INTERSENSORY MEMORY ABILITY FOR GRAPHIC SYMBOLS AND WORD-NAME CORRESPONDENCES IN GRADE 2 BOYS

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DISSERTATION ABSTRACT

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In the study of the relationship between word recognition skills and memory ability, much attention has been directed toward the comparison of good and poor readers' performances, while omitting the performances of average readers. The tasks employed were usually of a singular modality nature, that is using a visual or auditory modality presentation. Also assessment of short-term retention employing a sequential format has been the predominant characteristic of the response mode.

Researchers from various disciplines over the years have commonly made reference to the importance of establishing sound-symbol correspondences in the preliminary stage of learning word recognition skills. This study advances and tests the proposition that, important as deficits of sequential memory in word recognition may be, deficiencies in immediate and delayed memory, at an integrative level, also play an important role in accounting for some problems in young readers.

The tasks chosen for this study were intersensory memory tasks of graphic symbols and word-name equivalents. Each task involved a learning activity in which three pairs of graphic symbol and word-name correspondences were presented visually and auditorially respectively, employing the apparatus called the Caramate 3300. The subjects were 78 grade two Above-Average, Average and Below-Average readers from a school district in the Lower Fraser Valley in B.C. Following the learning session a response interval of five seconds or five minutes was imposed. After the response interval had expired, each equivalent of the pair was presented separately, either visually or auditorially. Each subject was required to respond with the corresponding counterpart, either auditorially or graphically, or matching the equivalents by pointing.

The six intersensory memory tasks were scored for the number of correct responses on three items per task. The resulting scores were viewed as entries in a three-way ANOVA: Reading Ability x Response Interval x Presentation-Response Mode, yielding a 3 x 2 x 3 ANOVA with repeated measures on the second and third factors. All factors were fixed.

Standard ANOVA procedures revealed a statistically significant Reading Ability x Presentation-Response Mode interaction. That is, a subjects ability to remember one-to-one graphic symbol and word-name correspondences was dependent on both his word recognition ability level and the type of presentation-response mode presented. A statistically significant Response Interval x Presentation-Response Mode interaction was present as well. That is, for all subjects their ability to remember one-to-one word-name and graphic symbol correspondence was dependent on both the response interval imposed and the presentation-response mode presented. Some of the results suggested that a dual processing route was employed to access lexical information (McCusker, Hillinger, and Bias, 1981). In addition, the suggestion was put forth that what previously has been interpreted to be a memory deficit may be simply a reflection of a developmental hierarchy of this cognitive skill under different presentation-response mode conditions.

The implications of the interactive roles of Reading Ability x Presentation-Response Mode and Response Interval x Presentation-Response Mode were explored relative to education and recommendations for future research were presented.

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DEDICATION

I would like to dedicate this manuscript to the following people:

To My Parents:

For their unending love and support throughout all my life long endeavours, in both good times and bad times.

To Dr. Leonard Fratkin:

For his excellent care, support, expertise and knowledge. Since 1981 we have been good friends. During this time he has given me new direction to my life.

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Who gives me such sweet inspiration throughout my academic and professional endeavours.

Knowing her is a privilege and a pleasure.

CHAPTER ONE

Introduction

In auditory and visual learning one of the most important functions is the establishment of strong appropriate correspondences between auditory and visual stimuli. The formation of auditory-visual intersensory correspondence is an essential aspect of learning spoken language, reading, writing, spelling, as well as arithmetical operations (Chalfant and Flathouse, 1971, pp. 273-274).

Over the last several decades, considerable research has been conducted to study the nature of reading problems and the possible causes of such difficulties. Reading research involving the disciplines of psychology, neurology, educational psychology, reading and special education, suggests that the etiology and nature of reading difficulties is as complex and diversified as the subjects who present these problems.

One segment of this reading research has been concerned with the performances of young word recognition readers on various memory tasks. Mote specifically, investigators interested in the relationship between memory span and word recognition ability have tended to emphasize the use of a singular modality approach; that is, visual or auditory modality presentation, the use of short-term retention only, and the use of a sequential component in the memory tasks (Rizzo, 1939; Heulsman, 1970; Rugel, 1974; Koppitz, 1975; Spring, 1976; Beech and Harding, 1984; Lindgren and Richman, 1984; Granetz, 1984/1985). Modality matching and memory span studies have incorporated the use of the same or matching and memory span studies have incorporated the use of the same or similar types of task conditions (Birch and Belmont, 1964; Jorgenson and Hyde, 1974; Milner and Bryant, 1970; Badian, 1977). Some investigators have studied the relationship between short-term memory only and reading achievement using a paired-associate learning paradigm (Gascon and Goodglass, 1970; Otto, 1961; Firth, 1972; Jorm, 1977).

The term decoding involves such broad skills as whole word analysis and word attack (Guthrie and Seifert, 1978). Venezky (1975) analyzed decoding into a number of subskills including the association and retention of labels for letter strings.

The task of learning word recognition skills involves a complex series of direct and indirect cognitive processes (Killen, 1978). For most young children, this task will be accomplished with the usual amount of struggle and frustration that any new task brings to bear. However, for a number of children in the elementary school population, acquiring the mechanical skills such as grapheme-phoneme correspondence in the early stages of the word recognition process will prove to be an arduous, frustrating and seemingly never-ending struggle.

Some young children are identified by teachers as having difficulties learning word recognition skills through traditional synthetic or analytic instructional approaches. Then these children typically are assessed in terms of their strengths and weaknesses relative to their knowledge of reading subskills, and visual and auditory perceptual abilities.

On a superficial analysis the sight or phonetic approaches do involve visual and auditory learning. From a task analytic viewpoint both of these reading approaches require the student to learn and remember the pairing of visual equivalents such as words and letters, and auditory counterparts such as word-names and sounds (Lerner, 1985).

Presently, diagnostic educational assessment procedures typically assess, among other abilities, immediate visual and auditory memory. Chalfant and Flathouse (1971) have stated, "Furthermore, these functions are tested separately. Standardized tests to date do not measure recall after more than a few seconds have elapsed, nor do they assess the integrative aspects of establishing correspondences between auditory and visual information" (p. 287). There are virtually no standardized tests available to assess visual and auditory memory at an intersensory level; that is, there appear to be no tests of a formal nature that can assess whether or not "the child is able to learn and remember the auditory equivalents of letters as seen or the visual equivalents of letters as heard" (Myklebust, 1973, p. 175).

A number of researchers have made reference to the importance of associational learning or developing sound-symbol correspondence in the initial stage of learning word recognition skills (Burtch, 1974; Rath, 1974; Liberman and Shankweiler, 1979; Haring and Bateman, 1977; Brown, 1979/1980; Ehri, 1983, 1984; Ehri and Wilce, 1985, 1987; Kilian 1984/1985; Manis, 1985).

Goodman (1968) suggested that in the initial stages of learning word recognition skills, the nature of this correspondence learning, which he refers to as recoding, "can take the form of assigning phonemic values to letters. It can take the form of assigning patterns of phonemes to patterns of letters. It can take the form of putting oral names on written word shapes" (pp. 16-17).

With regard to grapheme-phoneme correspondence and reading achievement, researchers have investigated the learning strategies good and poor readers use to induce such associations (Fox and Baker, 1980). In another instance, development of grapheme-phoneme conversion was assessed at a recognition level only (Snowling, 1980). Still other researchers (Hardy et al., 1972) have studied the development of grapheme-phoneme and phoneme-grapheme correspondence in young children, while one investigator (Fusaro, 1977) examined the nature of difficulty level in such tasks.

More recently, there has been considerable research focusing on the relationship between phonological recoding and reading achievement. These studies have used recall memory or recognition memory paradigms under immediate and/or delayed recall conditions (Liberman et al., 1977; Byrne and Shea, 1979; Mann et al., 1980; Johnston, 1982; Bisanz, Das, and Mancini, 1984; Tuton, 1982/1983; Winbury, 1984; Lean and Arbuckle, 1984; Siegel and Linder, 1984; Mann and Liberman, 1984).

Vernon (1977) found that establishing associations between graphemes such as letter symbols and phonemes such as letter sounds was a frequent problem for the beginning reader. However, she further suggested that at a more specific level difficulty in establishing grapheme-phoneme correspondence may be due to memory deficiencies. In some studies the emphasis has been placed on how children remember the sequence of letters in words (Bakker, 1972; Bryden, 1972; Mason, Katz, and Wickund, 1975; Spring, 1976; Corkin, 1974).

Calfee (1975) asserted that acquiring sound-symbol association skills is of major importance in beginning reading instruction. He suggests that a number of cognitive processes including translating and retrieving information make heavy demands on memory.

Myklebust (1978) stated that "in reading, deficiency in retrieval pertains to what has been read, not what has been spoken; it can involve either the auditory or visual aspects of graphemes" (p. 26). Deficits in recall reflect the child's inability to "remember words just drilled" (Killèn, 1978, p. 182).

The focus of this present investigation with regard to word recognition will be in the broad area of decoding, more specifically, the conversion process of graphemes to phonemes. Thus, for the purpose of this study, reading will be defined as the ability to convert graphemes or graphic symbols to corresponding auditory equivalents or word-names. Chall (1974, 1979) referred to this as the "Decoding Stage"; stage one in the reading process; Fries (1963), referred to it as the "Transfer Stage". Johnson and Hook (1978) stated, "It occurs in grade one and the first part of grade two" (p. 208). Myklebust (1971 1973, 1978) referred to this as interneurosensory learning.

The focus of this present investigation with regard to memory will be specifically in the area of recall and recognition at an intersensory level. This writer will use the definitions of memory recognition and recall stated by Chalfant and Flathouse (1971). Memory recognition ability will be defined as "the identification of a previously identified stimulus from among presently competing stimuli." Recall ability will be defined as "the identification of a previously identified stimulus with the original stimulus ... being absent" (Chalfant and Flathouse, 1971 p. 281).

This investigation will study specifically the relationship between recall and recognition memory ability, and symbol-word-name versus word-name-symbol correspondence conversions. The two concepts of memory and symbol-word-name versus word-name-symbol can be integrated producing clearer definitions of the terms recall and recognition. The definition of recall ability will be reworded as the identification of a previously identified stimulus, the symbol-word-name association, with part of the original stimulus, the word-name, being absent. This definition means symbol-word-name conversion will be formed. In reverse, the definition of recall ability will be reworded as the identification of a previously identified stimulus, the symbol-word-name association, with part of the original stimulus, the symbol, being absent. This definition means a word-name-symbol conversion will be formed. The definition of recognition memory ability will be reworded as the identification of a previously identified stimulus, the symbol-word-name association, from among presently competing stimuli, the symbols. This definition means a symbol-word-name match will be formed.

The purpose of this study was to begin to shed some light on an area for which there is little information namely the relationship between young readers' intersensory memory abilities and establishing one-to-one visual and auditory equivalent conversions. Toward this aim, task materials and conditions that more closely simulated the conditions of learning and evaluation in present day classrooms, were used.

Description of Terms

The following terms have been used in this manuscript, in a different way perhaps than other researchers have used them. Therefore, for classification purposes and convenience of the reader, a description of these terms will be presented.

Reading (Word Recognition) - is described as the ability to convert graphic symbols to corresponding auditory equivalents or word-names.

Reading Achievement - is used in this manuscript as a reference to those studies in which the investigators usually assessed reading ability in terms of word recognition skills employing the Wide Range Achievement Test or the Peabody Individual Achievement Test.

Decoding - is used to describe such broad skills as whole word analysis and word attack. It also includes skills of association and retention of labels for letters.

Intersensory - is used to describe the process by which one converts acquired information from one modality to equivalents of another. An example of this would he converting word-names to graphic symbols or converting graphic symbols to word-names.

Grapheme - refers to isolated graphic elements, for example individual symbols used in this study  or alphabet letters a, c, f.

Phoneme - refers to isolated phonological elements, for example, 's' 'w' 't'.

Response Interval - that lapse of time occurring at the termination of the learning task and before the commencement of the testing task - five seconds or five minutes.

Intelligence - is used to describe the subjects' overall ability as tested by the subtests of the Wechsler Intelligence Scale for Children-Revised Test.

Statement of the Problem

General Problem

The general problem is the relationship between intersensory memory performance and word recognition skills. This problem is very complex. Certain subproblems have been identified for closer inspection. These are as follows:

Subproblem 1 - Are there significant differences in mean intersensory memory performance scores among the Above-Average, Average and Below-Average reading groups?

<u>Rationale</u> - These three reading categories represent the normal distribution of reading ability in most regular grade two classes. Studies that are concerned with the importance of memory ability as it relates to reading achievement usually compare the memory performances of good and poor readers. The average reading group tends to be ignored in this type of research.

<u>Subproblem 2</u> - Are there significant differences in mean intersensory memory performance scores between the immediate response interval and delayed response interval?

<u>Rationale</u> - Studies that are concerned with the importance of memory as it relates to reading achievements have evaluated memory performance under immediate and delayed response interval conditions employing serial ordered information. Yet there appears to be little reading-memory research in which memory was evaluated under similar response interval conditions utilizing non-serial information.

<u>Subproblem 3</u> - Are there significant differences in mean intersensory memory performance scores among the Visual-Auditory, Auditory-Graphic and Auditory-Visual presentation-response modes?

<u>Rationale</u> - Outlined in the British Columbia Curriculum Guide for teachers is a sequence of language art tasks. However, it is not clear how such a sequence was formulated. Nor is it clear on what research this sequence is based. Task analysis of the teaching and evaluation of some of these very basic skills

would suggest that the Visual-Auditory, Auditory-Graphic and Auditory-Visual presentation-response modes would be utilized.

Studies that are concerned with the importance of memory ability as it relates to reading achievement typically employ either the Visual-Auditory or Auditory-Visual modes. On a rare occasion both of these modes are employed in the same study. However, there is a paucity of reading-memory research combining all three presentation-response modes utilizing non-serial information.

Subproblem 4 - Are there significant interaction effects involving reading ability and response interval?

Rationale - Some studies concerned with the importance of memory ability as it relates to reading achievement have imposed response intervals in their task presentation procedures. However, these response interval conditions were not always included as factors in their analyses. There appears to be only one exception. Johnston (1982) found a significant joint effect for these two factors. She employed only two reading groups. Information as to whether such a joint effect exists between these three reading groups and two response intervals, utilizing stimuli of a non-serial nature seems not to be available.

Subproblem 5 - Are there significant interaction effects involving reading ability and presentation-response modes?

Rationale - Understanding more about the learning characteristics of these three reading groups would be important from a diagnostic viewpoint, and should produce a more descriptive analysis of their intersensory memory performance under certain presentation-response mode conditions. One study (Snowling, 1980) found a significant joint effect of reading ability and presentation-response modes. However, memory was assessed only at a recognition level. As well, only two levels of reading ability were utilized. It would appear that there is very little information concerning the joint effects of these three reading groups and these three presentation-response modes, employing stimuli of a non-serial nature.

Subproblem 6 - Are there significant interaction effects involving response interval and presentation-response mode?

Rationale - Studies concerned with the importance of memory ability as it relates to reading achievement have included either presentation-response modes or response intervals in their studies. It appears that there is very little research which has combined both of these conditions as factors in the same study. Clinical experience suggests that perhaps some differences in intersensory memory performance exist on certain presentation-response modes under different response interval conditions.

Subproblem 7 - Are there significant interaction effects involving reading ability by response interval by presentation-response modes?

Rationale - It appears that studies concerned with the importance of memory ability as it relates to reading achievement have not included a combination of conditions such as reading ability, response interval and presentation-response mode. From a learner and task analysis viewpoint it would be interesting to see whether these three reading groups' memory performances vary according to the presentation-response mode utilized and the response intervals employed.

Research Hypotheses

Hypothesis 1 - If the Above-Average, Average and Below-Average readers are measured on performance of intersensory memory tasks, there will be no statistically significant differences in the mean intersensory memory performances scores among the three reading groups at the $\mathcal{L} = .05$ level of significance.

Hypothesis 2 - If an immediate response interval and a delayed response interval are present in the intersensory memory tasks, there will be no statistically significant differences in the mean intersensory memory performance scores under these two response interval conditions at the $\mathcal{L} = .05$ level of significance.

Hypothesis 3 - If the three presentation-response modes (Visual-Auditory, Auditory-Graphic and Auditory-Visual) are employed in the intersensory memory tasks, there will be no statistically significant differences in the mean intersensory memory performance scores under these three mode conditions at the $\mathcal{L} = .05$ level of significance.

Hypothesis 4 - If the Above-Average, Average and Below-Average readers are measured under immediate and delayed response intervals, there will he no statistically significant interaction effects of these two factors on the intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance.

Hypothesis 5 - If the Above-Average, Average and Below-Average readers are measured under conditions of the different presentation-response modes, there will be no statistically significant differences in intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory task due to interaction effects of reading ability and presentation-response mode.

Hypothesis 6 - If all subjects are measured under conditions of different presentation-response modes and response intervals, there will be no statistically significant differences in intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory tasks due to the interaction effects of presentation-response mode and response interval.

Hypothesis 7 - If the Above-Average, Average and Below-Average readers are measured on intersensory memory tasks which involve the three presentation-response modes and two response intervals, there will be no statistically significant differences in the intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory tasks due to the interaction effects of these three factors.

CHAPTER TWO

Review of Related Literature

Research exploring the relationship between reading achievement and memory ability has taken a variety of directions. The review that follows has focused on those avenues most closely related to this present research study. It deals almost exclusively with the theoretical positions and findings of persons who are concerned with memory span and reading achievement; memory span and modality matching; verbal memory in paired-associate learning; the nature of grapheme-phoneme correspondence difficulty; grapheme-phoneme correspondence and reading achievement; phonological recoding, memory and reading achievement.

Memory Span and Reading Achievement

The psychometric approach using standardized tests for investigating the relationship between memory span and reading achievement has received considerable use over the past four decades (Rizzo, 1939; Heulsman, 1970; Rugel, 1974). In the last two decades researchers concerned with the importance of memory span as it relates to reading ability frequently have employed standardized subtests of the Illinois Test of Psycholinguistic Abilities (ITPA) and The Wechsler Intelligence Scale for Children (WISC). These subtests are the Visual and Auditory Sequential Memory and the Digit Span, respectively. The ITPA subtests purport to measure sequential memory skills. The Visual Sequential Memory subtest requires the subject to reconstruct sequences of abstract designs which are viewed for five seconds. The Auditory Sequential Memory subtest formulated from the Digit Span test of the WISC requires the subject to repeat in correct order forwards and backwards sequence of digits presented orally.

Relative to the ITPA, comparison of good and poor readers have produced inconsistent results. Kass (1966) found that grade two, three and four 'retarded' readers performed inadequately on the Visual Sequential Memory subtest but not on the Auditory Sequential Memory subtest. In contrast, Golden and Steiner (1969) found that grade two poor readers performed deficiently on the Auditory but not on the Visual Sequential Memory subtest. Yet Guthrie and Goldberg (1972) found that the good readers outperformed the poor readers significantly on the Visual Sequential Memory subtest. In a careful study by Badian (1977) significant differences between ten year old able readers and less able readers on the Auditory Sequential Memory subtest were demonstrated. In another study, Stanley (1975) found 'retarded' readers to perform poorly on the Auditory Sequential Memory subtest of the ITPA.

A number of profile studies reviewed extensively by Huelsman (1970) and Rugel (1974) have employed the WISC. Many of these studies found significant differences in performance between good and poor readers on the Digit Span subtest. Good readers consistently outperformed poor readers (Corwin, 1967; Robeck, 1960, 1963, 1964; Coleman and Rasof, 1963; Neville, 1961; Graham, 1952). Other investigators have found disabled readers' performances significantly lower than average readers' performances on the Digit Span subtest of the WISC (DeBruler, 1967/1968; McLean, 1963/1964; Hunter and Johnson, 1971).

More recently, Beech and Harding (1984) investigated whether or not there was a developmental lag in skills associated with phonemic processing in poor readers of normal non-verbal intelligence. The researchers compared poor readers, young readers of the same reading age, and normal readers of the same chronological age as the poor readers, on tasks involving phonemic processing and memory. These subjects' mean chronological ages were 9-9 years, 7-2 years and 9-5 years, respectively. Their mean reading ages were 7-6 years, 7-6 years and 10-2 years, respectively. Control groups were matched on non-verbal intelligence with poor readers using the Raven's Colored Matrices. Two memory tasks which were presented to the subjects were the Digit Span subtest of the Wechsler Intelligence Scale for Children-Revised (WISC-R) and a word memory task. On the latter task, the subjects were required to remember four words. Exactly what words were used and how they were presented was not reported. On all phonemic processing tasks as well as the short-term sequential memory and word memory tasks results indicated that the poor readers performed as well as the younger children of the same reading age, but significantly more poorly than the normal readers of the same chronological age. These researchers concluded that the results of the study support the hypothesis of a developmental lag in phonemic processing in poor readers.

A number of studies employing memory span tasks similar to the Digit Span subtest of the WISC and subtests of the ITPA have demonstrated memory deficits in poor readers. Spring (1976) using a method similar to the WISC, found a digit span deficit in 'retarded' readers. Koppitz (1975) assessed the digit span skill of learning disabled non-readers, learning disabled readers and average readers. The mean chronological age of these three groups was nine years. These groups were represented as group A, B and C, respectively. Groups A and B were matched on age and intelligence using the WISC Full Scale intelligence quotients. Group C's intelligence was assessed on the California Test of Mental Maturity. The reading recognition score range for each group as measured by the Wide Range Achievement Test (WRAT) was .8 to 2.1, 2.7 to 7.0 and 3.0, or better, respectively. One test of a battery of tests administered to these subjects was the Visual-Aural Digit Span Test. It consisted of four subtests: (a) auditory presentation of a series of digits and oral recall - A-0; (b) visual presentation of a series of digits and oral recall - V-0; (c) auditory presentation of a series of digits and written recall - A-W; (d) visual presentation of a series of digits and written recall - V-W. The results of the group performance showed that the subtests A-0, V-0, and V-W differentiated significantly between the special class pupils who could read and those who could not - groups B and A, respectively. The V-O subtest was the one most closely associated with reading achievement. The A-W subtest failed to differentiate between groups A and B. For group A versus group C, four subtests differentiated significantly between the non-readers and average pupils. Finally, the subtests failed to differentiate significantly group B and group C. Koppitz' analysis was such that it is not clear whether there was an interaction effect between reading groups and presentation-response modes. Corkin (1974) also used an auditory digit span task in which either all digits within a string were different or one of the digits was repeated. She assessed inferior and average readers across three chronological age groups: six and seven year olds, eight and nine year olds, and ten and eleven year olds. In all instances the inferior readers were found to be less competent with strings that involved a repeated digit except at the ten and eleven year old level.

Burns (1975) investigated the performance of reading-disabled and normal children on various sequential memory tasks. Subjects were 18 reading-disabled and normal boys, aged 9 years to 13 years. The first set of tasks using a sequence of digits employed visual, auditory and visual-auditory inputs with two outputs, vocal and graphic. The results indicated a significant difference between these two groups. However, the differences was not specific to any modality of input and/or output. She concluded that the reading-disabled children have a general sequential memory deficit. This study also included two bisensory sequential memory tasks which employed auditory-visual inputs such as digits, with requirements to recall the digits in aural-visual pairs. Again, vocal and graphic response modes were employed. Performance on these tasks indicated a significant difference between the reading-disabled and normal children. These two bisensory tasks were found to be the best predictors of which subjects belonged to the normal or disabled reading groups. She concluded that the reading-disabled children showed significant deficits in the ability to shift attention across modalities and transduce visual inputs for vocal responses.

More recently, a study by Lindgren and Richman (1984) attempted to evaluate the immediate memory span skills of reading-disabled and normal male readers across two age groups; eight year olds and twelve year olds. Intelligence was assessed by the WISC-R Verbal, Performance and Full Scales. Short-term sequential memory was assessed by the Color Span Test (Richman and Lindgren, 1978). Four intra- and inter-modal conditions were employed: (a) Visual-Visual - the examiner points to the color chips in order, on one card, and then replaces the card with an alternate card for the child to point to the same colors in sequence; (b) Visual-Verbal - the examiner points to the color chips in order, covers the color card and asks the child to name in sequence the colors previously indicated by the examiner; (c) Verbal-Visual - the examiner reads a sequence of color names with the color cards covered. Another color card is presented and the child is asked to point in sequence to the colors named by the examiner; (d) Verbal-Verbal - no color cards are used. This task is similar to the digit span test except that colors are used instead of digits. The examiner reads color names to the child and asks the child to repeat these in the correct order. The results of this study were as follows: (a) both of the reading-disabled age groups recalled fewer colors than the aged-matched normal children; (b) the eight year old reading-disabled group recalled fewer colors under the visual-verbal verbal-visual and verbal-verbal conditions; (c) the twelve year old reading-disabled group recalled fewer colors under the verbal-verbal condition only; (d) for the eight and twelve year old reading-disabled groups versus the eight and twelve year old average readers, the errors in recall were due to the sequencing aspect of memory rather than memory for items; (e) there were no significant main effects for presentation-response modes; (f) there were no significant interaction effects for presentation-response modes and reading achievement. The authors appear to be vague as to whether the subjects were tested for color blindness prior to testing. The reader is only told that "The examiner must be sure that the child recognizes each color prior to administration" (Lindgren and Richman, 1984, p. 223). These authors were vague as to the procedure used to determine this. It was unclear whether the method employed was consistent for all subjects.

In another study, Granetz (1984/1985) evaluated the short-term memory ability of three reading groups; dyslexics, normal and poor readers, ranging in chronological age from eight years to fifteen years, using digit strings. Under the two memory conditions of free recall and sequential order, and under the three task conditions of visual, auditory and visual array presentations, she found that: (a) normal readers have better short-term memory performances and longer memory spans than the two reading disabled groups; (b) the effects of sequential order were greatest on the short-term memory of the two reading disabled groups.

The psychometric approach to studying the relationship between reading achievement and memory span has been criticized by some investigators. Torgesen (1978-1979) suggested that this processes are actually problematic in reading-disabled students. Tarver and Hallahan (1974) suggested that the auditory or visual sequential memory task is more than likely a marker for attentional processes. However, contradictory evidence of the notion of selective attention was found in a study Torgesen and Houck (1980) on 'retarded' readers with a digit span deficit. Although poor performance on memory span tasks is often interpreted as being indicative of an attentional deficit (Ross, 1976, 1977), these investigators' results indicated otherwise. They hypothesized that if such children were distractible, they would show greater variability in their digit span performance. In contrast, the results showed that children with digit span deficit performed consistently across a series of digit span tests. These investigators concluded that retarded readers can adequately attend to digit sequences presented at a rate normally used in a digit span task. Studies by Bauer (1977a, 1979), Hagen (1967) and Pelham (1979) also have supported the notion that some retarded readers do not have a selective attention deficit. Koopman (1985) suggested that it is not so much the fact that subjects cannot attend per se, but that they do not know which components within the task are important to attend to. This could be compounded by ambiguous task instructions. There is evidence (Torgesen, 1977; Torgesen et al., 1979; Bauer, 1979; Dallago and Moely, 1980; Cohen and Netley, 1981) that poor readers do not use strategies such as verbal coding and rehearsal adequately (Jorm, 1983). Bayliss and Livesey (1985) have shown that dysphonetic and dyseidetic reading-disabled boys aged nine years to eleven years clearly differed in their cognitive strategies in visual sequential recognition memory tasks. When the nature of the stimulus was compatible with modality preference, they were able to remember information presented sequentially. Normal readers also demonstrated strategy preferences on these tasks. As a group, reading-disabled boys proved to be just as competent on these tasks as the normal readers. A study by Enhis (1983) suggested that some types of reading-disabled boys aged eight years to thirteen years are able to form visual-verbal associations and use these to aid memory on sequential tasks.

Summary

The studies reviewed in this section tend to compare the performances of only two groups of readers: either good readers and poor readers, or average readers and poor readers on sequential memory tasks. The present investigation, however, compares the performances of three groups of readers: Above-Average, Average and Below-Average.

Comparison of good and poor readers on sequential memory subtests of the WISC and ITPA for the most part have been in favor of the good readers. Some researchers have concluded that the results of their study support the hypothesis of a developmental lag in the phonemic processing in poor readers.

Although the majority of studies have employed either an auditory or visual presentation, a few studies have attempted to assess sequential memory under various presentation-response mode conditions, namely Auditory-Oral, Visual-Oral, Visual-Written and Auditory-Written. In some instances a statistically significant interaction effect between presentation-response modes and reading groups has been found. In other studies no such interaction effects have been apparent.

Memory Span and Modality Matching

A number of researchers have made reference to the place of memory in modality matching. They tested short-term memory separately, through either the auditory or visual modalities. A sequential component was included in the tasks.

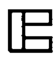
In their original study, Birch and Belmont (1964) found that children with low and high auditory-visual integration scores were not significantly different in memory ability as measured by the Digit Span subtest of the WISC. Other investigators, Ford (1967), Kahn and Birch (1968), obtained similar results employing WISC Digit Span scores. Jorgenson and Hyde (1974) found no significant relationship between auditory-visual integration and auditory sequential memory as tested by the ITPA. In contrast, these researchers found a significant relationship between visual sequential memory and auditory-visual integration for grade two subjects. Milner and Bryant (1970) approached the task somewhat differently. They imposed delays between the presentation of the standard and matching stimulus, and found that delays of more than five seconds added a memory component to the task. Badian (1977) followed suit and imposed delays of ten seconds between the standard and matching stimulus. He also found, as did Birch and Belmont (1964), Ford (1967), and Kahn and Birch (1968), that there was no relationship between auditory-visual integration and memory for digits, as tested by the Auditory Sequential Memory subtest of the ITPA. However, he did find that the 'retarded' readers' auditory-visual integration performance deteriorated as memory demands increased.

Summary

Several researchers noted in this section have been concerned with whether a relationship between auditory-visual integration and sequential memory exists. The results of these studies were somewhat inconsistent depending in part on whether the Digit Span subtest of the WISC or the sequential memory subtests of the ITPA was employed. Two of these studies were concerned with the impact of response interval on auditory-visual integration performance. These researchers employed response intervals between the standard and matching stimulus. In most cases, no relationship between auditory-visual integration and sequential memory was found. It was suggested that as memory demands increased, auditory-visual integration performance deteriorated.

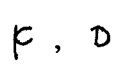
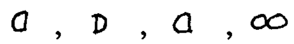
Verbal Memory in Paired-Associate Learning

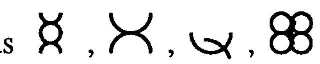
The paired-associate learning paradigm is the closest learning paradigm to the one-to-one graphic symbol and word-name correspondence learning framework employed in this present investigation. Atkinson, Atkinson and Hilgard (1983) defined paired-associate learning as: "the learning of stimulus-response pairs, as in the acquisition of a foreign language vocabulary. When the first member of a pair (the stimulus) is presented, the subject's task is to give the second member (the response)" (p. 633). Paired-associate learning studies that investigated the relationship between memory and reading achievement are reported below.

On a paired-associate learning task in which the immediate recall of nonsense syllables, clarf, plesh, blaif as responses to letter-like symbols, ,  was required, Gascon and Goodglass (1970) found that the poor third grade male readers were inferior to the good readers. Intelligence was assessed employing the WISC. As to whether intelligence was based on the Full Scale is not clear. The Stanford Achievement Test was used to assess reading ability. In this study each visual stimulus was exposed for five seconds, with the examiner providing the spoken name two seconds after the exposure commenced. The series of four pairs was presented five times in randomly varied order, with a test trial following each presentation run. However, it is not clear exactly how much time elapsed between termination of stimulus presentation and the testing of the association tasks. The recognition task was conducted in a less controlled environment. The four visual stimuli of each set were placed on a table and the subject was required to point to a shape when the examiner said a nonsense syllable. The set was shuffled and rearranged after each trial. These investigators found the 'retarded' readers were inferior to the normal readers on the recognition test. No attempt was made to study the level of difficulty of recall and recognition tasks.

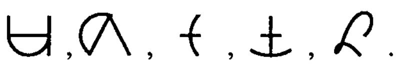
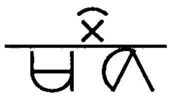
It has been noted previously that researchers tend to compare two groups of readers. However, a study by Otto (1961) is one of the few exceptions. He assessed good, average and poor readers from grades two, four and six. Intelligence was assessed using the Otis Quick Scoring Test. Otto employed a paired-associate learning task involving the association of geometric shapes, as ♦, ●, ▲, ■, ✦, for example, and nonsense syllables such as fep, miv, wuc, yad and gox. The form-trigram pairs were presented in three different ways with three modes of reinforcement: (a) auditory - the form was presented for four seconds, followed by a second four-second presentation, plus the experimenter's articulation of the form name; (b) visual - the form was presented for four seconds, followed by a second four-second presentation of the form, plus the experimenter's articulation of the form name plus a visual presentation of the trigram; (c) kinesthetic - the form was presented for four seconds, followed by a second four-second presentation of the form, plus the experimenter's articulation of the form name plus a visual-kinesthetic presentation of the trigram. For the visual-kinesthetic presentation the child was able to trace the trigram with his finger. The results of this study indicated that the main effects of grade, reading level and mode of reinforcement were statistically significant. However, these effects had to be qualified because of the presence of two statistically significant interaction effects: (a) Grade x Reading Level, and (b) Grade x Mode of Reinforcement. Otto (1961) concluded that the number of trials subjects required to learn paired-associates was dependent on both the grade level and reading level of the subjects. That is, poor readers across the Grade levels two, four and six required more trials to learn the paired-associates than did the good readers across the same grade levels. The average readers' performance fell between the good and poor readers' performances in this respect. For all reading levels, the grade two subjects required more trials to learn paired-associates than did the grade four or grade six subjects. The latter grade required the fewest trials. A second conclusion by this researcher was that the number of trials subjects required to learn paired-associates was dependent on both the grade level of the subjects and the mode of reinforcement given. That is, the grade two subjects required the most trials to learn paired-associates under the visual mode of reinforcement, followed by the auditory and then the kinesthetic modes. For grade four subjects the most trials required to learn paired-associates occurred under the auditory mode of reinforcement followed by the kinesthetic, and then the visual modes.

The grade six subjects required the most trials to learn paired-associates under the auditory mode of reinforcement followed by the visual, and then the kinesthetic modes.

Firth (1972) compared the performance of inferior and average six and eight year olds, male and female readers, of low and average intelligence. Among the psycho-educational tests administered was a rote-learning test or paired-associate learning test. On this test, Firth used words such a ship and bath. He employed letter-like symbols such as  and   . Firth found little difference in recall performance between low intelligence inferior and average eight year old readers, or between average intelligence inferior and average eight year old readers. Data relative to the six year olds were not available. Firth concluded the paired-associate learning test was not related to reading or intelligence.

Vellutino, Harding, Phillips and Steger (1975) attempted to assess normal and poor readers on transfer of training tasks. They employed two different types of tasks: (a) visual-auditory association, and (b) visual-visual association. Visual designs such as  were paired with nonsense syllables HEGPID, ZONJEC for example. Boys and girls with intelligence quotients 90 or better, from grades four, five and six participated in the study. When the two pre-experimental trials had been administered, where all the visual designs and nonsense words were paired and presented, the experimental trials began. The subject was shown only the design card and asked to give the corresponding nonsense word. Subjects had five seconds to respond to each card.

It is not clear exactly how much time elapsed between the termination of the pre-experimental trials and the beginning of the experimental trials. In the case of both training and transfer, little difference between normal and poor readers could be noted on the visual-visual condition. However, as they predicted, on the visual-auditory condition, normal readers were superior to the poor readers in both training and transfer.

In contrast, Jorm (1977) found that male 'retarded' readers with a mean age of 9-6 years performed as well as the normal readers of the same mean age on the paired-associate learning tasks. These subjects were assessed for intelligence employing the Australian Council for Educational Research Junior Nonverbal Test. The nature of the paired-associate task was such that it required the subjects to associate high and low imagery spoken words with letter-like symbols, when forced to use a whole word reading strategy. Each word, table, flower and cost, was paired with a string of three of Gibson et al. (1962) letter-like forms  . For five of the high and low imagery words, there was a drawing below the string of letter-like forms which showed the word incorporated in a picture related to its meaning. For example, the word table was paired to  and the drawing looked like this: .
Twenty words were presented on individual cards in letter-like form, one at a time. The experimenter then said, "Here is the first word. It says 'arrow' " (p. 51). Each subsequent string of letter-like forms was exposed for five seconds of study. During the test trials, strings of letter-like forms were exposed either until the

child responded or until ten seconds had expired. Four study test trials were given to each child.

Jorm (1981) again found that the 'retarded' readers performed as well as the normal readers on a learning task, this time involving the association of spoken words with visually-presented digit strings.

Similarly, Jorm et al. (1986) found that 'retarded' readers, backward readers and normal readers with a mean age of five years, four months and a mean IQ (based on the non-verbal intelligence test, the Columbia Mental Maturity Scale) of 76, 106, and 102 respectively, did not perform significantly differently from each other on a paired-associated task. In this learning task the child was required to associate two spoken English words with two pseudowords made up of nonsense symbols and also to reproduce them from memory.

In contrast to Jorm (1977, 1981), Vellutino et al. (1978) investigated the learning of English meanings of Chinese characters in grade two and grade six students. These subjects were of two age groups: (a) seven and eight year olds, and (b) eleven and twelve year olds. These investigators found that the poor readers learned more slowly than the normal readers. Jorm and Share (1983) pointed out the fact that the rate of stimulus presentation, 150ms, in Vellutino et al.'s study was much faster than the rates of stimulus presentation in other studies of Firth (1972); Jorm (1977, 1981). Jorm and Share (1983) felt that this faster presentation rate would account for the differences in results.

Summary

All but one study reviewed in this section have focused again on two reading groups, for example poor versus good readers, or inferior versus average readers. Out of many studies noted in this literature review, only one study in this section included three reading groups.

Some of the researchers in paired-associate studies paired nonsense syllables and geometric or visual designs; others paired nonsense syllables and letter-like symbols.

As has been noted in earlier summaries, a common feature of these studies in this section was the use of sequential memory tasks. The results of these paired-associate studies have been somewhat inconsistent. In some cases normal readers were superior to poor readers in recall performance under the Visual-Auditory presentation-response mode condition. In contrast, other researchers have reported little difference in performance between these reading groups under similar presentation-response mode conditions.

Phoneme-Grapheme and Grapheme-Phoneme Correspondence

Hardy et al. (1972) attempted to assess the development of the mastery of phoneme-grapheme and grapheme-phoneme correspondence of children in grades one, two and three. Hardy used English consonant and vowel letters to represent the elements. He administered two tests. The first, a phoneme-grapheme test involved the recognition of an appropriate grapheme, given a phoneme as a stimulus. On this test the subjects were required to choose from four alternatives. The second test required the child to judge whether a given grapheme could be employed to produce a particular phoneme. On this test the subjects were required to give only a yes or no response. The results of this study revealed distinct developmental trends in mastering the visual-auditory equivalents. In addition, the results showed that the associations from phoneme to grapheme appeared to be easier than those from grapheme to phoneme. The authors caution the reader that the differences found could be due to differences in test format and task demands.

Fusaro (1977) suggested that a major limitation of the Hardy et al. (1972) study was the procedure by which the letter-sound correspondence was assessed. Instead of requiring the subjects to say the sound when they were presented with the corresponding letter, the subjects were presented with a letter and then a sound, which may or may not have corresponded to the letter. To overcome this limitation Fusaro (1977) assessed grade two children's knowledge of letter-sound and sound-letter correspondence employing 21 letters and sounds of the Supplementary Phonics Tests of the Spache Diagnostic Reading Scales. The sound-letter correspondence task required the examiner to present the letters visually and the subjects to respond orally with the corresponding sounds. Each subject was tested individually. The results indicated that when the sound-letter test was administered first, both tasks were of equal difficulty. In contrast, when the letter-sound test was presented first, making a sound-letter correspondence was an easier task than making a letter-sound correspondence.

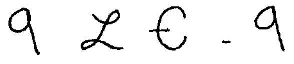
Fusaro (1978) replicated his own study (1977) in order "to determine whether graphemic recall has properties that yield higher scores than phonemic recall" (p. 172). The results showed that actual difference between the mean score for graphemic and phonemic recall was small. He also attempted to assess whether the skills needed for phonemic and graphemic recall were identical. He found that, although a relationship between the two types of correspondence existed, the skills to make the two types of correspondence were not identical.

Summary

Researchers noted in this section have attempted to assess the development of the mastery of phoneme-grapheme and grapheme-phoneme correspondence of young children. Their results suggest distinct developmental trends in mastering the visual-auditory equivalents. However, it was suggested that differences found could also be due to task demands and test format. Other researchers have pointed to weaknesses with which letter-sound correspondences have been assessed. When such weaknesses have been eliminated the results suggest that order position is an influential variable. That is, when the letter-sound was presented first it was easier to make a sound-letter correspondence than to make a letter-sound correspondence. However, when the sound-letter test was administered first both tasks were of equal difficulty. Finally, research has suggested that skills to make the sound-letter or letter-sound correspondence were not identical although a relationship between the two exists.

Grapheme-Phoneme Correspondence and Reading Achievement

A number of studies investigating the relationship between grapheme-phoneme correspondence and reading ability are noteworthy for this literature review.

Fox and Baker (1980), using an artificial orthography, investigated the relationship between reading achievement and the ability to induce grapheme-phoneme associations. Real words employed consisted of consonant-vowel-consonant trigrams, using a total of seven letter-like forms with one-to-one grapheme-phoneme correspondences. For example, the real word SUN became  for S,  for U and  for N. They chose for the study, good and poor readers, and assessed their intelligence on the Peabody Picture Vocabulary Test (PPVT). In order to assess grapheme-phoneme acquisition strategy, the grade one good and poor readers were presented with a word learning task followed by a grapheme-phoneme association task. The good readers learned the word list faster with fewer errors than the poor readers. The authors suggested that the results showed that good and poor readers applied different word learning strategies, the former using a "principle solution", while the poor readers applied an "associative solution".

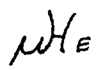
Snowling (1980) investigated the development of grapheme-phoneme conversion ability in normal and dyslexic readers. The normal readers ranged in age from 6-6 years to 10-9 years, while dyslexic readers ranged in age from 9-2 years to 15 years. The reading ages for both groups ranged from seven years to eleven years. The subject's verbal intelligence was assessed employing the WISC. The tasks utilized in this study involved the auditory and visual recognition of nonsense words immediately after a visual or auditory presentation. Examples of four letter pronounceable nonsense words employed were: sond - snod; and dron - dorn. Overall, no significant difference was found between the normal and dyslexic reading groups. There was a significant main effect for conditions. This main effect however, had to be qualified because of the statistically significant interaction effect between conditions and reading groups. Normal readers were superior to the dyslexic readers under the visual presentation-auditory recognition condition. No significant difference was found between the reading groups under the auditory presentation-visual recognition or under the visual presentation-visual recognition condition or under the auditory presentation-auditory recognition condition.

In two studies, Savage (1983) assessed the relevance of consistency and conditionality for the acquisition of spelling-sound correspondence knowledge of normal and disabled readers. In the first study, groups of readers were compared on a paired-associate learning task using sets of symbol-word correspondence. Some sets contained a rule relationship; others did not. Learning differences were found between normal and disabled readers when a rule was present within a set, but were not found when no rule was present within a set. In a second study, groups of readers were compared on a pseudoword decoding task in which spelling-sound correspondence was also categorized on the dimensions of consistency and conditionality. Disabled readers performed less accurately on the decoding task than the two normal reading groups (a) of the same chronological age as the disabled readers, and (b) of the same reading grade level as the disabled readers. All groups had less difficulty decoding unconditional than conditional correspondences. The researcher concluded that disabled readers fail to acquire knowledge about words, particularly knowledge about spelling-sound correspondence, because of their difficulty in learning complex rule systems.

Kilian (1984/1985) examined the correlates of the performance of second and third grade average, and poor readers on a list of words commonly found in grade one to four basal readers. The researcher employed skills such as phonemic segmentation to predict the subjects' reading performance on the word list, and complexity of the letter-sound correspondence to predict the number of errors made on each word. The results of this study suggest that the complexity of letter-sound correspondence within words is a crucial factor in beginning reading failure. That is, students who had not mastered the complex letter correspondence system were less likely to read words correctly than students who had mastered this system. Phonemic segmentation skill was not related to performance on the word list. Words which were more complex in terms of the number and difficulty of the letter-sound correspondence were less likely to be read correctly than words with few and simple correspondence.

Manis (1985) assessed the ability of 20 fifth and sixth grade boys and girls of normal and deficient reading ability to learn meaning and pronunciation of unfamiliar words. These words varied in word length and in letter-sound regularity and complexity. The normal readers' intelligence was assessed on the

Otis-Lennon Mental Ability Test. Disabled readers' intelligence was assessed on the WISC-R or Stanford-Binet Intelligence Test. The normal readers' reading comprehension was assessed by employing the comprehension subtests of the Iowa Test of Basic Skills (ITBS) or the Stanford Reading Achievement Test. Their reading grade score range was 6.0 to 7.6. The disabled readers' reading comprehension was assessed by using the comprehension subtests of the ITBS, the Stanford Diagnostic Reading or Peabody Individual Achievement Tests. Their reading score range was 1.9 to 3.8. Only those subjects with intelligence quotients of 90 or above, and scoring two years below grade level on a standardized reading comprehension test were included in the disabled reading group. Of the word recognition performances, nine of the ten disabled readers were somewhat inferior on the Wide Range Achievement Test (WRAT) or ITBS. The word recognition score range for these subjects was 1.9 to 3.8. From his results, Manis concluded that (a) disabled readers were slower to name the unfamiliar words than normal readers, even after three sessions of practise; (b) the disabled readers were capable of using regular letter-sound correspondence to pronounce printed words but their weaker knowledge of those correspondences limited their performance. It is unclear to this writer whether Manis assessed the word recognition skills of the normal readers. Both reading groups were required to learn meaning as well as pronunciation of unfamiliar words. Finally, relative to the delay pronunciation task, disabled readers performed significantly more poorly than the normal readers, even when the disabled readers were apparently familiar with the letter-sound correspondence contained in the low-complexity regular words. Manis reasoned that some of the difference in quality of performance was due to slower execution of vocal responses by disabled readers. More specifically, Manis suggested that phonological coding and retrieval processes are less efficient in disabled readers.

Finally, a study by Ehri and Wilce (1985) evaluated the ability of kindergarten children to read words. These children were divided into pre-readers, those who could not read words; novices, those who could read two or three words; and veterans, those who could read more than two or three words. These subjects were taught to read two kinds of word spellings; simplified phonetic spellings whose letters corresponded to sounds, for example MSK for mask; and visual spellings whose letters bore no sound correspondence but were more distinctive visually,  for mask. Their results showed that the pre-readers learned to read the visual spellings more easily than the phonetic spellings, while the novices and veterans learned to read the phonetic spellings more easily than the visual spellings. They concluded that in order to move effectively into word reading, one has to shift from visual to phonetic cue processing. The form of phonetic processing employed at the outset of reading is one which involves the use of a letter-sound recognition mechanism. This mechanism they suggest is used to preserve associations between spellings and pronunciations in memory.

Summary

The emphasis on the assessment of two reading groups continues to be a common factor in this literature review in general and specifically in this section.

In the assessment of recognition memory utilizing nonsense words as stimuli, a statistically significant joint effect between conditions and reading groups was found by one researcher. Normal readers were superior to dyslexic readers under the Visual-presentation-Auditory recognition condition. In another study the investigator concluded that disabled readers fail to acquire knowledge about words because of difficulty learning complex rule systems. Another researcher also concluded that disabled readers' weaker knowledge of certain correspondences limited their performance to pronounce printed words with regular letter-sound correspondence. Finally, other researchers concluded from their results that a shift from visual to phonetic cue processing is required in order to move effectively into word reading.

Phonological Recoding, Memory and Reading Achievement

Considerable research over the past ten years has focused attention on the relationship between phonetic recoding and reading achievement. Memory was assessed under immediate and delayed conditions employing sequencing tasks.

Liberman et al. (1977) set out to explore the hypothesis that good and poor readers differed in the degree to which they used phonetic coding in short-term memory. In one experiment, second grade good, marginal and poor readers' performances were compared on recall of phonetically confusable and non-confusable letters, that is, rhyming and non-rhyming letters, respectively. Their mean word recognition scores were grade 4.9, grade 2.5 and grade 2.0, respectively, as assessed by the WRAT. Intelligence was assessed employing the

PPVT. The stimuli employed in the recall tasks were strings of five uppercase consonants, half-rhyming and drawn from the set BCDGPTUZ: and half-non-rhyming drawn from the set HKLQRSWY. These stimuli were presented tachistoscopically in a three-second exposure. Recall performance was tested under two conditions: (a) immediately after the stimulus presentation, and (b) 15 seconds after the stimulus presentation. Liberman et al.'s (1977) study showed that the main effects of reading group, time delay and confusability were statistically significant. However, these effects had to be qualified because of the statistically significant interaction effect for Reading Group x Delay x Confusability. That is, for superior readers delay had a significantly greater effect on recall of confusable sequences than on the recall of non-confusable sequences. In contrast, among the marginal and poor readers, delay did not differentially affect performances on the two types of sequences.

In another experiment (Shankweiler and Liberman, 1976), the same procedure was followed, with the difference that the letters were presented orally on tape. The results indicated that the good beginning readers were more affected than the poor readers by the phonetic characteristics of the visually-presented items in a recall task. That is, the good readers made significantly more recall errors on the strings of letters with rhyming names than on those with non-rhyming names. On the other hand, the poor readers made approximately equal number of errors on the rhyming and non-rhyming letter strings. For all groups recall was significantly better on the immediate than on the delayed recall conditions. Some researchers have criticized these studies on the basis of two points: first, given the type of stimuli enjoyed in these studies, for example, strings of unrelated stimuli, the degree of generalizability to more realistic reading situation is questionable. Second, the method of study did not control for the effects of rehearsal, and thus differences found could be accounted for as differences in rehearsal strategies. In order to address these criticisms a third experiment was conducted by Mark et al. (1977). In this study second grade good and poor readers' intelligence was assessed by the WISC-R. These subjects were tested on rhyming and non-rhyming words for recognition memory. Consistent with earlier studies good readers were more affected than poor readers by the phonetic similarity of rhyming words. That is, the good and poor readers do differ in their ability to access a phonetic representation. They concluded that the nature of the poor readers' deficit is related to the accessing and use of a phonetic representation in working memory.

Studies by Byrne and Shea (1979) and Mann et al. (1980) produced findings similar to those of Liberman and Shankweiler (1979). That is, poor beginning readers made less use of phonetic coding in short-term memory recall and recognition tasks than good beginning readers. Jorm (1983) suggested that these results reflect the accessibility of phonological codes in long-term memory, given that working memory can only hold small amounts of phonological coded information. He noted further that in these studies demands made on recognition memory were considerable.

Johnston (1982) studied recall performances of nine, twelve and fourteen year old dyslexic children. For each age group there was a chronological and reading age control group. With the exception of one control group all the chronological age control groups' reading ages were commensurate with their actual age. In order to determine their reading ages all subjects were tested on the British Abilities Scale Word Reading Test. Intelligence was assessed by the WISC Verbal Scale only. Task variables employed by Johnston were item type, that is, rhyming versus non-rhyming words, and conditions such as immediate versus delayed memory. The results of this study were as follows: (a) at the nine year old level there were statistically significant main effects for groups, item type and conditions. More specifically, the chronological age group performed significantly better than the dyslexics and reading age controls. Recall performance levels were significantly higher on non-rhyming items than on rhyming items. A significantly higher recall performance was found under the immediate rather than the delayed time condition. There were no statistically significant interaction effects between groups and item type, or groups and conditions. (b) at the 12 year old level, a statistically significant interaction effect between groups and item type was found. More specifically, the reading age controls' recall performance was poorer than the dyslexics' recall performance on the non-rhyming items. No significant difference was found between the two groups' recall of rhyming items. The chronological age controls' performance was superior to the dyslexics, on both rhyming and non-rhyming items. In addition, a statistically significant interaction effect was found between groups and conditions. The dyslexics performed significantly better than the reading age controls under the immediate condition. No significant differences in recall performance by these groups was found under the delayed condition. The chronological age controls performed better than the dyslexics under both the immediate and delayed conditions. (c) at the 14 year old level there were statistically significant main effects for groups, item type and conditions. More specifically, the chronological age controls performed better than both the dyslexics and reading age controls. There was a significant difference in item type in favor of the non-rhyming items. Items were recalled better under the immediate condition than under the delayed condition. Finally, no statistically significant interaction effects were present between groups and item type, or groups and conditions.

More recently, Bisanz, Das and Mancini (1984) compared the memory performance of average grade two, four and six readers, with grade four disabled and superior, and grade six disabled readers, respectively. These researchers employed rhyming and non-rhyming letter strings similar to those letter strings used by Shankweiler and Liberman (1976). Intelligence was assessed using the Canadian Cognitive Abilities Test. Memory recall was assessed after a 15-second delay. Three other conditions were employed: (a) Standard condition - subjects were asked to remember six consonant letter strings over a 15-second delay; no attempts were made to reduce rehearsal or phonemic coding during the delay; (b) Partial condition - the same as (a) except that suppression of rehearsal occurred during the 15-second delay; children had to repeat the word "cola"; (c) total condition - the same as (b) except that subjects had to repeat the word "cola" during the presentation of the stimulus as well as in the 15-second delay to suppress phonemic coding and rehearsal. The results of this study were as follows: (a) for the average readers significant main effects had to be qualified with the presence of a statistically significant interaction effect between age and conditions. Mote specifically, under each condition recall performance improved with age. Moreover, recall performance under the standard condition was superior to recall performance under the partial suppression and total suppression conditions at each age. A significant recall difference between the partial and total suppression conditions was only evident for grade four average readers. Finally, there was a greater difference in recall performance between the standard and suppression conditions for grade six students than for the two other age groups. A second statistically significant interaction effect was found, namely a joint effect by the factors, letter type and conditions. That is, recall performance using non-rhyming letters was superior to real performance employing rhyming letters under the standard condition, whereas little recall performance differences between non-rhyming and rhyming letters was found under the other two conditions. (b) for reading groups grade four and grade six, a statistically significant group by condition interaction was present. More specifically, under the standard and total suppression conditions, good readers were superior to average and disabled readers in recall performance. (c) relative to grade six reading groups, a statistically significant letter by condition interaction was present. More specifically, recall performance employing non-rhyming letters was superior to recall performance using rhyming letters under the standard condition; no significant differences were present between the two types of letters under the partial suppression condition, while a slight advantage for rhyming versus non-rhyming letters was present under the total suppression condition.

(d) for the matched reading groups, that is, the grade two average readers matched in reading skill with grade four disabled readers there were only statistically significant main effects for conditions and age. With respect to the grade four and grade six matched reading groups, that is grade four average readers matched in reading skill with grade four disabled readers, and grade six average readers matched in reading skill with grade four superior readers, there was a statistically significant interaction effect for letter by condition. More specifically, recall performance employing the non-rhyming letters was superior to recall performance using rhyming letters under the standard condition, while no significant differences in recall were found under the other two conditions. These recall differences in the use of phonemic codes by good and poor readers in grade four and six, were less than the recall differences found in previous research of younger children, and consistent with findings by Johnston (1982).

Winbury (1984) attempted to compare the memory performance patterns of good and poor readers in order to confirm and extend the findings of Mark et al. (1977) in which words were read, and Byrne and Shea (1979) in which words were heard. In Winbury's study, second and fourth grade good and poor readers were administered a non-standardized recognition memory test involving phonetically and semantically confusable words. Poor readers made more recognition memory errors than good readers. However, differential effects of age, phonetic and semantic confusability, or mode presentation were not found. The author attributes these findings to differences in design, stimuli employed, modifications in task structure, and test reliability.

In another recent study, Lean and Arbuckle (1984) investigated the use of phonetic coding in pre-readers aged 3-5 years to 4-10 years, and 5-0 years to 5-10 years. Only those children who were able to name the letters of the alphabet were selected for the study. The stimuli employed were letter strings; and the memory conditions utilized were immediate and 15-second delays. These variables were similar to those employed by Liberman et al. (1977). Lean and Arbuckle assessed memory in two ways: first, free recall or item memory, as serial reconstruction or order memory. Their results indicated that a large phonetic similarity effect was present in both age groups in both types of memory. The 15-second delay before the subjects were permitted to respond produced a significantly poorer recall performance under the oral free recall than under the serial reconstruction. These authors suggested that preschool children do appear to code visually presented letters in terms of their verbal labels and persist in the use of this phonological code even when it penalizes recall. There was no evidence of developmental increase in the use of this phonological coding strategy.

Finally, Siegel and Linder (1984) studied the role of phonetic coding in 45 children with reading disability, 38 children with specific arithmetic disabilities and 89 children achieving "normally" in school. These researchers used the rhyming and non-rhyming letter sequencing tasks similar to those employed by Liberman et al. (1977). Subjects of this study were aged seven years to thirteen years. Intelligence was inferred through the use of a receptive vocabulary measure, the PPVT. Three presentation-response mode conditions were included in the data collection. These were as follows: (a) Visual-Written condition, V-W

- the subject was shown cards with either five or six letters on them, for three seconds and then the word was removed. The subject was required to write down the letters presented on the card. (b) Visual-Oral condition, V-O - the subject was shown the letters in the same manner as the V-W condition, but instead had to repeat orally the letters presented on the card. (c) Auditory-Written condition, A-W - the subject heard the stimuli presented on a tape recorder and was required to write the letters that he had heard. The results of this study showed that:
(a) seven year olds and eight year olds with reading disability did not show any difference in recall performance between non-rhyming and rhyming letters, whereas normal children of the same age did show differences in recall performance between these two types of letters. (b) the older reading-disabled children, the nine years old to thirteen year olds, like their normal counterparts, had significantly poorer recall of rhyming as opposed to non-rhyming letters. However, this older reading-disabled group's overall levels of performance were significantly lower than those of the normal group. These researchers concluded that younger learning-disabled children tend to be characterized by phonological coding deficits, while the older children with learning disabilities appear to use a phonemic code but have a more generalized memory deficit. In terms of the presentation-response modes employed, this study was an obvious source of information and relevance to the writer's present study. These investigators included three presentation-response mode conditions, two of which were the same type of condition utilized in this present study. However, they did not appear to include presentation-response mode conditions as a factor in their analysis. Their research design, given the variables employed in the study,

required a four-way analysis of variance (ANOVA) design. Instead, a three-way ANOVA was utilized. Therefore, it is the opinion of this writer that a presentation-response mode conditions is a confounding variable, and thus clouds the "true" results of this study. In addition, Liberman and Shankweiler (1979) have been critical of researchers who employ strings of unrelated consonants as stimuli. They felt that such stimuli lacked the generalizability to more realistic reading situations.

Summary

Investigators noted in this section have focused their attention on the relationship between phonetic recoding and reading achievement. These studies have suggested that good readers were more affected by the phonetic similarity of rhyming words than poor readers. That is, good and poor readers differed in their ability to access a phonetic representation. As noted earlier in other summary sections, memory was assessed employing sequencing tasks. The sequencing tasks in this section involved recalling rhyming and non-rhyming consonants. In some of these studies memory was clearly assessed under immediate and delayed response interval conditions. In one study the investigators found that for superior readers delay had a significantly greater effect on recall of confusable sequences than on recall of non-confusable sequences. The delay did not affect the performances of the marginal and poor readers on these two types of sequences. In another similar experiment among the results reported was the finding that for all groups recall was significantly better on the immediate delay than on the 15-second delay condition. With respect to the variable of response interval, another investigator found a significant interaction effect between groups and conditions. The dyslexics performed significantly better than the reading age controls under the immediate delay. Finally, a potentially relevant study was conducted utilizing rhyming and non-rhyming letter strings. The investigators included presentation-response mode conditions in the data collection. Two of these modes were the same as those utilized in this present study. However, the researchers did not include these modes as a factor in the analysis. Therefore it would appear that the presentation-response mode condition was a confounding variable which may have affected the true results of the study.

CHAPTER THREE

Method of Study

Outlined in this chapter is the method of study of the present investigation. Included is a description of the population; sampling and subjects; instrumentation; data collection, data processing and analysis.

Population

The target population consisted of male grade two pupils in Canadian schools in British Columbia, of low, middle and high socio-economic status. The age range of this population was 7-0 years to 7-11 years. This population was chosen because they have had one year of school experience in the development of decoding skills and are still in the process of continued learning of these skills. Males were chosen because research indicates boys have more difficulties learning to read than girls.

The characteristics of the accessible population and subjects of this study are presented in Table 1, p. 51. Noteworthy characteristics of this population are the number of boys, mean age, age range, gender and socio-economic status (SES). With regard to the last characteristic, the mixture of SES tends to be somewhat uneven with a greater number at the higher end of the scale. According to the 1981 Census Tract data from Statistics Canada, the communities in which the seven schools were located incorporated a mixture of low, middle and high SES. A mixture of SES within the communities would allow for greater generalizability of the results. With respect to this study, there was no possibility of verifying the level of schooling of the parents on which the SES was based.

Table 1

Characteristics of the Accessible Population and the Subjects of the Study

Description	X	N	Range
Number of Grade 2 Males in Accessible Population		154	
Age of 154 Boys	7-5 yrs		7-0 - 7-11 yrs.
School District 'C' In Which Subjects Reside			
Number of Schools Involved		7	
Number of Grade 2 Classes Involved		14	
Socio-Economic Status		45	Low
		46	Middle
		63	High

Sampling and Subjects

Children in the accessible population who fit in certain categories were considered to be outside the scope of the study and therefore were excluded from the study. These categories were as follows:

1. Those with known vision and hearing difficulties.

2. Those with known speech and/or language problems.

3. Those with known visual-motor and/cr fine-motor coordination difficulties.

4. Those for whom English was their second language.

5. Those who were unable to vocally imitate all 18 word-names presented verbally in Selection Instrument 1.

6. Those who were unable to follow the procedures and instructions in Selection Instrument 2.

Thirty-six subjects were excluded on the basis of the first four categories. No subjects had to be excluded from the study on the basis of categories five and six. Ten subjects were excluded due to failure to gain parental consent. Two subjects moved, and two were absent due to illness while initial testing was in progress.

Since all testing was individually conducted by one examiner, the sample size of 104 subjects was considered too large for further data collection. Therefore, the sample was reduced. Thus, the obtained reading scores, with a range of grade 1.5 to 7.9 and a mean of 3.51, were rank-ordered and divided into quartiles of 26 subjects in each. Six subjects were randomly selected from each quartile, using a table of random numbers. As a result of this procedure, the sample size was reduced to 80 subjects The remaining scores were rank-ordered again. The upper third represented the Above-Average readers, while the middle and lower thirds represented the Average and Below-Average reading groups, respectively. Two additional subjects were absent due to illness during the later stages of testing.

The sample, 78 subjects, consisted of three equal groups of 26 boys, representing the Above-Average, Average and Below-Average reading groups. Characteristics of the reading groups are presented in Table 2. From the data presented in Table 2, very little difference is noted between the Below-Average and Average reading groups relative to word recognition and intelligence scores.

Table 2

Characteristics of the Reading Groups

	Below-Average Readers N=26		Average Readers N=26		Above-Average Readers N=26	
	X	S.D.	X	S.D.	X	S.D.
Age, Months	89.77	2.86	89.37	1.59	90.00	2.87
IQ, Full Scale	107.19	11.87	107.73	9.34	117.85	10.74
Reading Standard Scores	94.04	5.88	109.15	3.79	126.31	4.93
Word Recognition Grade Level	2.13	.37	3.24	.48	5.00	1.04

However, an obvious difference between these two reading groups and the Above-Average readers was noted relative to word recognition and intelligence scores. For the Below-Average readers, the reading grade scores ranged from 1.5

to 2.5; for the Average readers the range was 2.6 to 3.8; and for the Above-Average readers the range was 3.9 to 7.9. Within the Below-Average reading group the Full Scale Intelligence scores ranged from 89 to 130; for the Average readers the intelligence scores ranged from 94 to 126; while for the Above-Average readers the range was from 100 to 133.

Instrumentation

Selection Instrument 1

The purpose of Selection Instrument 1 was to assess exclusion category 5, listed above; subjects unable to vocally imitate, that is, articulate all 18 word-names presented verbally. Any subject who could not imitate all 18 word-names correctly and failed further readministrations would be excluded from the study at this point. Selection Instrument 1 instructions will be found in Appendix B.

Selection Instrument 2

The purpose of Selection Instrument 2 was to assess exclusion category 6, listed above; those who were unable to follow the procedures and instructions of Selection Instrument 2. Linguistic competence was defined as an ability to follow with understanding the oral instructions and procedures presented in Selection Instrument 2. It allowed the subjects to become familiar with the type of material, equipment and general procedure to be followed in the intersensory memory tasks. The child was required to look at the practise symbols on the Caramate 3300 screen and to listen to the pre-recorded tape of the practise word-names.

The importance of looking and listening was stressed. One practise set of symbols was used. Any child who was unable to follow the oral instructions and procedures was excluded from the study. Selection Instrument 2 instructions will be found in Appendix C.

Dependent Variable and Independent Variables

For this study, the dependent variable and the independent variables, and the covariate, are presented in Table 3. The tasks were designed to measure a combination of sensory input and output modes. The analyses will measure the dependent variable of intersensory presentation as a single variable.

Table 3

Dependent Variables and Independent Variables and the Covariate

Dependent Variable	
	Performance Scores on the Intersensory Memory Tasks
Independent Variables	
	Factor A - Reading Ability
	Factor B - Response Interval (Time Interval)
	Factor C - Presentation-Response Mode
Covariate	
	Intelligence

Dependent Variable: Construction of the Intersensory Tasks

The intersensory memory tasks consisted of six sets of three pairs of graphic symbols that were randomly assigned to 17 word-names, to form 18 pairs of symbol-word-names. Second, three pairs of symbol-word-name equivalents were randomly selected without replacement, to form the first set of symbol-word-name correspondences. This procedure was repeated until six sets of three pairs each were established. Third, two sets of graphic symbols and word-names were randomly assigned to each of three presentation-response modes. Fourth, one set within each mode presentation was randomly assigned to either the immediate testing time or delayed testing time. The other set within the mode of presentation was automatically paired with the testing time remaining. Figure 1 gives a brief description of the six tasks. The order in which each child did each task was randomized.

Construction of the Presentation Format of the Tasks

These intersensory memory tasks allowed the subjects to pair the symbol-word-name information. For each set, six permutations were possible. For example: Given a set of three letters: A, B and C each representing a different pair of symbol-word-name correspondences, the six permutations were:

1. A, B, C
2. A, C, B
3. B, C, A
4. B, A, C
5. C, A, B
6. C, B, A

Response Interval Immediate - 5 secs.	Presentation-Response Mode	Response Interval Delayed - 5 mins.
1. Stimulus Child is shown three graphic symbols individually. Response Child says three word-names individually that correspond to three graphic symbols.	Visual-Auditory	2. Stimulus Child is shown three graphic symbols individually. Response Child says three word-names individually that correspond to three graphic symbols.
3. Stimulus Examiner says each of three word-names. Response Child reproduces each of three graphic symbols corresponding to the word-names	Auditory-Graphic	4. Stimulus Examiner says each of three word-names. Response Child reproduces each of three graphic symbols corresponding to the word-names.
5. Stimulus Child is shown three graphic symbols and Examiner says corresponding word-name. Response Child points to one of three graphic symbols that correspond to the word-name given.	Auditory-Visual	6. Stimulus Child is shown three graphic symbols and Examiner says corresponding word-name. Response Child points to one of three graphic symbols that correspond to the word-name given.

Figure 1.

Description of the Stimulus and Response Conditions for Each of Six Intersensory Memory Tasks.

These six permutations defined the frequency of occurrence, that is, the number of exposures and order within each set presentation, during the intersensory tasks. The order of presenting the six permutations was randomized for each set.

In order to gain a closer look at the variables operating in the intersensory memory tasks, a video-tape demonstration employing a grade two student was carried out prior to conducting this study, that is in the early stages of task development. As a result of this video-tape, the visual stimuli were enhanced and the role of the examiner was reduced and replaced to a large degree by the Caramate 3300 machine which could present the information without bias and with utter consistency. This machine allowed the examiner to play the role of operator rather than participant.

Construction of the Testing Format of the Tasks

The testing of the Visual-Auditory and Auditory-Graphic tasks was such that each test symbol within that particular set being assessed, was presented separately, allowing for three items per mode. The order of presentation for these three items was randomized. For the Auditory-Visual task, a multiple choice format was used for testing. That is, each of three multiple choice items was made up of three symbols. One of the three symbols represented the test symbol, and the other two represented the distractor symbols. Of the latter two symbols, one was selected randomly from the pool of 17 remaining symbols. The other distractor symbol was selected randomly from the remaining two symbols of that particular set. The position order of each symbol within each multiple choice item was randomized, as was the order of presentation for the three multiple choice items. Details relative to the complete formation and layout of the intersensory tasks, and of the testing of the intersensory tasks will be found in Appendix D. A second demonstration employing a grade two boy was carried out in front of a group of observers who sat behind a one-way mirror. The observers were asked to make written comments about improvements for the program. Changes such as, reducing the length of the response interval from ten minutes to five minutes, incorporating a light system to control the response time of the child, and developing a verbal activity for the response interval period were helpful notations made by the observers. These comments were then incorporated into the program. Using the Caramate 3300, the demonstration pre-recorded program, employing 35mm slides of graphic symbols in a Kodak Carousel, ran for 35 minutes.

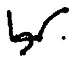
Construction of the Word-Names

An investigation was conducted utilizing thirty grade two children, fifteen boys and fifteen girls from school district 'A' located in a suburban area. The purpose of this investigation was to establish and determine the word-names that would represent the auditory stimuli for the intersensory tasks. Initially, it was felt that nonsense words similar to those used in previously reviewed studies, such as 'nert' and 'tolb' for example could represent the auditory stimuli. Such words were selected as initial candidates because they reduced considerably any association of meaning with "real" vocabulary in the child's curriculum or in their own environmental experience. Nonsense words that are typically used in reading tests that often contain "real" words with the nonsense word framework, were avoided because of the obvious associations the child could make through meaning and experience. It became clear to the examiner that these grade two children were having great difficulty remembering word-names that were "true" nonsense words. An important consideration in determining the most suitable word-names was to choose word-names that were not too difficult to remember by themselves. Otherwise such words could seriously confound the outcome of integrating and recalling Visual-Auditory and/or Auditory-Graphic correspondences. As a result of this investigation, the word-names determined to be the most appropriate for this age group, even though such names do carry some degree of affect were some of the suggested names for males proposed by Rule (1963). Eighteen names for males from this source were selected on the basis of two criteria. First, only those names that contained one syllable were used. Second, only those names that were considered not to be homonyms within the lexicon of grade two children were used. For example, the word-name 'Bob' was discarded, while the word-name 'Ben' was accepted. Three additional names that met the first criterion but not the second were selected for use in Selection Instrument 2. Finally such stimuli satisfied certain requirements; for example they offered the familiarity and generalizability to the school environment, as well as an appropriate level of difficulty. The word-names used will be found in Appendix E. There were fifteen subjects whose first name matched eight of the eighteen word-names selected for the study. These fifteen subjects were spread evenly across the three reading groups without any manipulation on the part of the examiner.

As a result of the procedures employed for reducing the sample size, nine subjects from fifteen subjects whose name matched word-names employed in the study remained in the final sample, three in each reading group. The name Stephen was represented twice in the Above-Average group; once in the Average group; twice in the Below-Average group. The name Tom was represented once in the Average group. The name David was represented once in the Above-Average group. The name Paul occurred once in the Average group. The name Chris occurred once in the Below-Average group.

Construction of the Symbols

A second investigation was conducted utilizing thirty grade two children, fifteen boys and fifteen girls from school district 'B' located in a suburban area. The purpose of this study was to establish and determine the graphic symbols which would represent the visual stimuli or graphemes for the intersensory memory tasks. A wide range of symbols was created as possible candidates for the graphic symbols required. An extensive search was made through numerous international alphabets. Only four graphic symbols were chosen from the Greek alphabet from all international alphabets reviewed as possible candidates. The majority of letters in these alphabets resembled to a significant degree the letters of the English alphabet, and therefore were rejected because of the associations the child could make through meaning and experience with the English language.

It became clear in this investigation the difficulty grade two children had in trying to reproduce from memory symbols that were either too complex, that is, they had too many elements, for example,  ,  , or too asymmetrical in appearance, for example  , . Only those symbols that could be reproduced with a high level of accuracy by all children were utilized as graphic symbols in the study. In some instances, further modifications were required, in order to make the symbols more symmetrical in appearance; these were tested before they were accepted as being appropriate. Again, as was the case with the auditory stimuli, an important consideration in determining the most suitable symbols was to choose symbols that were not too difficult to remember by themselves, otherwise such symbols could seriously confound the outcome of integrating and recalling Visual-Auditory and Auditory-Graphic correspondences. Thus, eighteen two-dimensional black symbols, two inches by three-sixteenth inches were created and eighteen 35mm slide transparencies were produced. Three additional 35mm slides were made using rejected symbols for Selection Instrument 2. Four other 35mm slides were made using geometric shapes, for the light system training session. The symbols used for Selection Instrument 2, for the Intersensory memory tasks and for the light system training session, will be found in Appendix F. For the purposes of testing ease, six complete duplicate sets of slides were made for the intersensory memory tasks.

Validity

For the purposes of this study, memory recognition ability was defined in Chapter 1 as "the identification of a previously identified stimulus from among presently competing stimuli ... recall ability was defined as the identification of a previously identified stimulus with the part of the original stimulus ... being absent" (Chalfant and Flathouse, 1971, p. 281). Employing the procedure of task analysis, it was possible to make sure with some degree of certainty that the intersensory memory tasks in this study were congruent with the definitions of the constructs presented in Chapter 1. In light of these definitions, and the careful analysis conducted, it was considered that these intersensory memory tasks were valid for the purposes of this study.

Reliability

With the inclusion of a learning component in the intersensory memory task program, traditional methods of demonstrating reliability, such as test-retest procedures, were not feasible for this study. This is because the time period required between testing and retesting would have been too lengthy for the timeframe possible within the remainder of the school year. However, other steps were taken to reduce error and thus increase the credibility of the study's results. A live demonstration carried out at the beginning and towards the end of the program development allowed for greater precision and pointed to necessary changes. By doing this, it removed potential sources of error. As well, some of the technical equipment for example, the Caramate 3300, removed possible error on the part of the examiner in terms of consistency of presentation and examiner bias.

Scoring

An individual program record form was developed for each subject. It included all six intersensory memory tasks and testing items. Responses for the Visual-Auditory and Auditory-Visual modes were recorded on these forms. For the Auditory-Graphic mode, separate record forms were produced for the subjects' responses, that is, graphic productions, one for each of the immediate and delayed response intervals. Examples of these record forms will be found in Appendix G. The six intersensory memory tasks were scored for the number of correct responses on three items per task. Scoring criteria for each of these tasks will be found in Appendix H.

Administration

Master tapes were developed for various designated sections of the total program that is, for the intersensory memory tasks and testing of these tasks, as well as for Selection Instrument 2 and the training session for the light system. These tapes were made using a Wollensak 3M Model No. 2873V sync-cue recorder. The master tapes were then used to create the individual programs for each of 80 subjects. The order of presentation of each of the six tasks was randomized for each subject. This was possible by using two Wollensaks - Model No. 2873V was used to record from the master tapes and Model No. 2851 was used to play the master tapes.

The presentation of the visual stimuli, that is the graphic symbols, and the auditory stimuli, that is the word-names, was possible by using the Caramate

3300 machine with a playback built-in cassette system and a Kodak Carousel Transvue 140 slide tray on top of this machine. The Caramate 3300 combined in one apparatus the necessary features found in separate pieces of equipment, that is the slide projector and the sync-cue recorder. Another advantage of this machine for this age group was its portability and its resemblance to a computer or television set. It was activated and deactivated manually by the examiner as the program required.

Following each intersensory memory task learning session, a response interval was imposed. For the purposes of this study a response interval was defined as immediate, that is five seconds, beginning immediately after the learning task was terminated; or defined as delayed, that is, five minutes, beginning immediately after the learning task was terminated. In order to diminish the possibility of subjects using rehearsal strategies during each delay, each subject was required to look at and tell a story about each of two books of pictures without words. Information relative to these materials will he found in Appendix I.

In order to encourage and guide the subjects to respond in the testing sections of the program, a light system was developed. This system limited the amount of time, yet gave the subject sufficient time to respond to the testing items. The light system with a built-in automatic stop mechanism was activated manually by the examiner. The ten second time duration between the reset mechanism and the green light represented the time the subject had to formulate and respond to the item, if the child was ready to do so. The time duration between the green and yellow light was five seconds, as was the time duration between the yellow and red light. This ten second time duration represented the final and remaining time for the subject to verbally recall the word-names, or recall and produce the graphic symbol on paper; or recognize and point to the visual symbol on the Caramate 3300 screen. Thus there was a total of 20 seconds possible to respond to each testing item. A graphic representation of the electrical circuit will be found in Appendix J. Each child was introduced to the light system and received a five minute training session to practise responding appropriately to the light system, before the program was begun. Directions for the training session will be found in Appendix K.

The intersensory memory tasks were administered to all 78 subjects.

Reading Ability: Peabody Individual Achievement Test, Reading Recognition

This test was selected because the focus of this investigation relative to reading ability was reading recognition skills, and not reading comprehension. This subtest incorporated two highly advantageous features for this type of reading test. First, it used two different print sizes for ease of discrimination and clarity in general. Second, there were fewer words per page, which added further clarity to the presentation, while reducing confusion and possible anxiety on the part of the subject.

Validity

The purpose of content and item validity is to determine "whether or not the individual items measure the subject matter to be measured and the extent to which a test adequately samples the universe of material or content appropriate for the test" (Dunn and Markwardt, 1970, p. 50). The authors indicated a broad investigation was made of the curriculum materials; and consultations were made with subject matter experts in all areas to be incorporated later as subtests, including Reading Recognition. From this, a basic pool of 300 items per area was written. Field testing was done over a period of seven years. Results of the field testing were subjected to item analysis procedures. Item difficulty and item discrimination were the two main criteria used to select items. In the final battery, only 84 of the 300 original items were in the Reading Recognition subtest. The subtests, including Reading Recognition, were to measure over a wide grade level range, from kindergarten to grade 12.

Reliability

Reliability evidence is reported in the test manual (Dunn and Markwardt, 1970). Test-retest reliability procedures were carried out on several subtests including the Reading Recognition subtest across several grades excluding grade two. Test-retest reliability coefficients of .89 and .94 were reported for grade one and grade three, respectively, on the Reading Recognition subtest. A time interval of one month had expired between the two testing sessions.

Scoring

Printed record booklets were secured for each subject for scoring purposes. Scoring was carried out according to the test manual instructions.

Administration

One hundred and forty-four children were tested for reading ability, according to the test manual instructions, at the mid-grade two stage of the year.

Covariate: The Wechsler Intelligence Scale for Children-Revised

The WISC-R was selected to assess intelligence. It was considered to be the most appropriate standardized intelligence test available.

Validity

Although many educational research studies use, for example, the Peabody Picture Vocabulary Test for the purpose of measuring intelligence, it is not considered to be a valid measure of intelligence according to standard psychological practices. One of the accepted measures of intelligence in the field of psycho-educational assessment is the WISC-R. This is the intelligence test most frequently used by school psychologists in British Columbia and, in particular, in the school district where this study was conducted. It was for these reasons that the WISC-R was employed and considered a valid test for the purposes of this study.

Reliability

The manual (Wechsler, 1974) reports high split-half reliability coefficients for Verbal, Performance and Full Scale intelligence quotients across the entire age range with average reliabilities being .94, .90 and .96, respectively. The average split-half reliabilities for the individual tests ranged from .77 to .86 for the Verbal tests and from .70 to .85 for the Performance tests. Standard Errors of Measurement (which indicate the precision of a test score), for the Verbal Performance and Full Scale intelligence quotients on average were 3.60, 4.66 and 3.19 intelligence quotient units, respectively.

Scoring

Printed record booklets were secured for each subject for scoring purposes. Scoring was carried out according to the test manual instructions. The Full Scale intelligence scores were used in this study. The Full Scale represents the verbal and "spatial" components and is thus more validly related to the experimental tasks that either the Verbal or Performance scales woud have been.

Administration

For the purpose of controlling statistically for the variable of intelligence, all 78 subjects were tested for intelligence, according to test manual instructions. Both the Verbal and Performance Scales were administered to each subject. (Research has indicated that reading ability is highly correlated with intelligence.) As intelligence was considered by this writer to be a variable in this study, a procedure known as Analysis of Covariance was employed to control for this variable. In simple terms, this procedure "removes the variance due to intelligence ... from the dependent variable measures before the test of significance is applied" (Kerlinger, 1973, p. 370).

Data Collection and Data Processing

Raw scores of seventy-eight subjects for six intersensory memory tasks will be found in Appendix L.

In March 1983, approval for conducting the study was obtained from the Community Relations Officer of the greater Vancouver area school district designated 'C'. In early June 1983, the writer contacted the principals of those schools that were located in a pre-defined area of the school district to be used for the study. This writer arranged interviews with principals and teachers, to explain the purpose and nature of the study. In those interviews principals received a printed outline of the procedures to be followed, indicating what would be required of the school by the project. Due to lack of testing space, two schools chose not to participate. Final approval from the principals and teachers was received late September 1983.

School policy dictated that parental consent was necessary in order for subjects to participate in the study. Therefore, in accordance with this policy, a letter was sent home to all parents of grade two boys. It outlined the purpose of the study and where to check (✓) to indicate whether they were giving or withholding permission for their child to take part in the study.

This investigation was carried out as a blind study. During the administration of the intersensory memory tasks and intelligence testing, the reading scores and tests were inaccessible to this writer. Code numbers replaced the names on all test forms to ensure confidentiality. All testing was conducted individually, in a variety of relatively undisturbed rooms, by the writer, as was the test scoring. The timeframe for the data collection is presented in Table 4.

Table 4

Timeframe for Data Collection

Tests	Starting Date	Finishing Date	Administration Time (per child)
PIAT-Reading Recognition Subtest	Jan./84	Feb./84	15 minutes
Intersensory Memory Tasks	Feb./84	Mar./84	40 minutes
WISC-R, Verbal and Performance Scales	Mar./84	May/84	1 hour and 20 minutes (average)

Analysis

In order to address the research hypotheses stated on p. 12-13, the following statistical hypotheses were tested at the $\mathcal{L} = .05$ level of statistical significance.

1. H_{01}: $\sum_{1}^{3} \alpha_i^2 = 0$

The first statistical hypothesis is that based on the sample data, there will be no statistically significant reading ability effects on the intersensory memory task performance scores.

2. H_{02}: $\sum_{1}^{2} \beta_j^2 = 0$

The second statistical hypothesis is that, based on the sample data, there will be no statistically significant response interval effects on the intersensory memory tasks performance scores.

3. H_{03}: $\sum_{1}^{2} \gamma_k^2 = 0$

The third statistical hypothesis is that, based on the sample data, there will be no statistically significant presentation-response mode effects on the intersensory memory task performance scores.

4. H_{04}: $\sum_{1}^{3} \sum_{1}^{2} (\alpha\beta)_{ij}^2 = 0$

The fourth statistical hypothesis is that, based on the sample data, there will be no statistically significant reading ability by response interval interaction effects on the intersensory memory task performance scores.

5. H_{05}: $\sum_{1}^{3} \sum_{1}^{3} (\alpha\gamma)_{ik}^2 = 0$

The fifth statistical hypothesis is that, based on the sample data, there will be no statistically significant reading ability by presentation-response mode interaction effects on the intersensory memory task

6. H_{06}: $\sum_{1}^{3} \sum_{1}^{3} (\beta\gamma)_{jk}^2 = 0$

The sixth statistical hypothesis is that, based on the sample data, there will be no statistically significant response interval by presentation-response mode interaction effects on the intersensory memory task performance scores.

7. H_{07}: $\sum_{1}^{3}\sum_{1}^{2}\sum_{1}^{3}(\alpha\beta\gamma)_{ijk}^{2}=0$ The seventh statistical hypothesis is that based on the sample data, there will be no statistically significant reading ability by response interval by presentation- response mode interaction effects on the intersensory memory task performance scores.

Where,

i designates a particular reading group

j designates a particular response interval

k designates a particular presentation-response mode

A graphic representation of the research design used in this study is presented in Figure 2, p. 73. The data were collected to fit in a three-way analysis of variance (ANOVA): Reading Ability x Response Interval x Presentation Response Mode, yielding a 3 x 2 x 3 ANOVA with repeated measures on the second and third factors (Winer, 1971, p. 549). All factors were fixed.

		Response Interval: (B)	Immediate (5 sec.) B_1			Delayed (5 min.) B_2		
Reading Ability: (A)	Subjects	Presentation-Response Modes: (C)	C_1 Vis. -Aud.	C_2 Aud. -Grph.	C_3 Aud. -Vis.	C_1 Vis. -Aud.	C_2 Aud. -Grph.	C_3 Aud. -Vis.
Above Average Readers (A_1)	1 2 : 26							
Average Readers (A_2)	1 2 : 26							
Below Average Readers (A_3)	1 2 : 26							

Figure 2. Experimental Design: 3 x 2 x 3 ANOVA, Fixed Effects Model Two Within Subjects Variables and One Between Subjects Variable

CHAPTER FOUR

Results

Outlined in this chapter are the results of the present investigation. Included is a summary of the data, analysis of variance results and a summary of this chapter.

For the convenience of the reader, a restatement of the research hypotheses will be presented.

Research Hypotheses

Hypothesis 1 - If the Above-Average, Average and Below-Average readers are measured on performance of intersensory memory tasks, there will be no statistically significant differences in mean intersensory memory performance scores among the three reading groups at the $\mathcal{L} = .05$ level of significance.

Hypothesis 2 - If an immediate response interval and delayed response interval are present in the intersensory memory tasks, there will be no statistically significant differences in the mean intersensory memory performance scores under these two response interval conditions at the $\mathcal{L} = .05$ level of significance.

Hypothesis 3 - If the three presentation-response modes (Visual-Auditory, Auditory-Graphic and Auditory-Visual) are employed in the intersensory memory tasks, there will be no statistically significant differences in the mean intersensory memory performance scores under these three mode conditions at the $\mathcal{L} = .05$ level of significance.

Hypothesis 4 - If the Above-Average, Average and Below-Average readers are measured under immediate and delayed response intervals, there will be no statistically significant interaction effects of these two factors on intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance.

Hypothesis 5 - If the Above-Average, Average and Below-Average readers are measured under conditions of the different presentation-response modes, there will be no statistically significant differences in intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory tasks due to interaction effects of reading ability and presentation-response mode.

Hypothesis 6 - If all subjects are measured under conditions of different presentation-response modes and response intervals, there will be no statistically significant differences in intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory tasks due to interaction effects of presentation-response mode and response interval.

Hypothesis 7 - If the Above-Average, Average and Below-Average readers are measured on intersensory memory tasks which involve the three presentation-response modes and two response intervals, there will be no statistically significant differences in the intersensory memory performance scores at the $\mathcal{L} = .05$ level of significance on intersensory memory tasks due to interaction effects.

Summary of the Data

In Table 5, p. 77, the mean correct response scores from their performances on intersensory memory tasks for the three reading groups are presented. From Table 5 it appears that overall, the Above-Average readers' performances on the intersensory memory tasks were somewhat better than those of the Average and Below-Average readers. However, less of a difference is noted between the Average and Below-Average readers' performances on the intersensory memory tasks. In terms of the response intervals, for all readers it appears that their performances on the intersensory memory tasks were somewhat better on the immediate five second response interval than on the delayed five minute response interval. Relative to the three presentation-response modes which were employed in the intersensory memory tasks, it appears that all readers performed somewhat differently under these presentation-response mode conditions. The mean intersensory memory response scores suggests that the order of difficulty of the presentation-response modes in performing the intersensory memory tasks was, from easiest to hardest, for all subjects: Auditory-Visual mode, which requires the subject to match the symbol and word-name equivalents presented; then the Visual-Auditory mode, which requires the subject to recall the word-name for the symbol presented; and then the Auditory-Graphic mode, which requires the subject to reproduce on paper the symbol for the word-name presented verbally.

Table 5

Mean Intersensory Memory Performance Scores

Reading Ability: (A)	Subjects	Response Interval: (B)	Immediate (5 sec.) B_1			Delayed (5 min.) B_2			Means:
		Presentation-Response Modes: (C)	C_1 Aud. -Vis.	C_2 Vis. -Aud.	C_3 Aud. -Grph.	C_1 Aud. -Vis.	C_2 Vis. -Aud.	C_3 Aud. -Grph.	
			X (S.D.)	X (S.D.)	X (S.D.)	X (S.D.)	X (S.D.)	X (S.D.)	
Above Average Readers (A_1)	1 2 : 26		8.54 (1.42)	8.15 (1.71)	6.38 (1.75)	8.54 (1.30)	6.27 (1.85)	5.92 (2.02)	7.30 (1.68)
Average Readers (A_2)	1 2 : 26		8.15 (1.62)	6.81 (2.08)	4.46 (1.53)	8.15 (1.71)	4.73 (1.80)	4.50 (1.50)	6.13 (1.71)
Below Average Readers (A_3)	1 2 : 26		8.62 (1.27)	8.00 (1.52)	5.04 (1.66)	7.96 (1.61)	5.08 (1.90)	4.54 (1.66)	6.54 (1.60)
		Means:	8.43 (1.44)	7.65 (1.77)	5.29 (1.65)	8.22 (1.54)	5.36 (1.85)	4.98 (1.73)	
		Means:		7.12 (1.62)			6.19 (1.71)		

In order to establish these apparent results on more solid ground, an analysis of variance study was carried out as described in Chapter 3.

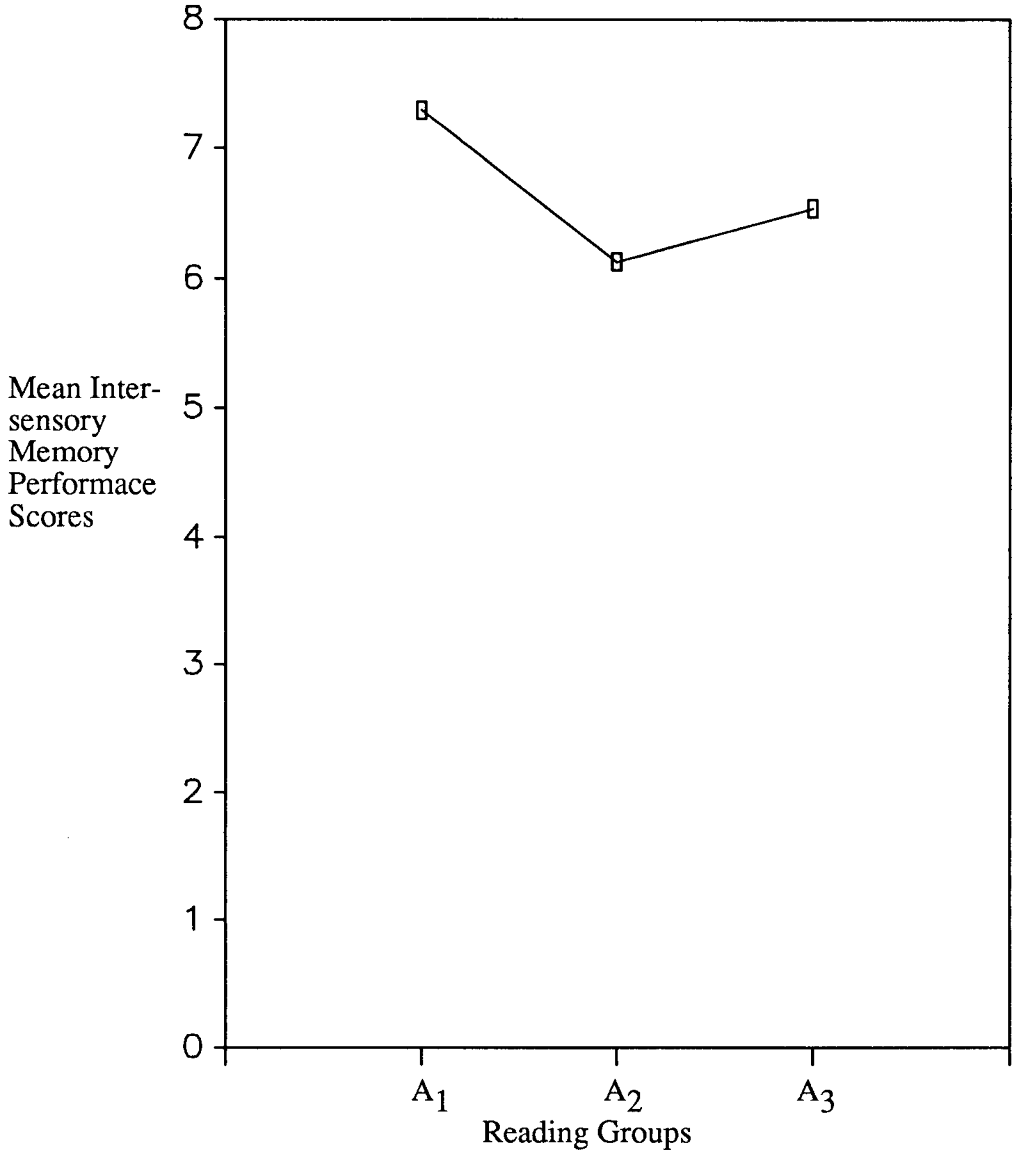
Analysis of Variance Results

The analysis of variance table is presented in Table 6. Reading ability, response interval and presentation-response mode are represented by A, B and C, respectively. From Table 6, it can be seen that the main effects of A and B were statistically significant at the $\mathcal{L} = .05$ level. However, because of the statistically significant interaction effects of A x C and B x C, factor C which is presentation-response mode has to be interpreted in conjunction with factor A (reading ability) and factor B (response interval). Finally, the interaction effect involving Reading Ability x Response Interval x Presentation-Response Mode was not significant. The Covariance study where intelligence was the covariate, is presented in Appendix M, but it does not change significantly the results given Table 6.

The main effect for reading ability will be found in Figure 3; while the main effect of response interval and presentation-response mode will be found in Figure 4 and Figure 5, respectively.

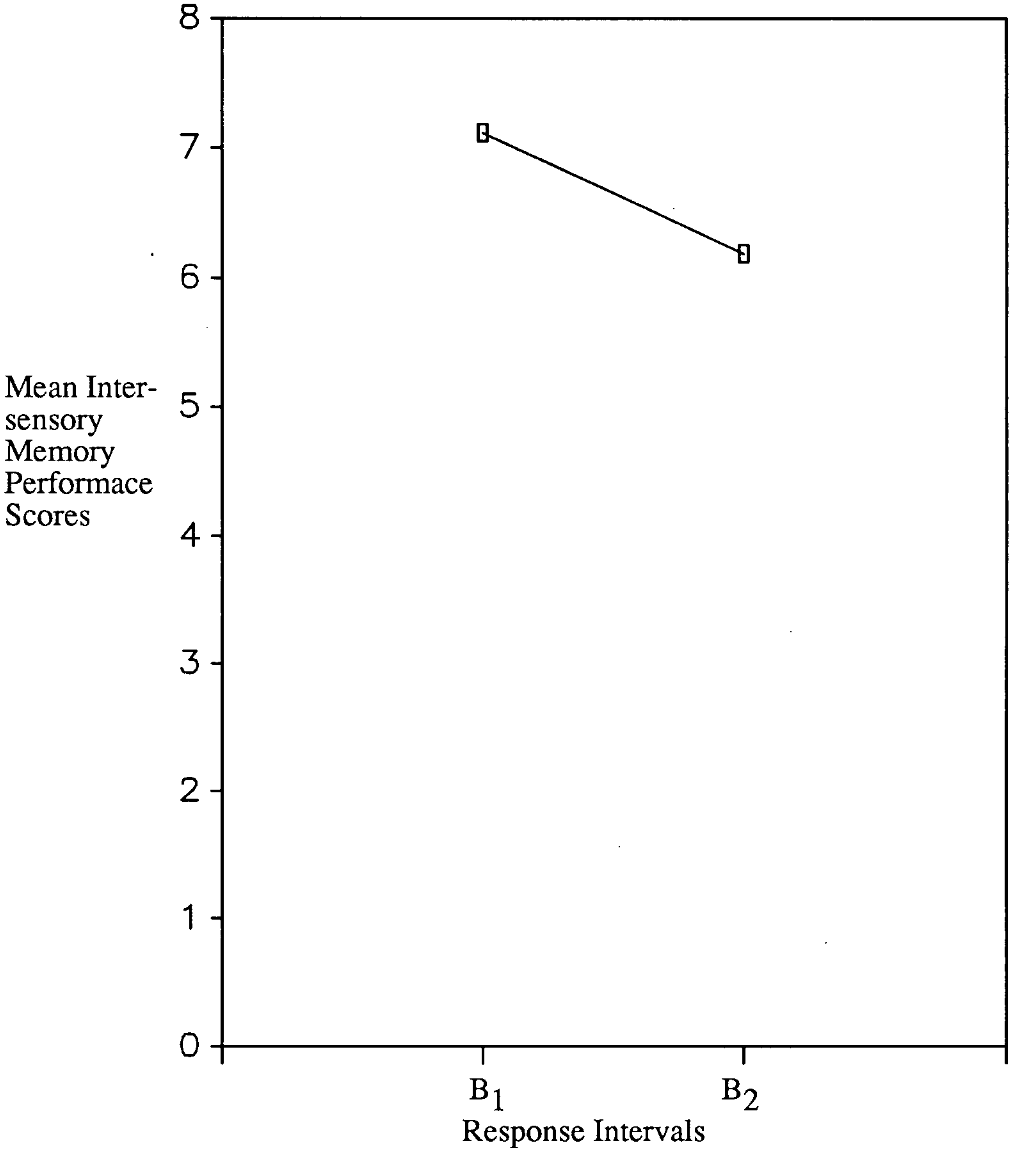
Pedhazur (1982) states:

When the interaction is significant it is generally not meaningful to interpret the main effects. This is because the presence of an interaction indicates that the treatments of a given factor do not have constant effects,



A_1 - Above Average Readers
A_2 - Average Readers
A_3 - Below Average Readers

Figure 3. Main Effects A, Reading Ability



B_1 - Five seconds, Immediate
B_2 - Five minutes, Delayed

Figure 4. Main Effects B, Response Interval

Table 6

Summary of Analysis of Variance for 78 Subjects

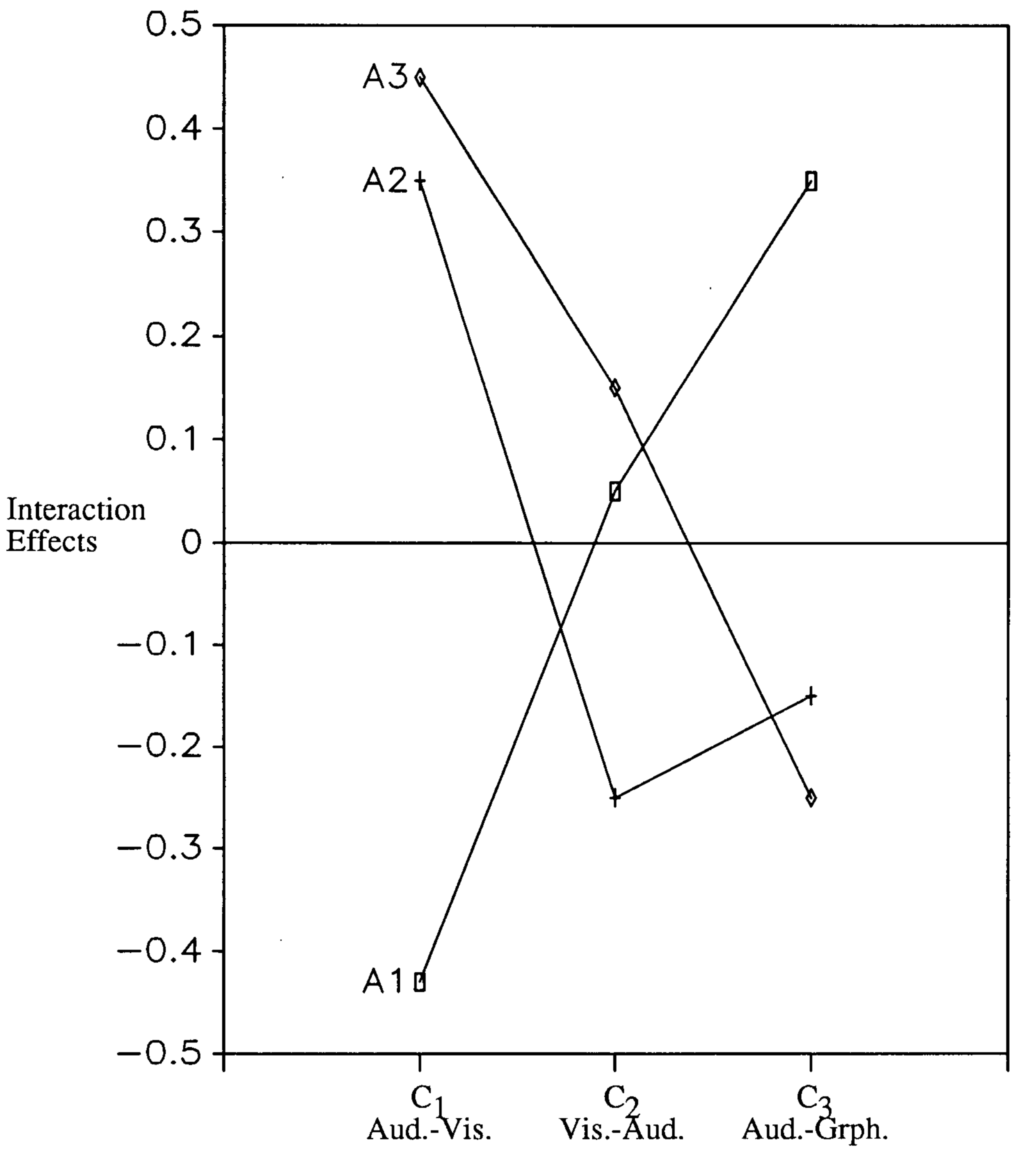
Source	Sums of Squares	Degrees of Freedom	Mean Square	F	P
Between Subjects	--	--			
A	109.51	2	54.76	13.17	0.00*
Error	311.78	75	4.16		
Within Subjects	--	--			
B	103.42	1	103.42	45.59	0.00*
AB	10.47	2	5.23	2.31	0.10
Error	170.11	75	2.27		
C	797.08	2	398.54	146.58	0.00*
AC	31.09	4	7.77	2.86	0.03
Error	407.83	150	2.72		
BC	107.52	2	53.76	21.62	0.00*
ABC	3.52	4	0.88	0.35	0.84
Error	372.96	150	2.49		

* P < .05

but rather that their effects vary depending on the treatments of the other factors with which they are combined (p. 362).

With respect to Figure 3, a significant quadratic trend was present (Rosenthal and Rosnow, 1985). That is, the Average reading group performed lower over all on the intersensory memory tasks than the Above-Average and Below-Average readers.

The Reading Ability x Presentation-Response Mode interaction effects, that is, A x C effects, is graphically presented in Figure 5, according to Rosenthal and Rosnow (1985, p. 54). The graph clearly showed that the subject's ability to remember the graphic symbol and word-name correspondence was dependent on both his reading ability and the type of presentation-response mode presented. For example, and consistent with the statements of Ehri and Wilce (1987), the Above-Average readers' memory performance was best under the Auditory-Graphic mode condition, where the subject was required to reproduce on paper the graphic symbol for the word-name presented verbally; while their poorest performance occurred under the easiest condition, the Auditory-Visual mode, where the subject is required to match the graphic symbol and word-name presented. Their intersensory memory performance under the Visual-Auditory mode condition, where the subject is required to remember the word-name for the graphic symbol presented, the task that is similar to early reading tasks, fell between the Auditory-Graphic mode and the Auditory-Visual mode condition. In contrast, the Below-Average readers' best memory performance occurred under the Auditory-Visual mode condition, where the subject is required to match the



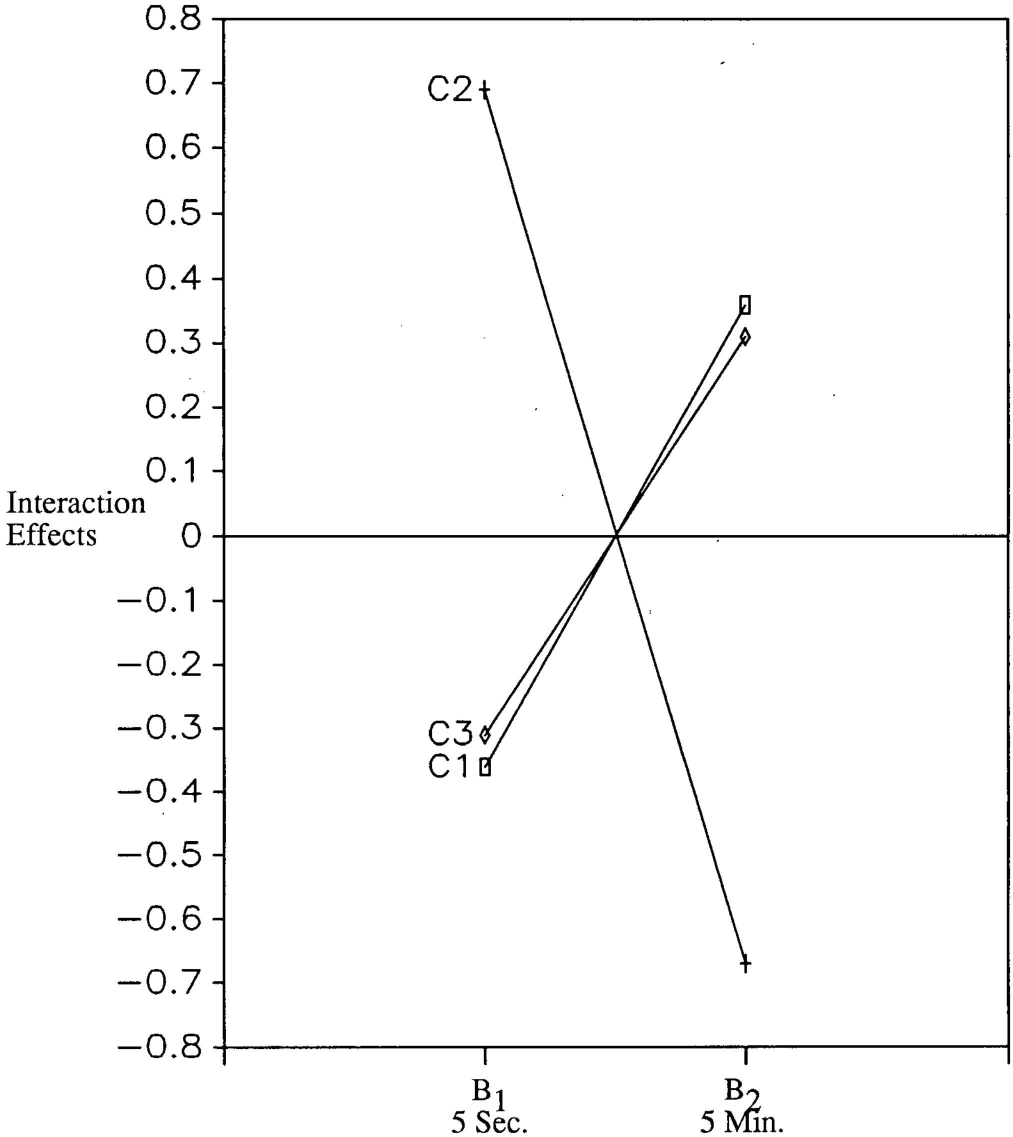
A_1 - Above Average Readers
A_2 - Average Readers
A_3 - Below Average Readers

Figure 5. Reading Ability x Presentation-Response Mode Interaction Effects, A x C

graphic symbol and word-name presented. Snowling (1980), on the other hand, employing recognition level tasks, found normal readers performed better than dyslexics on the Visual presentation, Auditory recognition task. The fact that she used different reading groups, different age ranges that is, 6:6 to 10:9 years and 9:2 to 15 years; and different stimuli, that is nonsense words, may have accounted for the discrepancy in results between her study and this investigation. Gascon and Goodglass (1970) found good readers performed better than poor readers on the Recognition task under the Visual-Auditory condition. The fact that they employed different stimuli, that is, nonsense syllables paired with letter-like high and low imagery symbols, may have accounted for the difference in results between their investigation and this study. In this present study the Below-Average readers' poorest memory performance occurred under the hardest condition, the Auditory-Graphic mode, where the subject is required to reproduce on paper the graphic symbol for the word-name presented verbally. Seiters (1982/1983) also found that her low reading achievers did poorer than the high reading achievers on language arts tasks that required an Auditory-Graphic motor performance. Relative to this present study, like the Above-Average readers, the Below-Average readers' intersensory memory performance under the Visual-Auditory mode condition, where the subject is required to remember the word-name for the graphic symbol presented, fell between the intersensory memory performance under the Auditory-Visual mode condition and the intersensory memory performance under the Auditory-Graphic mode condition. In fact, the Below-Average readers' intersensory memory performance was somewhat better than the Above-Average readers' performance under the Visual-Auditory mode condition. Jorm (1977) found normal and 'retarded' readers performed equally well on a learning task where spoken words were paired with letter-like symbols. Vellutino et al. (1975) found normal readers were superior to poor readers in recall under the Visual-Auditory mode condition. In this study they paired designs with nonsense syllables. Both Koppitz (1975), and Siegel and Linder's (1984) analyses were limited and did not provide information concerning reading ability by presentation-response mode interaction effects.

The Average reading group, like the Below-Average readers, found the intersensory memory performance under the Auditory-Visual mode condition the easiest task. However, unlike the Below-Average and Above-Average readers, the Average readers found the intersensory memory performance under the Visual-Auditory mode condition, where the subject was required to remember the word-name for the graphic symbol presented, the most difficult task. This task closely simulated the beginning reading tasks. Otto (1961) employing good, average and poor readers using a paired-associate learning task, pairing geometric shapes and nonsense syllables, did not find a significant reading ability by presentation-response mode interaction effect. Under the Auditory-Graphic mode condition, where the subject was required to reproduce on paper the graphic symbol for the word-name presented orally, the Average readers' intersensory memory performance was somewhat better than the Below-Average readers' intersensory memory performance.

The Response Interval x Presentation-Response mode interaction effects, that is, B x C effects, is graphically presented in Figure 6, according to Rosenthal and Rosnow (1985, p. 88). The graph clearly showed that for all subjects their ability to remember graphic symbol and word-name correspondences was dependent on both the response interval imposed and the presentation-response mode presented. For example, under the five second response interval and Visual-Auditory mode condition all subjects' intersensory memory performance was much stronger than their intersensory memory performance under the other two presentation-response mode conditions. The former task closely simulates the beginning reading task of development sound-symbol or word-name correspondences when a response interval after teaching has occurred. For all subjects their intersensory memory performances under the Auditory-Graphic and Auditory-Visual mode conditions, respectively, were much below their intersensory memory performance under the Visual-Auditory mode condition. However, their intersensory memory performance under the Auditory-Graphic mode condition, where the subject was required to reproduce the graphic symbol for the word-name presented, was somewhat better than their intersensory memory performance under the Auditory-Visual mode condition, where the subject was required to match the graphic symbol and word-name presented. In contrast, under the five minute response interval condition the findings were reversed. For example, for all subjects their poorest intersensory memory performance occurred under the Visual-Auditory mode condition, where the subject was required to remember the word-name for the graphic symbol presented. Their intersensory memory performances under the Auditory-Visual and Auditory-Graphic conditions, respectively, were obviously superior to their intersensory memory performance under the Visual-Auditory mode condition.



C_1 - Auditory-Visual
C_2 - Visual-Auditory
C_3 - Auditory-Graphic

Figure 6.

Response Interval x Presentation-Response Mode
Interaction Effects, B x C

However, their intersensory memory performance under the Auditory-Visual condition, where the subject was required to match the graphic symbol and word-name presented, was somewhat better than their intersensory memory performance under the Auditory-Graphic condition, where the subject was required to reproduce on paper the graphic symbol for the word-name presented.

There are studies which have included one or two presentation-response mode conditions similar to those employed in this present study (Jorm, 1977; Otto, 1961; Snowling, 1980; Siegel and Linder, 1984; Savage, 1983; Kilian, 1984/1985; Manis, 1985; Ehri and Wilce, 1985); and there are studies which have included response intervals:(Liberman et al., 1977); Shankweiler and Liberman, 1976; Johnston, 1982; Bisanz, Das, and Mancini 1984; Lean and Arbuckle, 1984). As far as this writer can discern, there appear to be no studies that have included both presentation-response mode and response interval as factors in the analysis of the same study, as this present investigation has done.

Summary

The analysis of variance study shows the main effects of reading ability and response interval were statistically significant at the $\mathcal{L} = .05$ level. However, because of the statistically significant interaction effects of Reading Ability x Presentation-Response Mode and Response Interval x Presentation-Response Mode, presentation-response mode has to be interpreted in conjunction with reading ability and response interval. Finally, the interaction effect involving

Reading Ability x Response Interval x Presentation-Response Mode was not statistically significant.

CHAPTER FIVE

Discussion

The purpose of this study was to investigate the intersensory memory performances of Above-Average, Average and Below-Average readers at a second grade level, as measured by Intersensory memory tasks, under three presentation-response modes and two response interval conditions. The aim was to understand more about the process of word recognition, that is, Chall's (1979) first stage of her reading framework. For the purpose of this study, word recognition was defined as the ability to convert graphemes or graphic symbols to corresponding auditory equivalents or word-names. It was thought that understanding more about the word recognition process could be done in part through learning more information about the characteristics of good, average and poor readers' memory ability employing intersensory memory tasks using graphic symbol and word-name correspondences. An inherent aim was to use task materials and conditions that more closely simulated the conditions of learning and evaluation of early word recognition skills in present day grade two activities. Of particular concern with regard to the latter point was the need to reduce the sequencing element found in the majority of the studies reviewed in Chapter 2 that was believed to confound memory ability. This was done by assessing pairs of word-names and graphic symbols one at a time presented in as precise, consistent and objective manner as possible. In this study a response interval occurred after the presentation of the intersensory learning tasks. Combining the response intervals with the presentation-response mode conditions, which has not been done, in word recognition memory research as far as this writer can discern, would help to simulate similar delays which often occur in classroom learning and evaluation procedures of curriculum materials. The three presentation-response modes selected for this study were felt to be the most relevant for performing early oral and written language arts tasks. One or two of these modes used in this present study had been employed by other investigators. They were attempting to gain information about the characteristics of good and poor readers on memory tasks utilizing nonsense syllables or geometric shapes. Other concerns of this study were to control for intelligence differences of the reading groups being compared using the most appropriate standardized intelligence test available. A major concern of this investigation was to include an average reading group. There has been a paucity of word recognition ability-memory research in which the average reading group has been given the same consideration as the good and poor readers. To ignore this average reading group while including the good and poor readers leaves one open to statistical regression effects.

Tuckman (1978) states:

> There would be a tendency on any posttest measurement for the scores of the high scorers to decrease toward the mean while the scores of the lower scorers would increase toward the mean. Thus there would be differences between the groups on the posttest even if no treatment were given. The reason is that chance factors are most sic likely to contribute to extreme scores than to average scores, and such chance factors are unlikely to

reappear during the second testing (or in testing on a different measure (p. 99).

In addition, it was felt that to exclude an average reading group was to lose some valuable comparative information.

This present study attempted to begin to shed some light on how Average male readers stack up against Above-Average and Below-Average male readers on intersensory tasks utilizing visual and auditory information.

Summary of the Findings

In this study it was found that a subject's ability to remember the graphic symbol and word-name correspondence was dependent on both the subject's word recognition ability level and the type of presentation-response mode presented.

Above-Average Reading Group - The Above-Average readers' performance was best under the Auditory-Graphic mode condition, while their poorest memory performance occurred under the Auditory-Visual mode condition. Their intersensory memory performance under the Visual-Auditory mode condition, a situation that is similar to some early word recognition task conditions, placed between their intersensory memory performances under the Auditory-Graphic and Auditory-Visual mode conditions, respectively.

Below-Average Reading Group - The Below-Average readers' best intersensory memory performance occurred under the Auditory-Visual mode condition, while their poorest performance occurred under the Auditory-Graphic mode condition. As with the Above-Average readers', the Below-Average readers' performance under the Visual-Auditory mode condition placed between their performance under the Auditory-Visual mode condition and their performance under the Auditory-Graphic mode condition.

Average Reading Group - The best intersensory memory performance of the Average readers, like that of the Below-Average readers, occurred under the Auditory-Visual mode condition. The Average readers like the Above-Average readers performed better under the Auditory Graphic mode condition than under the Visual-Auditory mode condition. However, unlike the Below-Average and Above-Average readers, the Average readers' intersensory memory performance under the Visual-Auditory mode condition proved to be their most difficult.

A second finding of this study was that for all subjects their ability to remember graphic symbol and word-name correspondence was dependent on both the response interval imposed and the presentation-response mode presented.

Response Interval - five seconds - Under this interval all subjects' intersensory memory performance was better under the Visual-Auditory mode condition than under the Auditory-Visual and Auditory-Graphic mode conditions.

Response Interval - five minutes - Under this interval for all subjects their poorest intersensory memory performance occurred under the Visual-Auditory mode condition; and their best performances occurred under the Auditory-Visual and Auditory-Graphic mode conditions. Their performance under the Auditory-Visual mode condition was somewhat better than under the Auditory-Graphic mode, a reverse of their performance under the five second response interval condition.

Discussion of the Findings

Reading Ability x Presentation-Response Mode Interaction

The consistency and uniqueness with which the Above-Average and Below-Average readers have performed on memory tasks as evidenced by numerous studies in the field of word recognition-memory research is supported by this present study. As has been noted earlier in the text, little information in general, let alone information of a descriptive nature, is available about the performance of average readers on memory tasks relative to the word recognition process. What is generally demonstrated in all too few studies with regard to the average readers is that they do less well than the good readers but somewhat better or similar to the poor readers. The results of this present study suggests a more descriptive pattern of performance on the intersensory memory tasks. This study also suggests that the Average readers do not follow a pattern of performance unique to their own group as do the Above-Average and Below-Average readers. Rather the Average readers appear to adopt some of the patterns of both the Above-Average and Below-Average readers. Consistent with Baddeley and Hitch's (1977) and Jorm's (1983) statements for example, like the Above-Average readers', the Average readers' ability to store spatial codes in long-term memory was somewhat better than their ability to store phonological information but not to the same degree as the Above-Average readers. The average readers also appear to share with the Below-Average readers a high level of intersensory memory performance under the Auditory-Visual mode condition. Consistent with Baddeley and Hitch's (1977), and Jorm's (1983) statements, however, this writer suggests that unlike the Above-Average and Below-Average readers, the Average readers appear to have difficulty storing phonological codes in long-term memory.

The Above-Average readers were superior to the Average but not to the Below-Average readers in their ability to remember word-names for graphic symbols presented. Consistent with the statements of Baddeley and Hitch (1977), and Jorm (1983) this writer would suggest the Above-Average readers were better at storing phonological information in long-term memory. Jorm (1977) found no difference between his good and poor readers in phonological recall ability. Consistent with the statements of McCusker, Hillinger and Bias (1981), this writer would suggest that the good and poor readers employed different routes to access lexical information. The Above-Average readers may have used a visual route while the Below-Average readers used a phonological recoding route for lexical access. Both reading groups were efficient in their own situations. Why the Average readers performed less well than the Below-Average readers in storing phonological information is not completely clear. The fact that the Average readers had difficulty suggests perhaps that they as a group may not be as "average" or as "normal" in some word recognition tasks as researchers have assumed them to be. The question this writer raises is this: is having problems in beginning word recognition tasks an exclusive characteristic only of poor or below-average readers? The findings of this study suggests that this may not be so. More research relative to the relationship between reading achievement and memory ability with the inclusion of the average reading group is needed to provide more information as to how this group performs on similar or related tasks. It is not an overstatement to say that the average reading group has been neglected in word recognition-memory research. Yet this is the very group we consider to be the "norm", to which we compare all other reading groups. Another possibility as to why the Average readers had difficulty remembering phonological information is that the Average readers were in a transition stage. That is, they no longer relied on the phonological recoding route but they were not yet very competent at employing the visual route to access lexical information. Finally, it is possible that the performances of the reading groups may illustrate the existence of a three stage developmental hierarchy of presentation-response modes. What we have thought to be memory deficits may be simply a reflection of a developmental sequence of this cognitive skill under different Presentation-Response mode conditions.

The Above-Average readers were superior to both the Average and Below-Average readers in their ability to store spatial codes in long-term memory (Baddeley and Hitch, 1977; Jorm, 1983). Roper (1984/1985) has suggested that those readers with high levels of phonemic awareness produce better auditory-graphic motor performances. Backman et al. (1984) have stated that "one of the hallmarks of progress in learning to read is acquiring skill to cope with spelling patterns with multiple pronunciations" (p. 129). It is this characteristic they suggest that differentiates good readers from poor readers. In Seiters' study (1982/1983) high reading achievers were more accurate in the graphic recall of symbol sequences than the low reading achievers. Indeed, in this present study the one task that clearly distinguished the three reading groups in favor of the Above-Average readers was the task that required the readers to remember the visual symbols. This is consistent with the notion put forth by McCusker, Hillinger and Bias (1981) that good readers rely much more on a visual route to access lexical information.

There is no question that the Above-Average readers' word recognition skills were developed to a more advanced level than the Average and Below-Average readers' word recognition skills. This was confirmed on the reading test administered to these subjects. If the Above-Average readers are faced with a matching task where recall skills are not required, but are automatically applied then this could have been a sufficient condition for a weak performance on the least demanding task presentation-response mode. Other possibilities for such a performance could be related to lack of recent use or practise on such tasks and/or lack of interest on the part of these subjects, as it was a very easy task. In contrast, it is suggested that when confronted with a matching task where no recall skills are required, the Average and Below-Average readers' matching skills are more readily applied because they are more automatic than the recall skills. In addition, more recent practise with matching possibly gave them some advantage over the Above-Average readers. Snowling's (1980) recognition tasks required graphemic-phonemic conversions rather than matching the information as the tasks required in this present study. The fact that the dyslexics did not do as well as the normal readers on the Visual-Auditory recognition task, she suggests, was due to their weaker ability to make graphemic-phonemic conversions.

Response Interval x Presentation-Response Mode Interactions

Under the immediate five second response interval, the Visual-Auditory mode produced not only the best intersensory memory performance but an exceptionally high performance for all subjects. As to why this was the case may be answered in part by examining the nature of the teaching presentation session. This writer suggests that perhaps the way in which the pairs of graphic symbols and word-names were presented, that is, a visual presentation followed immediately by the corresponding word-name presented verbally, taught to the testing situation of the Visual-Auditory mode more closely than for the Auditory-Graphic and the Auditory-Visual modes. In other words, a conducive teaching session preceded the testing session of the Visual-Auditory mode, producing an overwhelming superior performance by all subjects. Little difference in intersensory memory performance was noted between the Auditory-Graphic and Auditory-Visual modes under the five-second delay, perhaps for the reasons alluded to above. In contrast, for the five minute response interval the question as to why the Visual-Auditory mode produced not only the weakest intersensory memory performance for all subjects, but an extremely weak performance suggests that the imposition of a five-minute delay makes a strong negative impact on the memory of phonological information. This type of information faded more quickly and resulted in weakened or faulty traces moving from short-term to long-term store. However, it appears that spatial information does not fade as quickly over time, but rather it improves to some degree.

Baddeley (1978) has suggested that part of the role of memory is to be responsible for the control processes or strategies employed to produce better recall performance. Such strategies require adequate use of verbal coding, rehearsal and organization (Jorm, 1983). A number of investigators (Hicks, 1980; Spring and Capps, 1974; Tarver et al., 1976: Bauer, 1977a; Torgesen and Goldman, 1977; Cohen and Netley, 1981) have asserted that differences found in performance on memory tasks in good and poor readers did not reflect deficiencies in memory ability, but rather an inadequate use of the control processes involving strategies including verbal coding and rehearsal. With regard to this investigation the question of whether such variables as verbal coding and rehearsal were influential variables, accounting for the differences found in the intersensory memory performances among the three reading groups, must be addressed. In terms of the verbal coding variable, as was noted earlier in this chapter, given the nature of the intersensory memory tasks presented, verbal coding was already an inherent part of the task. To add additional verbal labels would not be to the subject's advantage. With respect to the variable of rehearsal this investigation made overt efforts to control for this variable by insetting a picture story telling activity during the five second and five minute response intervals. As well, no overt movements by the subject's mouth or fingers during the presentation of the information in the learning session was permitted. It is interesting to note that Cohen and Netley (1981), and Torgesen and Houck (1980) were still able to demonstrate memory deficits when the opportunity for rehearsal was absent. This investigation shows similar findings.

The question of credibility must always be addressed when one is concerned with the results of any research study. This investigation is no exception. Relative to the overall results of this study it was noted in Chapter 3 that 24 subjects were moved randomly from the sample. This occurred after the administration of a word recognition test to all subjects available for the study, in order to reduce the amount of individual testing and meet completion dates, as only one examiner was possible. In spite of such an irregular but necessary procedure, a statistically significant main effect for reading ability was still present, although this main effect had to be qualified with the knowledge that a statistically significant interaction effect of reading ability by presentation-response mode was also present.

In addition it was noted in Chapter 3 that only one examiner conducted the data collection, whereas more than one examiner is preferable to negate possible examiner bias. However, with respect to the presentation of the intersensory memory tasks, the examiner's direct involvement was minimal and bias was reduced with the use of a rather sophisticated piece of equipment called the Caramate 3300. As previously noted in the text, it replaces the traditional but outdated combination of slide projector and synchronized tape recorder in a very compact piece of apparatus. With the recent introduction of the computer into the student's curriculum, even at a grade two level, these grade two subjects related very well to the Caramate as its appearance, to them, was likened to a computer, thus adding high interest and greater attention to the program as a whole. The built-in cassette recorder allowed for all programming to be pre-recorded for each child, which in essence gave this study the unique consistency of presentation of information across all subjects which all too often research studies are not able to incorporate into the methodology to this extent.

With respect to the data collection, it is important to note again that the examiner collected the intersensory task information and intelligence data without access or reference to the reading test results. With regard to the intelligence testing there was no access or reference to the intersensory memory task data.

Traditional methods of demonstrating reliability, for example using test-retest procedures, were not feasible. The time remaining in the school year was too short to permit testing and retesting. Thus, other steps were taken to reduce error and to increase the credibility of the study's results. In this study great care and attention was given to detail in the initial investigations in order to determine the most suitable and generalizable type of stimuli for grade two class material. Live demonstrations carried out at the beginning and towards the end of program development allowed for greater precision and removed sources of error. As mentioned previously, the equipment, that is the Caramate 3300, removed potential error on the part of the examiner in terms of consistency of presentation and examiner bias.

The light system which was incorporated into the program served to help the subjects respond to the testing items and yet helped to control the amount of time with which the subjects had to respond. This important mechanism added further credibility to the study's results.

In the final analysis replicating any research study is the only true way of testing the credibility of the results. Given the very nature of this study and methodological requirements, replication must be considered a priority in an agenda for future research.

Implications for Education

It should be stressed that this present investigation was not conducted in order to develop or validate a new reading approach. However the findings of this study suggest that the relationship between intersensory memory performance and reading performance may be important to consider when teaching reading (as defined in this study) or when teaching one-to-one correspondence.

Visual and auditory equivalents were taught utilizing a technique which emphasized the integration of visual and auditory information. Some remedial reading approaches do, in fact, incorporate this procedure as part of their word recognition reading program. The results of this study appear to suggest that from a practical viewpoint this technique is an effective way of teaching visual-auditory correspondence to at least two of the male grade two reading groups. This is assuming, of course, that the results of this study are ultimately shown to hold over time and to generalize to a much broader universe of grade two pupils than represented here.

If a male grade two pupil is diagnosed as having specific learning problems remembering visual-auditory correspondences similar to those employed in this study, one can expect to observe two types of behavior. First, when one evaluates his learning immediately after teaching, he will demonstrate quick mastery of information. He will appear to acquire this information like the rest of the class. Second, because of his difficulty in mastering the graphic symbol and word-name correspondences, due to his difficulty in remembering at an intersensory level, a response interval of five minutes or more between teaching and evaluation will significantly increase his chances of giving a poor performance. Therefore, for this child we cannot assume acquisition of new information after a single correct response directly after initial presentation, nor can we assume long term memory to be at fault if later he is unable to produce this same response. Rather, this study would suggest that for learning disabled children practice of new skills over time is necessary to ensure mastery. Without this kind of information teachers might, with the best of intentions, alter or discontinue the type of program or approach being employed, thinking it is not effective, when in fact the five minute response interval makes the recall of word-names for graphic symbols a very difficult task to accomplish. Although this study does not suggest specific types of remedial programs for this type of problem, it does imply, as Haring and Bateman (1977) suggested, that some learning disabled children often require much more practice in order to establish visual-auditory associations. From this writer's clinical experience, in general, programs that stress or emphasize the integration of visual and auditory information with the enhancement of stimulus cues tend to be quite effective.

The reading group which has been neglected to a great extent in word recognition-memory research is the average readers. In this present study subjects were classified as being Average readers if their word reading scores on the PIAT were in the range of 2.6 to 3.8. This investigation suggests that perhaps this group may not be as "normal" or as "average" as we tend to think they are in establishing visual-auditory correspondences. Within this group there may be some children who are, in fact, demonstrating specific learning problems in remembering at an intersensory level. These subjects tend to be ignored in terms of identification tor possible learning problems. They may be operating at an "average" reading level, when in fact their overall potential suggests they should be operating at an "above-average" reading level. The implication is that more attention should be directed toward the identification of so-called "average" readers for possible learning problems in memory performance at an intersensory level for visual and auditory information.

The presentation-response mode that clearly differentiated the grade two reading groups' performances in favor of the Above-Average readers, was the one that required efficient storage and retrieval abilities of auditory-graphic tasks. It was under the auditory-graphic presentation-response mode that the above average readers exhibit their best performance; the average readers demonstrate their second best performance; and the below average readers demonstrate their poorest performance; giving some credibility to the diagnostic validity of the auditory-graphic presentation-response mode. It is feasible that grade two teachers could identify more accurately who are his/her good, average and poor word recognition readers in the class by the students' performances under the Auditory-Graphic presentation-response mode, rather than under the Visual-Auditory presentation-response mode. Thus, for the purposes of differential diagnosis of disabled early readers one should include some evaluation of the student's auditory-graphic non-sequential memory performance at an intersensory level. This is assuming, of course, that the results of this study can be shown to hold over time and to generalize to a broader universe of non-sequential curriculum stimuli.

Limitations of the Study

Internal Validity

Tuckman (1978) states that this term refers to establishing experimental controls "that will enable the conclusion that differences occur as a result of his or her experimental treatment (p. 96).

With any research study one wants to insure some degree of internal validity. This study is no exception. For the most part, this writer believes that factors that would potentially threaten internal validity were dealt with in this study. However, the factor of reliability could not be controlled in the traditional manner. Most investigators interested in studying the relationship between memory skills and reading achievement traditionally employ testing tasks in which intentional learning is not a requirement. Therefore, the degree of reliability of the instruments employed can be demonstrated by using traditional methods such as test-retest method. In the case of this present study, employing traditional reliability methods to estimate the reliability coefficient was not feasible given the lengthy period required between testing and retesting, and the timeframe available for the study. It should be noted that steps were taken to reduce error wherever possible, thus giving greater credibility to the study's results.

Finally, as mentioned earlier in the text, the initial sample of subjects was reduced in size after the reading test data had been collected. This is often considered a highly irregular procedure and one to be avoided. The results of this study, however, suggests that this procedure may not be as damaging as previously thought if done carefully. In this case, a statistically significant main effect for reading ability and a statistically significant interaction effect involving reading ability and presentation-response mode was found.

An interpretation regarding internal validity affecting the interactions resented in Figure 5 is that history may play a part in the magnitude of the scores of the three reading groups by presentation-response mode. It is possible that due to slowness in reading acquisition skills, that the below average readers continue to receive instruction where the stimulus primarily is of an auditory-visual nature and that the above average readers have progressed to higher stages of reading competence, where the auditory-graphic presentation-response mode was being emphasized in the present classroom instruction. The possibility that there may have been instructional effects of this sort that influenced the findings should be acknowledged.

External Validity

Tuckman (1978) suggests that this term refers to "the generalizability or representativeness of the findings of a study" (p. 101).

With regard to the representativeness of this sample of students, clearly they were not representative of all grade two students, as the target population was restricted to grade two male pupils. Also, this sample was likely more representative of grade two male pupils residing in rural versus urban environments. However, employing a mixture of SES helped to broaden the range of representativeness, as did the use of three reading groups.

External validity was reduced somewhat because the writer was not able to demonstrate the reliability of the results employing traditional reliability methods. Without such evidence of reliability the tasks should not be used as a diagnostic instrument. The purpose of this study, however, was not to develop such an instrument. Rather the purpose was to demonstrate whether a relationship between intersensory memory performance and reading achievement exists. A certain degree of external validity was maintained by conducting the experiment in the school setting. As well, the nature of the task presentation and evaluation was similar to the way in which language arts tasks in the classroom are presented and evaluated. The Caramate 3300 apparatus was likened to a computer by the subjects. It was felt that such equipment offered greater generalizability of the results by using apparatus similar to equipment used in schools. Finally, the familiar nature of the stimuli selected for this study also allowed for greater applicability of the results to the classroom environment and curriculum.

The performance of the three reading groups on these measures should not be interpreted as a finding enabling the differential diagnosis of any educationally disabling conditions. For example, this researcher does not say that the below average readers can in any way be described as learning disabled. In fact, it is this writer's belief that learning disability may be present in all three reading groups which may account for some of the variability of performance in the average reading group.

Suggestions for Research

Studies which are considered to be "basic research" in addition to demonstrating the existence of certain phenomena are typically sources of ideas and for additional research. The following are a number of suggestions which appear to be productive avenues of inquiry arising from the present study.

1. A priority for additional research is the replication of this investigation. As this study was unable to employ traditional procedures to estimate the reliability coefficient, such a replication would allow a true test of the reliability and thus establish on more solid ground the stability of the results. Such tenability would make the research study that much more

substantial, and would give further reason for carrying out research arising from this investigation.

2. This study has demonstrated that a relationship exists between memory performance at an intersensory level and reading achievement. If this is accepted, then the question is, is there a relationship between word recognition ability, and recall and recognition performance at an intersensory level?

3. This present study provided information about how well Above-Average, Average and Below-Average male grade two readers performed on memory tasks at an integrative level. In light of 2. above, the question is, do grade two female readers perform differently than grade two male readers on recall and recognition tasks at an integrative level? That is, do the female readers perform better on verbal recall tasks than on non-verbal recall tasks and do male readers perform better on non-verbal recall than verbal recall tasks?

4. Very few studies in word-recognition-memory research have included three reading groups, that is above-average, average and below-average readers. More often than not two reading groups, for example, good and poor readers are compared on certain memory tasks. More word recognition-memory research needs to be conducted employing good and poor readers as well as average readers to see whether or not average readers share specific intersensory memory performance skills with both

above-average and below-average readers as suggested in this study. To not include this reading group is to lose valuable diagnostic information especially when this group is considered the "norm" to which we compare the other reading groups.

5. Do average and below-average readers in grade two who demonstrate weak spatial memory at an intersensory level continue to demonstrate such a pattern of performance when utilizing more complex stimuli, such as syllables and words? One way to explore this question would be to conduct a study with the same subjects over time.

6. Does the negative impact found with the five minute response interval under the Visual-Auditory mode continue to negatively influence the performance of readers at high reading levels, for example, syllabication skills?

7. The question arises as to the relationship between language proficiency, and recall and recognition performance at an intersensory level. Do preschool children who are demonstrating difficulty establishing visual-auditory correspondences, with respect to vocabulary development, demonstrate problems on word-name and graphic symbol correspondences or letter-sound equivalents when learning word recognition skills?

8. Another important area of future research will be to investigate whether early readers in other populations such as the mentally handicapped or emotionally disturbed, demonstrate similar differences on these

intersensory memory tasks as did the Above-Average, Average and Below-Average readers in this investigation.

9. Although most research relative to reading problems focuses on elementary students with some on secondary students, all these students do become adults. Another research question then emerges: do reading disabled adults demonstrate similar difficulties on intersensory memory tasks?

10. This study did not find statistically significant differences between the Above-Average and Below-Average readers in intersensory performance under the Visual-Auditory mode condition. However, the results of this study suggest the possibility that a developmental hierarchy exists within this cognitive skill under different Presentation-Response mode conditions. Although a memory deficit per se could account for these performance differences, a developmental progression of this cognitive skill, under different presentation-response mode conditions has to be considered a valid alternative explanation for these discrepancies in performance. For this reason, it would be interesting to study the intersensory memory performances of younger children to see whether they demonstrate a similar or different sequence within the presentation-response mode hierarchy.

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APPENDICES

Appendix A

General Directions

1. Always give Selection Instrument 1 before Selection Instrument 2.

2. Use only the standard instructions provided. Do not modify or delete any words.

3. Always record exactly what the child's response is, for example, each word-name or each symbol he points to, as he makes it.

4. All six learning and testing intersensory memory tasks will be administered to each subject.

5. Throughout the presentation of each of six intersensory memory tasks, do not allow the subject to use verbal or motoric strategies to remember word-names heard and graphic symbols seen.

6. Introduce the Caramate 3300 machine before proceeding to Selection Instrument 2. Likewise, introduce the light system to each child before proceeding to Selection Instrument 2 and the individual program.

Appendix B

Selection Instrument 1

Directions: All children will be given Selection Instrument 1 individually. It will require the child to vocally imitate each of 18 word-names after hearing the examiner say each word-name.

Say to Child: "I am going to say some names to you one at a time. After I have said the name, then I want you to repeat the name for me, so listen carefully." "Ready" (the examiner then says the first name on the list).

Additional Instructions:

If the child makes any mistakes or hesitates on the initial presentation, readminster several word-names including the confusing one again. If the child is correct on the initial administration, Selection Instrument 2 will begin. If the child errs on the first readministration, then a second and third consecutive readministration will be given. If the child errs on either one or both of these occasions, testing will be terminated. If the child is correct on both occasions Selection Instrument 2 will begin.

Appendix C

Selection Instrument 2

Script:

"I am going to show you some things. Sometimes you may see something like this: '  and hear something, like this: "Bob"; or you may see something like this: '  and hear this: "John"; or you may see something like this: '  and hear something like this: "Doug". So it will be important for you to look and listen carefully."

' - this mark represents a cue for making a pulse on the sync-cue recorder.

Appendix D

Teaching Scripts

For First Set Presentation

"Good, now you are going to see some new symbols and hear new names. This time I want to see how well you can learn what you see and hear. So remember to look and listen carefully." "Ready."

For Each Set Presentation Thereafter

"Let's try learning another set." "Ready."

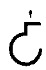
Appendix D (continued)

Learning Task

Five Second Response-Interval

V-A, P-R

Start Tape

3 Sec. →		3 Sec. →	"This one is called Tom"	2 Sec. →		3 Sec. →	"This one is called Frank"	2 Sec. →		3 Sec. →	"This one is called Steve"
2 Sec. →		2 Sec. →	"Frank"	2 Sec. →		2 Sec. →	"Steve"	2 Sec. →		2 Sec. →	"Tom"
2 Sec. →		2 Sec. →	"Frank"	2 Sec. →		2 Sec. →	"Tom"	2 Sec. →		2 Sec. →	"Steve"
2 Sec. →		2 Sec. →	"Steve"	2 Sec. →		2 Sec. →	"Tom"	2 Sec. →		2 Sec. →	"Frank"
2 Sec. →		2 Sec. →	"Tom"	2 Sec. →		2 Sec. →	"Steve"	2 Sec. →		2 Sec. →	"Frank"
2 Sec. →		2 Sec. →	"Steve"	2 Sec. →		2 Sec. →	"Frank"	2 Sec. →		2 Sec. →	"Tom"

Clear Screen

Appendix D (continued)

Testing Task

Visual-Auditory Mode

Five Second R-I

Script:

3 sec. cue "Tell me what this one is called."

5 sec. cue "Tell me what this one is called."

5 sec. cue "Tell me what this one is called."

3 sec. cue to clear screen

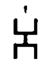
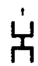
Appendix D (continued)

Learning Task

Five Second Response-Interval

A-G, P-R

Start Tape

3 Sec. →		3 Sec. →	"This one is called Dave"	2 Sec. →		3 Sec. →	"This one is called Ed"	2 Sec. →		3 Sec. →	"This one is called Paul"
2 Sec. →		2 Sec. →	"Ed"	2 Sec. →		2 Sec. →	"Paul"	2 Sec. →		2 Sec. →	"Dave"
2 Sec. →		2 Sec. →	"Paul"	2 Sec. →		2 Sec. →	"Ed"	2 Sec. →		2 Sec. →	"Dave"
2 Sec. →		2 Sec. →	"Paul"	2 Sec. →		2 Sec. →	"Dave"	2 Sec. →		2 Sec. →	"Ed"
2 Sec. →		2 Sec. →	"Ed"	2 Sec. →		2 Sec. →	"Dave"	2 Sec. →		2 Sec. →	"Paul"
2 Sec. →		2 Sec. →	"Dave"	2 Sec. →		2 Sec. →	"Paul"	2 Sec. →		2 Sec. →	"Ed"

Clear Screen

Appendix D (continued)

Testing Task

Auditory-Graphic Mode

Five Second R-I

Script:

3 sec. "Make the one called Dave."
$\longrightarrow$

5 sec. "Make the one called Ed."
$\longrightarrow$

5 sec. "Make the one called Paul."
$\longrightarrow$

Appendix D (continued)

Learning Task

Five Second Response-Interval

A-V, P-R

Start Tape

3 Sec. →		3 Sec. →	"This one is called Chris"	2 Sec. →		3 Sec. →	"This one is called Lou"	2 Sec. →		3 Sec. →	"This one is called George"
2 Sec. →		2 Sec. →	"George"	2 Sec. →		2 Sec. →	"Chris"	2 Sec. →		2 Sec. →	"Lou"
2 Sec. →		2 Sec. →	"Chris"	2 Sec. →		2 Sec. →	"George"	2 Sec. →		2 Sec. →	"Lou"
2 Sec. →		2 Sec. →	"George"	2 Sec. →		2 Sec. →	"Lou"	2 Sec. →		2 Sec. →	"Chris"
2 Sec. →		2 Sec. →	"Lou"	2 Sec. →		2 Sec. →	"Chris"	2 Sec. →		2 Sec. →	"George"
2 Sec. →		2 Sec. →	"Lou"	2 Sec. →		2 Sec. →	"George"	2 Sec. →		2 Sec. →	"Chris"

Clear Screen

Appendix D (continued)

Testing Task

Auditory-Visual Mode

Five Second R-I

Script:

3 sec. Cue "Point to the one called Lou."

5 sec. Cue "Point to the one called Chris."

5 sec. Cue "Point to the one called George."

cue to clear screen

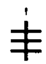
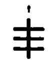
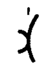
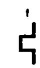
Appendix D (continued)

Learning Task

Five Minute Response-Interval

V-A, P-R

Start Tape

3 Sec. →		3 Sec. →	"This one is called Norm"	2 Sec. →		3 Sec. →	"This one is called Vic"	2 Sec. →		3 Sec. →	"This one is called Ross"
2 Sec. →		2 Sec. →	"Norm"	2 Sec. →		2 Sec. →	"Ross"	2 Sec. →		2 Sec. →	"Vic"
2 Sec. →		2 Sec. →	"Vic"	2 Sec. →		2 Sec. →	"Norm"	2 Sec. →		2 Sec. →	"Ross"
2 Sec. →		2 Sec. →	"Ross"	2 Sec. →		2 Sec. →	"Vic"	2 Sec. →		2 Sec. →	"Norm"
2 Sec. →		2 Sec. →	"Ross"	2 Sec. →		2 Sec. →	"Norm"	2 Sec. →		2 Sec. →	"Vic"
2 Sec. →		2 Sec. →	"Vic"	2 Sec. →		2 Sec. →	"Ross"	2 Sec. →		2 Sec. →	"Norm"

Clear Screen

Appendix D (continued)

Testing Task

Visual-Auditory Mode

Five Minute R-I

Script:

3 sec. cue "Tell me what this one is called."
$\longrightarrow$

5 sec. cue "Tell me what this one is called."
$\longrightarrow$

5 sec. cue "Tell me what this one is called."
$\longrightarrow$

3 sec. cue to clear screen
$\longrightarrow$

Appendix D (continued)

Learning Task

Five Minute Response-Interval

A-G, P-R

Start Tape

3 Sec. →	Ω	3 Sec. →	"This one is called Ben"	2 Sec. →	ᛟ	3 Sec. →	"This one is called Hugh"	2 Sec. →	⅄	3 Sec. →	"This one is called Merv"
2 Sec. →	⅄	2 Sec. →	"Merv"	2 Sec. →	ᛟ	2 Sec. →	"Hugh"	2 Sec. →	Ω	2 Sec. →	"Ben"
2 Sec. →	Ω	2 Sec. →	"Ben"	2 Sec. →	⅄	2 Sec. →	"Merv"	2 Sec. →	ᛟ	2 Sec. →	"Hugh"
2 Sec. →	⅄	2 Sec. →	"Merv"	2 Sec. →	Ω	2 Sec. →	"Ben"	2 Sec. →	ᛟ	2 Sec. →	"Hugh"
2 Sec. →	ᛟ	2 Sec. →	"Hugh"	2 Sec. →	Ω	2 Sec. →	"Ben"	2 Sec. →	⅄	2 Sec. →	"Merv"
2 Sec. →	ᛟ	2 Sec. →	"Hugh"	2 Sec. →	⅄	2 Sec. →	"Merv"	2 Sec. →	Ω	2 Sec. →	"Ben"

Clear Screen

Appendix D (continued)

Testing Task

Auditory-Graphic Mode

Five Minute R-I

Script:

5 sec. "Make the one called Merv."
⟶

5 sec. "Make the one called Hugh."
⟶

3 sec. "Make the one called Ben."
⟶

Appendix D (continued)

Learning Task

Five Minute Response-Interval

A-V, P-R

Start Tape

3 Sec. →		3 Sec. →	"This one is called Al"	2 Sec. →		3 Sec. →	"This one is called Walt"	2 Sec. →		3 Sec. →	"This one is called Joe"
2 Sec. →		2 Sec. →	"Joe"	2 Sec. →		2 Sec. →	"Walt"	2 Sec. →		2 Sec. →	"Al"
2 Sec. →		2 Sec. →	"Walt"	2 Sec. →		2 Sec. →	"Joe"	2 Sec. →		2 Sec. →	"Al"
2 Sec. →		2 Sec. →	"Al"	2 Sec. →		2 Sec. →	"Joe"	2 Sec. →		2 Sec. →	"Walt"
2 Sec. →		2 Sec. →	"Joe"	2 Sec. →		2 Sec. →	"Al"	2 Sec. →		2 Sec. →	"Walt"
2 Sec. →		2 Sec. →	"Walt"	2 Sec. →		2 Sec. →	"Al"	2 Sec. →		2 Sec. →	"Joe"

Clear Screen

Appendix D (continued)

Testing Task

Auditory-Visual Mode

Five Minute R-I

Script:

5 sec. $\longrightarrow$ Cue "Point to the one called Joe."

3 sec. $\longrightarrow$ Cue "Point to the one called Walt."

5 sec. $\longrightarrow$ Cue "Point to the one called Al."

cue to clear screen

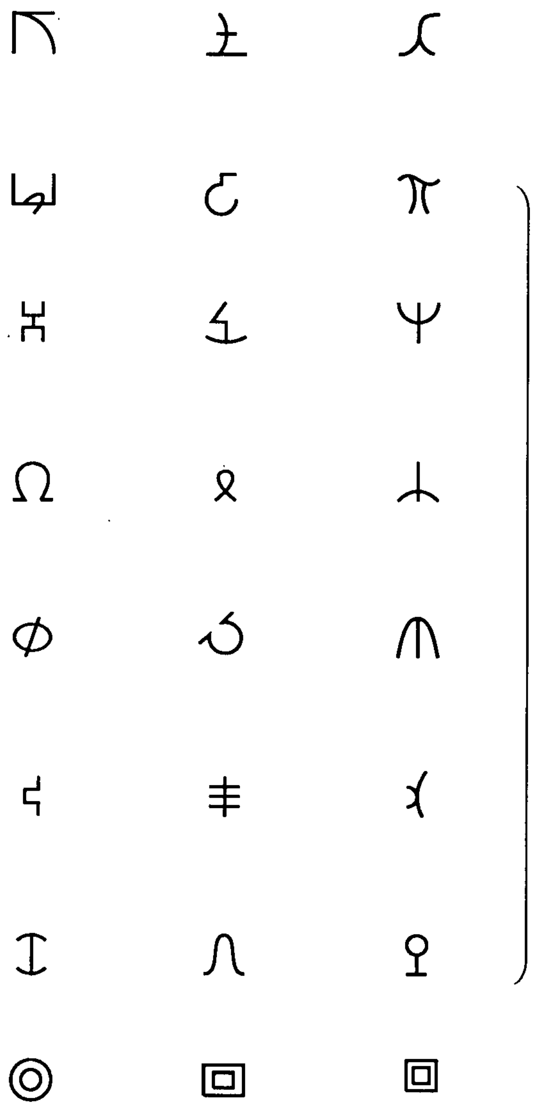
Appendix E

Word-Names

Word-Names	Use
Bob	Selection Instrument 2
John	
Doug	
Frank	Intersensory Memory Tasks
Hugh	
Ben	
Ross	
Vic	
Dave	
Chris	
Steve	
Ed	
Al	
Paul	
Joe	
Norm	
George	
Merv	
Lou	
Tom	
Walt	
Harry	Light System Training Session
Jimmy	
Bill	

Appendix F

Symbols



Selection Instrument 2

Intersensory Memory Tasks

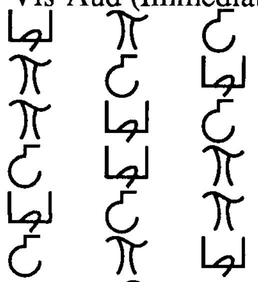
Training Session for Light System

Appendix G

Individual Program Record Form

Code No. __________ Subject No. __________

1. Vis-Aud (Immediate)

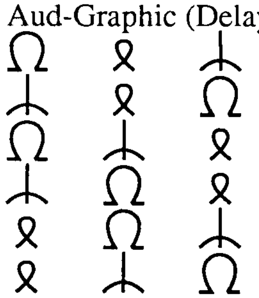


Called ? __________

Called ? __________

Called ? __________

2. Aud-Graphic (Delayed)

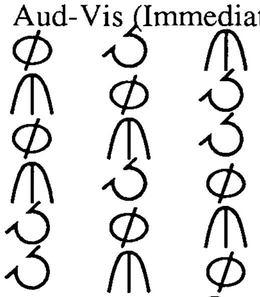


Draw Merv

Draw Hugh

Draw Ben

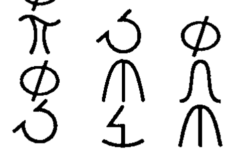
3. Aud-Vis (Immediate)



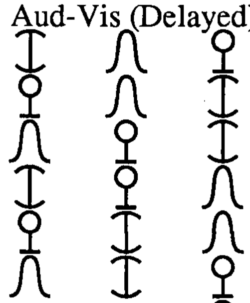
Pt. to Lou

Pt. to Chris

Pt. to George



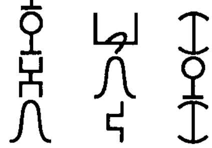
4. Aud-Vis (Delayed)



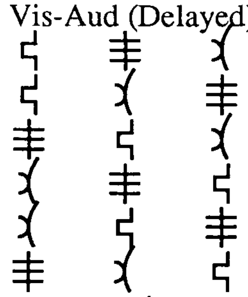
Pt. to Joe

Pt. to Walt

Pt. to Al



5. Vis-Aud (Delayed)

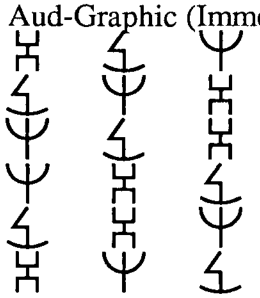


Called ? __________

Called ? __________

Called ? __________

6. Aud-Graphic (Immediate)



Draw Dave

Draw Ed

Draw Paul

Appendix G (continued)

Record Form for Auditory-Graphic Mode

Immediate Response Interval

Appendix G (continued)

Record Form for Auditory-Graphic Mode

Delayed Response Interval

Appendix H

Scoring Criteria for the Performance on the Intersensory Tasks

Visual-Auditory Presentation-Response

Score either: 3, 2, 1

Score 3 = Correct word-name given

Score 2 = Close approximation to correct word-name required (Example: "Ned" for "Ed)

Score 1 = No response given

= Incorrect word-name given

= Correct or incorrect word-name given, after time period had expired

Auditory-Graphic Presentation-Response

Score either: 3, 2, 1

Score 3 = Correct, accurate graphic reproduction for auditory equivalent presented

Score 2 = 1 element added to correct graphic reproduction

= 1 element omitted from correct graphic reproduction

= 1 distortion in an otherwise correct graphic reproduction

= 1 rotation no greater than 20 in an otherwise correct graphic reproduction

Score 1 = 1 element added and 1 element omitted

= 2 elements added

= 2 elements omitted

Appendix H

Auditory-Graphic Presentation-Response (continued)

Score 1 = 1 rotation 20

= 1 element omitted plus 1 distortion

= 1 element added plus 1 distortion

= Incorrect graphic symbol reproduced

= Correct or incorrect graphic symbol reproduced after time period had expired

= No response

<u>Auditory-Visual Presentation-Response</u>

Score either: 3 or 1

Score 3 = Child points to correct symbol equivalent

Score 1 = Points to incorrect symbol equivalent

= Points to correct or incorrect symbol after time period had expired

= No response

Appendix I

Wordless Story Books

During the five second and five minute response intervals, each subject told verbal stories about the pictures without words. The books employed were as follows:

1. The Good Bird

   by Peter Wezel

   Pub. Harper and Row, N.Y., 1964

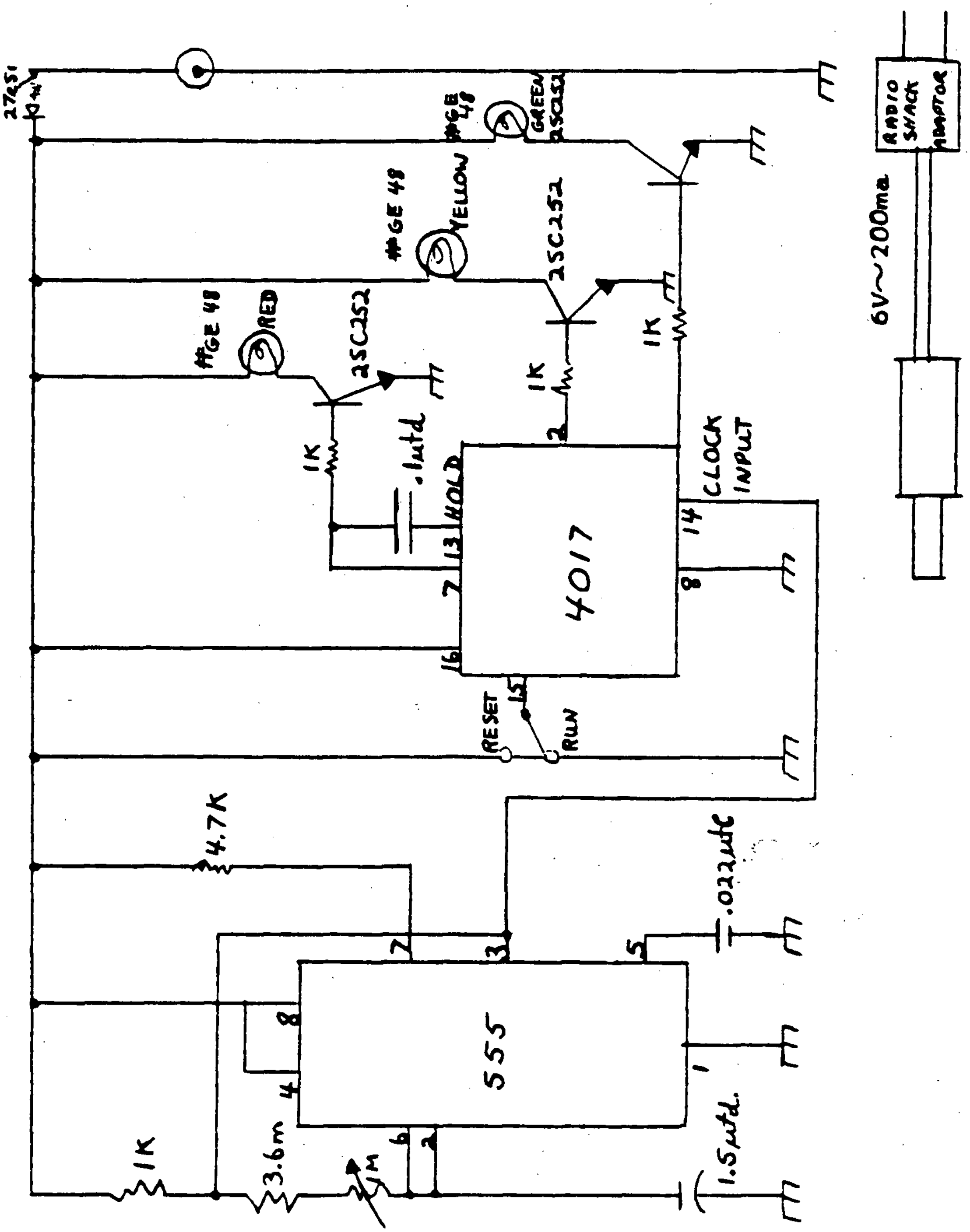
2. How Santa Claus had a Long and Difficult Journey Delivering His Presents

   by Fernando Krahn

   Pub. A Seymour Lawrence Book, Deacorte Press, N.Y., 1970

Appendix J

Graphic representation of the Electrical Circuit of the Light System



Appendix K

Training Session for the Light System

Duration of the training session was approximately five minutes.

Introduction to the Light System

"We are going to use this light system in our work today. Let me show you how it works (turn on the light system). When the green light comes on, this means you are to start the work; when the yellow light comes on it means you are halfway through your time and when the red light comes on it means your time is up."

Training Session

"I have three symbols to show you. We are going to practise them using the light system. Let's try it. Here is the first symbol ◎ (slide comes up on the Caramate screen). We are going to call this one Harry (remove symbol from the screen). Now when I turn on the light system I want you to tell me the name of he symbol you just saw; when you see the green light come on tell me your answer. If you cannot remember it, think about it, and tel me your answer before the red light comes on. What did we call this one?" (symbol appears on screen). Repeat the question until subject responds with an answer (whether correct or incorrect) within the appropriate green to red period).

Appendix K (continued)

"Here is the second symbol  (slide comes up on the Caramate screen). We are going to call this one Jimmy (remove the symbol from the screen). Now when I turn on the light system I want you to make the symbol you just saw. Make the symbol before you see the red light. Make the one called Jimmy." Repeat this statement until the subject responds with an answer (whether the drawing was correct or incorrect) within the appropriate green to red period). "Let's try one more symbol. Here it is  (slide comes up on the Caramate screen). We are going to call it Billy (remove the symbol from the screen). Now I am going to show you three symbols (slide comes up on the screen.    Point to the one called Billy before the red light comes on."

Appendix L

Key for Raw Scores

S = Subjects

Rd. Grp. = Reading Group

1 - Above-Average Readers

2 - Average Readers

3 - Below-Average Readers

I = Immediate

D = Delayed

FS IQ = Full Scale Intelligent Quotient

A - G = Auditory-Graphic

V - A = Visual-Auditory

A - V = Auditory-Visual

Appendix L (continued)

Raw Scores of 78 Subjects for 6 Intersensory Memory Tasks

and Subjects' Full Scale Intelligence Quotients

S No.	Rd. Grp.	FS IQ	A-G I	V-A I	A-V I	A-G D	V-A D	A-V D
01	1	126	7	9	9	5	9	9
02	1	131	8	9	9	7	7	9
03	1	117	5	9	9	8	9	9
04	1	106	7	9	9	5	7	9
05	1	128	9	9	9	5	8	7
06	1	133	8	9	9	9	7	9
07	1	104	5	9	9	4	5	9
08	1	133	9	9	9	6	9	9
09	1	112	6	3	9	4	5	7
10	1	100	3	7	9	3	3	9
11	1	106	5	7	5	5	3	9
12	1	117	9	9	9	6	7	9
13	1	126	5	7	9	5	3	9
14	1	133	4	9	9	5	7	9
15	1	129	7	9	9	3	5	9
16	1	108	5	7	9	3	7	7
17	1	107	7	9	9	8	4	9
18	1	109	7	9	9	7	5	9
19	1	121	5	9	9	9	9	9
20	1	112	5	3	9	3	7	3
21	1	124	7	9	7	5	7	9
22	1	112	5	9	9	8	6	9
23	1	100	4	7	9	6	7	9
24	1	124	9	9	9	9	7	9
25	1	120	8	9	9	7	5	9
26	1	126	7	9	3	9	5	9
27	2	101	6	9	9	7	3	9
28	2	112	5	5	9	3	3	5
29	2	120	7	5	9	5	5	3
30	2	108	3	9	7	7	6	9
31	2	116	3	5	7	7	6	9
32	2	120	3	7	9	5	3	5
33	2	107	3	5	9	5	3	9
34	2	126	3	7	9	3	3	9
35	2	91	3	9	9	5	5	9
36	2	109	7	9	9	7	5	7

Appendix L (continued)

S No.	Rd. Grp.	FS IQ	A-G I	V-A I	A-V I	A-G D	V-A D	A-V D
37	2	97	5	3	5	3	3	9
38	2	102	3	9	9	3	3	9
39	2	103	5	7	9	3	7	9
40	2	94	3	7	9	3	5	9
41	2	116	5	5	9	3	7	9
42	2	101	6	7	5	3	3	9
43	2	100	3	9	3	7	4	5
44	2	107	5	5	9	4	9	9
45	2	102	7	7	7	4	5	7
46	2	104	3	9	9	4	3	9
47	2	110	5	9	9	5	7	9
48	2	105	3	7	9	3	3	9
49	2	125	3	3	7	5	3	9
50	2	121	5	9	9	3	7	9
51	2	102	5	8	9	5	5	9
52	2	102	7	3	9	5	7	9
53	3	89	3	9	9	5	9	9
54	3	110	3	9	9	3	3	7
55	3	100	6	5	9	5	3	5
56	3	123	5	9	9	3	3	9
57	3	106	4	9	9	6	5	9
58	3	122	5	9	9	5	7	4
59	3	128	8	9	9	3	5	9
60	3	113	7	7	9	5	5	9
61	3	128	8	9	9	5	5	9
62	3	105	5	9	9	5	4	7
63	3	130	9	9	9	9	4	9
64	3	101	5	9	9	3	9	9
65	3	90	4	7	9	4	5	9
66	3	103	5	7	9	3	3	9
67	3	113	3	9	7	3	3	7
68	3	105	6	7	9	3	3	9
69	3	100	3	5	9	7	9	9
70	3	92	6	9	7	5	5	5
71	3	101	3	7	9	5	5	9
72	3	100	5	9	9	3	3	7
73	3	103	5	9	9	7	7	5
74	3	92	3	9	9	3	5	9
75	3	105	5	9	9	5	7	9
76	3	121	5	5	9	3	5	9
77	3	105	4	5	9	3	5	9
78	3	102	6	9	3	7	5	7

Appendix M

Summary of Analysis of Covariance for 78 Subjects

Source	Sums of Squares	Degrees of Freedom	Mean Square	F	P
Between Subjects	--	--			
A	63.79	2	31.91	8.06	0.00*
1st COVAR	19.22	1	19.22	4.83	0.03
Error	292.66	74	3.95		
Within Subjects	--	--			
B	103.42	1	103.42	45.59	0.00*
AB	10.76	2	5.23	2.31	0.11 NS
Error	170.11	75	2.27		
C	797.08	2	398.54	146.58	0.00*
AC	31.08	4	7.77	2.86	0.03*
Error	407.83	150	2.72		
BC	107.52	2	53.76	21.62	0.00*
ABC	3.52	4	0.88	0.35	0.84 NS
Error	372.96	150	2.49		

* $P < .05$