linguistic constructions, and (2) observational techniques that seek to identify aspects of the linguistic environment that facilitate language acquisition. S. Warren and A. Kaiser (personal communication, September 1986) are currently examining the efficacy of a language training technique that draws upon the general results of both areas of research. In this new approach, they make use of well-established behavior techniques for teaching linguistic skills while providing an enriched linguistic environment in which retarded children may learn. This approach is designed to take advantage of children's propensity to acquire language in a natural meaningful context. While it is still too early to draw firm conclusions about the effectiveness of this approach, we believe that it is an effort in the right direction.

PERCEPTION

Perception can be functionally defined as the process of extracting information emanating from the objects, places, and events encountered in the world around us (Gibson & Levin, 1975). Clearly, perceptual processing involves all of the senses, taken both individually and in combination. However, since the visual system has been the subject of the greatest number of experiments, the discussion here is limited to the processing of visual information. Only a selected set of experiments are reviewed that are relevant to two aspects of perceptual processing that make an important contribution to the understanding of retarded-nonretarded differences in cognitive performance: perceptual learning and perceptual processing speed.

Perceptual Learning

Higher order cognitive processing is not conducted on all information that impinges on the senses. In the early stages of perceptual processing, there is a considerable filtering of stimulus information, with some aspects of the information being selected for additional processing and other aspects of the information being ignored. The selected features are then transformed using processes that combine and organize information contained in individual features into a smaller number of larger perceptual units. A straightforward example of perceptual processing can be found in the way people distinguish constella-

tions in the night sky. From a random collection of stars, stars irrelevant to the constellation of interest are ignored, while relevant stars are given continued processing and are organized into a single higher order precept—for example, the "Big Dipper." The organization of features at this perceptual stage of processing serves to reduce the number of units that receive continued processing, and hence, allows the processing of the meaning of a pattern to occur more readily. It is generally believed that the efficient filtering of relevant features and the appropriate organization of features into larger units are strongly dependent upon learning experiences. The learning that takes place in establishing these aspects of perceptual processing is considered to be unlike other forms of learning (Gibson, 1969) and is thus afforded special status by researchers concerned with the cognitive development of the human organism.

One research program that addresses differences in perceptual learning between mentally retarded and nonretarded individuals is the one being conducted by Joseph Fagan at Case Western Reserve University. In his research, Fagan uses an infant visual recognition memory paradigm. The general procedure is quite straightforward and is based on the observation that an infant prefers to look at a novel visual stimulus rather than one that was previously seen. A visual stimulus is presented and after the infant has viewed the stimulus for a specified period of time it is removed and two more are presented, one that is new and one that is identical to the stimulus previously shown. To the extent that the infant looks at the new stimulus more than the previously viewed stimulus, it is inferred that the infant has abstracted and retained some information about the original stimulus. Fagan's own interest in this procedure is in the development of tests of infant recognition memory as valid predictors of later intelligence (see Fagan & Singer, 1983). However, it is also clear that the recognition memory paradigm requires the infant to use processes that are very similar to those involved in perceptual learning. That is, the infant must be able to discriminate relevant from irrelevant features of stimuli, filter out the irrelevant information, retain the newly acquired information, and identify the similarities across the stimuli. Hence, studies of infant visual recognition memory contribute to an understanding of many of the processes involved in perceptual learning.

In a series of studies, Fagan and his colleagues (Fagan, 1981; Fagan & McGrath, 1981) have assessed the relationship between infant visual recognition memory, or as we have suggested, perceptual learning and intelligence. For example, Fagan and McGrath (1981) examined the relationship between preference for novel stimuli at 4–7 months and performance on vocabulary tests at 4–7 years. The participants in the Fagan and McGrath study had previously participated in experiments on infant recognition memory conducted by Fagan (1971, 1973, 1976, 1977). The predictive validity coefficients between the infant's performance on the vocabulary tests at 4–7 years

of age ranged from 0.37 to 0.57, and were statistically significant. The strength of these correlations provides some support for the contention that early differences in perceptual learning capabilities may contribute to later differences between mentally retarded and nonretarded individuals in the performance of more molar cognitive tasks. An important goal of future research will be to delineate the particular aspects of the perceptual learning process that are deficient in individuals with mental retardation and to determine the manner and extent to which perceptual learning can be enhanced.

Perceptual Processing Speed

A second avenue of research that we believe has been and will continue to be fruitful examines differences between mentally retarded and nonretarded individuals in perceptual processing speed. While cognitive theory has not progressed to the point where it is possible to establish a direct relationship between perceptual processing speed and performance on more complex cognitive tasks, it seems logical that such a link exists. To the extent that many complex cognitive activities involve the parallel, or overlapping, operation of component processes (McClelland, 1979), then differences in processing speed at the perceptual level may result in subsequent processing that is based on incomplete or inaccurate data, resulting in a failure to complete the sequence of processing, or possibly qualitative differences in the final behavior (Sperber & McCauley, 1984).

McCauley and Merrill have completed a series of studies that investigate retarded-nonretarded differences in perceptual processing speed (Merrill et al., 1985; Sperber, Merrill, McCauley, & Shapiro, 1983). Their data indicate that mentally retarded individuals are significantly slower than nonretarded individuals at perceptually encoding picture stimuli for the purpose of making either a physical identity match (e.g., determining that two identical pictures of a dog match) or making a name identity match (e.g., determining that pictures of different dogs are the same because they have identical labels). The encoding process that precedes determining whether two stimuli physically match takes about 400 msec for mentally retarded and 300 msec for nonretarded adults. A same name identity match involves encoding times of 500 msec for retarded individuals and 400 msec for nonretarded individuals. Of major importance, the speed of perceptual processing exhibited by mentally retarded individuals is slower than that exhibited by both their equal chronological age (CA) and equal mental age (MA) counterparts. This latter finding suggests that perceptual processing speed may be related in some fundamental way to differences in IQ independent of differences in MA. This conclusion is supported by the results of other investigators (Lally & Nettlebeck, 1977; Nettlebeck & Lally, 1979) who have obtained similar results using visual masking procedures. The research currently being conducted by Merrill and McCauley is designed to determine what factors may account for

retarded-nonretarded differences in perceptual processing speed and how differences in perceptual processing speed impact upon the performance of more molar cognitive tasks.

MEMORY

In the last 15 years, probably more research has been reported in the general experimental psychology literature on memory and memory-related processes than on any other topic. To a somewhat lesser degree, that has also been the case in mental retardation research. Memory research more than any area of cognitive psychology has made use of the computer metaphor. The metaphor includes such concepts as the storage and retrieval of information, and it specifies the structures (e.g., memory stores) and processes (e.g., memory search processes) that form the bases of thought. The next sections briefly discuss what this line of research has revealed in regards to mental retardation.

Sensory Memory

Each sensory system seems to have a holding mechanism associated with it, the properties of which are dictated primarily by the physiology of the system. Sensory memory is generally thought to be a relatively brief holding station where incoming information is registered, sorted out, and, via pattern recognition and attention processes, some information is sent to short-term memory for further processing. While some have questioned the centrality of the sensory memory's role in everyday cognition (e.g., Haber, 1983), it still seems important to determine the extent to which those structures are intact in persons with mental retardation. The data on that question are mixed, probably as the result of some methodological anomalies in some of the early studies. Recent work (e.g., Hornstein & Mosley, 1979) suggests that the sensory stores for vision and audition are structurally sound in retarded persons with respect to the amount of information that can be stored and how long that information can be retained (Stanovich, 1978). The mental retardation-related difficulties noted in earlier experiments (e.g., Spitz & Thor, 1968; Welsandt & Meyer, 1974) are probably the result of more general deficiencies in attentional processing skill, such as those involved in selecting and extracting information from a stimulus (Nettlebeck & Brewer, 1981).

Short-Term Memory

Much more is known about short-term memory (STM) in individuals with retardation than is known about sensory memory. Early theoretical formulations (e.g., Ellis, 1963) suggested that STM was an important locus of severe mental retardation-related deficiencies. While Ellis subsequently modified his theory (Ellis, 1970), his original formulation generated a great deal of research.

Because there has been so much research, the discussion of STM can be divided into issues about potential structural differences and issues about process differences. On the structure side, there is at this time only limited research suggesting a mental retardation-related deficiency. Clark and Detterman (1981) reported differences between retarded and nonretarded persons on memory for lifted weight, a task that minimizes the use of strategies. Laine and Baumeister (1985), however, found no evidence for structural deficiencies in STM in a task possibly even more nonstrategic than that used by Clark and Detterman. Laine and Baumeister asked retarded and nonretarded persons to discriminate intensity differences between pure tones. The critical interaction of delay interval between tones by subject group was not significant. In general, the ability of determined experimenters to eliminate the possibility of strategy use by intelligent subjects can have only limited success, and the question of structural defects in STM remains viable. Several important characteristics of STM that may be of the structural variety do seem to be IQ-related and thus relevant to the discussion of mental retardation. One is memory span (the number of digits, letters, etc. that can be repeated back to the experimenter verbatim) as has been thoroughly documented (e.g., Bachelder & Denny, 1977a, 1977b). The second is memory retrieval speed or search rate. Numerous studies indicate that information is retrieved from STM more slowly in lower than in higher IQ persons (e.g., Maisto & Baumeister, 1984). This difference may possibly be remediable or due to characteristics of the research paradigm, but that has yet to be demonstrated. Thus, the finding of retarded-nonretarded differences in STM search rate must be added to the growing data suggesting differences in the efficiency or speed with which basic mental processes can be executed by retarded and nonretarded persons (see Jensen, 1982; Sperber & McCauley, 1984, for reviews of this literature).

Rehearsal/organizational/attentional strategies are important to the discussion here given their central role in facilitating information storage in a relatively permanent form. Ellis concluded by 1970 that the failure of retarded persons to spontaneously rehearse information in STM was a major factor in their memory difficulties. Recent experiments have indeed shown this to be the case. The situation appears to be analogous to the situation with young nonretarded children that Flavell (1970) termed a ''production deficiency.'' A production deficiency simply means that under appropriate circumstances retarded persons and young children fail to initiate and execute a strategy that would facilitate their information processing. What followed from the initial experiments were a series of training studies aimed at encouraging developmentally immature and retarded subjects in strategy use and then evaluating their performance relative to subjects who used the strategies spontaneously. Results were encouraging. For example, Belmont and Butterfield (1969, 1971) conducted an extensive series of training studies using a subject-paced free recall task (i.e., subjects could study materials as long as they wanted). They developed a training procedure that impacted both on rehearsal activities

during learning and on retrieval activities during recall. Their training procedure proved to be quite successful. Other investigators have been successful in inducing the use of other types of rehearsal strategies, like grouping items by category before rehearsing them.

In summarizing the recent literature on rehearsal processes in persons with mental retardation, Borkowski, Peck, and Damberg (1983) have reached conclusions similar to those of these authors:

> Mentally retarded individuals typically exhibit a deficit in rehearsal and in STM. However, the growing number of successful training studies in which attention is paid to both rehearsal (or acquisition) strategies and retrieval techniques, and, more importantly, to explicit methods for generalizing these strategies to transfer tasks suggest that deficits in STM may be reduced by providing the mentally retarded with adequate cognitive instructions. The extent of improvement, however, seems limited. (p. 490)

One of the most frustrating and long-standing problems in mental retardation research is that even when mentally retarded persons can be shown to have retained a strategy for some time, they still are often unable to transfer and/or generalize the strategy to novel situations. Quoting Blackman and Lin (1984):

> There is firm and ample evidence that people classified as EMR can demonstrate the acquisition and maintenance of task-specific cognitive strategies. The generalizability of these strategies, however, is largely restricted to other laboratory tasks that differ minimally from the original training context in both stimuli and task demands. The generalization of these strategies to more meaningful academic or social problem solving has not been demonstrated. (p. 257)

It should be noted here that there are projects currently underway that may allow us to better understand the strategy transfer and generalization problems of persons with mental retardation. Those projects are based on sound theoretical models of the learning process and they extend far beyond the simple laboratory context. We refer to the work of Campione and Brown (1977, 1978, 1984) and Feuerstein, Haywood, and others on instrumental enrichment (Arbitman-Smith, Haywood, & Bransford, 1984; Feuerstein et al., 1980). This work shows promise but is still in its infancy.

Long-Term Memory

The first question that comes to many people's minds when long-term memory (LTM) and mental retardation are discussed is "Are there anatomically based structural deficits in the LTM of retarded individuals that cause them to forget information more rapidly than do nonretarded individuals?" This seemingly complex question can be answered quite simply—at the present time, the analysis of forgetting done in 1969 by Belmont and Butterfield still seems adequate: *if* the degree of initial learning is equal for retarded and nonretarded persons, then the forgetting rate is also equal. The problem is in

getting retarded and nonretarded individuals to exhibit equivalent degrees of initial acquisition, and that is why the focus on strategies, subroutines, and even more molar information acquisition processes is so prominent in behavioral research on mental retardation.

The discussion of LTM can profitably be divided into two sections (cf. Tulving, 1972). Most research on LTM has to do with the retention of autobiographical, temporarily based information of the sort encountered in list-learning experiments. This kind of episodic information is eventually forgotten, at least in part, and is usually recalled by trying to reconstruct the original acquisition situation. Common examples of reconstruction from long-term (episodic) memory are trying to remember the name of your fourth-grade teacher or what your parents gave you for high school graduation. Reconstruction in this case usually involves a search of LTM followed by an attempt to reconstruct or "put yourself back in" the context of the fourth-grade classroom or high school graduation party. It is research on this episodic type of LTM that has dominated mental retardation research. Unfortunately, much of this research is of questionable ecological validity. Of what importance is it in one's life to retain for long periods of time, lists of words, pictures, or anything else encountered in a laboratory experiment? What is needed to complete the picture of long-term episodic memory is experiments on the ability of retarded individuals to retain events, episodes, and so forth that happen in and are significant to their daily lives. We should note, however, that this problem is not unique to mental retardation research, as Neisser (1976), among others, have made this plea in the general experimental psychology literature.

The other, less researched, type of LTM involves the learning, retention, and organization of semantic/conceptual knowledge. This type of knowledge is extracted from our experience. It includes such things as word meanings, concepts, and rules relating them. From a series of studies that began in the mid 1970s and that is continuing, McCauley and Sperber and now McCauley and Merrill have reported data that suggest some rather clear conclusions about LTM for semantic knowledge in persons with mental retardation (see Sperber & McCauley, 1984). First, as noted above, there is reason to believe that once knowledge is acquired, it is stored in memory in a manner qualitatively the same for retarded and nonretarded persons. Second, and again as previously noted, there are clear quantitative differences in the rate with which semantic knowledge can be retrieved; that is, there are clear efficiency differences between retarded and nonretarded persons when retrieval speed is the dependent measure and both groups of subjects are highly familiar with the to-be-retrieved information. Third, under conditions in which semantic knowledge could be useful, mentally retarded persons often don't spontaneously retrieve it. This is a production deficiency of sorts just as was discussed for the spontaneous use of strategies. The failure of retarded

persons to use the semantic knowledge that they have often results in their scoring poorly on certain sections of achievement and IQ tests, like the similarities subtest of the Wechsler Intelligence Scale for Children (WISC) (e.g., how are a plum, banana, orange, and apple alike?).

ATTENTION

Attentional capabilities have long been assumed to play a potentially significant role in determining overall intellectual ability, and current empirical and theoretical approaches to understanding the cognitive aspects of mental retardation suggest that this belief is still widely held. The rationale underlying this conviction is quite straightforward. Because mentally retarded individuals exhibit performance deficits relative to nonretarded individuals across a wide range of cognitive tasks, it seems reasonable to consider the possibility that the performance deficits result, at least in part, from differences in the execution of fundamental cognitive abilities that are common to many of these tasks. Attentional processes are assumed to mediate virtually all cognitive activities, and thus are candidates for strong consideration.

It is important to recognize that "attention is not a single concept, but the name given to a complex field of study" (Posner, 1975, p. 441). It encompasses a variety of processes. We have divided these processes into two major categories. First, attention can be a selective process, whereby some information from external or internal stimulation is perceived and subsequently analyzed and other information is ignored (Pick, Frankel, & Hess, 1975). Second, attention can be viewed as a limited supply of central processing resources (Kahneman, 1973; Norman & Bobrow, 1975). This supply can be flexibly allocated to different cognitive activities or components of a single activity. Cognitive processes that are activated concurrently are assumed to compete for the available resources. Deficits in cognitive performance result when the resource demands of particular processes leave little capacity for other activities.

Selective Attending

The majority of theoretical and empirical work on attentional capabilities of persons with mental retardation has contrasted the performance of retarded and nonretarded individuals on discrimination learning tasks (Fisher & Zeaman, 1973; Zeaman & House, 1963). Since this literature and the resulting theory have been reviewed and evaluated elsewhere (Borkowski et al., 1983; Zeaman & House, 1979), we will not do so here. The fundamental results of this research suggest that mentally retarded individuals are deficient, relative to nonretarded individuals, at selecting the targeted dimension—color, shape, size necessary to discover the correct stimulus. Still in question, however, is the extent to which these differences represent, as

Zeaman and House (1979) contend, unmodifiable structural characteristics of the human processing system.

Attention as Processing Capacity

When attention is viewed as a limited amount of processing resources that can be allocated to cognitive processing in a flexible manner, two critical determinants of task performance emerge. First, individuals may differ in the efficiency with which they flexibly allocate capacity across component processes involved in complex cognitive tasks. Second, the amount of capacity required by each component process may differ for different individuals. It is generally regarded that with practice and experience, certain basic processes that initially require a considerable portion of an individual's supply of processing capacity become increasingly automated until they require minimal resources to be executed (Posner, 1978). The notion here is that as the basic processes of cognitive activities, for example perceptual encoding, come to require less of an individual's available resources, more is left over for the execution of more complex and higher order activities such as problem solving and inference making.

To the extent that mentally retarded individuals, relative to nonretarded individuals, inefficiently allocate their available processing resources or the basic processes of cognitive activities require more of the available resources of retarded relative to nonretarded individuals, then one would expect to find the performance deficiencies in persons with mental retardation across a wide range of cognitive tasks (Carr, 1984; Sperber & McCauley, 1984). The available literature, however, has not involved a comparison of mentally retarded and nonretarded individuals in these domains. Nonetheless, it has been reported that the ability to allocate efficiently processing capacity in accordance with task demands varies with developmental level (Lane, 1979) as does the attention requirements of basic component processes (Manis, Keating, & Morrison, 1980). These results are at least suggestive that this domain of research has the potential to be extremely illuminating.

PROBLEM SOLVING

The area of cognitive research in mental retardation in which the need for more research is self-evident is certainly that of problem solving. Virtually every activity in life involves, or at one time involved, a problem to be solved—how to get dressed in the morning, how to get to the dentist, how to get to work, how to do laundry. Even being a subject in a research study presents a problem to be solved; for example, a subject often asks, "What am I supposed to do here?" The quantity of theory and research conducted on problem solving, however, does not reflect the importance of understanding problem-solving difficulties, particularly when retarded people are involved.

Almost all of the theory and much of the research has been conducted with nonretarded people.

A "problem" is informally defined as the state of wanting something but not being able to obtain it directly. That is, a gap separates problem solvers from where they want to be. To solve the problem, the individual must: 1) understand the nature of the gap, and 2) find and employ procedures (operators, moves) to bridge the gap (Hayes, 1978).

Many theorists think of the second stage—finding and employing procedures to bridge the gap—as a search through alternative paths to find the correct (or an appropriate) path. Hayes (1978) distinguishes two basic search procedures: the random search and the heuristic search. Random search is essentially guessing and is a developmentally primitive strategy (i.e., an extremely inefficient study used by younger children). Heuristic searches, however, are much more efficient and consist of three major methods: proximity methods; pattern matching; and planning by modeling, analogy, and abstraction. The proximity method consists of getting closer and closer to the goal—frequently comparing where one is with where the goal is. Pattern matching consists of recognizing good moves or operations or situations because one has prototypes stored in memory. Thus recognizing a puzzle piece, a chess layout, or a familiar street corner can give one information about progress and directions toward the goal. Abstraction consists of finding a similar but simpler problem, solving it, and trying the solution strategies on the more complex problem.

The task of assessing intelligence-related differences in the various processes involved in problem solving has been undertaken by Herman Spitz and his colleagues. Spitz and Borys (1984) recognized that the first stage of problem solving is representing (understanding) the problem correctly. They subdivided the second stage of problem solving—that of finding and employing procedures for solving a problem—into three separate components: devising a solution plan, executing the solution plan, and deriving a general principle. In their research they have assessed the problem-solving abilities of mentally retarded individuals of differing levels of intellectual functioning. Their data indicated that the lower IQ subjects exhibited a tendency to guess at the solution (i.e., used a random search strategy), suggesting deficiency in the ability to understand the problem situation. The higher IQ subjects were able to understand the problems and devise solutions but could not execute these solutions when confronted with complex problems. Spitz and Borys suggest that this difficulty results from insufficient capacity available in working memory. More complex problems require more memory for past moves and actions than do less complex problems.

Based on his work with nonretarded children, Siegler (1981) has argued persuasively that age-related changes in problem-solving ability follow a consistent developmental or stage-like sequence. Mastery of the problem reflects only the final stage. Premastery level cognitive behavior reveals several dis-

crete stages in which incomplete solution strategies are consistently applied. For example, on problems that involve the consideration of two or more dimensions in order to be solved (e.g., conservation [height, width of container], balance beam [weight and distance from fulcrum]), very young children tend to reason by focusing on only the most salient dimension. In the next stage, subordinate dimensions come to be used, but only when the dominant ones are the same (e.g., if liquid in two glasses is the same height, then the width of the glass must be considered). In the third stage, both dimensions are considered but children exhibit an inability to resolve conflicts between the dimensions; that is, they cannot solve the problem if the two dimensions suggest opposite solutions. Finally, the fourth stage involves considering and appropriately weighing the contribution of all dimensions, thus resulting in the accurate resolution of the problem.

Butterfield and Ferretti (1985; Ferretti & Butterfield, 1983, 1985) have applied this rule-assessment approach to the study of retarded children. They reasoned that training problem-solving strategies to children should be most effective when one attempts to train only one rule level above the child's current cognitive status. In other words, children following Level I rules can be trained to solve a problem using Level II rules but not Level III rules, and so forth. Their results confirmed this hypothesis. However, compared to nonretarded children, the mentally retarded children needed a great deal of extra training and prompting to transfer the strategy to other structurally similar problems (1983). In a subsequent report (1985) these investigators proposed that a more effective approach would be to teach retarded individuals self-management procedures (e.g., selection, revision, and monitoring their strategies in addition to training them to solve specific problems). In an experiment to assess the efficacy of such an approach, three groups of gifted and three groups of retarded children were compared: those who were not instructed, those who were taught specific task strategies only, and those who were taught specific strategies *and* self-management procedures. The investigators found *no* evidence that teaching self-management procedures helped retarded children perform better on related transfer problems. They tentatively concluded that it may *not* be possible to minimize individual differences in problem solving by teaching these more general problem-solving strategies. Such strategies evolve or emerge in intellectually gifted people as a by-product of hundreds of encounters with environmental challenges. Ferretti and Butterfield suggest that a better understanding of the conditions of the emergence of strategies in nonretarded children may be a prerequisite to arranging for their appearance in retarded people.

METACOGNITION

Some people are efficient at solving problems and remembering names, lists, addresses, and so forth. In part, this efficiency is attributable to their knowl-

edge about their own cognitive states and processes (e.g., they know about their memory and their own strengths and weaknesses in remembering). They can thus plan and apply appropriate strategies to facilitate their learning and remembering. This kind of introspective knowledge about one's cognitive states and processes is called "metacognition" or "cognition about cognition" (Borkowski, Reid, & Kurtz, 1984; Flavell, 1976, 1978). Metacognition consists of both knowing *about* thought processes (academic knowledge) and knowing *how to carry them out* (practical knowledge). The two forms of knowledge do not necessarily coexist. The academic knowledge of cognitive processes is relatively easy to measure once the concepts are theoretically delineated; practical knowledge must be inferred from performance.

Metacognition in Act of Remembering

Most of the research on metacognitive processing has focused on memory processes and metamemorial knowledge. Remembering requires the organization of several metamemorial skills: One must be able to ask and answer the question, "Am I going to remember some particular material?" The answer depends on two aspects of knowledge: 1) knowledge about memory processes and 2) awareness of memory states.

Knowledge about Memory Processes Most of what we know about retarded people's knowledge of memory processes has come from interviews with them. These interviews generally consist of describing different memory contexts and either asking which context would make remembering the material easier or asking how they would make sure they remembered the information. Justice (1985) summarizes this work and lists five skills that appear to be MA related:

1. Understanding that memory is fallible (Brown, 1978; Eyde & Altman, 1978
2. Being aware that events intervening before recall can interfere with memory (Brown, 1978)
3. Knowing that immediate recall is more accurate than delayed recall (Eyde & Altman, 1978)
4. Choosing a longer study time as more effective in producing better recall (Brown, 1978; Friedman, Krupski, Dawson, & Rosenberg, 1977)
5. Generating appropriate strategies for accurate memory (e.g., rehearsal) (Eyde & Altman, 1978)

There are several dimensions of metamemorial knowledge that do not appear to be related to MA:

1. Knowing that relearning material should be easier than original learning (Eyde & Altman, 1978)
2. Knowing that learning material in isolation is more difficult than learning material in a context

3. Knowing that learning related pairs of words (e.g., dog-cat) is easier than pairs of unrelated words (Brown, 1978)

Awareness of Memory States The ability to assess accurately the current state of one's memory system is another aspect of metamemory. According to Justice (1985), three tasks have been used to assess this awareness:

1. A *Feeling of Knowing Task* asks children whether they think they would be able to recognize items that they couldn't recall earlier. Performance on this task appears to be MA related (Brown, 1978).
2. A *Recall Readiness Task* asks children to study material until they think they can recall it perfectly. Brown and Barclay (1976) found that mentally retarded children, even at MA-8, were quite poor at this task. With training, retarded people with higher MAs (8) became more proficient.
3. A *Study Time Apportionment Task* asks children to study a list of items that they have previously learned. Efficient use of time would be to spend the most time studying items that they had previously missed. Brown and Campione (1977) found that retarded children with MAs of 6 and 8 did not spontaneously apportion study time in this manner. However, it was possible to train the older MA children to use this strategy effectively.

While there is some evidence that metamemorial knowledge is related to memory performance (Kendall, Borkowski, & Cavanaugh, 1980), there are also research reports in which no relationship between the two variables was found (Kramer & Engle, 1981). Justice (1985) argues that conclusions about the metamemorial knowledge-performance relationship (or lack thereof) should await the production of a reliable test of metamemorial knowledge. Present tests either rely too heavily on verbal comprehension skills or are too procedurally complex to be a pure measure.

Generalization and Selection of Strategies

There is rather general agreement that people with mental retardation do not spontaneously use appropriate metamemorial strategies (Brown, 1974; Campione & Brown, 1977, 1978). Recent research has sought to discover whether experimenter-constructed strategies can be used by retarded people to facilitate learning. The results of this research are clear. When retarded people are instructed on what strategies to use, they can often use them to recall more efficiently and accurately (Campione & Brown, 1977; Glidden, 1979). The biggest problems come when such strategies are tested for longevity (maintenance) and generalizability (transfer to new learning tasks). Several variables have been isolated that facilitate the maintenance and transfer of memory strategies in educable mentally retarded children: 1) active (versus passive) participation by the children, 2) extensive (over)training of the strategy, 3) semantic processing of the items, 4) feedback concerning the effectiveness of

the strategy, 5) extensive examples provided by the experimenter concerning the use of the strategy, 6) systematic introduction of the components of the strategy, 7) gradual elimination of the experimenter's active role as training progresses, and 8) training of the strategy in a variety of contexts (Kendall et al., 1980).

Generalization of strategies to very new material (far generalization) is not often observed with retarded people. Burger, Blackman, Clark, and Reis (1982) believe that the problem in generalizing strategies lies in the ability of subjects to detect similarities between the training tasks and generalization tasks, regardless of whether the tasks are memory, verbal extraction, or so forth. It may be this ability to note similarities between problems that is the basis of retarded children's inability to generalize.

Not only are subjects required to generalize strategies, but they often must select from among a set of available strategies and sequence the application of those strategies. Training in these areas is possible with both mentally retarded and normally developing children. As is the case with most of these skills, there is no qualitative difference between mentally retarded and nonretarded children. The mentally retarded children often require more training at metacognitive skills to reach a given criterion, and demonstrate less generalization of the strategy to new material.

CONCLUSIONS

There is one domain of research in which investigators have not found compelling differences between mentally retarded and nonretarded individuals. It appears that the knowledge that mildly and moderately retarded individuals have about objects and relationships in the world is organized in a manner that is very similar to that of nonretarded individuals. This is an important conclusion because it suggests a fundamental similarity in the manner in which retarded and nonretarded individuals learn, at least when that learning occurs incidentally.

Despite this basic similarity, however, it is obvious from this review that mental retardation is characterized by deficiencies in a number of different cognitive abilities. The majority of the deficiencies can be grouped into two major categories. First, there are deficiencies that have to do with the general efficiency of the cognitive system. Mentally retarded individuals have been found to be less efficient, as indexed by processing speed, than nonretarded individuals at executing such processes as perceptual encoding, searching short-term memory, and retrieving well-learned information from long-term memory. Second, there are deficiencies that are associated with the ability to behave strategically. These deficiencies are manifest in the generally inferior performance exhibited by mentally retarded individuals, in tasks of learning/memory and tasks that involve problem solving.

Whether or not it is possible to remediate the cognitive deficiencies exhibited by mentally retarded individuals appears to depend in some measure on the nature of the deficiency. To date, there is no convincing evidence that indicates that retarded-nonretarded differences in basic cognitive processing speed can be minimized through training. In many instances, data relevant to issues of cognitive processing efficiency are obtained from individual subjects over the course of several days. Despite such extensive practice, large differences between retarded and nonretarded individuals are still obtained. Of course, it may be that practice alone is not sufficient to significantly alter the magnitude of the obtained differences. What is needed before firm conclusions can be drawn is a greater specification of the factors that underlie individual differences in processing efficiency, thereby enabling attempts at remediation to be focused more directly on those aspects of the cognitive system that are deficient in retarded individuals.

Researchers have, in general, achieved greater success with their attempts to modify the strategic functioning of mentally retarded individuals. It has been repeatedly demonstrated that persons with retardation can be taught specific strategies to be used in specific situations. However, there is little evidence to indicate that once a strategy is learned retarded individuals will generalize the trained strategy for use in similar but nonidentical situations in which the use of the strategy would enhance performance. Training persons with retardation to use more general self-management strategies has not proven to be effective in eliciting the spontaneous use and generalization of task-specific strategies. Perhaps an additional step in which an emphasis is placed on teaching retarded individuals to recognize similarities among different problem situations would make training procedures more effective. Still, there is a great deal yet to be learned about generalization before one can hope to achieve any major successes in the attempts at training. We therefore expect that these topics will receive considerable research attention in the next several years.

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