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**COMPARISON OF LEARNING DISABILITY SUBTYPES ON INDEPENDENT
AND CONCURRENT MEASURES OF METAMEMORY**

by

Catherine A. Greene

M.Sc. Acadia University, 1993

**A Dissertation
Submitted to the Faculty of Graduate Studies
through the Department of Psychology
in Partial Fulfillment of the
Requirements for the Degree
of Doctor of Philosophy at the
University of Windsor
Windsor, Ontario, Canada
1998**



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ABSTRACT

The current study examined the metamemorial functioning of students with different subtypes of learning disabilities. The performance of normally achieving students, students with arithmetic difficulties, students with reading difficulties, and students with both arithmetic and reading difficulties was compared on both a general measure of metamemory, as well as on in vivo tasks designed to assess strategy acquisition and application, memory monitoring, and strategy transfer. It was expected that students with arithmetic difficulties would perform less successfully on each of these tasks than would students with reading difficulties. Normally achieving students were expected to be most successful, while students with difficulties in both arithmetic and reading were expected to have the greatest difficulty with these tasks.

Analyses of group performance revealed that normally achieving students demonstrated significantly greater metamemorial knowledge, generated more precise and adequate elaborations and recalled more sentences using the elaborative interrogation strategy than did all three groups of students with learning disabilities. Although students with both arithmetic and reading difficulties consistently performed most poorly, expected differences between students with arithmetic difficulties and students with reading difficulties were not observed. Analyses designed to investigate the relative impact of both arithmetic difficulties and reading difficulties revealed that on both independent and concurrent measures of metamemory, although both arithmetic and reading difficulties were associated with poorer performance, there were no interactions between these factors. With respect to memory monitoring and strategy transfer, it was observed that

students with arithmetic difficulties (i.e., students with arithmetic difficulties and students with difficulties in both arithmetic and reading) were less likely to select the strategy that had been most effective for them during instruction and practice during subsequent strategy choice opportunities. These results were interpreted in the context of Rourke's (1982; 1987; 1989; 1995) model of neuropsychological functioning for students with both verbal and nonverbal learning disabilities.

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CHAPTER I

INTRODUCTION

Over the course of the last two decades, the concept of metacognition has been the subject of an ever-increasing body of research, particularly with respect to its implications for children with learning disabilities (e.g., Palincsar & Brown, 1987; Paris & Winograd, 1990; Short, 1992; Short, Schatschneider & Friebert, 1993; Wong, 1991). Metacognition has been described as referring to awareness of one's own knowledge and the ability to understand, control, and manipulate individual cognitive processes (Brown, Bransford, Ferrara & Campione, 1983; Flavell, 1979; Flavell & Wellman, 1977; Osman & Hannafin, 1992; Reeve & Brown, 1985). More specifically, metacognition has been described as factual, long-term knowledge about cognitive tasks, strategies, current memory states, and conscious feelings related to cognitive activity (Osman & Hannafin, 1992).

Of interest in the current study is an aspect of metacognition that can be subsumed under the previous description and involves the specific area of memory. Flavell and Wellman (1977) used the term metamemory to refer to students' knowledge and awareness of their memory systems and strategic behaviors, including awareness of different memory strategies and how to use them, as well as knowing which strategy to apply under specific memory demands.

The significance of metamemory has been linked to its relationship with successful memory performance (Best, 1993; Fatal & Kaniel, 1992; Pressley, Borkowski, & O'Sullivan, 1985; Schneider, 1985), an area of cognitive functioning that is thought to be less efficient in children with learning disabilities (Pressley, Scruggs, & Mastropieri, 1989;

Short, 1992; Torgeson, 1978). Characterizations of children with learning disabilities as "inactive learners" (e.g., de Bettencourt, 1987; Torgeson, 1977a), meaning students who fail to demonstrate the types of behaviors which are thought to fall under the direction of metamemory, have stimulated investigations of this phenomenon in children with learning disabilities (e.g., Cornoldi, 1990; Marfo & Ryan, 1990; Shepherd, Gelzheiser & Solar, 1985; Swanson, 1983). Unfortunately, the current state of knowledge with respect to metamemory in children with learning disabilities is incomplete by virtue of its failure to take into account the heterogeneous nature of such disabilities, as elucidated by research examining subtypes identified on the basis of academic achievement (Siegel & Linder, 1984; Siegel & Ryan, 1988; Share, Moffitt, & Silva, 1988) or neuropsychological battery profiles (Gross-Tsur, Shalev, Manor, & Amir, 1995; Harnadek & Rourke, 1994; Klin, Volkmar, Sparrow, Cicchetti & Rourke, 1996; Rourke, 1989; White, Moffitt, & Silva, 1992).

The notion that different subtypes of learning disabilities exist and present with unique neuropsychological and cognitive assets and deficits is of central importance to the current study, which will attempt to investigate metamemory and memory in two subtypes of children with learning disabilities. Recent work by Rourke and Tsatsanis (1995) has suggested that children who exhibit what has been described as the Syndrome of Nonverbal Learning Disabilities (Rourke, 1989) display very different patterns of memory functioning than do those whose disabilities are evident in the context of more "verbal" demands. Accordingly, it is not unreasonable to suggest that these two groups of students will also differ with respect to their metamemorial functioning, a finding that would have

significant implications with respect to current trends in special education that advocate and attest to the effectiveness of a metacognitive approach to instruction (e.g., Bos & VanReusen, 1991; Moely et al., 1992; Palincsar & Brown, 1987). Garner (1994) noted that metacognition has been designated as a curriculum priority in many school districts. To date, however, research in this area has focused on remediation of disabilities of reading and spelling rather than the visuo-spatial, concept-formation and other deficits noted in children with nonverbal learning disabilities. Consequently, interventions based on current conceptions of the metacognitive/metamemorial functioning of children with learning disabilities may not adequately address the potentially unique needs of children who display the nonverbal learning disabilities syndrome.

The remainder of this chapter examines in greater detail the concept of metamemory, its hypothesized role in children's learning, and our current understanding of the metamemorial functioning of children with learning disabilities. Subsequent sections review literature on learning disability subtypes and their associated cognitive assets and deficits, with particular attention to memory functioning. The chapter concludes with a rationale and hypotheses for the current study.

Metamemory

The term metamemory emerged in the early 1970s as a result of burgeoning interest by researchers in the development of children's awareness of their own memory (Reeve & Brown, 1985; Schneider, 1985). In the late 1960s, John Flavell observed that young children often did not employ cognitive strategies (e.g., rehearsal) in order to aid memory, in spite of having the capability to do so. He hypothesized that this failure by

children to use task-appropriate strategies occurred because they did not possess appropriate knowledge about memory. The term "metamemory" was coined to describe knowledge of all possible aspects of information storage and retrieval, including knowledge about memory functioning, limitations, difficulties, and strategies (Flavell, 1971, cited in Reeve & Brown, 1985; Flavell & Wellman, 1977).

Flavell and Wellman (1977) grouped metamemory with three other broad categories reflecting memory phenomena, including structurally-determined capacity, strategies, and the nonstrategic knowledge base of the learner. They further described a taxonomy which separated metamemory into two main categories reflecting sensitivity and variables. The sensitivity category included knowledge of when intentional memory activity is necessary, while the variables category was broken down into three subdivisions. The first of these included characteristics of the person relevant to memory (e.g., a child's view of his or her memory capacities), while the second division included characteristics of the task relevant to memory (e.g., familiarity of the material, length of time for study). Finally, the third division included potential memory strategies (e.g., strategies for encoding and retrieval) (Flavell & Wellman, 1977; Schneider, 1985; Schneider & Pressley, 1997).

In reviewing research on metamemory, both Schneider (1985) and Schneider and Pressley (1997) noted that alternative conceptualizations to the work of Flavell and Wellman (1977) have been developed, as well as extensions to more general models of metacognition. Although the scope of the current discussion precludes an in-depth examination of each of these models, the contributions of several researchers warrant

mention. In addition to Flavell's (1979) extrapolation of Flavell and Wellman's (1977) metamemory taxonomy to metacognition in general. Ann Brown and colleagues have examined memory in the context of an information-processing approach to metacognition (e.g., Brown, 1978; Brown et al., 1983). According to this orientation, cognitive activities are guided by the operations of a central executive that functions to guide and oversee problem-solving. This function can take the form of planning, monitoring, checking, and regulating of problem solving behavior (Brown, 1978). With respect to memory, Brown's focus was on what Flavell and Wellman (1977) referred to as "here and now memory monitoring," and held that memory monitoring played a significant role in the executive actions described above (e.g., when to continue with or replace a strategy based on its effectiveness for a particular task) (Schneider & Pressley, 1997). Schneider and Pressley (1997) noted that one of Brown's significant contributions to the development of metacognitive theory was her recognition that such theory should capture the relationship between memory and other cognitive activities such as learning and problem solving. Notions concerning the role of an "executive" as the coordinator of these relationships have continued to be the focus of current investigations, as reported in a recent chapter by Borkowski and Burke (1996).

Other significant contributions to metacognition and metamemory theory include Wellman's work on the development of preschoolers' "theory of mind" (e.g., Wellman, 1985b), and research by Kluwe and colleagues (e.g., Kluwe, 1982, cited in Schneider & Pressley, 1997) which elaborates on the notions of executive control processes put forth by Brown (Schneider & Pressley, 1997). A taxonomy including two categories of

metacognition was also proposed by Paris and colleagues (e.g., Jacobs & Paris, 1987; Paris & Jacobs, 1984; Paris & Oka, 1986). The first category is known as awareness of cognition and includes knowledge about task and strategy characteristics as well as knowledge about when, where, and why to use a particular strategy. The second category involves regulation of cognition or self-monitoring and includes the planning, evaluation, and regulation of ongoing cognitive processes.

The final approach to metacognition which will be discussed herein is that of Pressley and colleagues (e.g., Pressley, Borkowski, & O'Sullivan, 1985; Pressley, Goodchild, Fleet, Zajchowski & Evans, 1989; Pressley, Johnson & Symons, 1987) and is referred to as the Good Strategy User Model. Briefly, this model holds that individuals who are good strategy users exhibit certain types of knowledge and behaviors that interact. For example, they have general strategy knowledge whereby they understand general principles about strategy functioning (e.g., the idea that intentional mental effort is required to employ a particular strategy). They also display metacognitive knowledge about specific strategies (e.g., when and where to use a particular strategy). Finally, good strategy users exhibit skills that allow them to acquire more metacognition (e.g., evaluating new strategies by means of self-testing or comparing the effectiveness of different strategies for a certain type of memory problem) (Schneider & Pressley, 1997).

In examining the multiple theoretical perspectives described above, it becomes apparent that regardless of whether researchers discuss metamemory specifically or refer to it as a component of more general metacognitive knowledge, there appear to be a number of common elements which are thought to characterize this phenomenon. These

include awareness of the need for intentional strategic memory behavior, a repertoire of specific memory strategies and knowledge of their appropriate application, and the ability to monitor the efficacy of strategies under certain memory demands and to benefit from the results of such evaluations. It is these aspects of metamemory which will be under investigation in the current study.

The Relationship Between Metamemory and Memory Behavior

Implicit in the previous theoretical descriptions of metamemory is the notion that metamemory and strategic behavior share a bidirectional relationship, whereby metacognitive knowledge may promote successful memory strategy use and transfer, and successful strategic experiences may be incorporated into current metamemory (Kurtz & Borkowski, 1984). For example, Kendall, Borkowski and Cavanaugh (1980) found that metamemory (as assessed by a modified version of an interview developed by Kreutzer, Leonard & Flavell, 1975) predicted successful maintenance and generalization of an interrogative strategy by educable mentally retarded children. Conversely, Cavanaugh and Borkowski (1979) found that the use of a cluster-rehearsal strategy by third grade students improved their task-specific metamemory. Taken together, these two studies serve to provide evidence for the previously alluded to interaction between metamemory and subsequent strategic behavior. Schneider and Pressley (1997) concur that one of the major motivations for research on metamemory is based on the theoretical idea that the relationship between knowing about memory and actual memory behavior is an important one. However, the authors also note that the correlation between these two phenomena is not perfect, and provide a number of possible explanations for the often noted failure of a

child with "intact" metamemory to behave strategically, which have been acknowledged in the investigations and discussions of other researchers. Some of these variables include the motivational and affective state of the learner (Short, 1992), time constraints on the task (Osman & Hannafin, 1992), and the learner's causal attributions about the task, including beliefs about the task difficulty, and the impact of effort (O'Sullivan, 1993; Weed, Ryan & Day, 1990). In spite of these considerations, however, efforts have been made to examine the available empirical evidence with respect to the metamemory-memory behavior relationship, this in the form of meta-analyses by Schneider (1985) and Schneider and Pressley (1989).

In an effort to resolve the conflicting views that emerged from earlier attempts to examine such relationships (e.g., Cavanaugh & Perlmutter, 1982; Wellman, 1983, both cited in Schneider, 1985), Schneider (1985) reported a preliminary meta-analysis of studies which contained data on metamemory-memory relationships by averaging the correlation coefficients from 27 publications (producing a total of 47 correlations). He reported an overall correlation of 0.41. Developments in meta-analytic methods led Schneider and Pressley (1989) to update the original meta-analysis, incorporating a total of 60 publications (123 correlations) and averaging over individual correlations that were weighted by the sample sizes that generated them. Again, the correlation coefficient was 0.41, thereby suggesting a statistical association between metamemory and memory (Schneider and Pressley, 1989). Qualitative examination of the studies contained in Schneider and Pressley's (1989) meta-analysis reveals four major approaches which focused on various aspects of metamemory/metacognition and resulting memory

performance. The first of these examined relationships between the ability to predict one's accuracy on an upcoming memory task and memory performance. Studies of this type generally supported a linkage between prediction accuracy and memory, with increasing correlations corresponding with increasing age for students in grade school. However, it was noted that such relationships appeared to be task specific (i.e., occurred in recall but not recognition tasks).

A second group of studies included by Schneider and Pressley (1989) examined relationships between knowing which items require additional study and memory performance. They found that adequate metamemory in this regard resulted in reliable memory improvements for students at college level only.

A third group of studies examined relationships between metacognition and text processing (i.e., comprehension and recall of what has been read). A particular focus of many of these studies was on the relationship between students' knowledge of the relative importance of information in text and later recall of text. Correlations in such studies ranged from low to moderate (i.e., 0.10 to 0.50) and appeared to suggest that knowledge of importance levels is more likely to direct the text processing of students in later rather than early middle grades (Schneider & Pressley, 1989).

A final group of studies presented by Schneider and Pressley (1989) examined relationships between metamemory, strategy use, and recall of categorizable materials, noting clear and reliable correlations between metamemory about organizational strategies, the use of semantic organizational strategies and memory performance, particularly for children in upper elementary grades.

The current findings must be considered in light of a number of methodological issues, including difficulties in the assessment of metamemory/metacognition. Schneider and Pressley (1997) describe a number of approaches that have been used to assess metamemory, making a distinction between measures that are taken without concurrent memory assessment (independent measures) and assessments of metamemory which are taken in conjunction with measures of memory activity (concurrent measures). These approaches to measurement have also been described in the literature as assessing general and task-specific metamemory (e.g., Short et al., 1993; Weed et al., 1990). Independent or general measures assess information a person has about his or her memory capacities, strategies, etc., and have taken the form of questionnaires and interviews. One of the difficulties associated with such approaches concerns the validity of self-reports and interview data. For example, Schneider and Pressley (1997) note that younger children may lack the verbal skills necessary to describe their knowledge about memory.

Concurrent or task-specific measures of metamemory assess awareness of ongoing processing and can be described as measures of monitoring. Asking children to make predictions and postdictions about memory performance, and assessing children's "feeling of knowing" about information to be remembered are both examples of such monitoring. Difficulties have been noted with this type of approach as well. For example, within the "feeling of knowing" paradigm, a child is shown a series of items and asked to name them. When unable to recall the name of an item, he or she is asked whether the name would be recognized if the experimenter provided it, with these ratings then related to subsequent performance on a recognition test. However, Schneider and Pressley (1997) note that this

particular paradigm may confound or confuse the subject with respect to the distinction between what he or she knows and does not know. The current study will seek to make use of both an independent measure (a metamemory battery designed to minimize verbal demands) and a concurrent measure (in the form of a strategy choice paradigm) of metamemory, in an attempt to examine the relationship between knowledge of memory and the subsequent implementation of this knowledge during an actual memory task.

In spite of the issues associated with the measurement of metamemory, both quantitative and qualitative review of data on metamemory-memory relationships appears to provide support for such relationships, although certainly these findings are complex. Schneider and Pressley (1997) note that the relationship between metamemory and strategic behavior appears to be more consistent, even when more general factors such as intelligence are taken into account. The relationship between metamemory and actual memory performance appears to be less consistent, perhaps because recall may be affected by factors other than strategy use (e.g., memory capacity, information-processing speed) (Schneider & Pressley, 1997). In addition, the learner's age (Henry & Norman, 1996; Schneider & Sodian, 1991), prior knowledge and experiences (Best, 1993), as well as unique characteristics of the task must be taken into consideration (Osman & Hannafin, 1992; Schneider, 1985). Overall, however, there does appear to be sufficient evidence to view metamemory as having a significant role in the strategic behavior and memory performance of nondisabled learners, and on this basis, as warranting investigation in children who may come to learning situations with fewer or less well-developed cognitive resources.

Metamemory in Children With Learning Disabilities

A number of researchers have suggested that children with learning disabilities resemble younger children with respect to their metamemory development (Loper, 1980; Pressley et al., 1985; Swanson, 1983; Swanson & Cooney, 1991; Torgeson, 1977b). They demonstrate poorer memory performance that is thought to be related to a less well-developed awareness of person, task, and strategy variables. In addition, they may be less likely to spontaneously employ memory strategies or to monitor memory performance.

Pressley, Scruggs, and Mastropieri (1989) observed that there has been little programmatic research on the spontaneous use of memory strategies by children with learning disabilities, with only a few strategies receiving substantial attention (e.g., rehearsal and categorization). The authors note that in spite of the lack of data with respect to actual strategy use by this population, the failure to use a simple strategy such as rehearsal has been taken as evidence of a more general failure by children with learning disabilities to use strategies, in what has been variously described as the production deficiency hypothesis (Pressley, Scruggs & Mastropieri, 1989; Swanson, 1983), the strategy-deficit model (Swanson, 1989) and the inactive learner hypothesis (Torgeson, 1977a; Short, 1992). What these descriptions share is the notion that children with learning disabilities may either fail to use effective strategies or fail to recognize the utility of a known strategy, often in spite of having the necessary cognitive competence to complete a given task (Short, 1992).

Research by Torgeson and colleagues has provided considerable support for the above hypotheses regarding the memory behaviors of children with learning disabilities.

Torgeson (1978) reviewed research that investigated the performance of good and poor readers of the same general intelligence on serial memory tasks. In addition to differentiating normal and reading disabled children on the basis of structural features of memory (e.g., information processing skills that are less likely to be under conscious control), Torgeson noted that children with reading disabilities are less likely than normally achieving children to demonstrate voluntary memorization activities or strategies.

For example, Torgeson and Goldman (1977) compared the performance of second grade children who were classified as good and poor readers on a sequential recall task for which verbal rehearsal had been shown to be an effective mnemonic strategy. Results indicated that the poor readers did not spontaneously use verbal rehearsal as a strategy to the same extent as good readers. However, following exposure to a task which required overt labeling of the items to be remembered, the poor readers demonstrated significant improvements in both amount of verbalization (rehearsal) and recall of the items.

A similar study by Torgeson (1977b) employed observational techniques to investigate the use of mnemonic strategies by fourth grade students identified as good and poor readers. Good and poor readers were noted to differ significantly with respect to their study behavior on two tasks which required the use of rehearsal and categorization, respectively. Poor readers failed to apply such strategies prior to specific instruction and demonstrated poorer recall than good readers.

More recent studies have expanded on the work of Torgeson and colleagues with respect to the metamemory of children with learning disabilities. Marfo and Ryan (1990) compared the performance of fourth grade children who were classified as average and

poor readers on metacognitive knowledge, strategic behavior, and recall. A series of metamemory tasks was administered which sought to assess: a) children's knowledge about the efficacy of elaboration as a memory strategy, b) planning behavior in preparation for future retrieval, c) systematic approaches to memory search for a past event, and d) whether or not children recognized the advantages of paraphrasing a story over learning it by rote (word for word) in order to recall it. Results from these measures indicated that average students demonstrated higher levels of metamemorial knowledge than did poor readers, even after the potential effects of verbal IQ differences had been covaried out. Another study by Short et al. (1993) compared elementary school students identified as average or low achieving on a number of variables, including general and task-specific metamemory. On measures of general metamemory, which included assessment of taxonomic knowledge about working memory and knowledge of strategies, average learners demonstrated higher scores than did low-achieving students. Task-specific metamemory was measured by the question "Did you do anything special to help yourself win the game?" following visual scanning and digit span tasks performed on computer. Results on these measures indicated that average learners also demonstrated greater task-specific metamemory than did low-achieving students.

Although evidence exists in support of the idea that children with learning disabilities experience difficulty with a number of information-processing components related to memory (see Swanson & Cooney, 1991 for a review), further support for the view that the memory deficits observed in such students is often due to their failure to behave strategically has come in the form of studies that have successfully implemented

strategy training with this population. Both Palincsar and Brown (1987) and Pressley et al. (1989) have reviewed research that describes improvements in the strategic behavior and memory performance of both normally-achieving children and children with learning disabilities by means of instruction that provides not only information about specific strategies, but metacognitive information about their appropriate use.

Pressley et al. (1989) reported on the work of Scruggs, Mastropieri, Levin and colleagues. These investigations differed from the "spontaneous use" studies previously described in that their explicit focus was on the instruction of adolescents with learning disabilities in the use of specific strategies. A number of studies conducted by this group examined the use of the keyword and pegword methods with various types of associative content, including hardness levels of minerals, English and foreign language vocabulary, chemical elements and their properties, and basic social studies content. Consistent results have been obtained in these studies, whereby students with learning disabilities receiving such instruction have realized higher levels of recall in comparison with teacher-led questioning and free-study approaches to remembering. In addition, students with learning disabilities have outperformed control subjects who did not receive such instruction.

Another strategy that has been demonstrated to improve recall in children with learning disabilities is known as elaborative interrogation and involves answering "why" questions about information to be learned. Again, Scruggs, Mastropieri and colleagues have been influential in investigating the use of this strategy by children with learning disabilities (e.g., Scruggs, Mastropieri, Sullivan & Hesser, 1993; Scruggs, Mastropieri &

Sullivan, 1994; Sullivan, Mastropieri & Scruggs, 1995), and have noted significant improvements in the recall by such children of reasons for dinosaur extinction, and facts about familiar animals. A study by Greene, Symons, and Richards (1996) examined the types of materials for which elaborative interrogation is most effective for children with learning disabilities, noting it to be particularly useful for materials which involve the presentation of arbitrary relationships.

Although the previously-described studies do not constitute an exhaustive review of the literature addressing strategy instruction with children with learning disabilities, they certainly serve as evidence that such students can be taught elaboration strategies and realize gains in learning as a result. As such, they also serve to underscore the view that the memory deficits often noted in children with learning disabilities may be related to inadequate metacognition about memory or metamemory. However, these studies also serve to illustrate a major methodological issue which concerns researchers in the area of learning disabilities, that being the problem of definition.

One of the more widely accepted definitions of learning disabilities has been that set out in U.S. Public Law 94-142, which states:

"Specific learning disability" means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage.

A close examination of the criteria by which students were identified as learning

disabled in the previously-cited studies reveals tremendous variability in subject selection methods. It is clear that the methods used by the authors of the studies reported herein resulted in the creation of groups of children who could be described as learning disabled in terms of the above definition. However, it is also evident that these groups differed substantially from one another (i.e., across studies) on a number of parameters which include the following: the types of tests used to measure reading achievement (many of which differ with respect to the aspects of reading which are sampled), the level of achievement used to designate "disabled" reading, and the tests used to determine normal or average levels of general intelligence. On this basis, it is apparent that the above studies have investigated memory functioning in potentially highly variable groups of children under the common heading of learning or reading disabilities.

Thus, while the previous paragraphs have presented a considerable amount of evidence that could be taken as support for the use of metamemorial training techniques with children with learning disabilities, both de Bettencourt (1987) and Shepherd et al. (1985) have observed that not all children broadly described as learning disabled can be accurately described as "production deficient" or "inactive learners". Consequently, the strategy training approaches currently in vogue (Garner, 1994; Palincsar & Brown, 1987) may not be suitable for all children with learning disabilities, and there exists a need to identify the subgroups within this population for whom such training is effective (de Bettencourt, 1987). A particularly striking example of this need emerges in the context of research and definitional efforts which have acknowledged the heterogeneous nature of learning disabilities, and the recent identification of a subgroup of children whose

difficulties lie primarily in the visuo-spatial or nonverbal realm (e.g., Rourke, 1989). To date, investigations of metamemory in children with learning disabilities have been marked by a paucity of research examining individual subtypes, and appear to have focused exclusively on children whose difficulties are manifested in verbal tasks such as reading. The current study will seek to address this issue by examining the metamemorial functioning of children who display deficits of a nonverbal nature and by comparing their performance with that of children whose difficulties are more evident in verbal domains.

Learning Disability Subtypes: Academic Achievement and Neuropsychological Approaches

In a chapter examining the historical evolution of the field of learning disabilities, Torgeson (1991) points out the relative infancy of this area of study by observing that the term "learning disabilities" was first proposed by Samuel Kirk at the Conference on Exploration into Problems of the Perceptually Handicapped Child in 1963. Torgeson (1991) reports that Kirk's initial use of the term encompassed children who had disorders in development of language, speech, reading, and associated communication skills needed for social interaction. Excluded were children with sensory handicaps and mental retardation. A little over thirty years later, researchers in the field continue to struggle with questions related to the basic nature of learning disabilities and the development of definitions which capture this "nature" accurately (Lyon, 1994; Torgeson, 1991).

In a recent volume devoted to the assessment of learning disabilities, Lyon (1994) highlighted the need for critical evaluation of the multitude of theories and taxonomic methodologies which have emerged, in order to develop a valid classification system for

learning disabilities. Ideally, such a system would elucidate both interrelationships with, and distinctions from, other childhood difficulties, within both a developmental and a sociological context. Implicit in work of Lyon (1994), and of key interest in the current discussion, is the notion that learning disabilities constitute a heterogeneous group of disorders.

Fisk and Rourke (1983) reported that early studies of children with learning disabilities were often characterized by one of two opposing viewpoints. The first of these viewpoints held that learning disabilities could be seen as a single entity with a unitary cause, thereby promoting comparisons between undifferentiated children with learning disabilities and normal children. The other viewpoint maintained that children with learning disabilities demonstrated highly unique, nongeneralizable manifestations of their afflictions, and on this basis held that the single case study was the only valid approach to understanding the difficulties of such children. Fisk and Rourke (1983) note that criticisms of both of these extreme viewpoints created the context within which the study of learning disability subtypes emerged. Researchers began to describe groups of children with learning disabilities who differed in terms of their response to treatment programmes. Further investigation of the cognitive strengths and weaknesses of these groups led to speculations and developments in the understanding of functional localization and hemispheric differentiation, thereby demonstrating the existence of homogeneous subtypes within the general, heterogeneous population of children with learning disabilities.

Torgeson (1991) notes that it is now commonplace to recognize that children with learning disabilities are a highly variable group, although this has had a number of

problematic implications for research with respect to comparison of findings between studies and investigations of the efficacy of remedial techniques (among other difficulties). A number of approaches have been used to identify and conceptualize, or "subtype" the range of disorders encompassed by the term "learning disabilities". Although a comprehensive review of the numerous methods and findings of learning disability subtype research is beyond the scope of the current discussion (see Hooper & Willis, 1989; Newby & Lyon, 1991; Rourke, 1985, for more complete descriptions of subtyping approaches), a brief sampling of such methods will be presented as a precursor to the focus of the current study.

Both Torgeson (1991) and Siegel and Heaven (1986) provide overviews of the various methods used to identify subgroups of learning disabilities, noting that such children have been classified in terms of their performance on behavioral, academic, neuropsychological, and cognitive tasks. For example, McKinney and colleagues (e.g., McKinney, 1989; McKinney & Feagans, 1983) have grouped children with learning disabilities on the basis of patterns of classroom behavior, which have included attention problems, conduct problems, withdrawn behavior, global behavior problems, and normal behavior patterns. Other studies have employed statistical techniques such as Q-factor or cluster analyses to identify children similar to one another in their performance on batteries of academic, cognitive, and neuropsychological tests. For example, Swanson (1988) employed such an approach in order to identify memory subtypes in children with reading disabilities. Siegel and Heaven (1986) report the research of both Lyon and Doehring and their colleagues, who have used similar techniques to identify subgroups of poor readers.

Other subtyping approaches have focused on qualitative rather than quantitative differences in children's learning performance, by examining in greater depth children's performance on specific academic tasks. For example, Boder (1973) examined children's reading/spelling patterns and identified three subgroups on the basis of children's abilities to develop phonetic skills, their use of sound/symbol integration, and their ability to read whole word visual gestalts (pattern recognition).

In a similar vein, the final subtyping approach to be noted in the current discussion involves the examination of groups of children who have been differentiated on the basis of their patterns of academic achievement, an endeavor which has subsequently led to the investigation of the neuropsychological implications of such patterns. A number of researchers have used the Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1965), to identify academic achievement subtypes reflecting specific disabilities in reading, spelling, and arithmetic (e.g., Brandys & Rourke, 1991; Fletcher, 1985; Rourke & Finlayson, 1978; Rourke & Strang, 1978; Siegel & Linder, 1984; Siegel & Ryan, 1988; Strang & Rourke, 1983). Similar patterns have also been identified using alternate measures of achievement (e.g., the Progressive Achievement Test, Elly & Reid, 1969; Reid & Hughes, 1974, both cited in Share et al., 1988 and White et al., 1992).

Of particular interest here are the efforts of Rourke and colleagues, whose subsequent neuropsychological investigations of academic subtypes have led to the development of a model which, in part, serves as the basis for the hypotheses of the current study. Investigations of academic achievement subtypes by Rourke and Finlayson (1978), Rourke and Strang (1978), and Strang and Rourke (1983) were stimulated by the

observation of unexpected patterns of WRAT reading, spelling, and arithmetic performance in the context of earlier investigations of the relevance of Verbal IQ - Performance IQ discrepancies in children with learning disabilities. The observation of three distinct achievement patterns on the WRAT led to a series of investigations which examined whether children exhibiting certain achievement patterns would also exhibit predictable patterns of neuropsychological features.

In the first investigation (Rourke & Finlayson, 1978), children with learning disabilities between the ages of 9 and 14 years were divided into three groups on the basis of their WRAT reading, spelling, and arithmetic scores. Group one was composed of subjects who were equally deficient in their reading, spelling, and arithmetic performance, and will hereafter be referred to as group R-S-A. The subjects in group two demonstrated arithmetic performance which was significantly better than their performances in reading and spelling, although still below age expectations. This group will be referred to as group R-S. Finally, the third group demonstrated normal reading and spelling and significantly impaired arithmetic performance. This group will be referred to as group A (NLD). It is important to note that all three groups performed significantly below what would be expected in terms of arithmetic performance for children their age. However, groups R-S and A (NLD) demonstrated superior performance in arithmetic relative to group R-S-A, and in fact, were equivalent to one another in terms of their impaired levels of arithmetic performance.

Comparison of the three groups' performance on 16 measures assessing various aspects of verbal and visual-spatial abilities yielded two particularly significant findings.

First, the subjects in groups R-S-A and R-S demonstrated performances superior to those in group A (NLD) on measures assessing visual-perceptual and visual-spatial abilities.

Second, the subjects in group A (NLD) showed superior performance on measures of verbal and auditory-perceptual abilities as compared to groups R-S-A and R-S.

Following this first study, Rourke and Strang (1978) attempted to determine whether the same three groups of children with learning disabilities would show differing patterns on a group of neuropsychological tests assessing motor, psychomotor, and tactile-perceptual skills. The purpose of this study was to investigate the hypothesis that the patterns demonstrated by these groups of children reflected differing manifestations of impairments in functional systems thought to be mediated by structures and systems within the left or right hemispheres. Rourke and Strang (1978) found that the children in group A (NLD) demonstrated significant deficiencies (i.e., below age expectations as per test norms) on some psychomotor and tactile-perceptual skills when compared with children in groups R-S-A and R-S, whose performances fell within normal limits.

In light of the findings of these two studies, Rourke and colleagues observed that the children in group R-S demonstrated significantly poorer performance with respect to skills that are thought to be mediated by the left hemisphere (i.e., verbal and auditory-perceptual abilities), and age-appropriate performance in terms of skills thought to be mediated by right hemisphere systems. Conversely, children in group A (NLD) appeared to demonstrate the opposite pattern of assets and deficits, with poorer performance noted in areas thought to be served by the right hemisphere.

The final study in this series (Strang & Rourke, 1983) investigated a new group of

children aged 9 to 14 years, who were divided into groups equivalent to groups R-S and A (NLD) in the previous two studies. This study sought to investigate the concept-formation and problem-solving abilities of these two groups of children with learning disabilities, and used the Halstead Category Test as a measure of nonverbal abstract reasoning, hypothesis-testing, and the ability to benefit from positive and negative informational feedback. Children in group A (NLD) were noted to make significantly more errors on the Category Test as compared to children in group R-S, whose performance was age appropriate. Of particular interest was the finding that children in group R-S significantly outperformed children in group A (NLD) on subtests requiring more complex visual-spatial analysis, and also on a subtest requiring memory for solutions which were successful on previous subtests. As such, this latter subtest provides a measure of children's ability to benefit from previous exposure to a task, a skill which is of interest in the current study.

In summary, the findings of the above three preliminary studies conducted by Rourke and colleagues served to identify two groups of children with learning disabilities who are of particular interest in the current study. The children in group R-S appear to demonstrate deficiencies in the areas of verbal and auditory-perceptual skills. The children in group A (NLD) appear to have difficulties in a wider realm, which includes psychomotor, tactile-perceptual, visual-perceptual-organizational, and concept formation abilities.

Since these initial investigations, both of these subtypes have been subject to extensive scrutiny, both by Rourke and colleagues and by independent researchers (e.g.,

Siegel & Linder, 1984; Share et al., 1988). The features of children in the A (NLD) group have been referred to as nonverbal learning disabilities, in order to distinguish them from the psycholinguistic or "verbal" difficulties noted in children in group R-S.

Rourke (1987; 1989; 1993; 1995) has provided a comprehensive description of the clinical manifestations of the nonverbal learning disability syndrome, which has been noted not only in children referred specifically for learning disabilities, but in children who demonstrate a wide range of developmental disabilities and neurological diseases (Rourke, 1995; Rourke & Tsatsanis, 1995). These manifestations include bilateral tactile-perceptual and psychomotor coordination deficits which are usually more evident on the left side of the body, outstanding deficiencies in visual-spatial-organizational abilities and outstanding relative deficiencies in mechanical arithmetic in the context of well-developed word recognition and spelling (Rourke, 1987; 1995). These children also demonstrate well-developed rote verbal capacities (including rote memory) in the context of language which may be lacking in appropriate and meaningful content. They appear to rely on language for the purpose of information gathering and relief from anxiety, as well as for social relating, but demonstrate limited verbal comprehension. These children also display significant deficits in social perception, judgement, and interaction skills and are thought to be at greater risk for disturbance in this realm (Rourke, 1987; 1995). Finally, and of particular interest in the current study, children who display the nonverbal learning disability syndrome exhibit significant deficits in nonverbal problem-solving, concept-formation, hypothesis-testing, and in the capacity to benefit from positive and negative informational feedback in novel or complex situations. Their difficulties in seeing cause-

and-effect relationships and their tendency to rely on rote or overlearned behaviors may produce inappropriate responses by these children in novel and complex situations (Rourke, 1987; 1995).

Nonverbal Learning Disabilities: The Model

Learning disabilities of a nonverbal nature were perhaps first reported by Johnson and Myklebust (1971), in their descriptions of a group of children who were unable to comprehend the significance of many nonverbal aspects of their environment in spite of average or above average verbal intelligence. In an attempt to explain this phenomenon, Rourke (1982; 1987; 1989) has developed and refined a model which attempts to link specific patterns of central processing abilities to their associated behavioral and academic manifestations.

Rourke's model has its basis in a theoretical position developed by Goldberg and Costa (1981), as well as some aspects of Piagetian developmental theory (Harnadek & Rourke, 1994). In a comprehensive review of cytoarchitectonic, neurophysiological, and neurobehavioral evidence, Goldberg and Costa (1981) have put forth the suggestion that the two hemispheres of the brain have different processing modes which are suited for different aspects of cognition. On the basis of the neuroanatomical finding that the right hemisphere appears to be larger and contains more white than gray matter than the left hemisphere, Goldberg and Costa (1981) have suggested that the right hemisphere has more association areas and is able to specialize in intermodal integration as a result of a greater number of interregional connections. The left hemisphere is thought to process by means of specific modality areas and is therefore geared toward integration between these

areas, as a result of having a greater number of intraregional connections. Goldberg and Costa (1981) describe a shift from right to left in terms of hemispheric processing of information, suggesting that the right hemisphere is best suited to processing novel and complex information which may come from a number of modalities, and constructing new descriptive systems which are then shared with the left hemisphere. The left hemisphere is thought to be best suited for the processing of unimodal stimuli and discrete motor acts, as well as analyzing and classifying stimuli into existing schemas or descriptive systems which have already been learned (e.g., natural language).

Rourke (1982; 1987; 1989) has extended the position of Goldberg and Costa (1981) (which was based primarily on investigations with adults) to account for certain patterns of central processing deficiencies in children, with particular emphasis on children who demonstrate deficient mechanical arithmetic performance in the context of normal word recognition and spelling skills. In light of the observation that this group of children demonstrates difficulties with problem-solving and concept-formation in novel situations, and appears to have difficulty benefitting from exposure to tasks or situations which deviate from their existing descriptive systems, Rourke has hypothesized that such children may demonstrate faulty right hemispherical systems, while at the same time exhibiting well-developed modality specific, routinized left hemispherical capacities (Rourke, 1987).

Support for such a conceptualization has come in the form of studies which have reported the features of the NLD syndrome in both adults (e.g., Weintraub & Mesulam, 1983) and children (e.g., Voeller, 1986) with known right hemispherical damage or

dysfunction. Also, as previously noted, the pattern of neuropsychological assets and deficits seen in children with both R-S and A (NLD) type learning disabilities is consistent with the notion of differential hemispheric impairment (Rourke, 1982). For example, in addition to the well-documented pattern of difficulties seen in group A (NLD) (e.g., Rourke & Finlayson, 1978; Rourke & Strang, 1983; Semrud-Clikeman & Hynd, 1990; Share et al., 1988; Strang & Rourke, 1983), the same body of research has revealed that children with R-S type learning disabilities also display a consistent pattern of assets and deficits. These children demonstrate deficits in language and related skills (which are thought to be mediated by the left hemisphere), but exhibit normal performance with respect to their skills in visual-spatial analysis, tactile-perceptual tasks, psychomotor coordination, and nonverbal problem-solving and concept-formation. Their ability to cope with novel situations, work with competing problem-solving strategies, and to benefit from and adapt to performance-related feedback suggests the presence of an intact and functional right hemisphere (Rourke, 1982; 1987; 1989).

Implications of the NLD Model for the Current Study

The model of neuropsychological functioning which Rourke has proposed to account for the behavioral and academic manifestations noted in children with R-S and A (NLD) type learning disabilities has important implications for the current study. Of particular interest is the idea that the right hemisphere is of central importance with respect to children's ability to deal with novel tasks or situations, as well as their ability to make use of informational feedback in the context of particular activities. Included within this realm of cognitive behavior is the use of strategies to deal with particular problems,

and the ability to assess or monitor the efficacy of these strategies based on performance outcomes. It is this very skill, in the specific area of memory (described in detail under the heading of metamemory) which is under investigation in the current study, and thus Rourke's (1982; 1987; 1989) model of hemispheric functioning will serve to guide hypothesis development in this area.

Another aspect of Rourke's theory which has significance for the current study incorporates aspects of Piaget's theory of child development (e.g., Piaget, 1954). Like many developmental theorists, Piaget held that the adequacy of a child's sensory-motor experience is of considerable importance with respect to the later development of concept-formation abilities and the ability to establish cause-and-effect relationships. Rourke (1989) suggests that, due to presumed right hemispheric deficiencies, this developmental stage may be compromised in children with type A (NLD) learning disabilities. This hypothesis is based on the idea that the exploratory behavior of these children (which is highly relevant to sensory-motor development) is expected to be less than adequate for a number of reasons. The possibilities include the presumed preference of such children for rote material and their subsequent avoidance of highly demanding novel situations, their difficulties with respect to essential psychomotor skills (e.g., climbing), and their noted preference for auditory rather than visual approaches to information processing (Rourke, 1989).

The early failure by children with type A (NLD) learning disabilities to explore and manipulate their environment has both direct and indirect implications within the current context. In a direct sense, the failure of this group of children to reap the benefits of the

sensory-motor stage of cognitive development may interfere with their attainment of formal operational thought and the higher cognitive processes which accompany this, such as strategic behavior. Indirectly, the impoverished early sensory-motor development of children who display deficiencies in right hemisphere functioning has a significant impact on their social behavior (Rourke, 1989), which has been linked by metacognitive theorists to the development of self-regulatory behavior such as performance monitoring. For example, Reeve and Brown (1985) and Wertsch (1979) have suggested that children may gain conscious control of their cognitive processing by means of the transition from other-regulation (e.g., parents and teachers) to self-regulation. Wertsch (1979) has observed that although the parent initially assumes most of the responsibility in joint problem-solving, as development proceeds, the child gradually assumes a greater portion of this responsibility. Implicit in Wertsch's (1979) position is the assumption that children engage in exploratory activity within their environment in order to encounter problem-solving situations, and also that they possess the social repertoire needed in order to be engaged by parents in such social interactions. Given that children with type A (NLD) learning disabilities may be deficient in both of these areas, it is not unreasonable to suggest that the metacognitive (and therefore metamemory) development of these children may be adversely affected.

The Present Study

The current investigation will attempt to address a gap which exists in terms of our understanding of the metamemory functioning of children with learning disabilities.

Literature in this area is notable for its failure to incorporate the idea of heterogeneity

within the learning disabled population. There is a paucity of research which reports direct investigations of metacognition in children with learning disabilities, and it appears that the issue of potential differences in metacognitive functioning among different subtypes of learning disabilities has yet to be empirically investigated.

The current study will compare the performance of children demonstrating several subtypes of learning disabilities (as well as normally achieving children) on both a general metamemory battery and a more direct, on-line task which will provide an assessment of the ability to acquire new strategies, to monitor their effectiveness in the context of a memory task, and to transfer this strategy when presented with a different situation in which its use is also appropriate. The composition of the groups included in the study will attempt to address several methodological issues which have been noted in previous studies of learning disability subtypes. Share et al. (1988) noted that restricting investigations to differences within populations of children with learning disabilities may obscure important information about the appearance of children with learning disabilities relative to their nondisabled counterparts. For example, in studies which have compared learning disabled groups to normative data on a number of measures, Rourke and colleagues have observed that children with R-S type disabilities demonstrate verbal deficits, while children with type A (NLD) disabilities show deficits in nonverbal areas. However, a similar investigation by Share et al. (1988) which included a nondisabled control group found that those areas considered to be strengths in the learning disabled groups (i.e., verbal skills for children with type A disabilities) were nonetheless below the performance levels of the nondisabled students and therefore may have contributed to the

overall difficulties of these children. In light of these findings, the current study will include a group of children who demonstrate normal achievement.

Also under investigation in the current study are two different subtypes of learning disabilities: reading disabilities and arithmetic disabilities (as manifested in the NLD syndrome). Although historically, efforts to define learning disabilities have focused on the notion of a discrepancy between students' intellectual ability and their expected achievement (Kavale, Forness, & Lorschach, 1991; Lyon, 1987; Swanson, 1991), critics of this approach have identified a number of concerns with respect to the methods used to operationalize the concept (e.g., Kavale, 1987; Siegel, 1988b; 1989; Stanovich, 1991).

For example, Siegel (1989) has examined problems associated with the use of IQ tests as measures of intelligence and subsequent potential. Implicit in discrepancy definitions of learning disabilities is the notion that intelligence can be measured independently of academic achievement. However, close inspection of IQ tests such as the Wechsler Intelligence Scale for Children - Revised (WISC-R) reveals that scores are dependent upon, among other things, specific knowledge, expressive language and vocabulary, memory, and fine motor skills, and thus may be affected by specific deficits in any one or more of these areas (Siegel, 1989). For example, evidence suggests that students who have reading difficulties may have less experience with print (Stanovich, 1986b). It follows that these students may have less well-developed vocabularies and may thus obtain lower scores on this subtest of the WISC-R that are more reflective of actual achievement than "potential".

Other concerns have also been identified. Siegel (1988b) reported data indicating

that actual reading skill predicted students' performance on a number of cognitive tasks much more strongly than did IQ, while Stanovich (1991) reported that there is a paucity of data indicating that discrepancy-defined poor readers respond differently to educational treatments than do "garden-variety" poor readers. Swanson (1991) has further noted that intercorrelational patterns between IQ and achievement measures are not distinct between ability groups, and also that discrepancy definitions have been questioned in terms of the statistical techniques used in their calculation.

Although the majority of data used as evidence of problems with discrepancy definitions of learning disabilities appears to come from the study of reading difficulties, it seems logical that the same arguments should apply to other specific learning disabilities (Siegel, 1989). Therefore, for the purposes of the current study, academic achievement data will be used to identify three groups of students with specific learning disabilities in the areas of: 1) reading (as in the R-S type); 2) arithmetic (as in the syndrome of nonverbal learning disabilities); and 3) both reading and arithmetic.

The model of neuropsychological functioning suggested by Rourke (1982; 1987; 1989), as well as extensions of this theory into the area of memory functioning in learning disability subtypes by Rourke and Tsatsanis (1995) serve as the basis for the following hypotheses:

Hypothesis 1

General metamemorial knowledge. Rourke and Tsatsanis (1995) state that children with type A (NLD) learning disabilities frequently demonstrate difficulties in perceiving how a particular strategy or concept may apply to several different situations or

topics. This description appears to stress a more general deficit in metacognitive knowledge in comparison with the more specific deficits in metacognitive knowledge about reading which they infer for children with R-S type disabilities. This idea is consistent with previously presented research attesting to the deficits in higher cognitive functioning (under which metacognition and metamemory can be subsumed) which may result from the inadequate sensory-motor and subsequent social development that children with this particular type of learning disability exhibit. On this basis, it is hypothesized that students demonstrating relative difficulties in arithmetic (as evident in the NLD syndrome) will have lower levels of general metamemorial knowledge than will students demonstrating difficulties in reading (as evident in students with R-S type disabilities). Further, it is expected that students who demonstrate difficulties in both arithmetic and reading will have the lowest levels of general metamemorial knowledge, while students who demonstrate difficulty in neither of these areas (i.e., normally achieving students) will have the highest levels of general metamemorial knowledge.

Hypothesis 2

Acquisition and application of elaborative interrogation. Recent studies have confirmed the ability of children with reading disabilities (i.e., resembling the R-S type) to learn and benefit from a strategy known as elaborative interrogation. This strategy involves answering "why" questions about information to be learned. It is thought that by providing an elaboration or explanation for the presented fact (e.g., The fat man got into the car. Why? The fat man got into the car to go to the restaurant.), students are able to encode the information in a more semantically appropriate or meaningful form (possibly by

integrating it with their prior knowledge on that topic). Such skills are consistent with Rourke's suggestion that children with R-S type learning disabilities have intact right hemisphere functioning, which is thought to mediate the development of such skills.

The second hypothesis is presented in light of the presumed deficits in right hemisphere functioning which characterize children with type A (NLD) learning disabilities, as well as more specific observations by Rourke and Tsatsanis (1995) that, in spite of possessing at least average rote verbal memory, such children have difficulties in dealing with novel tasks and in understanding and utilizing meaningful verbal and nonverbal content as a memory aid (the presumed basis of elaborative interrogation and most memory strategies). Thus, it is hypothesized that students demonstrating relative difficulties in arithmetic (as evident in the NLD syndrome) will be less successful in both a) acquiring and b) applying the elaborative interrogation strategy than students demonstrating difficulties in reading (as evident in R-S type disabilities). Further, it is expected that students who demonstrate difficulties in both arithmetic and reading will have the greatest difficulty acquiring and applying the strategy, while students who show difficulty in neither arithmetic or reading (i.e., normally achieving students) will be most successful with respect to these two tasks.

Hypothesis 3

Memory monitoring and strategy transfer. On the basis of previously stated evidence, it is further hypothesized that students demonstrating difficulties in arithmetic will be less likely to 1) demonstrate accurate memory monitoring during the on-line task and 2) demonstrate successful strategy transfer than will students demonstrating

difficulties in reading. Further, it is expected that students who demonstrate difficulties in both arithmetic and reading will be least likely to demonstrate accurate memory monitoring and successful strategy transfer, while students who perform within the average range with respect to both arithmetic and reading will be most likely to demonstrate these skills.

CHAPTER II

METHOD

Participants

The participants were 74 children ranging in age from 10 years 7 months to 14 years 8 months. Four groups of subjects were identified, with the first group consisting of 22 children recruited from a Southwestern Ontario school board on the basis of performance within the average range on the reading and arithmetic subtests of the WRAT-R (Wide Range Achievement Test-Revised, Jastak & Wilkinson, 1984). Performance in the average range was designated by individual arithmetic and reading standard scores equal to or greater than 80, with a discrepancy of less than 15 points between the two scores. These children were referred to as group NORM, for normally achieving.

The second group of participants was composed of 15 students who were identified by means of academic achievement data as meeting the criteria for reading disabilities and was referred to as group RLD. These students were identified on the basis of having standard scores on the WRAT-R reading subtest that were 15 or more points less than their standard scores on the arithmetic subtest (consistent with the academic achievement discrepancy criteria suggested by Casey et al. (1991); Rourke, personal communication, 1996). These students were referred for the current study on the basis that they had received psychological assessments and had been identified either by their school or agency as meeting criteria for a specific learning disability.

The third group was composed of 26 students who were identified as having a

nonverbal learning disability on the basis of academic achievement data. These students were referred to as group NLD and were identified on the basis of having standard scores on the WRAT-R arithmetic subtest that were 15 or more points less than their WRAT-R reading standard scores (consistent with academic achievement discrepancy criteria suggested by Casey et al. (1991); Rourke, personal communication, 1996). Within the NLD group was a subset of 10 students who had each been identified by a neuropsychologist as having a nonverbal learning disability prior to the current investigation. These students had received the diagnosis on the basis of meeting most or all of the criteria outlined by Casey et al. (1991):

- 1) Bilateral tactile perceptual deficits (performance on measures of finger agnosia, dysgraphesthesia, or astereognosis 1 SD or more below the norm).
- 2) Bilateral psychomotor deficiencies (performance on the Grooved Pegboard Test 1 sd or more below the norm).
- 3) Visuo-spatial/organizational deficiencies (performance on the Target Test 1 SD below the norm and Verbal IQ > Performance IQ by 10 or more standard score points).
- 4) Good verbal capacities (Verbal IQ > 79 and performance on either the Speech Sounds Perception Test or the Auditory Closure Test no less than or equal to 1 SD below the norm).
- 5) Mechanical arithmetic deficiencies (performance on the WRAT-R Reading and Spelling subtests exceeding that of the WRAT-R Arithmetic subtest by 10 or more standard score points).

These students were notable in that all but one achieved WRAT-R arithmetic

standard scores that were at least 30 points less than their WRAT-R reading standard scores. Given the likelihood that these 10 students demonstrated a more severe manifestation of the nonverbal learning disability syndrome, analyses were also conducted to compare their performance with that of the remaining 16 students in the NLD group, as well as on the NLD group as a whole. The ten students identified by neuropsychologists as having the NLD syndrome were referred to as group NLD1, and the remaining 16 students were referred to as group NLD2.

The fourth and final group consisted of 11 students whose WRAT-R reading and arithmetic scores both fell within the borderline range (both standard scores less than 80) and who demonstrated a discrepancy of less than 15 points between the two scores. This group was identified during the process of screening students with possible reading disabilities and was referred to as group GLD, for general learning disabilities. According to their school records, these students were not documented as having global learning difficulties, but rather one or more specific learning disabilities.

Participants in the latter three groups were recruited from the Regional Children's Centre (RCC, Neurodevelopment Department), the Children's Achievement Centre (CAC), the private practice of a local neuropsychologist, the Windsor Public School Board, and through the Learning Disabilities Association of Mississauga (see Appendices A through C for the consent forms used at these sites, and Table 1 for group demographics).

Materials

The metamemory battery developed by Belmont and Borkowski (1988) was used

Table 1

Means and Standard Deviations for Age and WRAT-R Arithmetic and Reading Scores by**Group**

Group	N	Mean Age	Mean WRAT-R Arithmetic	Mean WRAT-R Reading
NORM	22	159.64 (7.27)	94.68 (11.42)	98.68 (12.63)
RLD	15	156.53 (14.80)	93.80 (18.17)	71.27 (15.36)
GLD	11	158.18 (12.10)	71.36 (4.90)	66.64 (6.93)
NLD Combined	26	154.58 (9.28)	77.69 (17.76)	102.38 (18.34)
NLD 1	10	152.20 (12.93)	69.60 (13.21)	103.80 (16.52)
NLD 2	16	156.06 (6.09)	82.75 (18.71)	101.50 (19.87)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. GLD refers to students with both arithmetic and reading difficulties. NLD refers to students with arithmetic difficulties. NLD1 refers to students identified by neuropsychological assessment as having the syndrome of nonverbal learning disabilities. NLD2 refers to students whose academic achievement patterns are consistent with those observed in the syndrome of nonverbal learning disabilities. Age scores are in months. WRAT-R arithmetic and reading scores are standard scores. Scores in parentheses are standard deviations.

in the first session to provide a general measure of children's knowledge about memory. Three of the five subtests included on this measure are based on portions of the individually administered tasks developed by Kreutzer et al. (1975) and Kurtz, Reid, Borkowski, and Cavanaugh (1982), while the remaining two are based on laboratory studies of memory strategy development conducted by the authors.

The first subtest is called Memory Estimation and is designed to provide an estimate of the student's ability to judge his or her own memory capacity. First, the student is presented with a list of 15 words and is asked to predict how many of the words he or she would be able to recall if given one minute to study the list. Later in the session, the student is given the same list of 15 words and one minute to memorize the list. He or she is then asked to recall, within one minute, as many of the words on the list as possible. A final list of 15 words is presented at the end of the session and students are again asked to predict their recall of the list. A score is created based on the weighted combination of the relationship between the first predicted recall and the student's actual recall, and the second predicted recall and the student's actual recall.

The Organized List is the second subtest and is made up of three pairs of lists which are designed to assess whether or not students understand that categorical organization aids in memory. Within each pair, one list is made up of between six and nine words which can be placed into between one and three categories. The second list in each pair is composed of between five and eight words which cannot be easily categorized. For each pair, students are asked to mark the one which would be easier to memorize, with two points given for each of the three lists marked correctly.

The third subtest is called the Preparation Object and consists of a single question that assesses students' ability to understand a memory problem and to generate appropriate strategies for its solution. Students are asked to write down as many (up to seven) different methods as possible that could be used some evening in order to help them remember to bring a pair of skates to school the next morning. Each method is then assigned to a class (e.g., external aid, passive: write a note; external aid, active: set an alarm clock to go off just before I leave). Students can achieve a maximum of eight points, including a) one point for each different class used (up to a maximum of seven points), b) one bonus point if more than three different classes are used (a maximum of one point), and c) one bonus point for each different class that is used more than once (up to a maximum of three points). For example, a participant who uses all seven classes receives seven points under a), and one bonus point under b), but no bonus points under c), for a total of eight points. A participant who uses six different classes, but uses one of those on two occasions, would receive six points under a), one point under b) and one point under c), also for a total of eight points.

The fourth subtest, Study Time for Paired Associates, involves the presentation of two sets of four pairs of related (e.g., shoe-foot) or unrelated (e.g., doll-tree) words. This subtest requires students to allocate study time for each of the pairs, in order to investigate whether or not students understand the increased mnemonic associations (which would therefore require less study time) between words that are related in comparison with words that are not. Students can allocate study time in three ways, including allowing equal study time for related and unrelated pairs, allowing a greater amount of time for

unrelated word pairs, and allowing a greater amount of time for related pairs. Combinations of these allocation approaches serve to provide the score for this subtest, and students can achieve a maximum of six points if they assign a greater amount of study time to unrelated rather than related pairs.

The fifth and final subtest, Study Time for Circular Recall, requires students to determine the appropriate amount of study time for a string of six words, in order that they may recall those words in a circular order. Students are presented with two sets of six words. For the first set, they are instructed to remember the list so that the words presented in the fourth, fifth and sixth positions can be recalled first, and then the words presented in the first, second and third positions. Students are further instructed that they can allocate study time for these triplets in one of three ways: equal time for the two sets, a greater amount of time for the second set (the words in the fourth, fifth, and sixth positions), or a greater amount of time for the first set (the words in the first, second and third positions). It is thought that this final approach represents the most efficient method, and scoring is conducted in the same manner as for the Study Time for Paired Associates subtest.

In an effort to determine the reliability of this metamemory battery, Belmont and Borkowski (1988) administered the test to 24 children in third grade, and 20 children in fifth grade. They noted that the battery appears to be sensitive to age, given that fifth graders scored higher in their memory knowledge than third graders on each of the subtests. Belmont and Borkowski (1988) reported a test-retest reliability of .69 for third graders and .61 for fifth graders, with an overall test-retest reliability of .66 for the battery.

They also noted a correlation of .65 between fifth graders' composite scores on the metamemory battery and their scores on the Cognitive Abilities Test. Finally, Belmont and Borkowski (1988) found weak correlations among the subtests, a finding that was consistent with correlations among individually administered metamemory items (e.g., Cavanaugh & Perlmutter, 1982) and suggests that metamemory may be better thought of as task-specific knowledge rather than as a broader dimension (e.g., intelligence).

Geary, Klosterman, and Adrales (1990) attempted to provide an independent assessment of the validity of Belmont and Borkowski's (1988) metamemory battery by administering it to a group of second grade children and a group of fourth grade children. Both of these groups contained both normally achieving children and children identified as having learning disabilities in the area of reading, mathematics, or both. Consistent with the findings of Belmont and Borkowski (1988), Geary et al. (1990) found significant age-related performance differences on four of the five subtests, with the exception being the Study Time for Circular Recall task. In light of this finding, and the questionable relevance of that particular subtest for the current study, it was dropped from the current administration of the metamemory battery.

Geary et al. (1990) also noted that the metamemory battery may be better suited for children in the older age group, as three of the four performance differences appeared to be due to a floor effect, whereby second graders performed at chance levels for all but one of the subtests. They noted modest correlations between scores on the metamemory subtests and academic achievement test scores, the magnitude of which were consistent with the empirical relationship which has been demonstrated between metamemory and

memory performance (Schneider, 1985). Finally, for the fourth graders, significant group differences (between normal children and children with reading and/or mathematics learning disabilities) were noted for two of the five subtests (Organized List and Study Time for Paired Associates) and for the overall battery score, providing preliminary evidence for the ability of the metamemory battery to discriminate between academically normal children and children who are presumed to have metacognitive deficits.

The fact lists used in the second experimental session were composed of sentences that have been used in the literature examining the effects of elaborative interrogation on recall (e.g., Pressley, Symons, McDaniel, Snyder, & Turnure, 1988; Wood, Pressley & Winne, 1990). These lists can be found in Appendix D and contain words that do not exceed the grade four level according to the Cheek Master Word List (Collins-Cheek & Cheek, 1984). The items consist of arbitrary pairings of subjects and predicates (e.g., The tall man bought the crackers), which consequently may be difficult to learn. A number of studies (e.g., Greene et al., 1996; Pressley et al., 1988; Wood et al., 1990) have investigated the use of the cognitive strategy known as elaborative interrogation with these sentences, whereby students are asked to answer a "why" question about the information presented (e.g., The tall man bought the crackers. Why?). It is thought that by answering the question "why", students provide or clarify the relationship between the subject and predicate, thereby making the fact more meaningful and easier to remember (e.g., The tall man bought the crackers that were on the top shelf). Elaborative interrogation has consistently been shown to improve recall of such facts, both in normally achieving children (Wood et al., 1990) and children with reading disabilities (Greene et al.,

1996). The man sentences are unique in that they require a minimum of prior knowledge on the part of the learner, a feature on which the groups in the current study may have differed. On this basis, these materials seemed appropriate for use in the current study.

The facts presented in the third experimental session included both a list of "man sentences" at the same reading level as those used in the second session, as well as a list of facts designed to examine whether or not students would transfer the use of elaborative interrogation to another task for which it would be appropriate (this list can be found in Appendix E). This second list was composed of facts about unfamiliar animals (e.g., The American pika likes to live in and around rock piles), again in an attempt to account for the possibility that some students may have a more well-developed knowledge base about more familiar animals, which might have given them an advantage in terms of strategy use and recall (e.g., see Schneider & Bjorklund, 1992; Schneider, Korkel, & Weinert, 1989 for a review of these issues). Both normally achieving children (Wood et al., 1990) and children with reading disabilities (Greene et al., 1996; Scruggs et al., 1994; Sullivan et al., 1995) have been observed to realize improved recall by using elaborative interrogation with such content materials.

Procedure

The first session of the experiment consisted of administration of the metamemory battery (Belmont & Borkowski, 1988) in order to gain a general measurement of children's metamemory (see Appendix F for session script). Where possible, group administrations were conducted at the sites from which students were recruited (e.g., the school board, CAC).

The second session of the current study was based on the experimental task (see Appendix F for session script). Students were seen at the site from which they were recruited, and participated in a one-on-one session with the experimenter. All students participated in the same procedure.

Students were told that they would be asked to learn facts about the activities of different types of men during the session (i.e., the previously described "man sentences"). Both the rehearsal and elaborative interrogation strategies were explained to them, with half of them learning about the rehearsal approach first and half of them learning about the elaborative interrogation approach first. All students received explanation and demonstration of both strategies by the experimenter and were given the opportunity to practice both strategies with corrective feedback until they were able to demonstrate successful use of both approaches.

In the rehearsal condition, students were instructed to repeat the facts in order to remember them, while in the elaborative interrogation condition, they were instructed to ask themselves why the presented fact might be true or makes sense, and to verbalize their elaboration or explanation. In the rehearsal condition, the number of times the student was able to repeat each sentence was recorded, while in the elaborative interrogation condition, the student's explanation was recorded. In both conditions, sentences were presented at 20-second intervals. The time required for each student to achieve mastery of the elaborative interrogation strategy was monitored.

For each practice session, students were told that their task was to learn the activities associated with each type of man so that they would be able to recall them when

presented with the question "Which man (e.g., went to the store)?" After receiving instruction in rehearsal, they were then given a list of facts to learn about different types of men, and were asked to use rehearsal to learn them in preparation for the recall test which followed almost immediately after (allowing for a short interview of approximately one minute to prevent a recency effect). The same procedure was followed after students had received instruction in elaborative interrogation. The order in which students were instructed in, allowed to practice, and tested on the two strategies (i.e., rehearsal before elaborative interrogation versus elaborative interrogation before rehearsal) was counterbalanced within each experimental group in order to control for the possibility of an order effect. The researcher recorded any occasions in which a student did not repeat a fact or create an elaboration for it.

For both strategies, after all of the "man sentences" were presented, students were tested for recall of the activities of each man. Students' recall was assessed by the experimenter by means of the question, "Which man (e.g., went to the store)?" This question was asked for each of the different men in a different random order than on the study trial.

After the practice sessions and testing for both strategies, students were instructed that another list of facts would be presented for study and that one of the methods just practiced could be used to learn it. After students had chosen their strategy, they were asked to predict how many facts they would be able to remember using that method of remembering. Students were then given the list of sentences to be learned and reminded to use the strategy they had selected to learn each fact. The facts were presented and tested

in the same manner described earlier and students were asked to predict how many facts they thought they had gotten correct, as well as questions designed to investigate the reasons for their strategy choice.

A third and final session was conducted approximately one week later (see Appendix F for session script). This procedure essentially mirrored that used in the second session, with the exception that a different type of materials (i.e., facts about animals) was used to investigate possible transfer of the elaborative interrogation strategy by students. Students were reminded of both of the strategies that they practiced a week previously, and were given the opportunity to practice them again with experimenter feedback. They were then presented with another list of "man sentences" and instructed to choose one of the two strategies in order to examine the effect of time on strategy choice. Recall was tested in the same manner as in the second session.

Following this, students were presented with a list of facts about unfamiliar animals and told that their task was to learn the facts so that they could recall them when presented with the question "Which animal.....(e.g., never builds a nest)" Students were then given approximately one minute to examine the material in order to think about an appropriate strategy choice. They were again asked to choose one of the strategies to use in order to learn the animal facts and to predict how many facts they would be able to remember using the method they had chosen. Students then practiced each sentence using the method they had chosen and were tested on the items in random order following a one minute interview as in the second experimental session. Following the recall test, students were asked how many they thought they had gotten correct, as well as whether or not they

felt they had selected the best strategy for the task (see Figure 1 for a summary of the experimental procedure).

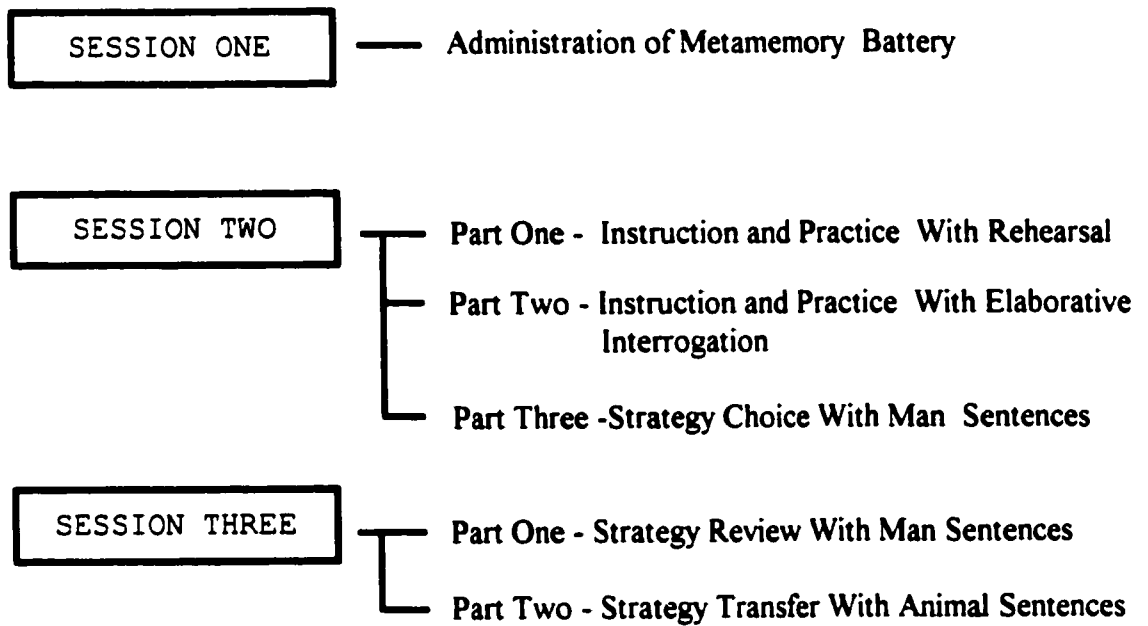


Figure 1. Summary of Experimental Procedure

CHAPTER III

RESULTS

Hypothesis 1

General metamemorial knowledge. It was expected that students with relative difficulties in arithmetic (as in the NLD group) would have lower levels of general metamemorial knowledge than would students with relative difficulties in reading (as in the RLD group). Students with difficulties in both arithmetic and reading (as in the GLD group) were expected to demonstrate the lowest levels of metamemorial knowledge, while normally achieving students were expected to have the highest scores on this measure.

Prior to analysis, the total metamemory battery score as well as the four subtest scores were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of their respective analyses. Boxplots were constructed for each group on all variables, and outliers were identified as those values that fell at least 1.5 hinge spreads outside the hinges (25th and 75th percentiles) of the box. One outlier was identified in the Memory Estimation subtest. As deleting the outlier did not alter the results of the statistical test, it was retained in the analysis. An outlier was also identified in the Preparation Object subtest. As the presence of this outlier did affect the results of the statistical test, it was deleted from the analysis.

In order to examine the hypotheses concerning general metamemory (as measured in the first experimental session), a one-way ANOVA was conducted on the group scores for the Metamemory Battery total. There was a significant effect of group on the total scores ($F(3,73) = 10.71, p < .001$) and post hoc Bonferroni comparisons between all

groups revealed that normally achieving students showed evidence of significantly higher levels of metamemorial knowledge than did students in the NLD, RLD, and GLD groups ($p < .05$). The three learning disabled groups did not differ significantly from each other with respect to metamemorial knowledge (see Table 2 for group means and standard deviations). A t -test conducted on the Total Metamemory Battery scores for the two subsets of the NLD group was not significant ($t(24) = -.483, p > .10$). [Note. T -tests were conducted on the scores for the two subsets of the NLD group on all variables that were subject to analysis of variance. As all t -tests conducted on these scores were nonsignificant, the two subsets were combined for all subsequent comparisons]. In order to examine the relative impact of both arithmetic and reading difficulties, a 2 (presence or absence of difficulties in arithmetic) by 2 (presence or absence of difficulties in reading) ANOVA was conducted on the Total Metamemory Battery scores. Significant main effects were noted for both arithmetic difficulties ($F(1,73) = 13.31, p < .001$) and reading difficulties ($F(1,73) = 18.50, p < .001$), with no interaction effect noted ($F(1,73) = .41, p > .50$). The ANOVA was also run with age as a covariate and age was not a significant covariate.

Further analyses were conducted in order to examine the relative impact of arithmetic and reading difficulties on the individual subtest scores. As with the Total Metamemory Battery scores, a 2 (arithmetic) by 2 (reading) ANOVA was conducted on the scores for the Memory Estimation subtest. A significant main effect was noted for reading difficulties ($F(1,73) = 21.39, p < .001$), but not arithmetic difficulties ($F(1,73) = 1.61, p > .20$). No interaction effect was noted ($F(1,73) = 10.69, p > .20$) (see Table 2

Table 2

Means and Standard Deviations for Metamemory Battery Subtests by Group

Group	Subtest				
	Memory Estimation	Organized List	Preparation Object	Paired Associates	Total
NORM <u>M</u> (SD)	6.99 (1.68)	3.73 (2.25)	4.86 (1.49)	5.14 (1.70)	20.76 _a (3.80)
RLD <u>M</u> (SD)	3.20 (2.70)	3.33 (1.45)	4.20 (1.61)	3.73 (2.25)	14.47 _b (5.73)
NLD <u>M</u> (SD)	5.37 (2.83)	3.08 (1.90)	3.38 (1.42)	3.46 (2.21)	15.30 _b (5.27)
GLD <u>M</u> (SD)	3.19 (3.48)	1.45 (1.57)	2.73 (1.35)	3.27 (2.24)	10.64 _b (6.30)

Note. NORM refers to students in the normally achieving group. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both arithmetic and reading. Scores in parentheses are standard deviations. Means within the Total column that do not share subscripts differ at $p < .05$ based on post hoc Bonferroni comparisons.

for group means). The 2x2 ANOVA was also conducted on the scores for the Preparation Object subtest. Significant main effects were noted for both arithmetic difficulties ($F(1,72) = 14.82, p < .001$) and reading difficulties ($F(1,72) = 5.23, p < .05$), with no interaction effect noted ($F(1,72) = .16, p > .60$) (see Table 2 for group means).

In light of the fact that the scores for the remaining two subtests were not continuously distributed (e.g., possible scores on the Paired Associates subtest were 0, 1, 2, 4, and 6, while possible scores on the Organized List subtest were 0, 2, 4, and 6), an ordinal measure of association, gamma, was used to examine the relative impact of arithmetic and reading difficulties on these subtests (Siegel & Castellan, 1988). For the Paired Associates subtest, scores were ordered from zero to six and on the basis of the hypothesized direction of performance, groups were ordered from lowest to highest in the following manner: 1) GLD, 2) NLD, 3) RLD, and 4) NORM. A significant gamma was obtained ($G = .403, p < .01$), suggesting the presence of an association between the magnitude of the subtest scores and the degree of learning difficulty as measured by arithmetic and reading scores. That is, higher scores on the subtest were more likely to be earned by students with less severe or no apparent learning difficulties (see Table 2 for group means). The gamma was also computed after ordering the groups as follows: 1) GLD, 2) RLD, 3) NLD, 4) NORM. Both the magnitude of the gamma statistic and the significance level were smaller than those obtained when groups were ordered according to the hypothesized direction.

In order to examine the impact of reading difficulties alone on the Paired Associates subtest, scores were again ordered from zero to six, and groups were ordered

according to the presence or absence of reading difficulties: 1 - yes (groups RLD and GLD) and 2 - no (groups NORM and NLD). The gamma statistic was not significant ($G = .239, p > .20$), indicating no association between reading difficulties and the magnitude of subtest scores. The same procedure was conducted in order to examine the impact of arithmetic difficulties, with groups ordered according to the presence or absence of arithmetic difficulties: 1 - yes (groups NLD and GLD) and 2 - no (groups NORM and RLD). The gamma statistic was significant ($G = .446, p < .05$), suggesting a positive association between the presence of difficulties with arithmetic and subtest scores. That is, lower subtest scores were more likely to be achieved by students with arithmetic difficulties.

The same ordinal measures were computed for the scores on the Organized List subtest. Scores were ordered from zero to six, and again groups were ordered from lowest to highest in the following manner: 1) GLD, 2) NLD, 3) RLD, and 4) NORM. A significant gamma was obtained ($G = .369, p < .01$), suggesting an association between the magnitude of the subtest scores and the degree of learning difficulty as measured by reading and arithmetic scores. That is, higher scores on the subtest were more likely to be earned by students with less severe learning difficulties (see Table 2 for group means). As with the Paired Associates subtest, the gamma was also computed with the RLD and NLD groups assigned in the opposite order. Again, both the magnitude of the gamma statistic and the significance level were smaller than those obtained when groups were ordered in the hypothesized direction.

To examine the impact of reading difficulties on performance on the Organized

List subtest, scores were again ordered from zero to six, and groups were ordered according to the presence or absence of reading difficulties: 1 - yes (groups RLD and GLD) and 2 - no (groups NORM and NLD). A significant gamma was not obtained ($\Gamma = .305, p > .07$), indicating no association between reading difficulties and the magnitude of subtest scores. The same procedure was conducted to examine the impact of arithmetic difficulties on the Organized List subtest scores, with groups ordered according to the presence or absence of arithmetic difficulties: 1 - yes (groups NLD and GLD) and 2 - no (groups NORM and RLD). A significant gamma was obtained ($\Gamma = .363, p < .05$), suggesting a positive association between the presence of difficulties with arithmetic and subtest scores. That is, lower subtest scores were more likely to be earned by students with arithmetic difficulties.

In examining each of the subtest scores, it was noted that students with reading difficulties obtained higher scores than did students with arithmetic difficulties on all subtests except Memory Estimation. The Memory Estimation subtest involved a rote memory activity, and thus was a task on which students in the NLD group could be expected to perform with greater success in view of their presumed neuropsychological and academic assets and deficits (Rourke & Tsatsanis, 1995). Accordingly, the Metamemory Battery Total score was re-computed without the Memory Estimation subtest score, in order to determine whether this subtest was responsible for the finding that students in the NLD group obtained higher Total scores than did students in the RLD group. A one-way ANOVA conducted on group Total Metamemory Battery scores was again significant ($F(3,73) = 7.96, p < .001$), and post hoc Bonferroni comparisons

revealed that normally achieving students demonstrated significantly greater metamemorial knowledge than did students in the NLD and GLD groups ($p < .05$), but did not score significantly higher than did students in the RLD group. In contrast with the initial Metamemory Battery Total scores (containing Memory Estimation), group means for the Total score without the Memory Estimation subtest were reversed for the RLD and NLD groups, with students in the RLD group earning a higher Total score than did those in the NLD group (although this difference was not significant) (See Table 3 for a comparison of Metamemory Battery Total scores with and without the Memory Estimation subtest). The 2 (arithmetic) by 2 (reading) ANOVA was also conducted, and again revealed significant main effects of both arithmetic ($F(1,73) = 17.23, p < .001$) and reading ($F(1,73) = 7.22, p < .01$) on the Total score, and no interaction effect was noted.

Overall, results from investigations pertaining to the first hypothesis indicated that normally achieving students demonstrated significantly higher levels of general metamemorial knowledge than did students with difficulties in arithmetic, students with difficulties in reading, and students with difficulties in both arithmetic and reading. Expected differences between students with arithmetic difficulties and students with reading difficulties were not observed.

Hypothesis 2

Acquisition and application of elaborative interrogation. It was expected that students with relative difficulties in arithmetic would be less successful at both a) acquiring and b) applying the elaborative interrogation strategy than would students with relative difficulties in reading. Students with difficulties in both arithmetic and reading were

Table 3

Means and Standard Deviations for Metamemory Battery Total Scores With and Without the Memory Estimation Subtest by Group

Group	Total Score	Total Score Without Memory Estimation Subtest
NORM M (SD)	20.76 _a (3.93)	13.73 _a (3.48)
RLD M (SD)	14.47 _b (5.73)	11.27 _{ab} (3.97)
NLD M (SD)	15.30 _b (5.27)	9.92 _b (3.79)
GLD M (SD)	10.64 _b (6.30)	7.45 _b (3.75)

Note. NORM refers to students in the normally achieving group. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with both arithmetic and reading difficulties. Scores in parentheses are standard deviations. Means in the same column with different subscripts differ at $p < .05$ based on post hoc Bonferroni comparisons.

expected to have the greatest difficulty acquiring and applying the strategy, while normally achieving students were expected to be most successful with respect to these two tasks.

Baseline rote memory performance was examined by comparing students' recall scores for the Memory Estimation subtest of the Metamemory Battery, which was administered prior to strategy training. This recall test was composed of 15 items and could be considered a baseline measure of students' recall under circumstances in which they could employ whatever strategy they wished in order to remember the items (see Table 4 for group means and standard deviations). A one-way ANOVA conducted on these scores revealed a significant effect of group on recall ($F(3,73) = 12.72, p < .001$). Post hoc Bonferroni comparisons indicated that normally achieving students remembered significantly more items than did students with reading difficulties, students with arithmetic difficulties, and students with both reading and arithmetic difficulties ($p < .05$). In addition, students with arithmetic difficulties remembered significantly more items than did students with reading difficulties ($p < .05$).

2.a) Acquisition of elaborative interrogation. Prior to conducting the primary analyses with respect to the acquisition of elaborative interrogation, data were obtained on a number of additional variables associated with the acquisition of both rehearsal and elaborative interrogation. During session two, instruction and practice with rehearsal, the mean number of rehearsals per sentence generated by students, as well as the number of facts recalled using rehearsal during practice was recorded (see Table 5 for group means and standard deviations).

During session two, instruction and practice with elaborative interrogation, data

Table 4

**Means and Standard Deviations for Recall of Items During
the Memory Estimation Subtest by Group**

Group	Recall
NORM <u>M</u> (<u>SD</u>)	8.82 _a (2.04)
RLD <u>M</u> (<u>SD</u>)	4.53 _b (2.23)
NLD <u>M</u> (<u>SD</u>)	6.88 _c (2.34)
GLD <u>M</u> (<u>SD</u>)	4.82 _{bc} (2.99)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic. Recall scores are out of a possible 15 points. Scores in parentheses are standard deviations. Items with different subscripts differ at $p < .05$ based on post hoc Bonferonni comparisons.

Table 5

Means and Standard Deviations for the Number of Rehearsals and Recall During Session Two, Instruction and Practice With Rehearsal by Group

Group	Mean Number of Rehearsals	Recall Using Rehearsal
NORM <u>M</u> (SD)	9.81 (1.70)	4.63 (2.58)
RLD <u>M</u> (SD)	9.88 (1.53)	4.40 (2.26)
NLD <u>M</u> (SD)	9.67 (1.82)	5.31 (3.93)
GLD <u>M</u> (SD)	8.15 (1.11)	4.73 (2.20)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic. Mean number of rehearsals is based on students' mean number of rehearsals over 15 sentences. Recall scores are out of a possible 15 correct answers. Scores in parentheses are standard deviations.

were collected on the following variables: 1) the number of practice examples required for students to master the elaborative interrogation strategy; 2) the time required for mastery of the strategy; 3) the total number of elaborations generated; 4) the number of elaborations generated that were precise (the focus of primary analyses concerning acquisition of E-I); 5) the number of facts recalled correctly after using elaborative interrogation during practice (see Table 6 for group means and standard deviations). In addition, when students were re-acquainted with elaborative interrogation during the third session (strategy review), the number of practice examples required for students to “re-master” the strategy, as well as the time required to do this was recorded (see Table 7 for group means and standard deviations).

Previous studies of the elaborative interrogation strategy have examined the quality of the responses generated by students, describing elaborations as either precise or imprecise (e.g., Stein et al., 1982; Pressley et al., 1988; Wood et al., 1990). Precise elaborations were those that clarified or made more meaningful the relationship between the subject and predicate. For example, the elaboration “The tall man bought the crackers...that were on the top shelf” would be coded as precise, whereas the elaboration “The tall man bought the crackers...because he was hungry” would be coded as imprecise, as it does not specify why it was the tall man rather than some other kind of man. As the primary goal of the elaborative interrogation strategy is the generation of precise elaborations, all responses by students were coded as precise or imprecise and this score was used as a measure of how well students’ had mastered the strategy. Two independent raters scored all explanations, with 88.1 percent agreement on precision. Disagreements

Table 6

Means and Standard Deviations for Acquisition Variables During Initial Instruction and Practice With Elaborative Interrogation by Group

Group	Number of Practice Examples Required for Mastery	Time Required for Mastery	Recall Using Elaborative Interrogation	Total Number of Elaborations Generated	Number of Precise Elaborations Generated
NORM <u>M</u> (SD)	3.50 (.73)	77.96 (37.18)	12.56 (2.53)	14.06 (1.73)	8.06 _a (3.11)
RLD <u>M</u> (SD)	4.13 (1.06)	109.53 (81.63)	10.53 (3.31)	12.87 (2.00)	6.27 _{ab} (2.19)
NLD <u>M</u> (SD)	3.88 (1.11)	114.91 (83.72)	9.77 (3.72)	14.15 (1.35)	6.04 _{ab} (3.50)
GLD <u>M</u> (SD)	3.82 (1.78)	104.82 (96.08)	9.91 (2.81)	13.18 (2.96)	4.36 _b (3.11)

Note. Time required for mastery is in seconds. Recall scores, total number of elaborations and number of precise elaborations are out of a possible 15 points. Scores in parentheses are standard deviations. Means in the same column that do not share the same subscript differ at $p < .05$ based on post hoc Bonferroni comparisons.

Table 7

Means and Standard Deviations for Variables Associated With Acquisition of Elaborative Interrogation During Session Three, Strategy Review by Group

Group	Number of Practice Examples Required for Re-Mastery	Time Required for Re-Mastery
NORM <u>M</u> (SD)	3.62 (.80)	43.55 (26.15)
RLD <u>M</u> (SD)	3.47 (.52)	42.53 (22.81)
NLD <u>M</u> (SD)	3.77 (.95)	70.25 (72.25)
GLD <u>M</u> (SD)	3.45 (.69)	48.87 (24.70)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic. Time required for re-mastery is in seconds. Scores in parentheses are standard deviations.

were resolved by discussion.

Prior to analysis, the scores reflecting the number of precise elaborations generated by students were examined for accuracy of data entry, missing values, and fit between the distribution and the assumptions of univariate analysis. Again, boxplots were constructed and one outlier was identified. As the presence of this outlier did not alter the results of the statistical test, it was retained in the analysis.

In order to investigate the hypothesis concerning acquisition of the elaborative interrogation strategy, a one-way ANOVA was conducted on the group scores for the number of precise elaborations generated during initial instruction and practice. There was a significant effect of group on the number of precise elaborations generated ($F(3,73) = 2.91, p < .05$), and post hoc Bonferroni comparisons between all groups revealed that normally achieving students generated significantly more precise elaborations than did students in the GLD group ($p < .05$) (See Table 6 for group means and standard deviations). In order to examine the relative impact of difficulties in arithmetic and reading, a 2 (presence or absence of difficulties in arithmetic) by 2 (presence or absence of difficulties in reading) ANOVA was conducted on the scores representing the number of precise elaborations generated by students. Significant main effects were noted for both arithmetic difficulties ($F(1,73) = 5.32, p < .05$) and reading difficulties ($F(1,73) = 4.06, p < .05$), with no interaction effect noted ($F(1,73) = .05, p > .80$). The ANOVA was also run with age as a covariate and age was not a significant covariate.

2.b) Application of elaborative interrogation. During session two, following instruction in both strategies (as described in the previous section on acquisition), students

were asked to select one of the strategies in order to learn a new list of man sentences (session two, strategy choice). Of 74 students, only seven chose rehearsal, including five students in the NLD group and two students in the GLD group. For the remaining 67 students who chose elaborative interrogation, the total number of elaborations generated, the number of elaborations generated that were precise, and the students' recall using elaborative interrogation were all recorded (see Table 8 for group means and standard deviations). Elaborative interrogation was noted to have been the most effective strategy for 66 out of 74 students and there were two students for whom elaborative interrogation and rehearsal were equally effective.

The same procedure was followed during the first part of session three, whereby students were re-acquainted with both rehearsal and elaborative interrogation and then asked to select one of the strategies to learn a new list of man sentences (session three, strategy review). Of 74 students, five chose rehearsal, including one student in the NORM group, three students in the NLD group, and one student in the GLD group. For the remaining 69 students who chose elaborative interrogation, again the total number of elaborations generated, the number of precise elaborations, and students' recall using elaborative interrogation were recorded (see Table 9 for group means and standard deviations).

Of the 67 students who chose elaborative interrogation during session two, strategy choice, 63 of those students also chose elaborative interrogation during session three, strategy review. Given that the tasks in these two sessions were essentially identical in their demands (that is, both required selection of a strategy for use with man sentences

Table 8

Means and Standard Deviations for Students Choosing Elaborative Interrogation During Session Two, Strategy Choice by Group

Group	Total Number Of Elaborations Generated	Number of Precise Elaborations Generated	Recall Using Elaborative Interrogation
NORM M (SD)	14.77 (.69)	10.95 (2.24)	12.41 (1.92)
RLD M (SD)	14.53 (1.30)	10.07 (1.87)	10.00 (2.20)
NLD M (SD)	14.52 (1.12)	9.90 (3.43)	10.24 (2.07)
GLD M (SD)	14.56 (.73)	9.11 (2.03)	9.22 (1.99)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic. All scores are out of a possible 15 points. Scores in parentheses are standard deviations.

Table 9

Means and Standard Deviations for Students Choosing Elaborative Interrogation During Session Three. Strategy Review by Group

Group	Total Number of Elaborations Generated	Number of Precise Elaborations Generated	Recall Using Elaborative Interrogation
NORM <u>M</u> (<u>SD</u>)	14.29 (1.74)	9.62 (3.12)	12.38 (1.80)
RLD <u>M</u> (<u>SD</u>)	14.00 (2.07)	8.60 (3.04)	10.40 (2.23)
NLD <u>M</u> (<u>SD</u>)	14.43 (1.04)	9.26 (2.91)	10.61 (2.86)
GLD <u>M</u> (<u>SD</u>)	13.80 (2.82)	6.80 (2.30)	8.60 (2.86)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with both reading and arithmetic difficulties. All scores are out of a possible 15 points. Scores in parentheses are standard deviations.

following review of both rehearsal and elaborative interrogation), students' scores using elaborative interrogation were collapsed across the two sessions to create combined scores for the total number of elaborations generated, the number of elaborations that were precise, and students' recall using elaborative interrogation (see Table 10 for group means and standard deviations). Combined scores for both the number of precise elaborations generated and recall were the focus of analyses designed to investigate students' ability to apply the elaborative interrogation strategy. Therefore, these combined scores were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of univariate analysis. Boxplots were again constructed. One outlier was identified in the scores for precise elaborations and was deleted from the analysis. An outlier was also identified in the recall scores. As the presence of this value did not alter the results of the statistical test, it was retained in the analysis.

In order to investigate the hypothesis concerning students' application of elaborative interrogation, a one-way ANOVA was conducted on the group scores for the number of precise elaborations generated. The ANOVA was not significant ($F(3,61)=2.37, p > .05$), nor were post hoc Bonferroni comparisons (see Table 10).

In order to investigate the relative impact of arithmetic and reading difficulties, a 2 (presence or absence of difficulties in arithmetic) by 2 (presence or absence of difficulties in reading) ANOVA with age as a covariate was conducted on the combined scores for the number of precise elaborations generated. Age was a significant covariate ($F(1,61) = 5.22, p < .05$) and there was a significant main effect for reading difficulties ($F(1,61) =$

Table 10

Combined Means and Standard Deviations for Variables Associated With the Application of Elaborative Interrogation During Session Two, Strategy Choice and Session Three, Strategy Review by Group

Group		Total Number Elaborations Generated	Number of Precise Elaborations Generated	Recall Using Elaborative Interrogation
NORM	<u>M</u> (SD)	29.05 (2.36)	20.57 (4.95)	24.85 _a (3.23)
RLD	<u>M</u> (SD)	28.53 (3.29)	18.67 (4.37)	20.40 _b (3.11)
NLD	<u>M</u> (SD)	28.84 (2.19)	20.00 (5.69)	21.74 _b (3.40)
GLD	<u>M</u> (SD)	29.38 (.92)	16.13 (4.26)	19.00 _b (2.39)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic. All scores are out of 30 possible points. Scores in parentheses are standard deviations. Means in the same column with differing subscripts differ at $p < .05$ based on post hoc Bonferroni comparisons.

8.03, $p < .01$), but not arithmetic difficulties ($F(1,61) = .55, p > .40$). No interaction effect was noted ($F(1,61) = 2.44, p > .10$).

The same one-way ANOVA was conducted on students' combined recall scores using elaborative interrogation in order to assess specific group differences. There was a significant effect of group on recall scores using elaborative interrogation ($F(3,62) = 9.65, p < .001$) and post hoc Bonferroni comparisons between all groups revealed that normally achieving students demonstrated significantly higher recall scores than did students in the RLD, NLD and GLD groups ($p < .05$) (see Table 10). The remaining three groups of students with learning disabilities did not differ significantly from each other. In order to examine the relative impact of arithmetic and reading difficulties, the same 2 (arithmetic) by 2 (reading) ANOVA with age as a covariate was conducted on students combined recall scores using elaborative interrogation. Age was a significant covariate ($F(1,62) = 5.18, p < .05$), and there were significant main effects for both arithmetic ($F(1, 62) = 6.65, p < .05$) and reading difficulties ($F(1,62) = 20.30, p < .001$). No interaction effect was noted ($F(1, 62) = .40, p > .50$).

The task during session three, strategy transfer provided further opportunity to examine students' ability to apply the elaborative interrogation strategy, this time by having them select either rehearsal or elaborative interrogation to learn a new set of materials about animals. These analyses were performed separately given the content differences between the animal sentences and the previously used man sentences. The animal sentences also differed somewhat from the man sentences in that they did not involve arbitrary relationships, but rather more naturalistic content. Therefore, consistent

with coding approaches used for such materials in previous research on elaborative interrogation, elaborations were not coded as precise/imprecise, but rather as adequate or inadequate (e.g., Wood et al., 1990). Responses that were coded as adequate provided logical explanations that clarified why the fact was particularly relevant to the animal in question (e.g., The camel has a double row of eyelashes for each eye...because they live in the desert and need to keep the sand out of their eyes). Responses that were coded as inadequate did not make clear why the fact was relevant to that particular animal (e.g., The giraffe can completely close both its nostrils...because it is a really big animal). Two independent raters scored all explanations with 85.1 percent agreement on adequacy. Disagreements were resolved by discussion.

Of 74 students, 12 chose rehearsal, including three students in the NORM group, eight students in the NLD group, and one student in the GLD group. For the remaining 62 students who chose elaborative interrogation, the total number of elaborations generated, the number of adequate elaborations, and students' recall using elaborative interrogation were recorded (See Table 11 for group means and standard deviations). As in the previous analyses, scores for the number of adequate elaborations generated and recall were the focus of further investigations of students' ability to apply elaborative interrogation, this time with animal sentences. Therefore, these scores were examined for accuracy of data entry, missing values, and fit between their distributions and the assumptions of univariate analyses. Through the construction of boxplots, three outliers were identified in the recall scores. These scores were retained in the analysis, as their presence did not alter the results of the statistical test.

Table 11

Means and Standard Deviations for Students Choosing Elaborative Interrogation During Session Three. Strategy Transfer With Animal Materials by Group

Group		Total Number of Elaborations Generated	Number of Adequate Elaborations Generated	Recall Using Elaborative Interrogation
NORM	M (SD)	14.53 (1.22)	11.89 _a (2.08)	13.74 _a (1.56)
RLD	M (SD)	13.13 (2.88)	8.93 _b (3.15)	10.27 _b (2.43)
NLD	M (SD)	13.56 (1.79)	8.28 _{bc} (3.21)	11.50 _b (2.50)
GLD	M (SD)	11.50 (4.09)	5.50 _c (3.63)	9.20 _b (2.62)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with both reading and arithmetic difficulties. All scores are out of a possible 15 points. Scores in parentheses are standard deviations. Means in the Adequate Elaboration and Recall columns with different subscripts differ at $p < .05$ based on post hoc Bonferroni comparisons.

In order to further investigate the hypothesis concerning students' application of elaborative interrogation, a one-way ANOVA was conducted on the group scores for the number of adequate elaborations generated. There was a significant effect of group on the number of adequate elaborations generated ($F(3,61) = 11.00, p < .001$), and post hoc Bonferroni comparisons revealed that normally achieving students generated significantly more adequate elaborations for the animal sentences than did students in the RLD, NLD and GLD groups ($p < .05$) (see Table 11). In addition, students in the RLD group generated significantly more adequate elaborations than did students in the GLD group. In order to examine the relative impact of arithmetic and reading difficulties, a 2 (presence or absence of difficulties in arithmetic) \times 2 (presence or absence of difficulties in reading) ANOVA with age as a covariate was conducted on scores for the number of adequate elaborations generated for the animal sentences. Age was a significant covariate ($F(1,61) = 10.02, p < .01$) and significant main effects were noted for both arithmetic ($F(1,61) = 21.12, p < .001$) and reading difficulties ($F(1,61) = 14.43, p < .001$). No interaction effect was noted ($F(1,61) = .07, p > .70$).

The same one-way ANOVA was conducted in order to assess specific group differences in recall. There was a significant effect of group on recall ($F(3,61) = 11.20, p < .001$) and post hoc Bonferroni comparisons revealed that normally achieving students demonstrated significantly higher recall than did students in the RLD, NLD, and GLD groups ($p < .05$). The remaining three groups of students with learning disabilities were not significantly different from each other in terms of recall (see Table 11). In order to assess the relative impact of arithmetic and reading difficulties, the 2 (presence or absence

of difficulties in arithmetic) x 2 (presence or absence of difficulties in reading) ANOVA with age as a covariate was conducted on students' recall scores using elaborative interrogation with animal sentences. Again, age was a significant covariate ($F(1,61) = 12.81, p < .001$) and there were significant main effects for both arithmetic ($F(1,61) = 7.64, p < .01$) and reading difficulties ($F(1,61) = 26.70, p < .001$). No interaction effect was noted ($F(1, 61) = .41, p > .50$).

Overall, results were mixed with respect to investigations pertaining to the acquisition and application of elaborative interrogation. During the acquisition phase, normally achieving students generated significantly more precise elaborations than did students with difficulties in both arithmetic and reading. Expected differences between students with arithmetic difficulties and students with reading difficulties were not observed. During the application of elaborative interrogation with the man sentences, there were no group differences in the number of precise elaborations generated, but normally achieving students did recall significantly more facts than did students with arithmetic difficulties, students with reading difficulties, and students with both arithmetic and reading difficulties. During the application of elaborative interrogation with the animal sentences, normally achieving students generated more adequate elaborations and recalled more facts than did all three groups of students with learning difficulties. Expected differences between students with arithmetic difficulties and students with reading difficulties were not observed.

Hypothesis 3

Memory monitoring and strategy transfer. It was expected that students with

arithmetic difficulties would be less likely to demonstrate both accurate memory monitoring and successful strategy transfer than would students with reading difficulties. It was also expected that students with difficulties in both arithmetic and reading would be least likely to demonstrate accurate memory monitoring and successful strategy transfer, while normally achieving students would be most likely to demonstrate these skills.

3.a) Memory monitoring. Memory monitoring was first assessed by noting whether students chose the strategy that had been most effective for them (i.e., had resulted in the highest recall). This information was collected during several selection opportunities which followed session two, initial instruction and practice with both rehearsal and elaborative interrogation.

During the strategy choice portion of session two, students had their first opportunity to select either rehearsal or elaborative interrogation to learn a list of man sentences. Separate 2x2 contingency tables were constructed in order to examine possible differences in the frequency with which students did or did not choose the strategy that had been most effective for them in the context of: 1) the presence or absence of difficulties in arithmetic and 2) the presence or absence of difficulties in reading. (Note: There were two students, one from the NORM group and one from the NLD group, for whom rehearsal and elaborative interrogation had been equally effective during initial instruction and practice. These students were scored as having selected the strategy that was most effective for them).

With respect to arithmetic difficulties, the Fisher exact test revealed a one-tailed probability of .054. Based on a Type I error rate of $p < .05$, strategy choice was not

affected by the presence or absence of difficulties in arithmetic (see Table 12 for frequencies). With respect to reading difficulties, the Fisher exact test revealed a one-tailed probability of .527, again suggesting that strategy choice was not affected by the presence or absence of difficulties in reading (see Table 12 for frequencies). Specific group differences could not be assessed using the chi-square test for independent samples due to the finding that greater than 20 percent of cells had an expected count of less than five (Siegel & Castellan, 1988) (see Table 13 for frequencies).

During session three, strategy review, students had a second opportunity to select either rehearsal or elaborative interrogation to learn a list of man sentences. Again, separate 2x2 contingency tables were constructed in order to examine possible differences in the frequency with which students did or did not select the strategy that had been most effective for them during initial instruction and practice. With respect to arithmetic difficulties, the Fisher exact test revealed a one-tailed probability of .043, suggesting that strategy choice was affected by the presence or absence of difficulties in arithmetic (see Table 12 for frequencies). With respect to reading difficulties, the Fisher exact test revealed a one-tailed probability of .507, indicating that strategy choice was not affected by the presence or absence of difficulties with reading (see Table 12 for frequencies). Again, specific group differences could not be investigated using the chi-square for independent samples due to the finding that greater than 20 percent of cells had an expected count of less than five (see Table 14 for frequencies).

Memory monitoring was also assessed by examining the relationship between students' pre- and postdictions of memory performance and their actual recall. Pearson

Table 12

Frequencies With Which Students With and Without Arithmetic Difficulties and With and Without Reading Difficulties Chose the Most Effective Strategy During Session Two, Strategy Choice and Session Three, Strategy Review

Chose the Most Effective Strategy	Session Two (Strategy Choice)				Session Three (Strategy Review)			
	Arithmetic Difficulties		Reading Difficulties		Arithmetic Difficulties		Reading Difficulties	
	Yes	No	Yes	No	Yes	No	Yes	No
Yes	31	36	24	43	29	35	23	41
No	6	1	2	5	8	2	3	7

Table 13

Frequencies With Which Students Chose the Most Effective Strategy During Session**Two. Strategy Choice by Group**

Group	Chose the Most Effective Strategy	
	Yes	No
NORM	22	0
RLD	14	1
NLD	21	5
GLD	10	1

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to student with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic.

Table 14

Frequencies With Which Students Chose the Most Effective Strategy During Session**Three. Strategy Review by Group**

Group	Chose the Most Effective Strategy	
	Yes	No
NORM	21	1
RLD	14	1
NLD	19	7
GLD	9	2

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic.

product-moment correlations were calculated by group for students' predictions of recall and their actual recall during session two, strategy choice and session three, strategy review and strategy transfer (see Table 15 for correlations and standard errors.)

In those instances where the overall correlation between students' recall scores and their predictions of performance was significant, an effort was made to determine whether or not there were group differences with respect to the strength of the correlation between these two variables. In order to determine whether or not there were differences in the slopes produced by regressing students' recall scores on their prediction scores by group, an analysis of covariance was conducted on recall scores with students' prediction scores as the covariate. The assumption of equality of regression slopes was tested by fitting a model containing the main effects of group and prediction, and the group x prediction interaction, with the interaction term providing the test of the null hypothesis of equal slopes.

Of the three instances in which students made predictions about upcoming memory performance, the overall Pearson product-moment correlation between recall scores and predictions was only significant for session three, strategy review ($r = .376$, $SE = .227$, $p < .01$). At an alpha level of $p < .05$, the analysis of covariance did not reveal prediction scores to be a significant covariate ($F(1,61) = 3.23$, $p > .05$), but there was a significant group x prediction interaction ($F(3,61) = 3.30$, $p < .05$). Given the finding that the overall correlation between students' predictions and their actual recall scores was not significant, it was not appropriate to interpret group differences in the correlation.

Pearson product-moment correlations were also calculated by group for students'

Table 15

**Pearson Product-Moment Correlations Between Students' Predictions and Actual Recall
by Group**

Group	Prediction 1	Prediction 2	Prediction 3
NORM r (SE)	-.494 _a (.323)	-.278 (.419)	.162 (.286)
RLD r (SE)	.000 (.600)	.723 _b (.245)	.120 (.425)
NLD r (SE)	.363 (.417)	.576 _b (.370)	.252 (.286)
GLD r (SE)	.047 (.494)	.052 (.488)	-.207 (.284)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both arithmetic and reading. Prediction 1 refers to session two, strategy choice. Prediction 2 refers to session three, strategy review. Prediction 3 refers to session three, strategy transfer. Scores in parentheses are standard errors.

_a significant at $p < .05$

_b significant at $p < .01$

postdictions of recall and their actual recall during session two, instruction and practice with rehearsal, instruction and practice with elaborative interrogation, and strategy choice, and also for session three, strategy review and strategy transfer (see Table 16 for correlations and standard errors). The same analysis of covariance procedure described previously was used to determine whether there were group differences with respect to the strength of the correlations between students' postdiction scores and their actual recall scores.

The overall Pearson product-moment correlation between students' recall scores and their postdictions was significant at $p < .001$ for each of the five instances in which students were asked to make postdictions, with correlations ranging from .518 to .651. Therefore, the analysis of covariance procedure was conducted for each set of postdiction scores, with a Type I error rate of $p < .01$ for each procedure (for an overall Type I error rate of $p < .05$) (Tabachnick & Fidell, 1996).

Each of the five ANCOVA's revealed that students' postdiction scores did covary significantly with their recall scores (all at $p < .01$). However, there were no significant group x postdiction interactions (all p 's $> .01$), and thus no significant group differences with respect to the strength of the correlation between students' postdictions and their actual recall.

In order to gain further information about the accuracy of students' memory monitoring, frequencies were tallied with respect to the number of occasions on which students overestimated, underestimated, or were exactly correct in both their predictions and postdictions of performance. These frequencies were totaled over three separate

Table 16

**Pearson Product-Moment Correlations Between Students' Postdictions and Actual Recall
by Group**

Group		Post-Diction 1	Post-Diction 2	Post-Diction 3	Post-Diction 4	Post-Diction 5
NORM	r	.747 _a	.355	.630 _b	.477 _c	.666 _a
	(SE)	(.210)	(.243)	(.229)	(.245)	(.196)
RLD	r	-.044	.812 _a	-.032	.711 _b	.519 _c
	(SE)	(.455)	(.225)	(.555)	(.292)	(.370)
NLD	r	.777 _a	.625 _a	.523 _b	.721 _a	.454 _c
	(SE)	(.159)	(.337)	(.339)	(.198)	(.294)
GLD	r	.538	.686 _c	.557	.256	.586
	(SE)	(.404)	(.367)	(.465)	(.514)	(.488)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both arithmetic and reading. Postdiction 1 refers to Session Two, practice with rehearsal. Postdiction 2 refers to session two, practice with elaborative interrogation. Postdiction 3 refers to session two, strategy choice. Postdiction 4 refers to session three, strategy review. Postdiction 5 refers to session three, strategy transfer. Scores in parentheses are standard errors.

_a significant at $p < .001$.

_b significant at $p < .01$.

_c significant at $p < .05$.

opportunities in the case of predictions, and five separate opportunities in the case of postdictions. These data are presented in Table 17, 18 and 19.

3.b) Strategy transfer. During the two strategy selection tasks prior to session three, strategy transfer, a majority of students were noted to choose elaborative interrogation in order to learn the man sentences (e.g., 67 out of 74 students in session two, strategy choice, and 69 out of 74 students in session three, strategy review). Therefore, during the final experimental task, successful strategy transfer was considered to have occurred if students who had previously chosen elaborative interrogation recognized that the new materials presented to them (sentences about unfamiliar animals) were similar to the “man sentences” in that they could also be more easily learned using elaborative interrogation. Accordingly, data were again collected on which strategy students chose to learn the animal sentences, and whether or not that choice represented the strategy which had previously been most effective for them. Sixty-two of the 74 students chose elaborative interrogation to learn the animal sentences during the final task. For 56 of those 62 students, elaborative interrogation was the strategy that had been most effective for them during the previous tasks. There were two students (one from the NORM group and one from the NLD group) for whom rehearsal and elaborative interrogation had been equally effective in terms of their subsequent recall; these students were scored as having selected the strategy that had been most effective for them. For the remaining 12 students who chose rehearsal to learn the animal sentences, rehearsal had been the most effective strategy on previous tasks for only two of those students.

In order to examine the hypothesis concerning strategy transfer, separate 2x2

Table 17

Combined Frequencies for Accuracy of Predictions by Students With and Without Arithmetic Difficulties and With and Without Reading Difficulties

		Arithmetic Difficulties		Reading Difficulties	
		Yes	No	Yes	No
Combined Frequencies	Overestimate	41 (38.7)	18 (17.1)	24 (30.8)	35 (26.3)
	Equal	15 (14.2)	9 (8.6)	8 (10.3)	16 (12.0)
	Underestimate	50 (47.2)	78 (74.3)	46 (59.0)	82 (61.7)
	Total	106 (100)	105 (100)	78 (100)	133 (100)

Note. Numbers in parentheses are percentages.

Table 18

Combined Frequencies for Accuracy of Postdictions by Students With and Without Arithmetic Difficulties and With and Without Reading Difficulties

		Arithmetic Difficulties		Reading Difficulties	
		Yes	No	Yes	No
Combined Frequencies	Overestimate	87 (45.5)	47 (26.6)	58 (41.4)	76 (33.3)
	Equal	37 (19.4)	37 (20.9)	28 (20.0)	46 (20.2)
	Underestimate	67 (35.1)	93 (52.5)	54 (38.6)	106 (46.5)
	Total	191 (100)	177 (100)	140 (100)	228 (100)

Note. Numbers in parentheses are percentages.

Table 19

Combined Frequencies for Accuracy of Predictions and Postdictions by Group

		Combined Frequencies			
	Group	Overestimate	Equal	Underestimate	Total
Pre-Dictions	NORM	8 (12.7)	5 (7.9)	50 (79.4)	63 (100)
	RLD	10 (23.8)	4 (9.5)	28 (66.7)	42 (100)
	NLD	27 (38.6)	11 (15.7)	32 (45.7)	70 (100)
	GLD	14 (38.9)	4 (11.1)	18 (50.0)	36 (100)
Post-Dictions	NORM	24 (23.5)	20 (19.6)	58 (56.9)	102 (100)
	RLD	23 (30.7)	17 (22.7)	35 (46.7)	75 (100)
	NLD	52 (41.3)	26 (20.6)	48 (38.1)	126 (100)
	GLD	35 (53.8)	11 (16.9)	19 (29.2)	65 (100)

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both arithmetic and reading. Numbers in parentheses are percentages.

contingency tables were constructed. This allowed for examination of possible differences in the frequency with which students did or did not choose the strategy with which they had previously been most successful in the context of: 1) the presence or absence of difficulties in arithmetic and 2) the presence or absence of difficulties in reading. With respect to arithmetic difficulties, the Fisher exact test revealed a one-tailed probability of .009, thereby indicating that strategy choice was affected by the presence or absence of difficulties in arithmetic (see Table 20 for frequencies). With respect to reading difficulties, the Fisher exact test revealed a one-tailed probability of .326, suggesting that strategy choice was not affected by the presence or absence of difficulties in reading (see Table 20 for frequencies). Specific group differences could not be assessed using the chi-square for independent samples due to the finding that greater than 20 percent of cells had an expected count of less than five (see Table 21 for frequencies).

Overall, the results of investigations pertaining to the third hypothesis indicated that the presence of difficulties in arithmetic (as in the NLD and GLD groups) was associated with a decreased likelihood of selecting the most effective strategy during both monitoring and transfer opportunities.

Table 20

Frequencies With Which Students With and Without Arithmetic Difficulties and With and Without Reading Difficulties Chose the Most Effective Strategy During Session Three.
Strategy Transfer

Chose the Most Effective Strategy	Arithmetic Difficulties		Reading Difficulties	
	Yes	No	Yes	No
Yes	25	34	22	37
No	12	3	4	11

Table 21

Frequencies With Which Students Chose the Most Effective Strategy During Session**Three. Strategy Transfer by Group**

Group	Chose the Most Effective Strategy	
	Yes	No
NORM	20	2
RLD	14	1
NLD	17	9
GLD	8	3

Note. NORM refers to normally achieving students. RLD refers to students with reading difficulties. NLD refers to students with arithmetic difficulties. GLD refers to students with difficulties in both reading and arithmetic.

CHAPTER IV

DISCUSSION

Hypothesis 1

General metamemorial knowledge. The first hypothesis predicted that students with arithmetic difficulties would have lower scores on the Metamemory Battery than would students with reading difficulties. Normally achieving students were expected to obtain the highest scores, while students with difficulties in both arithmetic and reading were expected to obtain the lowest scores.

Consistent with the above hypothesis, results on the Metamemory Battery total score revealed that normally achieving students demonstrated greater metamemorial knowledge than did students with arithmetic difficulties (group NLD), students with reading difficulties (group RLD), and students with both arithmetic and reading difficulties (group GLD). This finding was consistent with the work of Geary et al. (1990), who noted that normally achieving fourth graders obtained significantly higher scores on Belmont and Borkowski's (1988) Metamemory Battery than fourth graders with reading and arithmetic difficulties. These results are also consistent with the findings of other investigations with younger children that have employed measures of general metamemory. For example, Marfo and Ryan (1990) selected four tasks from the interview questionnaire by Kreutzer et al. (1975) (portions of which form the basis for Belmont & Borkowski's (1988) Metamemory Battery), and compared the performance of average and poor readers in fourth grade. Average readers demonstrated greater levels of general metamemorial knowledge than did poor readers. In another investigation, Short et

al.(1993) also employed a general measure of metamemory based on tasks developed by Borkowski and colleagues, and reported that average learners in fourth and sixth grades were superior to low achieving learners in the same grades with respect to general knowledge about metamemory.

Findings with respect to the three groups of students with learning disabilities were not consistent with the current hypotheses. That is, students with reading difficulties (group RLD), students with arithmetic difficulties (group NLD), and students with difficulties in both reading and arithmetic (group GLD) did not differ from one another with respect to general metamemorial knowledge as measured by the Metamemory Battery total score. This finding may indicate that, as a larger heterogeneous group, students with learning disabilities possess less general knowledge about metamemory than do normally achieving students, while differences between individual learning disability subtypes in this area are minimal. As no other studies could be located that compared different learning disability subtypes on Belmont and Borkowski's (1988) measure, it is also possible that the metamemory battery was not sensitive enough to detect differences in general metamemorial knowledge between these groups. In addition, it is also possible that the small sample size used in the current study may have rendered the detection of group differences less likely.

In reviewing the results of the Metamemory Battery for students with different subtypes of learning disabilities, it was important to consider the possibility of both ceiling effects (where students obtained the maximum possible scores) and floor effects (where students performed at chance levels). Examination of group means revealed that, while

the performance of normally achieving students neared the maximum possible score on the Paired Associates subtest, the other group means for that subtest and the remaining three subtests and total score showed no evidence of ceiling effects. This finding suggested that Belmont and Borkowski's (1988) measure was adequate with respect to its sensitivity to the ability levels associated with the age range of the current sample. Although scores for the Metamemory Battery total did not increase with age, a finding that was not consistent with results obtained by Belmont and Borkowski (1988) and Geary et al. (1990), it could be speculated that students' skills on these subtests reach a plateau in early adolescence, particularly in light of the fact that no ceiling effects were noted.

Comparison of group means with the possible scores that could be obtained by chance as computed by Belmont and Borkowski (1988) revealed a floor effect for the Organized List subtest. That is, none of the group means on this particular subtest deviated substantially from chance performance. This finding was consistent with results obtained by Geary et al. (1990), who found that only the Memory Estimation, Preparation Object, and Paired Associates subtests, as well as the total score provided useful information about metamemory.

Examination of the relative impact of difficulties in arithmetic and reading on the individual subtests of the Metamemory Battery revealed that, for three of the four subtests (Preparation Object, Paired Associates, and Organized List), the presence of difficulties with arithmetic (as in the NLD and GLD groups) was associated with lowered scores. For one of those three subtests (Preparation Object), difficulties with both arithmetic and reading (as in the RLD, NLD and GLD groups) were associated with lowered scores,

while on the Memory Estimation subtest, the presence of difficulties with reading (as in the RLD group) was associated with lowered scores. It is interesting to note that, consistent with the descriptions of the memory assets and deficits of students with both verbal and nonverbal learning disabilities provided in the first chapter, students with arithmetic difficulties performed most successfully on a task that required rote memory (Memory Estimation), whereas students with reading difficulties performed with greater success on tasks that required recognition of the semantic associations between materials (e.g., Organized List, Paired Associates).

As the current hypothesis focused on general metamemory, only the total Metamemory Battery score was subject to analyses designed to investigate differences between groups. However, inspection of the group means for each subtest revealed that, for all subtests except Memory Estimation, group scores fell in the hypothesized direction. That is, normally achieving students obtained the highest scores, students with reading difficulties the next highest, students with arithmetic difficulties the next highest, and students with difficulties in both arithmetic and reading the lowest.

Of particular interest was the finding that, on both the Memory Estimation subtest and consequently the total score, students in the NLD group obtained higher scores than did students in the RLD group (although these differences were not significant). In view of the fact that the Memory Estimation subtest was based on a set of unrelated words and therefore involved rote memory, an area of relative strength for students with nonverbal learning disabilities (Rourke & Tsatsanis, 1995), this finding was not unexpected.

Therefore, the total score was re-computed without the Memory Estimation subtest. In

contrast with the initial total score, group means for the total score without the Memory Estimation subtest were reversed for students in the NLD and RLD groups and fell in the hypothesized direction. That is, normally achieving students obtained the highest scores, followed by students in the RLD group, students in the NLD group, and students in the GLD group. Although students in the normally achieving group scored significantly higher than students in the NLD and GLD groups, they did not score significantly higher than students in the RLD group. Scores obtained by the three groups of students with learning disabilities did not differ significantly from one another after the Memory Estimation subtest was removed from the total score.

The finding that students in the NLD group outperformed students in the RLD group on the Memory Estimation subtest but not on any other may suggest that Belmont and Borkowski's (1988) measure has some power to discriminate between students whose difficulties are evident in the area of nonverbal skills (e.g., certain types of mechanical arithmetic difficulties) and those whose difficulties are noted in the verbal domain (e.g., reading difficulties). These results provide further evidence for the notion that students with nonverbal learning disabilities have unique strengths and weaknesses with respect to memory and knowledge about memory, and preliminary support for the idea that this subgroup of students with learning disabilities may require metacognitive instruction that is tailored to their unique needs.

Hypothesis 2

The second hypothesis predicted that students with arithmetic difficulties would have greater difficulty acquiring and applying elaborative interrogation than would

students with reading difficulties. Normally achieving students were expected to be the most successful at these tasks, while students with difficulties in both arithmetic and reading were expected to be the least successful.

2.a) Acquisition of elaborative interrogation. The number of precise elaborations generated by students during instruction and practice with elaborative interrogation was used as a measure of their acquisition of the strategy. The presence of both arithmetic difficulties and reading difficulties was associated with decreased precision scores, with normally achieving students generating the most precise elaborations, followed by students in the RLD group, the NLD group, and the GLD group. However, the only significant group difference occurred between normally achieving students and students in the GLD group.

While this finding partially supported the second hypothesis regarding acquisition of elaborative interrogation, the expected performance differences between normally achieving students, students with arithmetic difficulties and students with reading difficulties were not observed. Such results may indicate that students with arithmetic difficulties and students with reading difficulties are as able as normally achieving students to acquire elaborative interrogation following instruction and practice, a finding that is somewhat consistent with previous research investigating the effectiveness of the strategy with main sentences for both undifferentiated groups of students with learning disabilities (e.g., Greene et al., 1996, Experiment 1) and students identified as poor readers on the basis of comprehension scores (e.g., Wong & Sawatsky, 1984). Both Greene et al. (1996) and Wong and Sawatsky (1984) found that such students could be effectively trained to

produce precise elaborations, and Wong and Sawatsky (1984, Experiment 1) found no differences in the number of precise sentence elaborations produced by average and poor readers. However, the finding that students with both arithmetic and reading difficulties generated significantly fewer precise elaborations than normally achieving students may suggest that these students suffered from a more severe combined deficit which did have an impact on their ability to acquire the strategy.

The finding that precision scores did not increase with age was inconsistent with results obtained by Wood et al.(1990, Experiment 1). These authors found that within a sample of nondisabled students ranging in age from nine years, one month to 14 years, eight months, older students (age 11 years, seven months and up) were more likely to generate precise elaborations for the man sentences than were younger students.

Although the current study employed a similar age range (10 years, seven months to 14 years, eight months), 94 percent of the students fell into Wood et al.(1990)'s older age range. This more restricted range may have made potential age effects more difficult to detect.

2.b) Application of elaborative interrogation. Students' application of the elaborative interrogation strategy was assessed by examining combined precision and recall scores for the man sentences during strategy choice opportunities (i.e., session two, strategy choice and session three, strategy review). With respect to the number of precise elaborations generated by students, the presence of difficulties in reading was associated with lowered precision scores. That is, students with reading difficulties (i.e., students in the RLD and GLD groups) obtained lower scores than did students who did not have

reading difficulties (i.e., normally achieving students and students in the NLD group). Normally achieving students generated the most precise elaborations, followed by students in the NLD group, the RLD group and the GLD group, although differences between the groups were not significant. The finding that reading difficulties and not arithmetic difficulties were associated with the generation of fewer precise elaborations was not consistent with the second hypothesis, nor was the finding that there were no group differences on this measure. Further, these findings were not consistent with those for precision scores during the acquisition phase of the current study.

Also in contrast with students' precision scores during acquisition, combined precision scores did increase with age during the strategy application sessions. This finding was consistent with results obtained by Wood et al. (1990, Experiment 1) for a sample of nondisabled students of approximately the same age range.

With respect to students' recall using elaborative interrogation, the presence of difficulties in both arithmetic and reading were associated with lowered scores. Normally achieving students obtained the highest recall scores, followed by students in the NLD group, the RLD group and the GLD group. Normally achieving students demonstrated significantly greater recall than all three groups of students with learning disabilities. As no other studies comparing the performance of students with different subtypes of learning disabilities could be located, these findings may provide preliminary evidence that, while students with learning disabilities as an undifferentiated group may realize fewer benefits in terms of recall than will normally achieving students when using the elaborative interrogation strategy, differences between groups of learning disabled children may be

minimal in this regard.

As with the combined precision scores, combined recall scores were noted to increase with age. This finding was consistent with the work of Wood et al. (1990, Experiment 1), who noted that for a sample of nondisabled children of approximately the same age range, recall for the main sentences after using elaborative interrogation increased with age.

Students' application of elaborative interrogation was also investigated with sentences about animals, again by examining the quality of elaborations and students' recall using the strategy. With respect to the adequacy of students' elaborations with animal sentences, difficulties with both arithmetic and reading were associated with lowered scores. Students in the normally achieving group obtained the highest scores, followed by students in the RLD group, the NLD group, and the GLD group. Normally achieving students generated significantly more adequate elaborations than did each of the remaining three groups of students with learning disabilities, and students in the RLD group generated significantly more adequate elaborations than students in the GLD group. The number of adequate elaborations generated by students increased with age. These results can be seen as somewhat consistent with the findings of Wood, Willoughby, Bolger, Younger and Kaspar (1993). These authors examined the use of elaborative interrogation by academically low, average and high achieving fifth grade students with passages about animals that were similar to the animal sentences used in the current study. Low achieving students were identified by means of scores below the 30th percentile on the Reading Vocabulary, Concepts of Number, and Spelling subtests of the Stanford

Achievement Test (SAT), and thus could be seen as comparable to the students with learning disabilities in the current study. Wood et al. (1993) found that high achievers (subtest scores above the 70th percentile on the SAT) produced significantly more adequate elaborations for animal sentences than low achievers.

With respect to students' recall of animal sentences after using elaborative interrogation, difficulties with both arithmetic and reading were again associated with lowered scores. Students in the normally achieving group obtained the highest scores, followed by students in the NLD group, the RLD group, and the GLD group. Normally achieving students demonstrated significantly better recall than did the remaining three groups of students with learning disabilities. Students' recall of the animal sentences was noted to increase with age. Again, these results were comparable to those obtained by Wood et al. (1993), who found that average and high achieving students recalled significantly more facts about animals than did low achieving students.

Examination of the results concerning students' acquisition and application of elaborative interrogation reveals a number of interesting findings. The first concerns the observation that scores reflecting the quality of students' elaborations did not increase with age during initial acquisition of the strategy, but did increase with age during subsequent opportunities to apply the strategy. While at first glance this finding seems unusual, particularly given that the tasks in each instance were virtually identical, it may suggest that although students were equally able to demonstrate optimal use of the strategy following instruction, older children were better able to apply the strategy during subsequent un-instructed opportunities. This explanation would be consistent with the

suggestion by Wood et al. (1990) that the increasing knowledge base acquired by students with increasing age allows them to generate more precise elaborations. Interestingly, the choice of the man sentences for the current study was motivated by a desire to minimize the amount of prior knowledge required, in order that possible differences in students' ability to acquire and apply the strategy would not be obscured by differences in prior knowledge resulting from specific learning disabilities. However, as prior knowledge appears to be an important predictor of success with the elaborative interrogation strategy (e.g., Willoughby et al., 1993; Woloshyn et al., 1992), the effort to create a level playing field through this choice of materials may have served to obscure naturally occurring differences between groups of students with specific learning disabilities.

With respect to the current hypothesis, although the expected differences between groups of students with learning disabilities were not observed, there was consistent evidence that difficulties with both reading and arithmetic contributed to lowered scores on measures of the acquisition and application of elaborative interrogation. Perhaps most interesting, however, was the failure to observe an interaction between reading and arithmetic difficulties on any of the relevant measures. This finding may provide support for Rourke's (1982;1987;1989) model of neuropsychological functioning, which holds that the difficulties experienced by students with nonverbal deficits (e.g., certain types of mechanical arithmetic difficulties) and those experienced by students with verbal deficits (e.g., reading difficulties) may have their basis in different hemispheres of the brain, and thus exercise their effects on students' learning somewhat independently. In considering the failure to detect the hypothesized differences between students with reading difficulties

and students with arithmetic difficulties, it is important to note that during the application opportunities that followed the initial instruction in elaborative interrogation, statistical tests were based on a reduced sample of students in the NLD group, as these students were more likely than others to choose the rehearsal strategy. It is possible that the reduced sample size of the NLD group may have obscured potential between group differences.

Hypothesis 3

The third hypothesis predicted that students with arithmetic difficulties would be less likely to accurately monitor their memory performance and to demonstrate successful strategy transfer than would students with reading difficulties. It was predicted that students with both arithmetic and reading difficulties would be least likely to demonstrate accurate memory monitoring and successful strategy transfer, while normally achieving students would be most likely to demonstrate these skills.

3. a) Memory monitoring. Memory monitoring was assessed by noting whether students chose the strategy that had been most effective for them after initial instruction and practice during subsequent strategy choice opportunities. Although it was not possible to statistically assess group differences in strategy choice due to the small experimental sample size, the relative impact of both arithmetic and reading difficulties was examined. Taken together, results for two strategy choice opportunities with the man sentences indicated that, while the presence of reading difficulties did not appear to affect students' strategy choice, students with arithmetic difficulties appeared less likely to choose the strategy that had been most effective for them. Examination of group strategy

choices over the two sessions supports this finding in that normally achieving students and students in the RLD group selected the strategy that had been most effective for them 97.7 and 93.3 percent of the time respectively, while students in the NLD group did so only 76.9 percent of the time, and students in the GLD group did so 86.4 percent of the time. These findings appear to provide partial support for the third hypothesis, in that students with difficulties in arithmetic were less likely to show evidence of memory monitoring with respect to strategy efficacy than normally achieving students, or students with only reading difficulties. However, in view of the finding that, for the majority of students, elaborative interrogation was the most effective strategy, it is also possible that students with arithmetic difficulties, (particularly students in the NLD group), found elaborative interrogation too cognitively demanding due to the fact that it required the generation of semantic associations, and therefore chose the rehearsal strategy on this basis, rather than as a result of inadequate memory monitoring.

These findings are interesting on a number of levels. First, they differ somewhat overall from the findings of previous investigations of nondisabled students' monitoring of strategy utility. Schneider and Pressley (1997) presented research by Pressley, Levin, Ghatala and colleagues and noted that children generally do not monitor the efficacy of strategies while using them (e.g., Pressley, Levin & Ghatala, 1984) or while observing other students using them (e.g., McGivern, Levin, Pressley, & Ghatala, 1990). However, these results must be considered in light of developmental trends in more general memory monitoring. Data reviewed by Schneider and Pressley (1997) appear to indicate that while grade school students experience significant increases in memory monitoring skills, these

skills continue to develop well into adolescence. Students in the study by Pressley et al. (1984) ranged in age from 11 to 13 years, and although the age span in the current study ranged from approximately 11 years to 15 years, the majority of participants were 12 years, six months or older. The finding that these students appeared to demonstrate an awareness of which strategy was more effective for them, whereas students in the study by Pressley et al. (1984) did not do so without explicit feedback, may serve as further evidence of developmental trends in memory monitoring in general, and more specifically, in the monitoring of strategy efficacy. This idea is further supported by the findings of McGivern et al. (1990), who noted that while second graders did not realize improved knowledge of strategy efficacy after watching a model using differentially effective strategies, seventh grade students did demonstrate improved strategy efficacy knowledge and were more likely to select the more effective strategy.

These findings must also be considered in terms of what could be described as the motivating features of each strategy. That is, although it was anticipated that elaborative interrogation would be the most effective strategy for most students, and this was true in the majority of cases, it is also important to consider features of the strategies other than effectiveness that made them more or less appealing to students. This issue became evident in the current study when students were asked to rehearse the man sentences. It was noted that during instruction and practice with rehearsal, a large proportion of students verbally expressed that they found this strategy tedious and found the sentences losing any kind of meaning after the multiple repetitions that were usually possible in 20 seconds given their relatively short length. Thus, it is possible that even if rehearsal had

been the strategy that was most effective for students, they may not have employed it during subsequent choice opportunities, simply because they had experienced it as tedious. This idea may be born out in the finding that, although there were six students for whom rehearsal was more effective during initial instruction and practice with both strategies, three of those students nonetheless selected elaborative interrogation during the first strategy choice opportunity.

Of further interest within the strategy selection data is the finding that, of the six students for whom rehearsal was more effective, five of those students were from the groups representing difficulties with arithmetic (three from the NLD group and two from the GLD group). The finding that the rote rather than meaning based strategy was more effective for these students may provide further support for descriptions of the unique neuropsychological and academic assets of students with arithmetic difficulties (e.g., as delineated by Rourke & Tsatsanis, 1995).

Memory monitoring was also assessed by examining the relationship between students' predictions and postdictions of memory performance and their actual recall scores. Results generally did not support a strong overall correlation between students' predictions of memory and their actual recall, and thus it was not meaningful to interpret group differences in this regard. These findings were complex in that examination of group correlation scores for each set of predictions and recall revealed tremendous variability in both the magnitude and direction of the coefficients (see Table 15). These results were somewhat unexpected given the report by Schneider and Pressley (1997) that, while zero correlations are frequently obtained when students make performance

predictions without experiencing a practice test on the materials in question, the accuracy of performance predictions is significantly increased when students are pre-tested on items identical to the actual test. As the first two tasks of the second experimental session involved testing with the same materials used in the third task (prior to which students made their first prediction), it seemed reasonable to expect some correlation between students' predictions of performance and their actual recall of these simple materials. Further, there was no trend toward improvement in the correlations between prediction and actual recall even though students had two more opportunities to experience the prediction-learning-testing cycle.

With respect to students' postdictions of memory performance, the overall correlations with actual recall were consistently strong and positive for each of the five occasions on which students made postdictions of performance, thereby suggesting that students were able to estimate their performance with some accuracy following testing. Although there were no group differences with respect to the strength of the correlations, these findings were more in keeping with what might be expected, given that students had repeated opportunities to monitor their performance using the same strategy after being tested.

The finding that students' postdictions of performance varied with their recall scores, while their predictions did not, may indicate that there are qualitative differences between these two acts. Perhaps the most obvious of these differences lies in the fact that predictions of performance prior to testing involve a somewhat hypothetical situation, whereas estimations of performance after testing are based on students' actual experience

with the task and therefore may be more easily accessed. In addition, Borkowski, Carr and Pressley (1987) and Weed et al. (1990) have noted the importance of students' attributions with respect to their potential performance. First, whether or not students believe they have the ability to control the outcome of a task may have an impact on their performance (Weed et al. (1990). This finding may be particularly salient for some students with learning difficulties who may experience themselves as having little personal control over academic events (e.g., Tarnowski & Nay, 1989; Johnson, 1981). Second, many students do not attribute performance improvements to appropriate strategy use without explicit instruction to do so (Borkowski et al., 1987). Therefore, although students in the current study may have realized improved recall using elaborative interrogation, they may not necessarily have attributed those improvements to the strategy, particularly if they did not perceive themselves as having control over the task outcome at the outset. It would appear that these factors could more easily influence predictions, which presumably are based at least in part on students' view of their memory capacities in general, rather than postdictions, which theoretically should be more strongly linked to students' perceptions of their actual performance on the task.

Although it was not possible to conduct statistical analyses on the frequencies with which students overestimated, underestimated, or were correct in their pre- and postdictions of memory performance, visual inspection of the data does appear to suggest some trends. With respect to predictions of performance, it appears that students with arithmetic difficulties (students in the NLD and GLD groups) were more likely than other students to overestimate their performance, while a greater proportion of normally

achieving students and students in the RLD group underestimated their performance. With respect to postdictions of memory performance, the same trends were noted in that, students with arithmetic difficulties (i.e., students in the NLD and GLD groups) were more likely to overestimate their recall performance, while normally achieving students and students in the RLD group appeared more likely to underestimate their performance. It might be speculated that the increased likelihood of overestimation by students with arithmetic difficulties is consistent with reports by Rourke (e.g., 1989) that students with the NLD syndrome often fail to recognize that a situation or problem is beyond their expertise, and may generate unreasonable solutions even when they have some familiarity with the task.

3.b) Strategy transfer. Successful strategy transfer was considered to have occurred if students who had previously chosen elaborative interrogation to learn the man sentences recognized that the strategy would also be most effective for learning the animal sentences presented in the final session. Again, group differences could not be statistically examined, but the relative impact of both arithmetic and reading difficulties was assessed. Consistent with strategy choice results for the man sentences, the presence of reading difficulties did not appear to affect students' strategy choice, while students with arithmetic difficulties appeared less likely to choose the strategy that had been most effective for them and thereby demonstrate successful strategy transfer. Again, examination of group strategy choices supported this finding, as 90.9 percent of the normally achieving students and 93.9 percent of students in the RLD group chose the strategy that had been most effective for them, while only 65.4 percent of students in the

NLD group did so, and 72.7 percent of students in the GLD group did so.

Before interpreting the performance differences reported herein, it is important to consider the overall results obtained by students in the current study within the context of previous research on strategy transfer. The current study differed somewhat from other investigations in that previous studies have manipulated the provision of specific strategy information (e.g., where and when to use the strategy in addition to how) immediately prior to the transfer task (Schneider & Pressley, 1997). The current investigation provided a review of the use of both rehearsal and elaborative interrogation using the materials with which the strategies were originally taught (the man sentences) one week after the initial instruction session. Following this, and during the same session, the new materials for transfer were presented to students in a separate trial with only the instruction that they could use either of the two strategies to learn them.

The finding that a significant proportion of the current sample (e.g., approximately 91 percent of the normally achieving students and 94 percent of the students in the RLD group) demonstrated transfer of the elaborative interrogation strategy to a new but similar task appears to represent a greater degree of successful transfer than has been reported in the literature. For example, Schneider and Pressley (1997) reviewed a number of studies that reported that children in early adolescence required explicit information about where and when to use a strategy during the instruction phase in order to ensure transfer of the strategy to other situations, but became more likely to do so on their own with increasing age. Accordingly, the current results may reflect developmental increases in strategy transfer, given the somewhat older age group in the current investigation. At the same

time, it is necessary to be cautious in interpreting these findings, given the methodological differences between the procedures used herein and those of previous investigations.

Finally, as noted previously, the finding that a large number of students selected elaborative interrogation for use with the transfer task may also have been related to the observation that most students reported finding the rehearsal strategy extremely tedious.

Taken together, results with respect to the monitoring of strategy efficacy appear to suggest that students with difficulties in arithmetic were less likely to choose the strategy that had previously been most effective for them, or to recognize that transfer of that strategy to a new, but similar, situation was appropriate. These findings were consistent with predictions made on the basis of Rourke's (1982; 1987; 1989) model of neuropsychological functioning, which suggests that students whose difficulties are evident in the nonverbal domain realize little benefit from performance-related feedback (e.g., as in the test experiences of the current study) and have difficulty coping with novel situations (e.g., as in the transfer task in the current study).

General Discussion

In attempting to integrate the current results with respect to metamemory in different subtypes of learning disabilities, a number of consistent findings must be considered. First, on both independent and concurrent measures of metamemory, normally achieving students repeatedly demonstrated the greatest levels of metamemory, while students with difficulties in both arithmetic and reading consistently demonstrated the poorest performance in this regard. The expected group differences between students with reading difficulties and students with arithmetic difficulties were not observed for the

most part, although nonsignificant performance trends were frequently in the hypothesized direction. While, as previously noted, this result may suggest that there is little variability in metamemorial knowledge across different learning disability subtypes, it is also possible that the relatively small sample size of the current study may have rendered between group differences more difficult to detect, an issue which should be addressed by future research efforts in this area.

In spite of the fact that the hypothesized group differences were not observed, investigations of the relative impact of both arithmetic and reading difficulties have provided important information which can be applied to the current hypotheses. Perhaps most significant was the finding that, while arithmetic difficulties (as in the NLD and GLD groups) and reading difficulties (as in the RLD and GLD groups) were both associated with poorer performance on various measures of metamemory, no interactions were noted between these two factors on any measure. Given the consistent finding that students with difficulties in both arithmetic and reading (the GLD group) performed most poorly on metamemory measures, it seems appropriate to conclude that, within the current sample, the effects of arithmetic and reading difficulties were additive, and may have originated from different sources in terms of brain functioning.

As suggested previously, such a finding would appear to provide support for the model on which the current hypotheses are based. Rourke's (1982; 1987; 1989) model of neuropsychological functioning posits that students who exhibit deficient mechanical arithmetic performance in the context of normal word recognition and spelling skills (among other cognitive and neuropsychological signs) may demonstrate faulty right

hemispherical systems and well-developed left hemispherical capacities, while students who exhibit deficient reading and spelling in the context of normal arithmetic skills demonstrate the opposite pattern of hemispherical functioning. The failure in the current study to observe any kind of interaction between arithmetic difficulties and reading difficulties does appear to support the notion that certain types of mechanical arithmetic deficiencies and reading difficulties have their origin in different hemispheres of the brain.

In considering the current findings, it is also important to acknowledge the fact that arithmetic difficulties can originate not only as a result of right hemisphere dysfunction (as theorized in the NLD syndrome), but also as a result of the phonological processing difficulties that can be associated with left hemisphere dysfunction (Rourke, 1989). Accordingly, an informal examination of the arithmetic errors made by students in the NLD group (arithmetic difficulties only), and students in the GLD group (both reading and arithmetic difficulties) was conducted. Rourke (1989) reported that, while students with reading and spelling difficulties generally exhibit problems with arithmetic that can be attributed to their disability in reading and/or their inexperience with the subject material, students with the NLD syndrome make errors in mechanical arithmetic that are characteristic of their deficits in visual-spatial-organizational, psychomotor, concept-formation and hypothesis-testing skills. Rourke (1989) has categorized these errors as reflecting deficiencies in spatial organization (e.g., misaligning numbers in columns), problems with visual detail (e.g., misreading the mathematical sign), procedural errors (e.g., applying a rule learned for one arithmetic procedure to another for which it is not appropriate), failure to shift psychological set (e.g., continuing to do addition when the

problem has been changed to subtraction), poor graphomotor skills, difficulties accessing remembered rules when needed during calculation, and difficulties with judgment and reasoning (e.g., attempting questions that are clearly beyond their current expertise).

A cursory review of the arithmetic errors made by students in the NLD group and students in the GLD group for mistakes reflecting the first two categories identified by Rourke (1989) (which could perhaps be seen as the easiest to identify conclusively) revealed that eight percent of the errors made by students with both reading and arithmetic difficulties represented difficulties with spatial organization and visual detail, while 20 percent of the errors made by students demonstrating only arithmetic difficulties represented these types of deficits. While this was by no means a standardized procedure, and was conducted on the very small sample of each students' mechanical arithmetic provided by the WRAT-R, it does serve to highlight the possibility that the arithmetic difficulties of students in the GLD group may have had a different neuropsychological origin than the arithmetic difficulties of students in the NLD group. Accordingly, inferences about metamemory based on findings related to the impact of arithmetic difficulties (i.e., as evaluated by the 2x2 analyses of variance and the Fisher exact tests, etc.) do not necessarily describe only the metamemorial capacities of students with presumed right hemispheric deficits (as in the NLD group), but perhaps also the capacities of students whose arithmetic difficulties may reflect some combination of right and/or left hemisphere dysfunction which produced difficulties in both arithmetic and reading.

In the absence of significant between group differences among learning disability subtypes, and bearing in mind the potentially heterogeneous nature of the arithmetic

deficits identified in the current study, results from investigations of the relative impact of reading and arithmetic difficulties nonetheless provide some support for the notion that students with the NLD syndrome possess less metacognition about memory than do students with reading disabilities. For example, the finding that arithmetic difficulties were associated with lower scores on three of the four subtests of the Metamemory Battery, in conjunction with the finding that students with arithmetic difficulties were consistently less likely to choose the strategy that had been most effective for them during both monitoring and transfer opportunities, at the very least provides justification for further comparisons between students with reading difficulties and students with arithmetic difficulties, albeit with much more stringent criteria for group inclusion.

Further investigations in this area would benefit from the inclusion of a significantly more comprehensive sample of arithmetic performance in order to conduct a more formal analysis of errors, in conjunction with neuropsychological assessment of students' assets and deficits. Although costly in terms of time and money, such identification procedures would allow for much more conclusive statements about the metamemorial functioning of students with the NLD syndrome as compared to students with other subtypes of learning disabilities. With regard to the assessment of strategy acquisition and application as it relates to metamemory, the current study employed a verbal rather than visually-oriented strategy in order to obtain a more general assessment of the metamemorial knowledge of students with the NLD syndrome, and to avoid the possibility that these students' metamemory for a task that would be more difficult for them would be less well-developed, thereby creating artificially large between-group

differences. However, future investigations seeking to provide a more comprehensive description of the metamemory functioning of students with the NLD syndrome may wish to include a nonverbal task in order to explore the task-specific metacognition about memory of these students.

Overall, results of the current study do appear to provide at least partial support for the idea that students with arithmetic difficulties (as in the NLD syndrome) possess less well-developed metamemory than students with reading difficulties, although the current investigation constitutes only a preliminary examination of this issue and results must be interpreted with caution in view of some of the methodological issues identified. However, on the basis of the current findings, and particularly those with respect to strategy selection and memory monitoring, it does appear that students with arithmetic difficulties may have different needs with regard to metacognitive instruction about memory strategies than do students with reading difficulties, thus making this an area of inquiry that is deserving of further study by educators and psychologists.

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Appendix A - Consent Forms for Regional Children's Centre

CONSENT FORM

I, _____ agree to allow my child _____ to participate in the research project which is being conducted by Catherine Greene, graduate student at the University of Windsor, under the supervision of Dr. Sylvia Voelker of the University of Windsor. I understand that this participation is entirely voluntary; I or my child can withdraw consent at any time and the results of the participation will be removed from the study. I also understand that the decision not to participate in this project will not affect services from the agency with which my child is involved.

The following points have been explained to me:

1) The reason for the research is to increase our understanding of what children know about their own memory. This information will be shared with teachers and parents so that they may help children learn more effective ways of remembering the types of materials taught in school.

2) The procedures are as follows:

a) Achievement testing (e.g., testing on the types of subjects children learn in school) may be necessary for those students who have not already had this completed at Windsor Regional Children's Centre.

b) In the first session, my child will be given a memory survey which will assess his/her knowledge about memory (e.g., what ways of remembering work best for them).

c) In the second session, the researcher will teach my child two different strategies. My child will pick one of these strategies to learn a list of facts.

d) In the third session, my child will again pick one of the two strategies in order to learn a new list of facts.

3) There is no apparent risk of psychological harm and my child will face no discomfort or stress during this project other than the time commitment of about two and one-half hours (over three weeks).

4) I understand that an identification number will be used and my child's name will not be recorded on any of the data.

5) The investigator will answer any further questions about the research, either now or during the course of the project. Parents may contact the investigator for a written summary of the results once they are available.

Parent Signature

Date

Parent Signature

Date

Child Signature

Date

Witness

Date

PLEASE SIGN BOTH COPIES. KEEP ONE AND RETURN THE OTHER TO THE INVESTIGATOR.

Research at the University of Windsor which involves human participants is conducted under the auspices of the University Ethics Review Committee and the Research Evaluation Committee of the Windsor Regional Children's Centre. Questions or problems regarding this project can be addressed to Catherine Greene, Psychology Department (252-4232, 258-6057) or Dr. S. Voelker (252-4232 x 2249), Ethics Committee, University of Windsor, or Ms. Kathy Rene (257-5219), Windsor Regional Children's Centre.

Appendix B Consent Form for School Board

CONSENT FORM

I have been asked to allow my child (print full name) _____, a student at _____ school, to participate in the research project which is being conducted by Catherine Greene, graduate student at the University of Windsor. I understand that this participation is entirely voluntary; I or my child can withdraw consent and participation at any time. I also understand that the decision not to participate in this project will not affect any services from the school.

I understand that the reason for the project is to increase our understanding of what children know about their own memory. This information will be shared in general with teachers and parents so that they may help children use their personal memory strengths to learn more effective ways of remembering the different types of materials taught in school.

I understand that Ms. Greene will need to examine my child's Ontario Student Record folder for achievement results to determine his/her suitability for the project. If my child is a suitable candidate, then he/she may be given a brief achievement test if the information is not available at the school or is outdated. Following the achievement testing, my child will have three meetings with Ms. Greene: the first will focus on my child's knowledge about memory (for example, what ways of remembering work best for him/her); the second meeting will involve teaching my child two methods of remembering, one of which will be chosen by my child to learn a list of facts; finally in the third meeting my child will again pick one of the memory methods to learn to learn a new list of facts. To save time, both written and audiotape methods will be used to record performance.

I understand that there is no apparent risk of psychological harm and my child will face no discomfort or stress during this project other than the time commitment of about two and one-half hours over a three week period. Children often find the activities presented enjoyable and challenging; the benefit for my child may be a greater awareness of his/her personal memory strengths.

I understand that although names will initially be used to contact potential participants, names will not be used on any of the actual activities or in the final project write-up.

I understand that Ms. Greene will answer any further questions about the project, either now or during the course of the project. A copy of the full write-up will be available in the Professional Library of the Windsor Board of Education once the project is completed.

Finally, I understand that research projects at the University of Windsor which involve children and/or adult participation are conducted under the auspices of the University Ethics Review Committee and the Research Review Committee of the Windsor Board of Education. Questions or concerns regarding this project can be addressed to Catherine Greene, Psychology Department (252-4232 or 258-6057); Dr. Sylvia Voelker (252-4232 x 2249) Ethics Committee and Supervisor of this project; or Dr. John J. Berek (255-3214), Head of Psychological Services. The Windsor Board of Education.

PLEASE SIGN A) I agree or B) I do not agree

A) I AGREE to have my child participate in Ms. Greene's project.

I AGREE to participate in Ms. Greene's project.

Parent Signature

Child Signature

B) I DO NOT AGREE to have my child participate in Ms. Greene's project.

I DO NOT AGREE to participate in Ms. Greene's project.

Parent Signature

Child Signature

DATE: _____

Please sign both pages; keep one for your records and return the other to the school by _____.

THANK YOU.

Appendix C - Consent Form for Children's Achievement Centre

CONSENT FORM

I have been asked to allow my child (print full name) _____, a student at The Children's Achievement Centre, to participate in the research project which is being conducted by Catherine Greene, graduate student at the University of Windsor. I understand that this participation is entirely voluntary, I or my child can withdraw consent and participation at any time. I also understand that the decision not to participate in this project will not affect any services from The Children's Achievement Centre.

I understand that the reason for the project is to increase our understanding of what children know about their own memory. This information will be shared in general with teachers and parents so that they may help children use their personal memory strengths to learn more effective ways of remembering the different types of materials taught in school.

I understand that Ms. Greene will need to examine my child's clinical file for achievement results to determine his/her suitability for the project. If my child is a suitable candidate, then he/she may be given a brief achievement test if the information is not available at The Children's Achievement Centre or is outdated. Following the achievement testing, my child will have three meetings with Ms. Greene: the first will focus on my child's knowledge about memory (for example, what ways of remembering work best for him/her); the second meeting will involve teaching my child two methods of remembering, one of which will be chosen by my child to learn a list of facts; finally in the third meeting my child will again pick one of the memory methods to learn to learn a new list of facts. To save time, both written and audiotape methods will be used to record performance.

I understand that there is no apparent risk of psychological harm and my child will face no discomfort or stress during this project other than the time commitment of about two and one-half hours over a three week period. Children often find the activities presented enjoyable and challenging; the benefit for my child may be a greater awareness of his/her personal memory strengths.

I understand that although names will initially be used to contact potential participants, names will not be used on any of the actual activities or in the final project write-up.

I understand that Ms. Greene will answer any further questions about the project, either now or during the course of the project. Parents will be provided with feedback about the findings of the project once it has been completed.

Finally, I understand that research projects at the University of Windsor which involve children and/or adult participation are conducted under the auspices of the University Ethics Review Committee. Questions or concerns regarding this project can be addressed to Catherine Greene, Psychology Department (252-4232 or 258-6057); Dr. Sylvia Voelker (252-4232 x 2249) Ethics Committee and Supervisor of this project; or Ms. Pat Thomas (252-3473), Programme Manager, The Children's Achievement Centre.

PLEASE SIGN A) I agree or B) I do not agree

A) I AGREE to have my child participate in Ms. Greene's project.

Parent Signature

I AGREE to participate in Ms. Greene's project.

Child Signature

B) I DO NOT AGREE to have my child participate in Ms. Greene's project.

Parent Signature

I DO NOT AGREE to participate in Ms. Greene's project.

Child Signature

DATE: _____

Please sign both pages; keep one for your records and return the other to The Children's Achievement Centre by _____.

THANK YOU.

Appendix D

"Man Sentence" Lists for Session Two

1. The short man bought the broom.
 2. The brave man gave money to the robber.
 3. The fat man read the sign.
 4. The tall man bought the crackers.
 5. The thin man found the scissors.
 6. The rich man picked up the chair.
 7. The sad man looked at his new boat.
 8. The kind man ate dinner.
 9. The smart man went to work.
 10. The bald man used the phone.
 11. The artistic man put down the knife.
 12. The frightened man ironed the sheet.
 13. The sleepy man bought the mug.
 14. The evil man wound up the clock.
 15. The blind man hit the fleas.
-
1. The bearded man threw out the coupon.
 2. The crippled man flicked the switch.
 3. The dying man used a feather.
 4. The religious man used the saw.
 5. The long-haired man looked for the pole.
 6. The Irish man counted the leaves.
 7. The weak man thanked the checkout girl.
 8. The patriotic man memorized the words.
 9. The dishonest man looked closely at the wrapper.
 10. The ugly man looked at the magazine.
 11. The lonely man picked up the newspaper.
 12. The funny man ran into the house.
 13. The handsome man went to the store.
 14. The loving man looked at the display.
 15. The shy man went outside.
-
1. The jealous man bought the camera.
 2. The cheap man arrived at the shop.
 3. The strong man helped the woman.
 4. The lucky man received the letter.
 5. The old man read the newspaper.
 6. The angry man walked into the school.
 7. The hungry man got into the car.

8. The happy man spent a lot of money.
9. The sick man rang the bell.
10. The confused man bought the map.
11. The hairy man went shopping.
12. The unemployed man stood in the line.
13. The French man looked at the dictionary.
14. The married man cut out the coupon.
15. The friendly man wrote a letter.

Appendix E**Sentence Lists for Session Three**

1. The loud man spoke to the police.
2. The nervous man went to the drugstore.
3. The excited man knocked on the door.
4. The freckled man used the umbrella.
5. The stiff man took the pill.
6. The patient man picked up the blocks.
7. The single man went to the pet store.
8. The business man threw away the newspaper.
9. The deaf man bought the batteries.
10. The honest man picked up the money.
11. The small man bought the shoes.
12. The poor man wrote his name.
13. The Italian man wrote the book.
14. The young man rented the office.
15. The curious man turned on the computer.

1. The grey seal sleeps in shallow water.
2. The blue whale only eats for about three months of the year.
3. The emperor penguin never makes a nest.
4. The townsend mole likes to live in warm, humid areas.
5. The American pika likes to live in and around rock piles.
6. Beavers' lips close behind their front teeth.
7. Bats make high frequency sounds which echo off objects and tell the bat their location.
8. Grizzly bears' sense of smell is better than that of a bloodhound.
9. The honey bear has a double layer of fur.
10. The vulture has no feathers on its head.
11. The camel has a double row of eyelashes for each eye.
12. The anteater has longer claws on its front feet than on its back feet.
13. The giraffe can completely close both its nostrils.
14. The alligator's ears and eyes grow on the top of its head.
15. The hippopotamus learns how to swim before it learns how to walk.

Appendix F

EXPERIMENTAL SCRIPTS

Session One

This session involves administration of the metamemory battery, which includes a scripted explanation of the task as well as instructions for each subtest.

Session Two

(Order of strategy presentation will depend on whether students are assigned to Rehearsal first or Elaborative Interrogation first, Rehearsal first is shown here)

"Today I'm going to teach you two different ways to try to remember things. The first way is one that you have probably used before; it is where you repeat the words out loud over and over again. A fancy name for this is rehearsal. So, if I say to you 'The old man bought the newspaper', you would say that sentence over and over until I give you the next fact, like this (demonstration). Why don't you try it now? (practice with feedback).

Now we are going to practice learning a list of sentences using "rehearsal". I am going to give you some sentences about different men, e.g., short men, fat men, etc., and what they do. After we have finished practicing the sentences, we will see how many you can remember. I will ask you who did what, so for example 'Which man bought the newspaper?', and I want you to tell me who did that activity.

When you are ready to start, I will give you the sentences one at a time. I want you to repeat each sentence out loud over and over until I let you know that the next sentence is coming up. Do you have any questions about what I want you to do? (Pause to provide explanation if necessary). Alright, lets get started.

(Practice sentences in order of appearance allowing 20 seconds between each sentence, record how many times they repeat each sentence. One minute interview when finished asking about what classes they are taking, favorite subjects etc. After interview, test on practice sentences in random order and then ask them to predict how many they got right on the test).

Now I'm going to show you another way to remember sentences. This way has kind of a fancy name, its called elaborative interrogation. We're just going to call it E-I for short. This is where you ask yourself the question "why?" about each sentence that I give you. So, if I give you the sentence 'The tired man got into the car', you would ask yourself, 'Why did the tired man get into the car?', and try to answer that question out loud. You should try to explain why it was the tired man who did the action rather than another type of man. For example, you might say, 'The tired man got into the car to drive

home from his long day at work'. Do you see how this answer tells you why it was the tired man who got into the car and not the short man or some other kind of man?

Why don't you try it now. I'll give you a few sentences to practice with (practice with feedback, time how long it takes them to master the strategy).

1. The deaf man bought the batteries (because he needed them for his hearing aid).
2. The lonely man went to the pet store (because he wanted to buy a pet to keep him company).
3. The stiff man took the pill (because he wanted his back to stop hurting).
4. The honest man picked up the money (and turned it in to the police).
5. The poor man wrote his name (on the job application).

(Students must provide three good explanations to show mastery. Ask them if they feel they've got it before proceeding, write down the number of practice sentences it took them to master it).

Good, now we are going to practice learning a list of sentences using E-I. I am going to give you some more sentences about different men and what they are doing, just like the ones we did earlier. After we have finished practicing the sentences, we will see how many you can remember, just like we did the first time. I'll say, "Which man.....", and you'll try to tell me who did that activity.

When you are ready to start, I will give you the sentences one at a time. For each sentence, I want you to ask yourself "why?" and try to come up with an explanation for why that sentence makes sense, just like we practiced. I want you to say your answer out loud and then wait for the next sentence. Do you have any questions about what I want you to do? (Pause for explanation as necessary). Alright, lets get started.

(Practice sentences in order of appearance, allow 20 seconds between each sentence and write down their answers. Give one minute interview when finished asking about school activities, hobbies, sports etc., then test them on the practice sentences in random order and ask them to predict how many they think they got right on the test).

Now that we have practiced both ways of remembering sentences, I am going to give you a new list of sentences to learn. You can use either one of the ways of remembering that we practiced. You can either repeat the sentences out loud or you can come up with explanations for why the sentences make sense, but you can only use one of those ways. Which one do you want to use? (Student indicates their choice).

Before we go ahead and practice the sentences, I would like you to try and tell me how many of the new sentences you think you will be able to remember. (Student's prediction).

Good, when you are ready, I will give you the new sentences. You picked (students choice), so please use that way to remember the sentences. We will see how many you can remember at the end, just like before. Are you ready?

(Practice sentences in order of appearance allowing 20 seconds between each sentence. Give a one minute interview asking about which high school they will be attending, what classes they want to take there, plans for university, etc. Then test on sentences in random order and ask them to predict how many they got right).

Now that we are all finished, can you tell me....

- which way of remembering was the easiest to do (e.g., in terms of the mechanics of it)
- did one of the ways of remembering help you remember the sentences more easily
- can you tell me why you decided to use (student's choice) to learn the last set of sentences
- anything else you can think of, comments

Session Three

"Do you remember the ways of remembering that we practiced last week? One was called rehearsal - remember how you repeated the sentences out loud over and over? The other way was called E-I - remember how you asked yourself why each sentence made sense and gave your answer out loud. Why don't we practice some sentences again to refresh your memory? (practice with feedback).

Rehearsal - The short man bought the broom.

E-I - The brave man gave money to the robber.

The sleepy man bought the mug.

The fat man read the sign.

The bald man used the phone.

(Note how many sentences it takes the student to regain mastery of E-I, time it, ask if they feel they've got it before proceeding).

Now I am going to give a list of sentences about different men. You can use either way of remembering them. Which way would you like to use? Can you tell me why you picked that strategy? How many sentences do you think you will get right out of 15?

When you are ready, I will give you the sentences. You picked (rehearsal or E-I) so please use that way to try to remember the sentences. We will see how many you can remember at the end and I will ask you which man did a certain activity, just like last week. Are you ready?

(Practice sentences in order of appearance allowing 20 seconds between sentences and recording either the number of repetitions or the answer given. Give one minute interview about how they feel about the end of the school year, etc., then test on sentences in

random order and ask them to predict how many they think they got right).

Now I am going to give you another list of sentences to learn. These sentences are about animals. I am going to let you look over the sentences and then you can pick one of the two ways of remembering that we practiced, in order to learn these new sentences. (Give students a minute to examine sentences).

Which strategy would you like to use? Can you tell me why you picked that strategy? How many do you think you will be able to remember out of 15?

When you are ready, I will give you the sentences. You picked (rehearsal or E-I) so please use that way to try to remember the sentences. We will see how many you can remember at the end and I will ask you which animal has a certain quality, does a certain activity, or lives in a certain place. Do you have any questions about what I want you to do? Alright, lets get started.

(Practice sentences in order of appearance allowing 20 seconds between each, record number of repetitions or answer given. Give a one minute interview asking about summer plans, vacations etc., then test them on the sentences in random order. Ask them to predict how many they think they got right and if they feel they picked the best strategy for the job).

VITAE AUCTORIS

Catherine Greene completed her Bachelor of Arts with Honors in Psychology at Acadia University in May, 1991, and her Master of Science in Community/Clinical Psychology at Acadia University in May, 1993. She received her Ph.D. in Clinical Child Psychology from the University of Windsor in September, 1998, and is currently employed in the Psychology Department of the Kawartha Pine Ridge District School Board.