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ABSTRACT

This document defines memory as a complex, interactive process that is a prerequisite for all higher learning. Without intact memory skills, a host of disorders may ensue ranging from mild learning problems to disorientation and helplessness (Lezak, 1983). Because of the pervasive and central role memory plays in people's lives, school psychologists should have at the very least a basic understanding of the memory process. In this regard, this paper addresses selected topics from the knowledge base on memory that have relevance for school psychologists. First, an information-processing model of memory is presented and the three separate memory systems through which information is processed are described (sensory memory, short-term memory, and long-term memory). A section on the developmental aspects of memory considers memory development in infants, children and adolescents. Metamemory, or the individual's conscious awareness of his/her own memory capabilities and functions, also is explained in this section. The final major section of the paper focuses on memory and reading. This information is discussed in the context of how it can be applied by school psychologists in their decision-making. (Author/NB)

Memory: Issues of Import to School Psychologists

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ABSTRACT

Memory is a complex, interactive process that is a prerequisite for all higher learning. Without intact memory skills a host of disorders may ensue ranging from mild learning problems to disorientation and helplessness (Lezak, 1983). Therefore, because of the pervasive and central role memory plays in our lives, school psychologists should have, at the very least, a basic understanding of this multidimensional process. In this regard, this paper addresses selected topics from the knowledge base on memory that have relevancy for school psychologists. Specific topics addressed are: (a) an information processing model of memory; (b) the development of memory in children and adolescents; and (c) memory and reading. This information is discussed in the context of how it can be applied by school psychologists in decision making.

Memory: Issues of Import to School Psychologists

Memory is a complex, interactive process that involves our capacity to store, retrieve, and manipulate information (Gerow, 1992). Not only is memory a prerequisite for all higher learning but it is that function of the mind that imparts meaning to human existence. Without intact memory skills a host of disorders may ensue ranging from mild learning problems to disorientation and helplessness (Lezak, 1983). Therefore, because of the pervasive and central role memory plays in our lives, school psychologists should have, at the very least, a basic understanding of this multidimensional process.

Memory as an Information Processing System

The concept of memory has been a provocative one for centuries, however, a universally accepted model of memory has not yet been formulated (Leahey & Harris, 1985). Although, as three kinds of memory are clinically distinguishable, a three-stage or elaborated two-stage model provides the clinician with a useful perspective from which to operate (Lezak, 1983). Therefore, it is not surprising that the theoretical framework provided by Atkinson and Shiffrin (1968) has become an influential model of memory in cognitive psychology.

According to Atkinson and Shiffrin (1968), three separate memory systems coexist through which information is processed: sensory memory, short-term memory (STM), and long-term memory (LTM). The most basic memory system is referred to as sensory memory or the sensory register. In the sensory register all environmental stimuli that impinge upon the senses are momentarily held (approximately 1 second for vision and approximately 3 seconds for hearing) in an unorganized perceptual copy (Leahey & Harris, 1985). This seemingly ineffective memory store is very essential to productive learning because it prevents the information-processing system from becoming overloaded with incidental, irrelevant stimuli. Moreover, the brief time exposure is long enough for attentional processes to selectively screen input for further processing which takes place in STM.

STM is the intermediate link in the information processing system where information is held in immediate consciousness for ongoing problem solving (Atkinson & Shiffrin, 1968). Sources of input into this system can be from new sensory information or from the LTM store. Transferring information into a memory store can be referred to as encoding and it is interesting to note that it often takes place at a phonetic level in STM. This has been demonstrated by the finding that similar sounding letters (e.g., c and

t) are more likely to be confused in STM than dissimilar ones (e.g., c and o), even if presentation is visual (Leahey & Harris, 1985).

Because of the active, conscious processing that takes place in STM it has frequently been referred to as working memory. However, as Miller (1956) found, the capacity of STM is limited to 7 ($\pm$ 2) bits of information at one time. Once this capacity has been reached no new material can be acted upon unless space is made. Space can be created by forgetting from STM or by storing the material currently in consciousness into LTM (Leahey & Harris, 1985). Furthermore, retention in STM, as in sensory memory, is of a transient nature and memory decay will soon occur (approximately 15 to 30 seconds) if active methods such as rehearsal are not used to maintain the memory (Baine, 1986).

Rehearsal, which involves any repetitive mental process to enhance recall (Lezak, 1983), can be applied at one of two levels depending upon the goal. Maintenance or simple rehearsal is geared at maintaining some information in STM long enough to carry out some action. Repeating a phone number until it is dialed would be an example of maintenance rehearsal. In contrast to maintenance rehearsal, elaborative rehearsal is used to move information into LTM. In this case, associations are drawn between the new data and previously existing concepts, already in LTM, so that the new data will be remembered (Baine, 1986).

LTM is the final major component of the memory system and it can be conceived of as our enduring storehouse of acquired knowledge. LTM is believed to be unlimited in capacity and memories stored here may last a lifetime (Gerow, 1992). Encoding information into LTM, however, is a varied process that involves the storage of qualitatively different types of memories. Generally, knowledge stored here has been referred to as episodic, semantic, or procedural (Leahey & Harris, 1985). Episodic memory (Tulving, 1972) refers to information that has been remembered in a personal context such as someone remembering where they were and what they were doing when President John F. Kennedy was assassinated. Conversely, semantic memory is general information that has been acquired but not attached to some personal event (Tulving, 1972). Reciting the names of the presidents of the United States would be an example of semantic memory. In contrast to semantic and episodic memory, procedural memory is skill knowledge. Procedural knowledge encompasses automatic motor and problem-solving skills that are not conducive to verbal processing. Riding a bicycle or driving a car would be examples of procedural knowledge (Leahey & Harris, 1985).

A discussion of memory would not be complete without mention of the concept of forgetting. Traditional views of forgetting claim that it can occur as a result of interference of similar material or through decay of a memory trace over time (Baddeley, 1982). However, forgetting may take place if encoding has not been complete and the information to be learned was not completely assimilated. (This, in fact, may explain the often made teacher comment: "he/she knew it yesterday but he/she does not know it today.") Moreover, the term "forgetting" may also be applied to retrieval failure. That is, because of ineffective retrieval cues, the information cannot be accessed from LTM where it has been stored (Lezak, 1983).

In summary, memory is a very complex process. The Atkinson and Shiffrin (1968) model provides a useful framework for understanding how this complex process may operate. Moreover, the model is consistent with neuropsychological research that has established the existence of distinct memory stores within the brain (Kolb & Whishaw, 1985). However, it must be noted that this model of memory is not without flaws. For example, Atkinson and Shiffrin (1968) proposed that for information to go into LTM it must first pass through the STM store for processing. In contrast, Baddeley (1982) has pointed out that long-term storage can take place without an intact STM system. Baine (1986) has also cited evidence that information processed through rehearsal in STM does not always lead to LTM storage as originally proposed by Atkinson and Shiffrin. Furthermore, Klapp, Marshburn, and Lester (1983) have provided evidence that STM may not be a unitary store but a system of subsystems.

Developmental Aspects of Memory

Memory, as all biologically-based processes, is subject to developmental change and observations of children's behavior reveals a regular sequence of progression in memory skills. Behaviors range from such basic functions as infants learning to distinguish faces to adolescents and adults using elaborate rehearsal strategies to retain information (Kail, 1984). Thus, the mnemonic codes used by a child are not fixed as they change over time as general cognitive skills are restructured.

In consideration of the dynamic nature of memory development, assumptions concerning memory performance must always be tempered by age-dependent factors. For example, memory span studies have shown that the immediate memory span for digits increases from two at age two to approximately eight digits in adulthood (Mishra, Ferguson, & King, 1985). Consequently, judgments concerning memory capacity, without regard for age, can be misleading and detrimental to remedial programming.

In mapping the development of memory, Flavell (1985) described four fundamental concepts that are helpful in understanding the ontogeny of memory. The concepts are: basic processes, knowledge, strategies, and metamemory. Beginning with an explanation of basic processes and moving through these various concepts in turn, a clear picture of memory progression, which parallels empirical measures of development, comes into focus.

Basic processes refers to those processes, such as pattern recognition and attention, upon which more enduring memory functions depend and evolve (Flavell, 1985). Habituation paradigms, which were designed to see how long infants would attend to stimuli (e.g., patterns and faces), have shed light on the memory of infants. For example, as determined by length of gaze, Fagan (1973) found 6-month-olds to look at pictures of novel faces significantly longer than familiar faces. This effect, which suggests the infants recognized thus remembered the faces, was reported to have lasted for as long as two weeks.

According to Kail (1984) however, memory skills that go beyond simple recognition develop from 6 to 12 months. The emergence of what Piaget referred to as object permanence clearly illustrates the semblance of recall memory in infants (Flavell, 1985). Flavell cited evidence to suggest that this ability comes into being by 9 months and is exemplified by the child who can find a toy, after a brief interlude, that has been hidden from sight.

With the onset and growth of the basic processes, the child's knowledge store begins to rapidly expand. This expansion of knowledge leads directly to more advanced and greater memory capacities as newly acquired knowledge sets the foundation for storage and retrieval of subsequent information. From this perspective, it can be argued that knowledge is a key influencing factor in memory development. In this regard, one could speculate that children, who are more knowledgeable than adults on a certain topic, should outperform adults on memory tasks related to that topic. Research (Chi,1978; Lindberg, 1980) has substantiated this position.

Working with 10-year-old chess players and adults who were not chess players, Chi (1978) found that the 10-year-olds outperformed the adults 2 to 1 on a memory task for a visual array. In this case, the visual array was a chessboard and its playing pieces. Lindberg (1980) has also provided support for the importance of knowledge to memory when comparing third graders and college students on tasks that were more meaningful to the third graders such as cartoon characters.

Another way to track the course of memory development has been to investigate the emergence, implementation, and refined use of specific strategies consciously used to aid retention of material (Kail, 1984). Concerning strategy employment, age-related transitional stages have been delineated. For example, on the basic strategy of rehearsal (repeated repetition of an item to be remembered), Kail (1984) stated that clear developmental differences were apparent. With children of 5 or 6 years of age rehearsal is not seen; however, by age 7 the rudimentary beginnings of the strategy are apparent. That is, children of this age group will rehearse, but they typically try to remember just one word. By age 10, rehearsal-type strategies are well-fixed, and by age 13, rehearsal will often be combined with the categorization of stimuli to enhance memory capabilities.

This developmental pattern has been demonstrated with retrieval strategies and study strategies as well. Kobasigawa (1974), for example, found a clear developmental pattern using an advanced grouping strategy. The goal of the strategy was to group items into categories so that recall of the category would lead to remembrance of the items. It was found that 8-year-olds would only try to remember one word from each category, whereas, 11-year-olds would attempt to exhaustively search each category for all items. Brown and Smiley (1978) provided additional supportive data from their work on study strategies. They reported that very few 5th graders know how to study a paragraph for meaning (e,g., taking notes or underlining key phrases). However, by high school, approximately 50% of the students have acquired this skill.

In summary, below 7 or 8 years of age, children are unlikely to use a memory strategy unless instructed to do so. From 7 to 10 years they will begin to use a basic rehearsal strategy. After age 10, however, children begin to structure rehearsal, so as to take advantage of the characteristics of the stimuli, and to increasingly hone these skills throughout the adolescence years (Kail, 1984).

More complex memory strategies involving organization and elaboration of the stimuli also follow a developmental pattern. However, the pattern of these more complex strategies differs from the more basic strategies in that they tend not to develop until middle childhood (Flavell, 1985). This tendency toward latter appearing expertise is also true of metamemory.

Metamemory is a person's conscious awareness of their own memory capabilities and functions. Knowledge about memory functions includes one's awareness of the difficulty level of various memory tasks and the strategies used to increase memory performance. In this regard, Kail (1984) provided evidence that children below the age of 7 or 8, as a group, tend to overestimate their memory span. Moreover, this group did not realize that tasks amenable to strategy usage are easier to remember nor which strategy (e.g., elaboration or rehearsal) would be more effective to use in any given situation.

Memory and Reading

Deficits in STM have frequently been associated with poor reading achievement (e.g. Brady, 1986; Mann, Liberman, & Shankweiler, 1980; Torgesen, 1978, 1985). Torgesen (1978), in a comprehensive review of the topic, concluded that serial memory tasks (aural or visual) reliably differentiate between good and poor readers. From a number of psychometric studies (e.g., Badian, 1977; Golden & Stein, 1969; Huelsman, 1970; Rugel,1974) that varied in experimental designs and populations, Torgesen reported that the convergence of data was remarkable.

A study by Jorm, Share, Maclean, and Matthews (1984) illustrated this relationship. These researchers assessed the STM functions of 477 children over a two year period. Sentences, matched for difficulty level, were constructed and used to assess recall. The children were evaluated with the tests of sentence memory at the beginning of kindergarten and again at the end of first grade. Reading achievement was also assessed at the end of first grade.

Results of this study revealed significant correlations ($p < .001$) between performance on the STM tasks and reading ability. Moreover, as STM was measured before formal reading instruction was initiated, evidence was established that the subaverage performance of poor readers on STM tasks is not a by-product of poor reading achievement. This finding holds potential significance as reading disability is a prevalent academic deficiency (Rattan & Dean, 1987).

When inconsistencies to this pattern of results have occurred, differences in performance were generally attributed to variations in tasks and populations (Stanovich, 1982). For example, if the material to be remembered is reliant upon verbal coding, such as is the case with digits, words, letters, or sentences, then a strong correlation between reading and STM exists. When the stimuli are not easy to represent linguistically (e.g. nonsense figures, unfamiliar photographs, or unfamiliar symbols), the discriminating power of the STM tasks to differentiate good and poor readers diminishes (Brady, 1986; John & Rattan, 1991).

In view of the well established relationship between performance on STM tests and reading achievement, a number of experimental paradigms (e.g., Brady, Mann, & Schmidt, 1987; Elbert, 1984; Jorm, Share, Maclean, & Matthews, 1984; Mann, Liberman, & Shankweiler, 1980; Olson, Davidson, Kliegl, & Davies, 1984; Torgesen & Goldman, 1977; Torgesen & Houck, 1980; Tarver, Hallahan, Kauffman, & Ball, 1976) have been designed to investigate the cognitive processes underlying the impaired performance of poor readers on STM measures. Such knowledge has more than heuristic value as it is crucial to appropriate remedial programming.

When investigating the underlying processes of memory, the theoretical conceptualization of Atkinson and Shiffrin (1968) has been useful in providing direction for experimental studies. In short, Atkinson and Shiffrin postulated that memory processes can be subdivided into two major divisions: structural and control processes. Structural processes (e.g., search rate and storage capacity) have been defined as those physical features and processes of the memory system which are fixed. These processes have also been referred to as nonstrategic as they are not under conscious control (Dempster, 1981). Control processes (e.g., rehearsal or chunking), on the other hand, can be actively and consciously manipulated by an individual to influence performance. These processes have sometimes been referred to as strategic variables

(Dempster, 1981). This dichotomy of memory functioning has been very useful in investigating the relationship between STM and reading achievement.

Through the study of mnemonic strategies, control processes have been implicated as a causative factor in the performance differences between good and poor readers on STM tasks. Tarver, Hallahan, Kauffman, and Ball (1976) demonstrated this phenomenon when examining normal and reading-impaired children of different age groups (8- , 10- , and 13-year-olds) with a serial memory task. In their study the children were required to locate the serial position of a picture in an array, relative to a cue card. Comparison of the overall performance patterns showed the good readers to significantly outperform the poor readers. However, the results were mitigated by a clear primacy memory advantage for the good readers in contrast to the poor readers. This was taken to mean that the poor readers did not use an efficient rehearsal strategy as primacy recall has been reported to be dependent upon verbal rehearsal (Torgesen, 1978).

Using a more direct method of monitoring the rehearsal strategies of good and poor readers, Torgesen and Goldman (1977) observed second grade students (16 good and 16 poor readers) as they completed a visual memory task for pictures. Signs of rehearsal (e.g., lip movements or word repetitions) were observed. It was found that good readers not only rehearsed more but also remembered more than the poor readers. Moreover, on inquiry, 15 of the good readers reported that they used a rehearsal strategy to perform the task, whereas, only nine of the poor readers indicated utilization of such techniques. In addition, the rehearsal strategy employed by the nine poor readers was scored to be less efficient than that used by the good readers.

In a more thorough examination of etiological factors, Torgesen and Houck (1980) conducted a series of experiments with 10-year-old learning-disabled (LD) and nondisabled children. Three groups were formed in this investigation based upon performance on a digit span test. One group consisted of LD children who scored well below average on the digit span test (standard score of 5 or below). Another group consisted of LD children who scored at average levels on the digit span task (standard scores ranging from 9 to 11) and the final group was composed of normal children who performed at average levels on the digit span test (standard scores ranging from 9 to 11). Comparisons were made among these groups on the variables of attention, motivation, repeated presentation, speed of presentation, strategy usage, and familiarity of stimuli.

Findings revealed that control processes can be influential. This conclusion was drawn based upon the differential effects of attention, incentives, and interference variables on digit span performance among the groups. Children who were assessed to be at average levels on the digit span task were found to be penalized by an interference task. The overall effect resulted in inhibition of rehearsal, a drop in performance over the course of the testing session, and improvement with monetary incentives. The performance of children with below average digit span ability was not significantly affected by these variables. Thus it was argued that this group did not effectively use control strategies to alter performance.

However, when comparing performance differences among groups, Torgesen and Houck (1980) estimated that at least 30% of the recall differences could not be accounted for by control processes. In this regard, it is possible that recall differences attributed to control processes overlap with structural influences. For example, although it can be assumed that control processes were influential in increasing performance in the incentive condition with the average (digit span) children, it cannot be unequivocally concluded that ineffective strategy usage, and not structural limitations, accounted for the lack of gain in the below average (digit span) group.

Another etiological consideration that has received support in recent years is phonetic coding in

STM. Brady, Mann, and Schmidt (1987) have outlined three lines of converging evidence to buttress this position. Foremost, the robust and striking performance patterns of good and poor readers on various STM tests that utilize linguistic stimuli were emphasized. As noted earlier, only tasks which require the coding of verbal information (e.g., words or common objects) consistently discriminate between the two groups. On STM tasks which are not dependent upon phonetic coding, good and poor readers do not perform at significantly different levels (Brady, 1986). In conjunction with this finding, evidence has been cited that poor readers tend to make a higher number of phonetic transposition errors on STM tests (Brady, Mann, & Schmidt, 1987) and that they tend to be penalized less by the phonetically confusing effects of rhyme (Mann, Liberman, & Shankweiler, 1980).

Conclusion

Memory operations play a vital and pervasive role in cognitive functioning. Therefore, school psychologists should keep abreast of the research concerning this dynamic process. Quality service delivery is ultimately dependent upon a broad and current knowledge base. Without a theoretical and/or empirical stance from which to operate, decisi n making is prone to overspeculation and error.

References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence, & J. T. Spence (Eds.), The psychology of learning and motivation: Vol. 2. Advances in research and theory (pp. 89-195). New York: Academic Press.

Baddeley, A. (1982). Your memory: A user's guide. New York: Macmillan Publishing Co.

Badian, N. A. (1977). Auditory-visual integration, auditory memory and reading in retarded and adequate readers. Journal of Learning Disabilities, 10, 108-114.

Baine, D. (1986). Memory and instruction. Englewood Cliffs, NJ: Educational Technology Publications.

Brady, S. (1986). Short-term memory, phonological processing, and reading ability. Annals of Dyslexia, 36, 138-153.

Brady, S., Mann, V., & Schmidt, R. (1987). Errors in short-term memory for good and poor readers. Memory and Cognition, 15 (15), 444-453.

Brown, A. L., & Smiley, S.S. (1978). The development of strategies for studying texts. Child Development, 49, 1076-1088.

Burtis, P. J. (1982). Capacity increase and chunking in the development of short-term memory. Journal of Experimental Child Psychology, 34, 387-413.

Chi, M. T. H. (1978). Knowledge structures and memory development. In R. Siegler (Ed.), Children's thinking: What develops? Hillsdale, NJ: Lawrence Erlbaum Associates.

Dempster, F. N. (1981). Memory span: Sources of individual and developmental differences. Psychological Bulletin, 89, 63-100.

Elbert, J. C. (1984). Short-term memory encoding and memory search in the word recognition of learning-disabled children. Journal of Learning Disabilities, 17, 342-345.

Fagan, J. F. (1973). Infants' delayed recognition memory and forgetting. Journal of Experimental Child Psychology, 16, 424-450.

Flavell, J. H. (1985). Cognitive development (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Gerow, J. R. (1992). Psychology: An introduction. (3rd ed.). New York: HarperCollins.

Golden, N. E., & Steiner, S. R. (1969). Auditory and visual functions in good and poor readers. Journal of Learning Disabilities, 2, 476-481.

Huelsman, C. B. (1970). The WISC subtest syndrome for disabled readers. Perceptual and Motor Skills, 30, 535-550.

John, K. R., & Rattan, R. (1991). A comparison of short-term memory tests as predictors of reading achievement for learning-disabled and educable mentally retarded students. Journal of School Psychology, 29, 309-318.

Jorm, A. F., Share, D. L., Maclean, R., & Matthews, R. (1984). Phonological confusability in short-term memory for sentences as a predictor of reading ability. British Journal of Psychology, 75, 393-400.

Kail, R. (1984). The development of memory in children (2nd ed.). New York: W. H. Freeman and Company.

Klapp, S. T., Marshburn, E. A., & Lester, P. T. (1983). Short-term memory does not involve the "working memory" of information processing: The demise of a common assumption. Journal of Experimental Psychology: General, 112 (2), 240-264.

Kobasigawa, A. (1974). Utilization of retrieval cues by children in recall. Child Development, 45, 127-134.

Kolb, B., & Whishaw, I. Q. (1985). Fundamentals of human neuropsychology (2nd ed.). New York: W. H. Freeman and Company.

Leahey, T. H., & Harris, R. J. (1985). Human learning. Englewood Cliffs, NJ: Prentice-Hall.

Lezak, M. D. (1983). Neuropsychological assessment (2nd ed.). New York: Oxford University Press.

Lindberg, M. A. (1980). Is knowledge base development a necessary and sufficient condition for memory development? Journal of Experimental Child Psychology, 30, 401-410.

Mann, V. A., Liberman, I. Y., & Shankweiler, D. (1980). Children's memory for sentences and word strings in relation to reading ability. Memory and Cognition, 8 (4), 329-335.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. The Psychological Review, 63, 81-97.

Mishra, S. P., Ferguson, B. A., & King, P. A. (1985). Research with the Wechsler Digit Span subtest: Implications for assessment. School Psychology Review, 14, 37-47.

Olson, R., Davidson, B., Kliegl, R., & Davies, S. (1984). Development of phonetic memory in disabled and normal readers. Journal of Experimental Child Psychology, 37, 187-206.

Rattan, G., & Dean, R. S. (1987). The neuropsychology of children's learning disorders. In J. M. Williams & C. J. Long (Eds.), The rehabilitation of cognitive disabilities (pp. 173-190). New York: Plenum Press.

Rugel, R. P. (1974). WISC subtest scores of disabled readers: A review with respect to Bannatyne's recategorization. Journal of Learning Disabilities, 7, 48-55.

Stanovich, K. E. (1982). Individual differences in the cognitive processes of reading: I. Word decoding. Journal of Learning Disabilities, 15, 485-493.

Tarver, S. G., Hallahan, D. P., Kauffman, J. M., & Ball, D. W. (1976). Verbal rehearsal and selective attention in children with learning disabilities: A developmental lag. Journal of Experimental Child Psychology, 22, 375-385.

Torgesen, J. K. (1978). Performance of reading disabled children on serial memory tasks: A review. Reading Research Quarterly, 14, 57-87.

Torgesen, J. K. (1985). Memory processes in reading disabled children. Journal of Learning Disabilities, 18, 350-357.

Torgesen, J. K., Bowen, C., & Ivey, C. (1978). Task structure versus modality of presentation: A study of the construct validity of the Visual Aural Digit Span Test. Journal of Educational Psychology, 70, 451-456.

Torgesen, J., & Goldman, T. (1977). Verbal rehearsal and short-term memory in reading-disabled children. Child Development, 48, 56-60.

Torgesen, J., & Houck, D. (1980). Processing deficiencies of learning-disabled children who perform poorly on the digit span test. Journal of Educational Psychology, 72, 141-160.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), Organization and memory (pp. 382-403). New York: Academic Press.