Direct and Indirect Testing of Memory in Children with Learning Disabilities

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Direct and Indirect Testing of Memory in Children with Learning Disabilities

A Thesis
Presented to the
Department of Special Education and Communication Disorders and the Faculty of the Graduate College
University of Nebraska

In Partial Fulfillment
of the Requirements for the Degree Masters of Arts: Resource Teaching and Learning Disabilities

University of Nebraska at Omaha

By
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Thesis Acceptance

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements for the degree (Masters of Arts: Resource Teaching and Learning Disabilities), University of Nebraska at Omaha.

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Janette Sodoro
Abstract

This study examined the relation between performance on direct and indirect measures of memory for pictures and words in children with learning disabilities. Recognition memory provided the direct measure and the magnitude of naming facilitation provided the indirect measure. Fourth grade learning disabled and nonlearning disabled children were asked to study a mixed list of pictures and words. A naming/recognition task was administered immediately following the study phase, as well as the following day. In addition, source memory was measured immediately following each recognition decision. For each item recognized as "old", subjects were required to render a decision about the source of that particular memory: "Did you hear the name of the picture?" or "Did you see the picture?" The results of this study found that learning disabled children were deficient on the recognition memory test, but produced greater repetition priming than nonlearning disabled children. Second, recognition memory declined over 24 hours, whereas repetition priming remained stable. Third, a within-subjects analysis indicated repetition priming was independent of recognition accuracy. Fourth, modality of presentation produced parallel effects on repetition priming and recognition memory. Fifth, source memory of learning disabled and nonlearning disabled children did not differ.
Review of Literature

Direct and Indirect Tests of Memory

Memory may be tested either directly or indirectly (Richardson-Klavehn & Bjork, 1988). Direct tests of memory require conscious recollection of a prior episode in a subject's history. Theorists have referred to direct tests using terms such as "autobiographical" (Jacoby & Dallas, 1981), "episodic" (Tulving, 1983), and "explicit" (Schacter, 1987). Direct memory tests include such traditional measures as free recall, cued recall, and recognition. An example of a recognition task would be when a subject is required to discriminate items that were presented during a prior episode from items that were not presented. Recall tasks require a subject to generate items previously presented. Both recognition and recall tasks explicitly measure a subject's conscious memory of a prior episode.

Indirect tests are another set of tasks which measure changes in performance as a function of prior experience. Unlike direct tests of memory, indirect tests do not require conscious recollection of an event and do not make any explicit reference to a prior learning episode. Memory for prior events is measured indirectly through a process known as priming. Repetition priming occurs when prior experience with an item or event facilitates the subsequent processing of that item (Schacter, 1987). Indirect tests
include tests of lexical knowledge such as lexical
decision, word identification, picture identification, word
completion, homophone spelling tasks, and picture naming.
In word and picture identification tasks, subjects are
given brief exposure to a stimulus and then attempt to
identify it. Priming on these tasks is indicated by the
greater speed and/or accuracy with which recently presented
stimuli are identified relative to completely new items. A
lexical decision task requires subjects to state whether or
not a particular letter string constitutes a legal word.
Priming is reflected by a decreased latency in making the
lexical decision. Word completion tasks require a subject
to complete word stems (e.g., TAB__ _) or fragments (e.g.,
_SS_SS__ _) with the appropriate word. Priming is reflected
by an enhanced tendency to complete the stems and fragments
with words presented in a prior study list. A homophone
spelling task requires a subject to hear a homophone in the
context of a question that is to be answered. Priming on
this task is measured by a subject's ability to spell
recently presented homophones. A picture naming task
requires a subject to say the name of the object aloud.
Priming on this task is measured by the decreased latency
in picture identification.

Dissociations of Direct and Indirect Tests of Memory

Direct and indirect tests of memory often may be
dissociated. For example, dissociations between direct and
indirect measures have been revealed in studies comparing normal adults and amnesic patients (e.g., Jacoby & Witherspoon, 1982). The distinguishing characteristic of amnesia is the inability to recall prior experiences. Such a severe memory disorder manifests itself typically on direct measures of memory. Jacoby and Witherspoon (1982) found a dissociation between normals and amnesics on direct and indirect measures of memory. Subjects were initially presented with homophones in the context of a question that biased their less common meaning (e.g., "Name a musical instrument that employs a reed."). Nonhomophones were also presented in the context of a question (e.g., "What is your favorite sport?"). Memory was subsequently tested directly (recognition test) and indirectly (perceptual identification). The perceptual identification test required both populations to interpret and spell previously presented biased-homophones and nonhomophones, as well as new homophones. The results indicated that both normals and amnesics were more likely to spell previously presented biased-homophones, rather than new homophones or old nonhomophones. Further, amnesics' spelling of previously presented biased-homophones was actually better than normals. In contrast, the yes/no recognition test revealed that amnesics performed poorly compared to normals. The implication of this study is that memory disorders only affect memory tests that require conscious reinstatement of
events in memory.

Dissociations have also been revealed by studies that have examined the variable of adult aging on memory performance. Mitchell, Brown, and Murphy (1990) compared the memory performance of young and old adults using direct and indirect tests. Subjects were initially presented with a task in which they were asked to name pictures as quickly and accurately as possible. Subjects were tested immediately following study and at intervals of 1, 7, and 21 days. During the test sessions, they were informed that their task was the same as in the first session. Subjects were presented with previously presented pictures, as well as completely new pictures. The facilitation pattern was similar for both younger and older subjects, with old pictures being named faster than new pictures. Furthermore, the amount of facilitation did not vary across retention interval for either age group. A picture recognition task was then administered in which subjects were asked to provide a recognition decision about old and new pictures. Results revealed that direct memory for pictures was significantly lower in older, relative to younger adults. Recognition performance showed a steady decline across retention interval for both age groups.

Dissociations have also been revealed by studies that have examined the level-of-processing variable. For example, although the manipulation of level-of-processing
has an effect on direct tests, there often is no impact upon indirect tests of memory. Such a dissociation is observed in the work of Jacoby and Dallas (1981). These investigators manipulated levels of processing of study words by asking different types of questions about words (e.g., "contains the letter R?"; "rhymes with train?"; "is the center of the nervous system?") at the time of study. The level of processing manipulation influenced yes/no recognition performance, but had no effect upon the speed with which subjects named words.

With regard to the variable of retention interval, Jacoby (1981) also provides evidence of a second type of dissociation. In his experiment, a word identification test was used to show that priming effects persist with little change across delays of a day and weeks, whereas direct memory declines along these delays (c.f. Mitchell et al., 1990).

Theoretical Accounts of Direct and Indirect Tests of Memory

Dissociations between explicit and implicit forms of memory have been explained by several theoretical accounts. One theoretical explanation is the threshold theory which proposes that implicit memory is influenced by weak memory traces that are unable to exceed the threshold of strength needed for explicit memory, thereby producing a dissociation between the two types of memory. This theory has been discounted by the fact that performance on an indirect
test is not affected by the same variables that affect performance on a direct test of memory. For instance, Jacoby and Dallas (1981) found that presentation of words during study produced parallel effects in perceptual and recognition memory on immediate and delayed tests. After a 24 hour interval, perceptual memory was found to be sensitive to study effects. Results on perceptual recognition performance provide evidence that information is remembered over intervals of time, rather than decaying rapidly (See Schacter, 1987 for a more detailed discussion).

A second theoretical explanation is the activation theory. This theory holds that dissociations occur because of different task requirements of direct and indirect forms of memory. For example, an indirect test requires automatic and short-lived activation of a logogen or abstract representation. In contrast, a direct test requires contextual information about an item's occurrence. Therefore, activation occurs automatically on an indirect test and does not require contextual information, whereas contextual information is required by a direct test.

A logogen is the basic unit of this model. This unit accepts information from auditory, visual, and semantic attributes during the processing of language (reading and hearing). The incoming information activates the logogen which is given a numerical value, and as this value rises
to a certain threshold, a response occurs. The response produced by the logogen is assumed to occur irrespective of its origin or context. Further, it is assumed that the activation will decay rapidly. Thus, medium of presentation and contextual information are not important to memory performance on an indirect test. In contrast, contextual information is necessary for memory performance on a direct test. For example, when contextual information is introduced, a constant numerical value can be maintained in a logogen.

The activation theory has been criticized on two counts. First, it has been shown that a prior visual presentation of a word produces greater facilitation in reducing one's visual threshold for a word than an auditory presentation (Morton, 1979; Clarke & Morton, 1983; Jacoby & Dallas, 1981). Second, experiments by Jacoby and Dallas (1981) and Jacoby (1983) found substantial priming on an implicit test of perceptual identification after a 2-day retention interval, thereby challenging the assertion that a schema rapidly declines.

A memory systems theory has also been proposed as an explanation for dissociations between implicit and explicit forms of memory (e.g., Squire & Cohen, 1984; Tulving, 1985). A memory systems account attributes dissociations on direct and indirect tests to the effect of different memory systems. For example, Tulving (1972, 1983) suggests
that dissociations between explicit and implicit tests reflect two memory systems, episodic and semantic memory, respectively. For example, episodic memory is presumed to be responsible for remembering previous episodes, whereas semantic memory is responsible for memory of abstract, conceptual knowledge. Support for this theory is provided by Jacoby and Dallas (1981). These investigators manipulated the level of processing of a word by having subjects pay attention to either graphemic, phonemic, or semantic details. They found that level of processing had a large effect on explicit or episodic memory, but not implicit or semantic memory. These results represent a dissociation between performance on a test of conscious recollection (recognition) and performance on a second test in which conscious recollection is not required (perceptual identification). The existence of two separate memory systems can be supported by these results because each memory system can be identified with different tasks. That is, perceptual performance relied on a perceptually based memory system, whereas recognition performance relied on an episodic based memory system.

The memory systems account has been criticized because it is unable to explain why a variable should affect one memory system and not the other. Expressed differently, the memory system's account cannot predict the type of interaction producing a dissociation, but only that an
interaction exists. This criticism spurs another theoretical explanation which attempts to explain dissociations in terms of processing interaction.

The final theoretical explanation proposed is the transfer appropriate processing view. The transfer appropriate processing view has been championed by Bransford, Franks, Morris, and Stein (1979), Roediger and Blaxton (1987), and Roediger, Weldon, and Challis, 1989. The transfer appropriate processing position relies on the following assumptions. First, memory tests benefit to the extent that the operations required at test overlap the encoding operations performed during prior learning. Second, explicit and implicit memory tests require different retrieval operations or access different information and, as a result, benefit from different types of processing during learning. Third, most direct tests rely on the encoded meaning of concepts (e.g., elaborative coding). For example, a variable such as deep elaborative coding has been found to enhance retention on direct tests such as recall and recognition. Direct tests are assumed to require conceptually-driven processing (Jacoby, 1983). Fourth, most standard indirect memory tests rely heavily on the match between perceptual processing during the learning and test episodes. Indirect tests, such as lexical decision, fragment or stem completion, and picture and word identification seem to rely on perceptual memory. These
tests are assumed to rely on data-driven processing (Jacoby, 1983). Therefore, variations in conceptual processing will have little effect on such indirect memory tests, but variations in surface features between study and test will greatly affect priming in perceptual memory tests.

Dissociations between direct and indirect tests are explained by distinctions drawn between data-driven and conceptually-driven processes (Jacoby, 1983). Direct tests are assumed to be primarily conceptually driven and indirect tests are considered to be data driven. Jacoby (1983) presented words in context and out of context. The no context condition involved reading a word out of context (e.g., xxx-Cold), whereas the context condition involved reading a word in the context of its antonym (e.g., Hot-Cold) or generating a word from its antonym (Hot???). Data-driven processing is greater when a word is read out of context. In this no context condition, there is no other way for a person to produce the word "cold" than for the data (letters that form the word) to be processed through the cognitive system. In contrast, conceptually-driven processing is greater when a word is generated than read in a no context condition. In this generate condition, the visual features are absent and the target word must be produced by generating the word from its opposite. Further, reading a word in context involves both
data-driven and conceptually-driven processing. In this context condition, expectations gained from context reduces reliance on the visual analysis of letters. Results reflected enhanced priming on perceptual identification of a word presented in the no context condition compared to both new words and words that had been generated. Reading a word in the context of an antonym produced word identification performance that was intermediate between the no context condition and generate condition. In contrast, recognition performance revealed that generating a word as an antonym of a context word produced greater recognition than did reading a word out of context. Also, reading a word in context produced greater recognition than did reading a word without context. Therefore, with regard to direct and indirect tests of memory, recognition memory is assumed to depend heavily upon conceptually-driven processing and will be affected by levels of processing. On the other hand, perceptual identification relies upon data-driven processing, and presumably is affected by the perceptual characteristics of the stimuli that are presented during study and test.

Support for the transfer appropriate processing theory has been provided in several studies. For example, Roediger and Blaxton (1987) found that changes in modality or surface form (typography) between study and test produce negative effects on an indirect test, but not on a direct
test. Roediger and Blaxton (1987) presented 96 words to subjects, half visually and half auditorily. Words were presented visually in two conditions: typed in lowercase or handwritten in uppercase. Items were also presented in two other conditions: either with or without instructions to imagine words in their typed form. Following presentation of the study list, one set of subjects received a standard yes/no recognition test in which the 96 old-items were randomly intermixed with 96 new-items. Another group of subjects received a word-fragment completion test in which 96 old-items were also randomly intermixed with 96 new-items. The rationale for this experiment is that test performance will improve to the extent that processing engendered at study matches processing at test. That is, word fragment completion is a data-driven task and should be highly sensitive to the way data are presented at study (visual vs. auditory). However, recognition is a conceptually-driven task and should be less sensitive to medium of presentation. Therefore, modality and typography should affect word fragment completion and not recognition. Results of this experiment show that priming from visual presentation was greater than for auditory presentation on the fragment completion test. Second, when typography of test words matched that which was used in the study episode, performance was better than when the two were mismatched. Third, when subjects were presented with words
auditorily, but told to imagine what the word would look like typed, fragment completion performance improved relative to the auditory-only presentation. Recognition results revealed that visual presentation was not superior to auditory presentation as was the case in the word-fragment completion test. Visual presentation produced the best results in fragment completion, whereas auditory presentation with instructions to imagine words yielded the best recognition performance. Second, when typography of test words matched that which was used in the study episode, performance was only slightly better than when the two were mismatched.

In conclusion, the results of this experiment indicate that fragment completion (an indirect test) is highly sensitive to the correspondence between study and test presentations for both modality and typography. Therefore, changes in surface form appear to have a negative impact on indirect tests of memory, but have no effect or a minimal effect on direct tests of memory. The above findings support the transfer appropriate processing account for dissociations between direct and indirect measures: memory performance is assumed to be a function of the similarity of processing operations engendered between study and test. Furthermore, the results support Jacoby's (1983) observation that direct tests are largely conceptually driven, whereas indirect tests are data driven.
In contrast to the foregoing findings that surface form and modality reveal repetition effects, some studies have not found that variation in surface form, context, and modality produce repetition effects. For example, Brown, Sharma, and Kirsner (1984) found that repetition effects on a lexical decision task were similar when writing systems were changed between study and test. In this study, identical words were repeated in the same scripts or in different scripts for Hindi-Urdu bilinguals literate in both scripts. Thus, variation in surface form did not make a difference to repetition effects. This evidence on surface-form effects is in direct contrast to Roediger and Blaxton's (1987) study which found that surface-form effects produced a difference in repetition effects. Roediger et al. (1987) used a fragment completion task and found that repetition effects were larger if the solution had been typed in letters of the same case as the fragment stem previously studied than if it had been handwritten in letters of the opposite case.

With respect to surface form and context, Carr, Brown, and Charalamous (1989) found that benefits of repetition were not affected by context and surface form variation when the task was held constant between study and test. Subjects were required to read either normal prose or scrambled prose at test. Results showed that reading times for the second repetition in each test situation were
independent of whether the first and second repetition was a match or mismatch. Therefore, match or mismatch of context between texts did not affect the magnitude of the repetition effect. Subjects were also required to read pairs of texts consisting of same word in the same order, but surface forms of texts either matched or mismatched (typed or handwritten). Results showed reading times for the second repetition were independent of the surface forms of the first text. Therefore, a match or mismatch of surface form of texts did not affect the magnitude of repetition priming. Such evidence contradicts an episodic account of repetition effects. Accordingly, the mixed results found in context and surface form variation appear because the task is not held constant between the first and second repetition.

The second point Carr et al. (1989) address is that experiments that show differences in repetition priming effects are not equal in the type of stimuli utilized. For example, Kolers (1973, 1975) used unfamiliar orthography (inverted texts) and found differences in repetition effects. In contrast, Carr et al. (1989) used familiar orthography (typed and handwritten) and found that repetition effects were not affected. Therefore, the type of stimuli used at study can produce a difference in the benefits of repetition effects.
Recognition Memory

Current recognition models that have parallels with the transfer appropriate processing theory are the dual process models of Mandler (1980) and Jacoby (1983). Jacoby hypothesizes that there are two forms of recognition memory. One form of recognition memory is referred to as "perceptual fluency." Recognition judgments that are based upon perceptual fluency are influenced by the perceptual familiarity of a stimulus. Judgments that are based on perceptual fluency are characterized by an automatic response from a subject. A second form of recognition memory is referred to as " autobiographical." Recognition judgments that are based upon autobiographical memory are influenced by conscious memory for prior episodes, and focus upon retrieval of characteristics of an item's context. Comparisons of effects on perceptual fluency and recognition memory reveal two classes of variables. Variables such as level of processing of words during study that involve elaboration of a word's context can influence recognition memory and not perceptual fluency. In contrast, variables such as number and spacing of repetitions that involve memory for graphemic information produce parallel effects in perceptual fluency and recognition memory. Therefore, variables that influence perceptual fluency can also have an effect on recognition memory (Jacoby & Dallas, 1981).

Mandler hypothesizes that recognition memory is based
on a dual process involving simultaneous integration and elaboration of an item. Although integration and elaboration may be simultaneous operations, integration is assumed to be an automatic, unconscious process, whereas elaboration is assumed to require conscious attention. Integrative processing is affected by a repetition variable, whereas elaboration is affected by levels of processing during study.

Jacoby and Mandler each hypothesized that the two forms of responding are possibly a function of different variables. Perceptual fluency and integration processes represent a fast, automatic, unconscious mode of responding, whereas autobiographical and elaboration processes represent a careful, conscious mode of responding. The parallel between these two dual-process models and the transfer appropriate processing theory is that they all emphasize the mental operations people perform in accomplishing tasks and the information these require (Roediger, 1984; Jacoby, 1983; Mandler, 1980). Accordingly, Jacoby and Mandler propose that memory performance is affected by bottom-up or data-driven processing and top-down or conceptually-driven processing. They hypothesize that some study and test conditions emphasize attention to data or surface form information and others emphasize attention to concepts (e.g., elaborations or associations). Examples of the distinction between data-driven and conceptually-driven
processing would be study activities emphasizing judgments of appearance versus judgments of meaning in an experiment involving levels of processing.

In support of Jacoby's two factor recognition model, Johnston, Dark, and Jacoby (1985) sought to differentiate between perceptual fluency and search (episodic) factors. The hypothesis that perceptual fluency serves as a basis for the feeling of familiarity was substantiated, as perceptual fluency was found to be used as a cue for discriminating old from new items. That is, words were more likely to be judged old if they were fluently perceived regardless of their actual old/new status. Second, Johnston et al. (1985) substantiated Jacoby's assumption that perceptual fluency and search factors both contributed to recognition judgments. In Experiment 1, subjects read a series of words and were then given a test containing previously seen words, along with new words. The time taken to identify the word was a measure of perceptual fluency, together with accuracy of identification. An old/new recognition test was administered that required subjects to judge whether a word was old or new. Results of this experiment revealed that some old words were perceived with high fluency but misjudged to be new, and that some new words were perceived with low fluency but were judged to be old. These misjudgments suggest the operation of two factors in recognition judgment: a
perceptual fluency factor and a search factor.

In Experiment 2, subjects were given nonwords in an attempt to reduce the utility of the search factor and cause subjects to rely more on perceptual fluency. Experiment 1 was replicated, except that previously presented words were turned into pronounceable nonwords. Item meaningfulness was manipulated to change reliance on the search factor. In contrast to Experiment 1, perceptual fluency was higher for items called old, and both measures of latency and accuracy of identification indicated perceptual fluency were greater for items called old but actually new (false alarms) than it was for items called new that were actually old (misses). Such results support Jacoby's hypothesis that perceptual fluency is one of two important factors contributing to recognition judgment (Jacoby & Dallas, 1981; Jacoby & Witherspoon, 1982). Also, results indicate that the processing involved on indirect memory tasks can affect performance on direct memory tasks. For example, recently studied words that were quickly identified on a word identification task were more likely to be given a recognition judgment of "old" than were more slowly identified words.

Further support for Jacoby's model of recognition memory comes from a developmental investigation by Carroll, Byrne, and Kirsner (1985). A new test of perceptual fluency, picture naming, was used and test results revealed
that perceptual memory is sensitive only to physical characteristics and not context. For example, old pictures were named faster than new pictures, and no relationship between oldness and the depth of manipulation (encoding) existed. Second, Carroll et al. (1985) found that a developmental dissociation existed between perceptual fluency and recognition memory of children five to ten years of age. For example, it was determined that this age group showed equal sensitivity to encoding context and that this ability improved with age. However, perceptual fluency performance did not vary with age and, therefore, is assumed to be developmentally stable. Carroll et al. 's (1985) research supports the distinction between the two forms of memory (Jacoby, 1981), extends Jacoby's research by adding pictorial stimuli to perceptual fluency tasks, and provides evidence that the indirect test of perceptual memory is developmentally stable.

Additional support for Jacoby's distinction between memory performance is found in Mitchell and Brown (1988). During the first session, subjects were presented with 100 pictures and asked to name them as quickly as possible. For the second session, subjects again named 100 pictures (50 old and 50 new), and were asked to identify those pictures that had been presented in the first session. Repetition priming was significant as old pictures were named faster than new pictures. Also, repetition priming
was independent of conscious recognition as naming facilitation of repeated pictures occurred whether or not they were correctly recognized. In Mitchell and Brown (1988), three other experiments were performed and repetition priming was revealed. A second important finding was that a time interval of six weeks did not affect repetition priming. In contrast, there was a steady decline in recognition memory. Further evidence for a dissociation between memory measures was revealed because naming facilitation for repeated pictures occurred regardless of whether pictures were consciously recognized or not. The above results add support to Jacoby's distinction between the two memory measures (Jacoby, 1983; Jacoby & Witherspoon, 1982; Carroll et al., 1985).

Additional evidence that a developmental dissociation may be found between memory measures has been revealed by Lorsbach and Morris (1991). This investigation focused on whether a developmental dissociation could be obtained between a direct and an indirect test of picture memory. Memory was tested directly and indirectly by obtaining measures of recognition accuracy and naming facilitation. Children in grades two and six were presented with a series of pictures, with instructions to name the pictures and to try their best to remember them. On the following day, children were presented with a naming/recognition task. The subject's task was to name each picture as rapidly as
possible and to then judge whether the picture had been seen on the preceding day. A developmental dissociation was found, with second and sixth grade children differing on the measure of recognition accuracy, but not on the measure of naming facilitation. Recognition memory was found to improve with age, whereas the magnitude of naming facilitation did not show any developmental improvement.

**Memory Performance of Children with Learning Disabilities**

Research on the memory skills of learning disabled has primarily focused on traditional direct tests of memory, such as free recall and serial recall. The memory performance of learning disabled children consistently has been found to be inferior to that of nonlearning disabled children (e.g., Bauer, 1977; Torgesen, 1977a; Swanson, 1984; Ceci, 1984). A variety of hypotheses have been advanced to account for the poor memory performance of learning disabled children. For example, Swanson (1984) suggests that differences in memory performance between learning disabled and nonlearning disabled children may be attributed to the amount of cognitive effort that can be expended. Cognitive effort represents the degree of mental input that a limited-capacity attentional system can produce. Therefore, it is suggested that the cognitive effort is related to individual differences in attentional capacity. It was hypothesized that superior word recall requires more cognitive effort than learning disabled
children's attentional capacity can accommodate. In this experiment, manipulation of task difficulty was used to infer cognitive effort. In a low-effort condition, anagrams were scrambled for only the first and second letters, whereas in the high-effort condition, all letters were rearranged. Results indicated that words from the high-effort condition were recalled better by nonlearning disabled children than learning disabled children. In contrast, learning disabled children recalled more words from the low-effort condition. These results indicate that individual differences exist in the amount of attentional capacity allocated to task demands. That is, the high-effort condition appears to have placed excessive demands on the attentional capacity of learning disabled children compared to nonlearning disabled children.

Bauer (1977) suggests that differences in memory performance between learning disabled children and non-learning disabled children may be the result of poor rehearsal. Evidence for poor rehearsal may be observed when a low primacy effect occurs in immediate or delayed free recall. A low primacy effect occurs when a subject has greater recall of the first few items presented. It is assumed that by virtue of the early input position of primacy items, they should be rehearsed more than items in a late input position. It was hypothesized that if rehearsal processes are deficient in learning disabled
children, free recall should show less of a primacy effect than nonlearning disabled children. In this experiment, subjects were presented with words and required to recall them immediately or after a delay. The results showed that in immediate and delayed recall, primacy was poorer for learning disabled children than nonlearning disabled children. These results indicate that active rehearsal is necessary for superior recall of primacy items (Cuvo, 1975).

Ceci (1984) has suggested that learning disabled children are deficient in purposive, as opposed to automatic, forms of semantic processing. Purposive semantic processing involves a deliberate plan to process meaning. Automatic semantic processing involves an "unconscious extraction of some aspects of a stimulus' meaning" (Posner, 1982). Automatic semantic processing can be measured by the ability to recall semantically related words which are adjacent to each other. In contrast, purposive semantic processing can be measured by recall of semantically related words which are spaced apart. Compared to nonlearning disabled children, learning disabled children have been found to be deficient in purposive semantic processing.

Torgesen (1982) suggests that learning disabled children are "inactive learners" compared to nonlearning disabled children. That is, learning disabled children
fail to use efficient learning behaviors required for good performance on cognitive tasks. Evidence for inefficient learning behaviors has been shown in studies involving memory tests (Bauer, 1979; Torgesen, Murphy, & Ivey, 1979), performance on academic tasks (Torgesen, 1977b), and observation of task performance in the classroom (Bryan, 1974; Forness & Esveldt, 1975). Torgesen further suggests that although learning disabled children do not use efficient strategies, they are able to learn strategies. For example, intervention strategies such as directing children to sort items prior to recall have reduced ability group differences (e.g., Dallago & Moely, 1980; Torgesen, Murphy, & Ivey, 1979). Also, it has been shown that organizational instructions such as directing children to make semantic relationships about items to be recalled have also reduced ability group differences (Dallago & Moely, 1980).

Although previous studies indicate that learning disabled children can be taught efficient learning behaviors, this finding has several limitations. First, the "inactive learner" concept is not characteristic of all learning disabled children (Torgesen et al., 1979). Further, this concept is also not applicable to learning disabled children who have specific cognitive limitations (Shankweiler, Liberman, Mark, Fowler, & Fisher, 1979; Torgesen & Houck, 1980). However, the observation that many learning disabled children have inefficient learning
behaviors provides some guidance for educational intervention, such as incentives, orienting tasks, and cognitive strategies.

To date, there have been only two published studies that have compared learning disabled children and non-learning disabled children using both direct and indirect tests of memory (Lorsbach & Worman, 1989, 1990). Lorsbach and Worman (1989) found learning disabled children to be deficient on direct tasks, but equal to nonlearning disabled children on indirect tasks. This study tested the hypothesis that direct tasks are sensitive to developmental and individual differences. Their study compared learning disabled and nonlearning disabled children in grades 3 and 6 on three tasks that measured memory for pictures. The first two tasks (free recall and cued recall) required subjects to consciously remember events of a prior learning episode. The third task was an indirect task (fragment completion) that did not require conscious recollection of a learning episode. After completion of a study list, a free recall task required subjects to recall aloud as many previously seen pictures as possible. A cued recall task was then presented. Subjects were told that most of the pictures previously seen belonged to one of four categories and were asked to recall as many pictures as possible when cued with each of the four category labels. The last test, a fragment completion task, was presented to subjects as a
guessing game. Subjects were asked to determine the identity of eight incomplete pictures, and were not told that any of the pictures were presented in the study test. Performance differences were revealed on the direct tests of memory, with sixth graders remembering more than third graders, and nonlearning disabled children remembering more than learning disabled children. In contrast, no differences were found between third and sixth-graders or between learning disabled and nonlearning disabled children on the fragment completion task. Results of this experiment are similar to those studies that have found that direct measures of memory are sensitive to both developmental and individual differences, whereas indirect measures are insensitive to these differences (Graf & Schacter, 1985).

Lorsbach and Worman (1990) also found learning disabled children to be deficient on a direct measure, but equal to nonlearning disabled children on an indirect measure of memory. Their study compared learning disabled and nonlearning disabled sixth-grade students on a pair-associate learning task, as well as an item recognition priming procedure. Subjects were given two cued recall tasks and a yes/no item recognition priming task. Half of the subjects in each group received the recognition task following the first cued recall task, and the other half received the task after the second cued recall task. The
study phase required subjects to listen to 16 sentences. Immediately following study, a cued recall task was given that required subjects to identify as much of the previously presented sentence upon presentation of a corresponding verb. Subjects were again required to listen to the same 16 sentences, followed by a second cued recall task. Subjects were given an item recognition priming task that measured the speed with which a subject was able to judge if an object noun had appeared in one of the preceding sentences. On this task, subjects were presented with a subject noun and asked to determine with accuracy and speed the corresponding object noun for a given sentence. Performance on the cued recall task indicated that learning disabled children experienced significantly greater difficulty than nonlearning disabled children in forming new associations. In contrast, priming effects on the item recognition task suggested that memory for newly learned associations was comparable for learning disabled children and nonlearning disabled children, regardless of the number of study presentations. These results suggest that learning disabled children can form recently studied associations, but have difficulty explicitly remembering those associations.

**Purpose of Research**

The present study compared learning disabled and non-learning disabled children on direct and indirect tests of
memory. Each subject was presented with a mixed list containing pictures and words. For items that were presented as pictures, subjects were asked to name each picture and provide a function for the object. For items that were presented as words, subjects were asked to listen and again provide a function for the object. Memory performance for pictures and words was tested directly and indirectly in a naming/recognition task. During the test, subjects were required to name pictures of previously presented pictures and words aloud and immediately make a recognition (old-new) decision on the picture. The magnitude of naming facilitation associated with old, relative to new, items provided the indirect test of memory. The accuracy of the recognition decision provided the direct test of memory. Half of the items were administered immediately following the presentation of the study list, while the remaining items were tested on the following day.

Recognition decisions may be made on the basis of an item's familiarity or the retrieval of the item and aspects of the original study context (Jacoby, 1983; Jacoby & Dallas, 1981; Mandler, 1980). In order to determine the extent to which subjects are basing their recognition decisions on conscious retrieval processes, a measure of source memory was also obtained. Decisions about source memory are particularly useful in that they involve the
deliberate retrieval of the original study context. For each item that is considered by the subject to be old, they were requested to render a decision about the source of that particular memory: "Did you see the item?" or "Did you hear the name for the item?"

Given the previous results of Lorsbach and Worman (1989, 1990), the performances of learning disabled and nonlearning disabled children on the direct and indirect tests of picture memory were expected to be dissociated. That is to say, learning disabled and nonlearning disabled children were expected to be comparable in the magnitude of naming facilitation. On the other hand, the performance of learning disabled children should be poorer than that of nonlearning disabled children on the recognition task. These differences are based on two assumptions: (1) performance on the recognition task to some extent requires the use of conscious retrieval processes, and (2) learning disabled children experience particular difficulty with memory tasks that place demands on conscious retrieval. Given that source memory may also be considered to be a recollective experience, and given that learning disabled children appear to experience greater difficulties than nonlearning disabled children in remembering source information (Lorsbach, Melendez, & Maher, 1991), the source monitoring performance of learning disabled children should be inferior to that of nonlearning disabled children.
Further, comparison of cross-modal priming of learning disabled and nonlearning disabled children was expected to differ. If the notion that learning disabled children are data driven is correct, they should rely more on a match between data presented at study and test. That is, learning disabled children should exhibit greater priming for pictures than words compared to nonlearning disabled children.

Method

Subjects

Subjects were selected from a predominantly white, suburban school district in the Midwest. Twenty-four language/learning disabled (L/LD) and 24 nondisabled (NLD) fourth graders participated in the experiment. There were 19 boys and 5 girls in the L/LD group, with a mean chronological age of 10.43 years (SD = .39). L/LD children were selected who had been previously identified by school district personnel as both learning disabled and language impaired. Verification of a learning disability by school district personnel was based primarily upon two criteria. First, the child's full scale IQ was above the -1 standard deviation level on an individually administered intelligence test. For those children who had a discrepancy between composite scores that was greater than 1 standard deviation, the higher score was used as an index of ability. Second, the child's standard score in one or more
academic areas was 1.3 standard deviations or more below the child's ability level. Furthermore, the standard score fell at or below 90 standard score points. Similar criteria were used to verify a language impairment. Again, at least average intellectual ability was documented and the child's communication performance yielded scores greater than 1.3 standard deviations below the child's overall ability level. The mean Verbal, Performance, and Full Scale scores on the Wechsler Intelligence Scale for Children - Revised (Wechsler, 1974) were 96.3 (SD = 12.3), 106.2 (SD = 13.7), and 100.8 (SD = 11.6), respectively. The mean standard scores in reading and math on the Wide Range Achievement Test - Revised (Jastak & Wilkinson, 1984) were 80.6 (SD = 12.4) and 85.1 (SD = 13.9), respectively. Finally, the mean standard scores for receptive and expressive language on the Clinical Evaluation of Language Fundamentals - Revised (Semel & Wiig, 1987) were, respectively, 77.9 (SD = 8.7) and 75 (SD = 9.7).

The selection of NLD students excluded those students who were receiving remedial services, as well as those who were enrolled in programs for gifted and talented students. The NLD group consisted of 9 boys and 15 girls, with a mean chronological age of 10.15 years (SD = .35). Performances on the Wide Range Achievement Test - Revised yielded a mean standard score of 102.2 (SD = 7.4) in reading and 96 (SD = 9.6) in math. No standardized test scores were available
that measured the cognitive abilities of NLD children.

Materials

Stimuli were presented in both a visual condition and an auditory condition. In the visual condition, stimuli consisted of black-and-white line drawings of common objects that were obtained from the norms of Snodgrass and Vanderwart (1980). Pictures were photographed and mounted on slides for presentation. One hundred twenty-eight pictures were randomly selected, with the restriction that they possess an "H" value that did not exceed 1.77. The "H" statistic has a range of 0-2.55 and reflects both the name agreement and the percentage of subjects who provided the same name for a given picture. The smaller the "H" value, the higher the name agreement and the proportion of subjects providing the same name for a given picture. For example, with an "H" value of 0, the picture of a "balloon" has perfect name agreement, whereas the picture of a "doll" has an "H" value of 1.42 and elicits alternate names (e.g., "baby" or "little girl").

Stimuli that were presented in the auditory condition consisted of the dominant name for each of the 128 pictures in the norms of Snodgrass and Vanderwart (1980). Picture names were tape-recorded using the voice of an adult female.

The 128 items within the pool were randomly assigned to one of four 32-item Sets: A, B, C, and D. The items in
each Set served two separate functions: they were presented either as (a) critical items in a 64-item study-list, or (b) foils in one of two 64-item naming/recognition tasks. The four Sets were equated on mean "H" value (Set A = 43.5, Set B = 43.6, Set C = 43.1, and Set D = 42.8).

Each of the four Sets was used equally often as study-list items and as foils in the naming/recognition tasks. In addition, the use of the four Sets was counterbalanced perfectly across the factors of population (L/LD and NLD), naming/ recognition test (immediate and delayed), and presentation modality (visual and auditory).

Four 64-item study lists were formed by combining the four Sets of pictures: A + B; B + C; C + D; D + A. Two Sets of stimuli comprised each 64-item study list, with one Set being presented in the visual modality and the other in the auditory modality. Items from each Set were presented randomly in a series of eight, 4-item blocks. The blocks representing each of the two Sets were presented in an alternating manner.

The immediate and the delayed naming/recognition tasks each consisted of 64-items: 32 targets and 32 foils. Unlike the preceding study lists, all items in the naming/ recognition tasks were presented as pictures (visual modality). The 32 targets used in the immediate test list consisted of 16 items that had been presented in the visual condition and 16 items that had been presented in the
auditory condition. Sixteen items from each of the two unused Sets served as foils. The remaining 32 untested targets and 32 foils from the unused Sets were used to form the delayed test. Test items were presented in a random manner, but with the restriction that no more than 4 "old" or 4 "new" items be presented successively.

Procedure and Apparatus

Each child was tested individually at his or her own school. During the initial session, subjects were told that they would be seeing pictures, as well as hearing the names of common objects. Subjects were presented with a 64-item study-list and asked to name each picture aloud and to listen to each word as it was presented. Each subject was also asked to provide a use for the object immediately following the presentation of each stimulus: "Whenever you see a picture or hear a word, think quickly of something you could do with the object." This task served two functions. First, indicating the use of each object served as a semantic orienting task. Second, providing a use for the object enabled the examiner to verify that the subject had, in fact, heard the intended word and not a similar sounding word (e.g., box for fox). Subjects were not given any information regarding the nature of the forthcoming memory tests, nor when they would occur.

Both pictures and words were presented using a 5 s presentation rate, with a 10 s pause between blocks.
Timing of events within and between trials was accomplished by synchronizing the projector with inaudible tones occurring on the Wollensak tape recorder. Pictures were projected onto a screen that was approximately 2 m directly in front of the child by means of a Kodak carousel projector. A stimulus duration of approximately 1 s was used in the presentation of the pictures. Picture names were presented by means of a Wollensak tape recorder.

One 64-item test-list was presented immediately following the presentation of the study-list, and a second test-list was administered following a 24 hour delay. Each test-list was presented as a picture naming/recognition task and was subject paced. Subjects were informed that some of the pictures would be the same ones they had just seen, some would be pictures of words they had just heard, and others would be completely new pictures (i.e., they had not seen the picture, nor had they heard the word). Subjects were instructed to provide the name and a recognition decision for each of the 64 pictures. Each subject was requested to name each picture as rapidly as possible without sacrificing naming accuracy. Naming latencies were obtained through the use of a Gerbrands millisecond clock (Model G1271) and voice operated relay (Model G1341T). Naming latencies were measured from the onset of the slide until the subject's vocal response. Immediately following the naming of each picture, they were asked to decide
whether or not that item had been presented on the pre­
ceding study-list by responding "old" or "new". In addi­
tion, for pictures that were judged to be "old"items, the
subject was also asked to render a decision about the
modality of presentation for that remembered item.
Modality memory was measured by asking the subject to
decide if the remembered item had been presented originally
as a picture or as a word. In this case, subjects were
asked to respond by indicating whether they "saw it" or
"heard it". The experimenter recorded the speed and
accuracy of naming and the memory decisions for each
picture.

Results

 Priming

Median naming latencies for pictures named both on the
immediate and delayed tests were computed for each subject.
Excluded from analysis were those trials in which an
equipment malfunction, a procedural error, a naming error,
or a naming change between study and test occurred.
Machine/procedural errors occurred when there was an
equipment malfunction (e.g., slide did not advance from the
carousel into the projector), when the timer was terminated
prematurely (e.g., subject touched the microphone, made
vocal a noise, coughed), or when the timer was not
terminated (e.g., subject moved further away from the
microphone or spoke in a voice that was not loud enough to
activate the voice key). A significantly greater number of machine/procedural errors occurred with L/LD children (M = 2.98) than with NLD children (M = 1.50), F(1,46) = 9.93, MSE = 10.575, p<.003. In addition, a greater number of machine/procedural errors appeared on the immediate test (M = 2.59) than on the test that occurred on the following day (M = 1.88), F(1,46) = 4.33, MSE = 5.558, p<.04.

Naming errors involved those trials in which the subject labeled the picture incorrectly according to the Snodgrass and Vanderwart (1980) norms. Also included in naming errors were those trials in which the subject provided different, yet normatively correct, names for repeated items that were presented on both the study and test lists. Analysis of naming errors revealed that items that had been presented originally as words produced a significantly greater number of naming errors (M = 3.84) than items that had been presented as pictures (M = 3.16), F(1,46) = 14.094, MSE = 1.561, p<.001. There were no significant differences in the number of naming errors between L/LD and NLD children, F(1,46) = 2.187, MSE = 11.336, p<.14, or between the immediate test and the test on the following day (F<1).

Table 1 shows the means of the median naming latencies on immediate and delayed tests. An analysis of median naming latencies for old and new pictures was performed disregarding hits, misses, correct rejections, and false
### TABLE 1

**Means of Median Naming Latencies for Old and New Pictures According to Retention Interval, Priming Format, and Population**

<table>
<thead>
<tr>
<th>Item Type</th>
<th>Pictures</th>
<th>Words</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immediate</td>
<td>1 Day</td>
</tr>
<tr>
<td>Language/Learning Disabled Children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>951 (196)</td>
<td>993 (243)</td>
</tr>
<tr>
<td>New</td>
<td>1048 (219)</td>
<td>1119 (237)</td>
</tr>
<tr>
<td>Nondisabled Children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>831 (131)</td>
<td>798 (125)</td>
</tr>
<tr>
<td>New</td>
<td>912 (100)</td>
<td>859 (142)</td>
</tr>
</tbody>
</table>

**Note.** Within each retention interval, the mean latencies of new items for both visually and auditorily presented items were based on the same pictures. Thus, for each retention interval, the mean latencies of new items are the same for visually presented and auditorily presented items. The numbers in parentheses represent standard deviations.
alarms. Naming latencies were analyzed in a 2 x 2 x 2 x 2 mixed analysis of variance (ANOVA), with population (L/LD or NLD) as the between subjects factor, and item type (old or new), and presentation format (picture or word) and test (immediate or delayed) as the within-subjects factors. Unless otherwise specified, all effects described as significant involve p<.05. The effects of population, $F(1,46) = 14$, $MSe = 209731.22$, and item type, $F(1,46) = 51.54$, $MSe = 9629.43$, were each significant, as was their interaction, $F(1,46) = 5.30$, $MSe = 9629.43$. The population x item type interaction was examined further by testing separately the effects of item type with each population. Although both populations were able to name old pictures faster than new pictures, the size of these differences was larger with L/LD children, $F(1,95) = 42.11$, $MSe= 10282.8$, than with NLD children, $F(1,95) = 32.69$, $MSe = 3500.96$. Therefore, the amount of facilitation associated with naming old, relative to new, pictures was significantly greater with L/LD children (95 ms) than NLD children (49 ms). The population x test interaction was significant $F(1,46) = 14.89$, $MSe = 18449.91$. The interaction was examined by separately testing the effect of test with each population. Relative to naming latencies on the immediate test, the latencies of NLD children became faster on the following day, $F(1,95) = 26.56$, $MSe = 5445.61$, whereas the latencies of L/LD children became slower, $F(1,95) = 10.61,$
The magnitude of priming was measured by subtracting the median naming latencies of old pictures from the median latencies of new pictures for each subject (e.g., Mitchell et al., 1990). As with the previous analysis, difference scores showed that the magnitude of priming was greater with L/LD children than with NLD children, $F(1,46) = 5.45$, $MSe = 19141.92$, and pictures primed pictures more than words primed pictures, $F(1,46) = 12.65$, $MSe = 5791.18$. No other main or interactive effects were significant.

Notable is that retention interval did not significantly affect the magnitude of repetition priming for either population. Figure 1 plots the magnitude of priming that was observed with L/LD children and NLD children at each retention interval.
Figure 1

Magnitude of Priming (msec)

- Immediate
- 1 Day

POPULATION

L/LD

NLD
Recognition Memory

Recognition performance was analyzed within the framework of signal detection theory. Signal detection analysis involves the calculation of d' which in this case provides a measure of the subject's ability to discriminate "old" previously seen pictures from completely "new" items. The higher the d' value, the greater is the subject's ability to detect "old" items in the presence of "new" items.

Table 2 provides the means of the various signal detection measures according to presentation modality and recognition test for both L/LD children and NLD children. The d' scores were submitted to a 2 x 2 x 2 x 2 mixed analysis of variance (ANOVA) with population (L/LD or NLD) as the between subjects factor, and presentation format (pictures or words) and recognition test (immediate or delayed) as the within subjects factor. The recognition performance of NLD children produced d' scores (M = 2.52) that were significantly larger than those of L/LD children (M = 1.96), F(1,46) = 13.02, MSe = 1.15. Both presentation format F(1,46) = 165.4, MSe = .25, and recognition test, F(1,46) = 133.58, MSe = .39, were significant, as was their interaction, F(1,46) = 14.38, MSe = .16. The interaction was examined by testing separately the effect of recognition test with each presentation format (pictures or words). When compared with the immediate recognition test,
### TABLE 2

**Means and Standard Deviations (in parentheses) of Signal Detection Scores**

<table>
<thead>
<tr>
<th>Recognition Score</th>
<th>Pictures</th>
<th></th>
<th>Words</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Immediate</td>
<td>1 Day</td>
<td>Immediate</td>
<td>1 Day</td>
<td></td>
</tr>
<tr>
<td>Language/Learning Disabled Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit Rate</td>
<td>.91 (.10)</td>
<td>.72 (.19)</td>
<td>.72 (.19)</td>
<td>.35 (.25)</td>
<td></td>
</tr>
<tr>
<td>False Alarm Rate</td>
<td>.10 (.11)</td>
<td>.13 (.12)</td>
<td>.10 (.11)</td>
<td>.13 (.12)</td>
<td></td>
</tr>
<tr>
<td>d' Score</td>
<td>2.87 (.70)</td>
<td>1.98 (.78)</td>
<td>2.14 (.77)</td>
<td>.86 (.85)</td>
<td></td>
</tr>
<tr>
<td>Beta Score</td>
<td>.19 (1.05)</td>
<td>.68 (1.01)</td>
<td>.85 (.99)</td>
<td>.67 (.97)</td>
<td></td>
</tr>
<tr>
<td>Nondisabled Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit Rate</td>
<td>.96 (.07)</td>
<td>.85 (.12)</td>
<td>.81 (.15)</td>
<td>.48 (.25)</td>
<td></td>
</tr>
<tr>
<td>False Alarm Rate</td>
<td>.05 (.05)</td>
<td>.08 (.07)</td>
<td>.05 (.05)</td>
<td>.08 (.07)</td>
<td></td>
</tr>
<tr>
<td>d' Score</td>
<td>3.35 (.52)</td>
<td>2.61 (.59)</td>
<td>2.67 (.65)</td>
<td>1.44 (.62)</td>
<td></td>
</tr>
<tr>
<td>Beta Score</td>
<td>.17 (.72)</td>
<td>.53 (.77)</td>
<td>.90 (.73)</td>
<td>.98 (.61)</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Means for the Beta Scores are based on natural logarithm values.
the delayed test declined with both presentation formats. However, the amount of forgetting was greater for the words, $F(1,47) = 122.67, \text{MSe} = .31$, than for the pictures, $F(1,47) = 68.97, \text{MSe} = .23$.

Figure 2 shows the differences in recognition performance between L/LD and NLD children according to presentation format and recognition test. Recognition performance of L/LD children was lower than NLD children regardless of presentation format or test delay. These results are in contrast to those obtained with priming, where L/LD children displayed larger repetition priming than did NLD children. The recognition and the priming results also differ in that recognition performance declined as retention interval was lengthened, whereas the magnitude of priming remained stable.

**Priming and Recognition Memory**

Jacoby and his associates (e.g., Jacoby, 1987; Johnston et al., 1985) have argued that perceptual fluency (i.e., the ease with which a picture is named) may form the basis of recognition decisions. If perceptual fluency is used as a guide for recognition decisions, then items judged "old" should be named faster than those judged to be "new", regardless of whether the item was a repetition. That is to say, for pictures that are readily named, subjects should tend to judge them as "old" regardless of whether that item had been presented previously. There-
Figure 2

d' Score

Immediate
1 Day

Words  Pictures  L/LD

Words  Pictures  N/LD

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40

0.0  0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40

0.0  0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0
fore, naming latencies should be faster for hits than for misses and for false alarms than for correct rejections (Johnston et al., 1985).

The relationship between naming speed and recognition memory was examined following the procedures that were used by Mitchell et al. (1990). In the first set of analyses, the naming speed of old items (hits and misses) was compared to determine whether the recognition decisions of either L/LD or NLD children were based on perceptual fluency. In addition, the magnitude of priming associated with hits and misses was compared to determine if a dissociation exists between priming and recognition memory for L/LD or NLD children. The second analysis examined whether naming speed varied with the accuracy with which new pictures were detected. Table 3 provides the naming latencies of both old (hits and misses) and new (correct rejections and false alarms).

**Priming in Hits and Misses**

Consistent with Mitchell et al. (1990), only those subjects who had at least four reaction times for both hits and misses were included in the analysis. All of the subjects in each population met this criterion. However, in order to obtain the minimum number of observations for each subject, it was necessary to collapse across the variables of presentation format and retention interval. The means of the medians for old latencies were submitted
### TABLE 3

**Means of Median Naming Latencies of L/LD and NLD Children According to Recognition Decision**

| Population | Old Items | | New Items | |
|------------|-----------|----------------|----------------|
|            | Hits      | Misses         | CR             | FA             |
| L/LD Trials| 993 (212) | 982 (196)      | 1043 (151)     | 1042 (264)     |
|            | 36.4 (8.9)| 17.4 (8.7)     | 45.4 (7.5)     | 9.2 (4.5)      |
| NLD Trials | 840 (126) | 820 (129)      | 928 (89)       | 974 (210)      |
|            | 44 (5.0)  | 12.4 (5.6)     | 51.81 (3.7)    | 5.8 (2.5)      |

**Note.** The number in parentheses represent standard deviations. CR=correct rejections; FA=false alarms; Trials=mean number of trials.
to a 2 x 2 mixed ANOVA, with population (L/LD or NLD) as the between subjects factor, and old item type (hit or miss) as the within subjects variable. As expected, L/LD children named old items significantly more slowly than NLD children, $F(1,46) = 11.47, MSe = 51947.49$. Neither the effect of old item type or the population x old item type interaction was significant (both $F$s<1). Thus, for both L/LD children and NLD children, naming latencies did not vary according to whether old items were remembered or forgotten.

The relation between priming and recognition memory was examined by comparing the amount of priming that occurred with hits (new latencies minus hit latencies) and misses (new latencies minus miss latencies). These priming values are graphically displayed in Figure 3. Overall, L/LD children exhibited a significantly greater amount of priming ($M = 96$ ms) than did NLD children ($M = 56$ ms), $F(1,46) = 4.14, MSe = 9428.6$. However, the magnitude of priming did not depend on whether old items were remembered or forgotten ($F<1$). In addition, the population x old item type interaction failed to reach significance ($F<1$). Together, these results indicate that the magnitude of priming did not vary significantly with the conscious recognition of old items for either L/LD or NLD children.  

**Naming Speed for Correct Rejections and False Alarms**

Consistent with the criterion used in the preceding
Figure 3

![Bar chart showing the magnitude of priming in milliseconds for different populations. The chart compares Hits and Misses for L/LD and NLD populations.]
analysis, each subject needed at least four correct rejection latencies and four false alarm latencies to be included in the analysis. It was necessary to again collapse across the variables of presentation format and retention interval in order to obtain a sufficient number of subjects in each population. As there were so few false alarms, only a total of 11 L/LD and 14 NLD children could be used in this comparison. There were no significant main or interactive effects of population or type of new item. As there were relatively few subjects used in this analysis, a lack of power may have contributed to the failure to find significant differences.

**Memory for Presentation Format**

Each subject's ability to remember presentation format was based upon a discrimination score. These discrimination scores were calculated by adding the number of items that were correctly identified as ones that had been previously seen plus the number of items that the subject correctly identified as ones they had previously heard, and dividing this sum by the total number of old items that were remembered by the subject (hits). L/LD and NLD children did not differ significantly in their memory for presentation format, $M = .85$ and $.88$, respectively. For both populations, there was a decline in memory for presentation format between immediate test ($M = .91$) and test administered on the following day ($M = .82$), $F(1,46) =$
When making source attributions of false positives, children appear to develop certain decision rules that are similar to those of adults (Foley, Johnson, & Raye, 1983). Lorsbach et al. (1991) recently found that L/LD and NLD children exhibit a similar developmental pattern in their source attributions of false alarms. The source attributions of false positives were analyzed in the current study to provide additional information about the decision rules that are used by L/LD and NLD children when dealing with false positives. The number of false positives was computed for each subject and submitted to a 2 (population) x 2 (retention interval) x 2 (presentation format) ANOVA. L/LD children (M = 1.63) committed a significantly greater number of false positives than NLD children (M = .97), F(1,46) = 3.99, MSe = 5.34. All subjects committed more false positives following a one day retention interval (M = 1.54) than when tested immediately (M = 1.06), F(1,46) = 6.38, MSe = 1.726. For both L/LD and NLD children, false positives were misidentified significantly more often as items that had been heard (M = 1.64) than as items that had been seen (M = .95) by the subject, F(1,46) = 9.09, MSe = 2.494.

Discussion

Summary of Major Findings

The present study identified a number of important
findings. First, this study revealed a crossover disso­ciation between L/LD and NLD children on direct and indirect measures of memory. Although L/LD children exhibited more priming than NLD children, the recognition performance of L/LD children was poorer than NLD children. Such a dissociation is consistent with the results of previous studies that have found dissociations between direct and indirect measures of memory in L/LD and NLD children (Lorsbach & Worman, 1989, 1990). Finding that the magnitude of priming was greater with L/LD children than with NLD children was unexpected and is difficult to explain.

A second finding of this study was that direct and indirect measures of memory were dissociated as a function of retention interval. Although priming was stable over a 24 hour retention period, recognition accuracy declined. This result is generally consistent with previous studies that have examined the effects of retention interval on direct and indirect tests of memory. For example, Mitchell and Brown (1988) demonstrated a dissociation between repeated picture naming and conscious recognition as a result of retention interval. Repetition priming remained stable after six weeks, whereas recognition performance showed a steady decline. The present study suggests that priming is persistent with both L/LD and NLD children, whereas recognition memory is fragile and declines with time.
A third finding was that repetition priming was found to be independent of recognition memory. The magnitude of repetition priming was not dependent on whether an item was consciously recognized; "hits" and "misses" produced equivalent amounts of priming. The finding of independence between repetition priming and conscious recognition is not particularly surprising, given the results of previous studies with adults (e.g., Tulving et al., 1982; Mitchell & Brown, 1988). Important, however, is that the present study demonstrates that repetition priming and recognition memory are independent in both L/LD and NLD children.

A fourth finding of this study was that the variable of presentation modality produced parallel effects on direct and indirect measures. That is, pictures primed pictures more than words primed pictures, and repeated pictures were recognized better than words. The parallel effects found between direct and indirect measures as a function of presentation modality appear to be inconsistent with the available literature, in that presentation modality often produces a dissociation between direct and indirect measures. For example, Jacoby and Dallas (1981, Experiment 6) and Jacoby and Witherspoon (1982) found that modality did not affect recognition, but did affect perceptual identification. Similarly, Roediger and Blaxton (1987) found presentation modality did not affect recognition, but did affect word fragment completion.
Finally, there were no differences between L/LD and NLD children on the supplementary measure of source monitoring. Source monitoring reflects memory for a specific memory trace. Although intended to serve as a measure of source monitoring, this supplementary task actually provided a measure of memory for modality. Performance on this task required memory for perceptual characteristics for a given stimulus input, and allowed subjects to remember modality in which an item was presented. Therefore, modality input becomes part of memory even though a test might not require memory for modality. That is, memory for modality is a natural result of perceptual analysis, and does not reflect discrimination of which information occurred.

Theoretical Interpretations of Major Findings

Activation Theory. Interpretation of the dissociation between L/LD and NLD children can be explained by activation theory (e.g., Morton, 1979). An activation account holds that priming effects on indirect memory tests are attributable to the temporary activation of abstract representations. Activation is assumed to occur automatically and is independent of the original study context. In this study, L/LD and NLD children revealed priming effects. An activation account would interpret this result as both populations having the ability to activate abstract representations. In contrast,
recognition performance is influenced by the original study context and is not influenced by activation. The present findings revealed that compared to NLD children, L/LD children were inferior on the recognition test. An activation account would interpret this result as L/LD children being deficient compared to NLD children in their ability to retrieve prior contextual information.

Activation theory can also explain the independence of repetition priming and recognition memory. According to this theory, repetition priming results because the same abstract representation is activated by pictures and words, whereas recognition memory is influenced by context of study presentation (presentation format). In the present study, independence can be explained by assuming repetition priming and recognition memory rely on different information. That is, repetition priming relied on abstract representations, whereas recognition memory relied on contextual information.

The finding that direct and indirect tests were dissociated as a function of time interval cannot be explained by the activation account. Results showed that priming remained stable after a 24 hour period, whereas recognition memory declined. This finding contradicts the assumption that priming decays rapidly.

The activation theory also cannot explain the parallel effects between direct and indirect measures. According to
activation theory, priming effects are attributed to activation of a mental representation and recognition effects are attributed to recovery of study context. The activation of a mental representation is not affected by the medium in which information is conveyed. For example, the same abstract representation is produced by visual and auditory presentations (Morton, 1969). However, recognition performance is affected by the medium in which information is conveyed because recovery of study context (pictures and words) contains contextual information. The activation theory is unable to explain why pictures primed pictures more than words primed pictures if the same abstract representation is activated for both.

Memory Systems Theory. The memory systems theory can explain the dissociation between populations by assuming that two separate memory systems exist, episodic and semantic (e.g., Tulving, 1972). The episodic system is responsible for recollection of personal experiences, whereas the semantic system is responsible for permanent knowledge. In the present study, differences between populations in recognition memory indicate that the episodic memory system of L/LD children is inferior to NLD children. On the other hand, the semantic memory system of L/LD children appears to be intact (c.f. Ceci, 1984).

The dissociation between direct and indirect measures as a function of retention interval can be explained by the
memory systems account. Recognition accuracy declined as a function of retention interval. In contrast, repetition priming did not decline as a function of this variable. Therefore, retention interval has a selective effect on the two memory systems; episodic memory is affected over time interval, whereas semantic memory is not.

The independence of repetition priming and recognition memory can be explained by a memory systems account by assuming that two memory measures are affected differently by the same study presentation. That is, pictures and words enhanced a subject's ability to name pictures, but such enhancement was identical for remembered words and pictures and those not remembered. Therefore, performance in repetition priming was not correlated with recognition accuracy.

The parallel effect of presentation modality on repetition priming and recognition memory can also be explained by the memory systems account. Measures of repetition priming and recognition respectively reflect the operation of semantic and episodic memory. Pictures and words had a parallel effect upon these tasks and the memory systems that were underlying these tasks. Both pictures and words produced priming, with pictures priming more than words. Similarly, pictures and words enhanced recognition accuracy, with pictures producing better recognition than words.
Transfer Appropriate Processing Account. The finding of independence between repetition priming and recognition within subjects cannot be explained by a processing view. An assumption of this view is that processing engendered at test recaptures that at study. As long as there is an overlap in processing responsible for differences between tests, dependence between the tests should result. Dependence is shown if processing at test recaptures processing at study. In the present study, repetition priming and recognition memory were found to be independent; the ability to name items was not dependent upon the ability to recognize items. Specifically, the processing involved at test (naming pictures previously presented) did not recapture processing during study (picture presentation).

A processing view is also unable to explain the dissociation which resulted because of time interval. An assumption of this theory is that compatibility between processing at study and test explain differences between tests. This assumption cannot explain why time interval produced a dissociation when the mechanism for processing remained constant for day 1 and day 2.

The transfer appropriate processing view can account for the dissociation between L/LD and NLD children. This account assumes that memory performance is determined by a match between processing at study and test, and that tasks contain both conceptually-driven and data-driven process-
ing. In the present study, differences between L/LD and NLD children on recognition performance can be explained as the result of NLD children relying more on conceptually-driven processing during the orienting task.

The parallel effect between direct and indirect measures as a function of presentation modality can also be explained by transfer appropriate processing. The parallel effect can be interpreted as direct and indirect forms of memory relying on a match between processing of data at study and at test. The fact that pictures produced greater priming than words can be explained as the result of a better perceptual match between data presented at study and test. This result supports Weldon and Roediger's (1987) finding that pictures prime better than words on a picture identification task, and words prime better than pictures on a word fragment task. Thus, the magnitude of priming is influenced by matching the physical form of the prime with the test. The fact that pictures were also recognized more than words indicates that the recognition test contained a data-driven component. That is, the recognition test was influenced by matching the physical form of the prime with the test. This result supports Jacoby's (1983) finding that recognition performance can rely on both data-driven and conceptually-driven processing.

Recent research by Brown, Neblett, Jones, and Mitchell (1991) suggest that support for the transfer appropriate
processing framework may depend upon the research design that is used in a given study. Brown et al. (1991) used both between-subject and within-subject designs and manipulated prime presentation format in each design. The purpose of these experiments was to evaluate the impact of changes in prime format (word vs. picture) in both experimental designs. When prime types were manipulated in between-subject designs, there was no significant difference between word and picture primes on either test. However, the opposite result was revealed in within-subject designs. Therefore, these results suggest that differences in effects of prime type on repetition priming may be due to different designs. Specifically, repetition priming is sensitive to a within-subject design (mixed prime list) and not a between-subject design (unmixed prime list). It is suggested that differences occur between designs because perceptual characteristics of primes are emphasized more than lexical representations of primes in a within-subject design than in a between-subject design.

Although the transfer appropriate processing account was the suggested theoretical interpretation for the present study, a memory systems account seems a more appropriate theoretical interpretation. The memory systems account is able to explain dissociations, as well as the parallel effects of presentation modality. The dissociation between L/LD and NLD children on direct and indirect
tests indicates L/LD children have a selective memory deficit. Episodic memory functioning of L/LD children appears to be impaired, while the semantic or procedural memory seems to be intact.

Implications for Education and Research of Children with Learning Disabilities

Although one must be cautious when commenting on the educational implications of basic research, the results of this study do have some relevance for the schooling process. Although learning disabled children are less accurate in deliberate retrieval of prior stimulus events, they are comparable to nonlearning children in that they show similar facilitation or repetition priming of repeated stimuli. Thus, educators may be sensitive to the finding that children may be primed for new knowledge.

With regard to future research, studies should focus on the extent to which memory for procedures is preserved with learning disabled children. Perhaps additional knowledge about a form of memory which is unimpaired in learning disabled children would enable this population to use memory for procedures to compensate for impairments in traditional memory tasks.

One limitation of the present study should be noted. That is, there were more girls than boys in the nonlearning disabled group, and more boys than girls in the learning disabled group. Though there are some inconsistencies in
the previous literature on gender differences, the general consensus is that girls have greater verbal ability than boys (e.g., Anastasia, 1958; Maccoby, 1966; Maccoby & Jacklin, 1974; Denno, 1982; Halpern, 1986).

Although a number of studies have found gender differences in verbal ability, Hyde and Linn (1988) analyzed 165 studies by meta-analysis and did not find gender differences. Analysis of effect sizes for different measures of verbal ability, such as vocabulary, analogies, reading comprehension, speech production, essay writing, anagrams, and tests of general verbal ability were small in magnitude. Similarly, analysis by age showed no significant change in the magnitude of gender differences at ages 5 years and younger, 6 to 10 years, 11 to 18 years, 19 to 25 years, and 26 and older.

Although a gender effect may have been responsible for the performance differences between L/LD and NLD children in the present investigation, the findings of Hyde and Linn (1988) suggest that gender differences did not play a significant role.
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