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AN EMPIRICAL INVESTIGATION OF THE RELATIONSHIP BETWEEN HEMISPHERIC FUNCTIONING AND CATEGORIZATION: IMPLICATIONS FOR READING

Cynthia J. Reid

Thesis presented to the School of Graduate Studies of the University of Ottawa as partial fulfillment of the requirements for the Degree of Master of Arts in Education

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CURRICULUM STUDORIUM

Cynthia Reid was born November 26, 1957, in Pembroke, Ontario. She received the Bachelor of Arts degree in Modern Languages in 1978 and the Bachelor of Education degree in 1979, both from the University of Ottawa.

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INTRODUCTION

A major concern, in recent literature, has been the question of the relationship between cerebral lateralization and learning. Since Orton first hypothesized that difficulty in learning to read may be caused by a left brain deficiency, a great deal of research has been conducted in order to investigate how hemispheric differentiation is related to learning ability, especially to learning to read efficiently.

Apparently, different intellectual functions have traditionally been associated with either the right or left hemisphere. The study of individuals who have suffered either right or left brain damage has enabled researchers to identify some of these abilities and their assumed hemispheric localization. To illustrate, it has been assumed that, among right-handed unilingual speakers of Indo-European languages, certain linguistic functions are most likely to be found in the left or "verbal" hemisphere, while the ability to determine visuo-spatial relations are most likely to be a function of the right or "non-verbal" hemisphere. This knowledge, in turn, has led to the speculation that most, if not all, language-based activities for these persons are the domain of the left hemisphere while most, if not all, visuo-spatial activities are located in the right.

Limiting the scope of this investigation to unilingual anglophones and francophones, the intent of the study was to research the relationship between hemispheric differentiation and those cognitive activities considered basic to one of the language-based activities: reading comprehension. According to psycholinguistic theory, reading comprehension is defined as

the reduction of uncertainty, a process which is achieved primarily through the immediate categorization of the words being read. Apparently, one of the major abilities which consistently distinguishes between proficient and disabled readers is the ability to immediately allocate to appropriate categories the words encountered in reading.

Unlike those who are less proficient, the fluent reader is able to employ what has been referred to as "immediate comprehension" or previously acquired categorization abilities which he brings to the reading encounter; that is, for the efficient reader, comprehension accompanies or precedes word identification. Anticipating word categories by their syntactic, semantic, orthographic and phonological attributes, the proficient reader can predict, by reducing the number of possible alternatives, the next word or category of words to be read.

Contrary to what might be expected, it has been found that better comprehenders, those who appear to utilize immediate comprehension, exhibit superior non-verbal or right hemispheric abilities when compared with older reading-handicapped subjects, left hemispheric or verbal abilities held constant (Namen, 1981). Using a Cloze technique, an instrument purportedly sensitive to those abilities associated with immediate comprehension, it was also found that proficient readers are more sensitive to syntactic and semantic attributes of word categories encountered in their reading.

In a Cloze passage such as:

Would _____ please _____ me _____ drink _____ water?

readers demonstrating stronger non-verbal abilities seem to be more readily able to reduce the uncertainty regarding the possible alternatives which can be applied to each space. To illustrate, in the second space, the proficient reader appears to reduce the number of possible alternatives by predicting a category using syntactic and semantic attributes either simultaneously or consecutively. Should the reader approach the space, testing attributes consecutively, he might syntactically reduce all possible alternatives to the category of verb, then to the subsumed category of transitive verb. At that point he might make a primary attribute shift, reducing the number of remaining possible alternatives, semantically, to the word or category of words which will convey the most appropriate meaning. How the right or non-verbal hemisphere is involved in reducing the number of possible alternatives in what would seem to be primarily a language-based activity does not appear to have been investigated, nor explained, anywhere in the literature.

Because it has traditionally been assumed that the language centres are seldom, if ever, located in the right hemispheres of the proposed subjects, it would appear that reading may represent a bilateral activity, a process in which the right, or non-verbal hemisphere, plays a notable role. But what is the nature of that role? As was speculated in the previously mentioned study, "It would appear that the ability to interpret the same 'non-verbal' stimulus in more than one way is closely associated with reading skills, presumably analogous to the ability to understand

that a single grapheme or group (category) of graphemes can be related to a number of different phonemes." (Mamen, 1981, p.127)

A survey of recent literature suggests that this "ability to interpret the same 'non-verbal' stimulus in more than one way", when applied to reading, represents categorization, the ability to recognize, in more than one way, basic criterial attributes of categories. To recognize and interpret criterial attributes in more than one way requires a subject to be able to cope with multiple attributes, either simultaneously or consecutively, to subsume certain attributes in deference to others, to make attribute shifts, and to distinguish between relevant and irrelevant attributes in determining categories. These basic abilities, in turn, determine the reading abilities suggested in the above Cloze example: the ability to utilize semantic, syntactic, orthographic and phonological attributes (multiple attributes), either simultaneously or consecutively, to utilize syntactic attributes while subsuming the remaining identified attributes, to shift from syntactic to semantic attributes while subsuming the others, and to recognize that, in poetry, phonological attributes may be more relevant than they are in prose.

Basic to the ability to categorize in reading, then, lie more fundamental abilities. In order for a reader to utilize orthographic, semantic, syntactic and graphophonic attributes, in more than one way, he must be able to cope with multiple attributes in more concrete, non-verbal, instances of categorization; he must be able to make attribute shifts, to subsume attributes in relation to others, and to assess the

relevance of selected attributes.

Available literature has suggested that these fundamental abilities are primarily a function of the right or non-verbal cortex, although verbal mediation necessitates left hemispheric involvement to a lesser degree. Assuming that these abilities are basic to successful reading, this study has been designed to investigate the relative involvement of each cerebral hemisphere in basic categorization abilities. The research question may be stated, therefore, as: Are basic categorization abilities a primary function of the right or non-verbal hemisphere with the left or verbal hemisphere serving a secondary role?

To conduct the study, two research instruments were selected. The WISC-R was used to assess relative "verbal" and relative "non-verbal" strengths. The second instrument, The Halstead-Reitan Category Test was used to assess the subjects' abilities to categorize where multiple attributes (size, shape, colour and position) are involved, to distinguish between relevant and irrelevant attributes, and to identify categories using relevant attributes while subsuming the irrelevant.

In the first chapter, a review of the literature on cerebral lateralization and categorization is presented. The chapter concludes with a summary and statement of the research hypothesis. Chapter II includes an outline of the research design. The design is described in terms of the research instruments, the research methods, the sample and the plan for the statistical analysis.

In the third chapter, results of the analysis are presented. The

results are discussed in terms of possible interpretation in Chapter IV. The study is then completed with a brief summary, a discussion of possible pedagogical implications with respect to the reading process, and a statement of the conclusions.

CHAPTER I

REVIEW OF THE LITERATURE

It now appears to be relatively well established in the literature that language centres for the majority of right-handed unilingual anglophones are located in the left cerebral hemisphere (Penfield and Roberts, 1959; Sperry, 1956, 1978; Gazzaniga, 1967, 1970; Luria, Sokolov and Klimkowski, 1967; Thompson, 1975; Plotnik and Mollenauer, 1978). Numerous clinical studies have demonstrated that damage to the left hemisphere usually results in language impairment, often both expressive and receptive in nature (Luria and Simernitskaya, 1977; Plotnik and Mollenauer, 1978; Gazzaniga, Steen and Volpe, 1979). Conversely, damage to the right hemisphere has been shown to have little or no effect on verbal ability, causing instead, various difficulties in perception and spatial organization (Thompson, 1975; Luria et al., 1977; Sperry, 1978; Gazzaniga et al., 1979).

Within the broader context of language, according to Searleman (1977), there is a great deal of evidence suggesting left hemispheric localization in adults for speech production. Experiments conducted with split-brained patients using haptic, dichotic and tachistoscopic presentation of verbal and non-verbal stimuli to the left and right hemispheres have indicated that the left cortex is highly verbal while the right is capable of producing little if any speech (Milner, 1958; Thompson, 1975; Plotnik and Mollenauer, 1978; Gazzaniga et al., 1979). Similarly, it has been shown that lesions

of the left hemisphere usually result in varying degrees of speech disorder or aphasia, depending on the specific area of damage, while right hemispheric lesions have no apparent effect on verbal ability (Plotnik and Mollenauer, 1978; Sperry, 1978; Gazzaniga et al., 1979). For this reason, the left hemisphere is usually referred to in the literature as the "verbal hemisphere" and the right as the "non-verbal hemisphere".

In many recent studies, however, results have indicated that, while certain linguistic functions are performed better in the left hemisphere, others may be carried out successfully in both hemispheres and some more efficiently in the right (Luria, 1974; Gibson, Pimond and Gazzaniga, 1972; McLaughlin, 1978; Albert and Obler, 1978; Gazzaniga et al., 1979). Recognizing the difficulty involved in identifying specific functions as they relate to cerebral lateralization, Searleman (1977), in his review of the literature, suggested that language might best be investigated in terms of production and comprehension. This approach seems to be very practical in view of the amount of research conducted in this area, the variety of methods used, and the seemingly inconclusive nature of the results. Consequently, this review of the literature will be directed primarily toward the nature of comprehension and, more specifically, the comprehension of written or visual language.

It should be noted, at this point, that the majority of the studies discussed in this section was conducted on adult patients, largely due to their clinical availability as a result of a higher incidence of cerebrovascular insult. In addition, researchers have often restricted their

samples to right-handed subjects because it has been suggested that, for some left-handers, hemispheric lateralization may likely be the reverse of that expected for right-handers.

Research with younger brain-damaged children has shown greater right hemispheric involvement in language and speech (Krashen, 1973; Searleman, 1977; McLaughlin, 1978). Evidently, pre-school aged children with lesions to the right hemisphere are more apt to suffer speech impairment than are adults with similar injuries. Furthermore, children with left-brain damage are often able to completely recover their expressive ability through the use of the right hemisphere (Krashen, 1973; McLaughlin, 1978). If the damage occurs after hemispheric lateralization of linguistic functions, however, it is seldom, if ever, possible to fully regain lost speech. Although some controversy exists concerning the age at which lateralization occurs, it has recently been suggested that it occurs by about the fourth or fifth year (Kimura, 1967; Krashen, 1973).

Results from these studies however, have suggested some right hemispheric involvement in language comprehension following lateralization of the language centres to the left hemisphere. An overview of related research reveals that the exact contribution of the right brain to comprehension remains, to some extent, unclear. Gazzaniga (in McLaughlin, 1978) noted that the non-verbal hemisphere does possess "language processing ability" and a very limited expressive ability. He observed that patients who have had a left hemispherectomy often retain their verbal comprehension despite suffering speech impairment. The patients are able to recognize

and identify written words although they are often not able to report these words verbally.

Apparently, right hemispheric involvement in processing visual verbal material may depend more on the demands of the task than on the verbal or non-verbal nature of the stimulus (Gibson et al., 1972). It has been suggested, for example, that the right hemisphere may process verbal stimuli when a non-verbal response is required (Gazzaniga and Sperry, in Searleman, 1977). The left hemisphere, conversely, may process information in order to communicate (Tomlinson-Keasey and Kelly, 1978).

To illustrate, Sperry (in Thompson, 1975) found that split-brained patients were able to recognize and point to the name of an object when the object was placed in their left hands and when its name was presented to the left visual field only. As it has been well established that the right side of the cerebral cortex receives information from and controls the movement of the left side of the body, and vice versa (Thompson, 1975; Plotnik and Mollenauer, 1978; Gazzaniga et al., 1979), it was concluded that the right hemisphere is able to process visual verbal material.

Luria, Sokolov and Klimkowski (1967) also observed right brain ability in the processing of visual information. They found that damage to the left temporal lobe affected the retention of only auditory verbal material, and did not disturb the retention of visual verbal information. Luria (1974), subsequently suggested left temporal cortex specialization for acoustic analysis and right brain involvement in the processing of "semantic units and systems which have a quasi-spatial organization".

While other studies have also linked auditory word presentation to the left hemisphere and visual word presentation to the right hemisphere (Zenhausern and Gebhardt, 1979), some evidence has accumulated indicating right brain involvement in both verbal and written comprehension (McLaughlin, 1978).

In brief, there appears to be general agreement in recent literature that the left hemisphere is responsible for speech production in the majority of adults. It also seems to have been fairly well established that the right hemisphere possesses some language comprehension ability. It has been shown, for example, that the right brain is capable of comprehending and identifying words when not required to express them (Sperry in Thompson, 1975). Although some questions persist relative to auditory verbal assimilation, the view that the right hemisphere is involved in the processing of visual verbal material has gained considerable support. What follows, then, is an attempt to suggest one possible explanation of the role of the right cerebral cortex in the comprehension of written or visual language.

It should be noted that most of the research mentioned in the previous section was conducted using "direct" methods, that is, clinical procedures with brain-damaged patients, while the majority of the studies to be discussed were conducted with normal subjects and, consequently, relied on "indirect" methods to determine relative cerebral involvement (Harris, 1979). Similarly, the reader should note that the focus of this investigation is one of studying the relative ipsilateral strengths once lateralization has occurred,

as opposed to many studies in which relative contralateral strengths have been the focus.

While it is generally accepted that the right hemisphere is able to deal with certain language input, the linguistic nature of written materials continues to lead many to assume a left brain superiority for the processing of this material (Witelson, 1976). Results from numerous studies, however, appear to cast some doubt on the validity of this assumption. Again, in the light of the division suggested by Searleman (1977), it may be that language production is a predominantly left hemisphere activity while language comprehension may require the use of both the left and right brains.

In a recent study designed to investigate comparative hemispheric involvement in early fluent (5.5 years) and older impaired readers (9.8 years), Mamen (1981) found, when subjects were controlled for age and left hemispheric ability, better visual comprehenders exhibit superior right hemispheric ability when compared with their reading-handicapped counterparts. Her results, obtained using a Cloze technique, were interpreted as

> ...indicating some degree of right hemisphere immaturity in the (reading impaired) group...and as being suggestive of the importance of right hemisphere functions for reading acquisition (Mamen, 1981, p.114).

Both support and opposition for these findings seem to be evident in the literature; however, when the specific nature of the tasks and the demands placed upon the subjects are taken into consideration, some recurring patterns begin to emerge.

Although the research is flawed by a seeming myriad of operational definitions of reading or comprehension of visual language, these recurring

patterns appear to centre on subjects' abilities to cope with an embedding context and to group or categorize stimuli into meaningful wholes, especially in "match" or "mismatch" activities. In each of these task situations, right hemispheric involvement is apparent.

To exemplify, in a clinical study involving six patients with right hemispheric lesions and a visual comprehension disability, Kinsbourne and Warrington (1962) found that all subjects were able to identify isolated letters correctly but were unable to identify isolated words where the letters were grouped into a meaningful pattern. In all six cases comprehension of the grouped letters was found to be impaired. Although the sample size in this particular study placed some restriction upon the conclusions that could be drawn, these results appear to be consistent with those reached in several other studies.

The right brain contribution to comprehension of written language was also noted by Ornstein, Herron, Johnstone and Swencionis (1979) and Tucker (1981). Ornstein et al. observed large right hemispheric involvement during story reading when normal subjects were asked to process the visual language while being given an EEG. The ability of subjects to group words into a meaningful pattern, or story line, was found to be dependent upon right hemispheric ability especially where an emotional dimension was involved (Tucker, 1981).

While most studies seem to indicate a positive correlation between right hemispheric ability and comprehension of visual language, especially where embedding or categorization to match or mismatch is involved,

experiments comparing normal and impaired readers in terms of lateral functions seem to provide less conclusive results. It has been noted, however, that the inconsistencies in the related research may be due to basic differences in design and to the use of different criteria by which comprehenders are classified as either normal or impaired (Young and Ellis, 1981; Mamen, 1981).

To illustrate, in different studies of visual language processing, basic ability has been assessed using a wide range of operational definitions and criteria: oral reading performance (Vellutino et al., 1975), word perception (Belmont and Birch, 1966; Kershner, 1977) or passage comprehension using the Cloze technique (Pierre, 1975; Mamen, 1981). Given that relative hemispheric involvement may be affected by the demands of the task, it is conceivable that results could differ in these studies. Vellutino et al. (1975) found that poor readers were inferior on word identification and spelling from dictation. Because the Gilmour Oral Reading Test was used to rate processing ability, poorer performance on the spelling test, which was given orally, may have been expected. Interestingly, Vellutino observed that poor readers were able to name and copy letters in words better than they could identify those same words as wholes, which may reflect a deficit in the global or gestalt processing associated with the right hemisphere. Indeed, Nelson and Binge (1975) noted a significant difference in performance on the Bender Visual Gestalt test between normal and impaired readers. While some studies have demonstrated that poor readers are characterized by a verbal deficit (Belmont

and Birch, 1966; Caplan, 1977), Belmont and Birch have pointed out that it remains unclear whether a verbal deficit causes or is caused by difficulty in processing visual language. Furthermore, it has been suggested that experiments conducted with reading-impaired subjects may have been conducted with subjects showing language difficulties (Witelson, 1976).

According to Witelson (1976, 1977), most studies appear to indicate normal left hemispheric specialization for language in poor processors of visual language. Many have observed that the reading-impaired show significantly less right hemispheric ability than their reading-proficient counterparts (Yeni-Komshian et al., 1975; Bouma and Legein, 1977; Witelson, 1977; Richardson, 1979; Mamen, 1981). Yeni-Komshian et al. (1975) found that poor readers showed a deficit in left visual-half-field scores and concluded that they may suffer either right brain processing difficulty or degraded transmission from the right to left hemisphere. In apparent agreement with Pierre (1975) and Mamen (1981), Bouma and Legein (1977) noted that the reading-impaired have greater difficulty distinguishing between figure and ground or relations between parts and wholes. Witelson (1976, 1977) has suggested that less able readers may have bilateral representation of spatial functions which could overload the left hemisphere and interfere with linguistic processing. In the Mamen (1981) study, early fluent readers were compared with a group of older imparied readers and a control group of kindergarten non-readers matched for age and IQ. Results showed a significant right hemispheric advantage in the precocious readers when they were compared with both the experimental and control

groups, indicating that visual processing ability, when measured by a Cloze test, may be enhanced by right brain activity.

Other experiments designed to test word recognition skills in relation to cerebral lateralization have demonstrated that the right brain is superior to the left in word recognition under certain conditions (Gibson et al., 1972; Polich, 1977; Tomlinson-Keasey et al., 1978; Bradshaw, Hicks and Rose, 1979). To illustrate, Gibson, Dimond and Gazzaniga (1972) found higher accuracy for words presented in the left visual-field (RH) when normal adult subjects were required to match the words to those previously exposed across both fields. It was subsequently suggested that

> ...word recognition is a multistage process and that spatial analysis (generally associated with the right cerebral cortex) must be used in the early stages of word recognition (Gibson et al., 1972, p.463-466).

The authors concluded that relative hemispheric involvement may depend on the demands of the task at hand which, in this case, were to categorize words as either "match" or "mismatch". The primary factor in this case appeared to have been the ability to categorize using one attribute: the orthographic or printed characteristic of the word.

There appears to be much evidence in the literature to support this conclusion. In order to test hemispheric changes in visual processing during development, Tomlinson-Keasey et al., (1978) randomly presented pairs of words or pictures, either matched or unmatched, to the left and right hemispheres of normal subjects. To test developmental changes three different age groups, eight, thirteen and twenty-seven year olds, were asked to categorize the pairs as "match" or "mismatch". While no lateral

specialization for matched visual words or pictures was noted in the eight year old group, it was found that adults categorized matched words in the right hemisphere faster than they did the pictures. Furthermore, the right hemisphere categorized unmatched words better than did the left hemisphere in all groups, leading the researchers to suggest that the right brain may categorize both non-verbal and verbal input when no verbal communication is required.

Apparently, the time requirements of a specific task may also affect cerebral preference (Polich, 1977; Eisert, 1979; Bradshaw et al., 1979). Polich and Bradshaw observed that speed of word recognition was greater for the right hemisphere than for the left, possibly because of holistic categorizing to memory processes. Bradshaw noted, however, that a right visual-field - left hemispheric superiority was evident when the word was exposed for increasing durations, presumably where immediate categorization was no longer necessary.

There also appears to be some evidence in the literature that the left brain superiority in letter identification noted by Kinsbourne and Warrington (1962) may be reduced under certain conditions. Studies conducted by Heron (1957) and Kimura (1966) showed similar right visual-field - left hemispheric preference when normal subjects were asked to identify single letters presented tachistoscopically to the left and right visual-fields. Interestingly, both also found that when letters were exposed in the two visual-fields simultaneously, all were reported more accurately in the left visual-field. Kimura (1966) attributed this left visual-field superiority

to the left-right scanning mechanism established through reading and suggested that "the left attending habit only operates when stimuli are close together around fixation, as in a line or page of print". Other research designed to test letter categorization has indicated that while the left brain is more efficient where easily identified or isolated letters are categorized, the right brain is superior when letters are embedded among more difficult visual displays (Hellige and Webster, 1979; Jonides, 1979). These results were expected given the right hemispheric advantage in the processing of visuo-spatial information (Hellige and Webster, 1979).

To summarize, it would appear that the participation of both cerebral hemispheres is necessary to the processing of visual language (Yeni-Komshian, Isenberg and Goldberg, 1975; Baty and McConnell, 1976; Pirozzolo, 1978). It has been shown that left or right brain superiority on a given task may depend, in part, on the specific demands of the task at hand (Gibson et al., 1972). The right hemispheric involvement in the comprehension of written language and its speed and accuracy in word identification seem to indicate the use of a holistic strategy of categorization; in other words, the identification of words occurs within the context of a larger category of similar words (Polich, 1977; Tomlinson-Keasey et al., 1978; Eisert, 1979; Tucker, 1981). Conversely, left hemispheric preference in isolated letter identification and its poorer performance in word recognition, when time is a factor, may be due to the use of a slower, relatively category-free analytic strategy (Eisert, 1979). While there seems to remain little doubt that comprehension of visual language requires the involvement of both the

right and left brains, some questions persist concerning which strategy, i.e. global or analytic, is more efficient and when the use of each has the most impact on visual language processing ability. The importance of right brain activity in the initial stages of visual language processing appears to have been fairly well established in the literature (Birch and Belmont, 1965; Pirozzolo, 1978; Hellige and Webster, 1979). It has been suggested that right hemispheric superiority in visuo-spatial processing facilitates the recognition of words and letters as gestalts, or parts of a larger grouping of words, which the left hemisphere then "converts into phonological units and into meaning" (Pirozzolo, 1978). Although many have stressed the importance of visuo-spatial abilities in only the initial stages of learning to process visual language, there is some indication, as was noted earlier, that the right brain processing method may increase efficiency on certain visual verbal tasks in all stages of printed language processing, especially those related to categorization (match-mismatch) where recognition of at least one attribute is required (Gibson et al., 1972; Baty and McConnell, 1976).

Generally, research designed to test the importance of each hemisphere in the processing of written language can be viewed in terms of two different approaches. First, there are those studies which have been conducted in order to determine the best predictors of processing success. Second, a number of studies has attempted to differentiate between normal and impaired readers based on tests of hemispheric differentiation.

Included in the first group are those studies which were conducted with normal readers in attempts to determine the relationship between various indices of laterality and reading performance. For example, Adams and Ollila (1979) found that when 150 first graders were tested on basic language concepts, spatial relations, predicting outcomes and auditory reception, only the spatial relations test was a significant predictor of readiness to process written language.

Apparently, there may also be a link between Witkin's (Witkin, Dyk and Paterson, 1974) field-dependence - field-independence construct and visual language processing ability. In a study designed to compare the Embedded Figures Test (EFT) with clinical tests of abstraction and memory, Reherman and Brun (1978) concluded that the EFT should be considered as a visuo-spatial test of abstraction. As this particular test is used as a measure of field-dependence - independence, it would appear that greater field-independence indicates a greater degree of lateralization of cognitive functioning, especially that normally associated with the right hemisphere (Oltman, Semple and Goldstein, 1978; Rapacznski and Ehrlichman, 1978).

This hypothesis was supported by Vaid and Lambert (1979) who noted that bilinguals are more field-independent than unilinguals and that they show greater right brain efficiency in processing meaning. For example, in one study designed to investigate the relationship between field-dependence - independence and visual language processing, it was found that those subjects who are most field-independent, as measured by the Embedded Figures Test, demonstrate superior visual language processing ability when

a Cloze procedure is used to measure variance in the dependent variable (Pierre, 1975).

In brief, it would appear that the processing of visual linguistic material may require the use of both the left and right hemispheres. It has been shown that studies in which the right hemisphere was found to be involved in visual language processing share a common denominator: either categorization (match-mismatch) or an embedding task such as the Cloze technique were used, thus suggesting a link between the two.

The term 'cloze' as used in the 'Cloze technique' is derived from the gestalt notion of closure, the impulse to complete a structural whole by supplying the missing element (Stauffer, 1975, p.271; Lamberg and Lamb, 1980, p.49). The Cloze task presents the subject with a sentence or passage from which a word has been deleted, that is, an incomplete pattern, and asks that the subject fill in the missing word. The reader attempts to anticipate meaning from context (the syntactic and semantic patterns) and to accurately supply the words deleted from the passage. In some instances the exact word is required and in others one may give a good synonym with a close meaning and the same grammatical function and form (Zintz, 1975, p. 292; Lamberg and Lamb, 1980). Expressed another way, the word selected must meet the syntactic and semantic attributes dictated by the context.

To illustrate, when given the phrase "Governor Bradford invited the Indians ____ come to a feast of Thanksgiving" (Woodcock Reading Mastery Tests in Mamen, 1979, p. 164), children will automatically fill in the space with "to". Syntactically and semantically there is no other choice.

In some cases, children are given a larger number of options. For example, with the sentence "Dick _____ home after school", the words came, ran, walked, raced, went and skipped could conceivably be used (Harris and Smith, 1976, p.182). All of these words share a common denominator; they are all members of the same category "verb". Subsumed within this category, they are all members of the sub-category of intransitive verb. The syntactic and semantic attributes obtained from the context enable the child to reduce uncertainty by limiting the number of possible word categories and, as a result, the number of actual words which might be used to fill in the blank. For example, having recognized that, syntactically, an intransitive verb is required the child would then subsume the syntactic attributes to the semantic attributes in order to reduce again the number of possible alternatives. In this manner he or she would recognize that while "rained" is an intransitive verb and therefore syntactically acceptable, it would not be appropriate in the sentence: semantically, it would not fit. Further reduction of uncertainty would result were the teacher to state that the word must start with "r", thereby introducing an orthographic attribute. With the added criterion, the number of possible words within the chosen category would again be decreased, limiting the answer to raced, ran, etc.

The child's development and ability to make this type of category association might best be described using the example of Victor, "a wild boy of eleven or twelve found living in the Caune Woods in France" (Stauffer, 1975, p.116). Dr. Jean-Marc-Gaspard Itard believed that Victor could be

taught to read and speak although he possessed no linguistic ability when he was found. Itard taught the boy to read the word 'book' by associating the word with an actual book. When he substituted this book for another however, Victor failed to make the category association. Initially, the word book applied to only one object. With a great deal of patience and effort, Itard was able to teach Victor that the word 'book' represents a group of objects that are similar. At this point, Victor came to identify books on the basis of only one attribute - pages - and, consequently, included pamphlets, newspapers etc. within his category of 'book'. Only after learning that books can be identified using more than one attribute, i.e. "any dimension on which objects or events can differ" (Brown in Stauffer, 1975, p.117), was Victor able to recognize that a book was not to be confused with a newspaper or pamphlet. In a similar manner, Itard was able to teach the boy to understand words defining qualities and relations. According to Stauffer,

> Itard showed Victor that words had referents...that words name classes or categories and that not all referents are objects but that some label qualities and relations. (Stauffer, 1975, p.117).

It is this ability to categorize based on multiple attributes that numerous studies appear to indicate may be primarily a function of the right or non-verbal hemisphere. Pendse (1978) suggested that the non-verbal hemisphere may possess a greater number of optimal categories into which to breakdown information. He indicated that, because the right brain does not have to process material in order to communicate as does the left brain, it may be better able to process or categorize incoming

stimuli. In addition, Bisiach, Capitani and Spinnler (1975), having noted the right brain involvement in perceptual categorization stated,

> The possibility can...be envisaged that generalization processes (within categories) and discrimination processes (between categories) are better performed by the right hemisphere (p.119).

Briefly, it has been shown that the right brain has been found to demonstrate superior ability when required to identify words and pictures as either 'match' or 'mismatch'. In this type of exercise, the subject is required to recognize similarity and differences in attributes of words and objects and, on the basis of these attributes, decide whether or not they belong to the same category. It is important to note that most objects and events can belong to more than one category. For example, while newspapers and pamphlets may not be included in the category 'book', all three of these objects can be subsumed into the larger category of 'things to read'. As such, the subject may be required to interpret the same stimulus in more than one way.

The Cloze technique also tests this ability to categorize on the basis of multiple attributes. Just as words are symbols representing categories of objects or events, they too comprise categories based on certain identifiable attributes. According to Luria,

> We now conceive a word as a complex multi-dimensional matrix of cues and connections (acoustic, morphological, lexical and semantic) and we know that in different states one of these connections is predominant (Luria, 1975, p.306).

To return to the Cloze task cited earlier, it was noted that in the sentence "Dick _____ home after school" the process of supplying the

missing element involves selecting the appropriate word category based on certain identifiable attributes. Initially, the number of possible word categories was reduced because of the position of the blank (syntax) and the nature of the phrase (semantics). By suggesting that the word must begin with "r" an orthographic attribute was introduced and this served to further reduce the number of possible answers. In this manner, the Cloze technique allows the tester to determine the subject's ability to use syntactic, semantic and orthographic attributes in order to achieve comprehension.

To summarize, it has been noted that a recurring pattern appears to emerge from those studies demonstrating right hemispheric involvement in visual language processing. Briefly, it was shown that the tasks employed in these studies involved either identifying a word or picture as belonging or not belonging to a certain category (match-mismatch) or completing a Cloze passage where the subject is required to fill in a missing element. Both of these tasks appear to be predicated upon the basic ability to categorize ideas, words, objects or events on the basis of the successive or simultaneous recognition of multiple attributes.

It has been noted in the literature that this basic ability to utilize multiple attributes, to subsume attributes and to shift from inappropriate to appropriate attributes is not easily assessed. According to Flavell,

> ...special testing is required to diagnose hidden gaps in this understanding. The child's ability to bandy about classification - relevant phrases (e.g."dogs are animals",

> "some of these are red" etc.) either under ordinary questioning or spontaneous discourse is likely to be a most unreliable guide (1963, p.306).

It would appear that a language-free test may be required in order to avoid any confusion between verbal and categorization abilities. In her review of Piaget, Donaldson noted,

> It might be too inadequate a summary of the book to say that it consists in an attempt to show that, in the absence of special inquiry, the child's ability to handle language may grossly mislead us as to his ability to handle classificatory concepts (1960, p.182).

Summary and Research Hypothesis

In summary, it has been suggested in the literature that, for the majority of right-handed unilingual anglophones, the language centres are located in the left cerebral hemisphere. Similarly, there is a great deal of evidence indicating left hemispheric localization in adults for speech production. Conversely, it would appear that the ability to determine visuo-spatial relations may be a function of the right or non-verbal hemisphere.

While it has been demonstrated that certain linguistic functions are performed better by the left hemisphere, many recent studies have suggested that the right brain is involved in the processing of visual verbal material. An overview of related research reveals that the contribution of the right cerebral cortex remains, to some extent, unclear.

It has been suggested that right brain involvement on a given activity may depend on the demands of the task at hand. For example, the right

hemisphere may process verbal stimuli when a non-verbal response is required. The left hemisphere, conversely, may process information in order to communicate. It has also been noted that the right brain involvement in visual processing may be due to the 'quasi-spatial' nature of written language. Although some questions persist relative to the role of the right hemisphere in visual verbal comprehension, there remains little doubt that the non-verbal hemisphere is capable of processing written material.

An overview of the studies in which the non-verbal hemisphere was found to be involved in the processing of visual material revealed that the tests required of the subjects appeared to share a common denominator. It was noted that each of the studies required the basic ability to categorize ideas, words or pictures based on the simultaneous or successive recognition of multiple attributes. For example, it was shown that in 'match-mismatch' tasks subjects were asked to state whether stimuli belonged to the same category, according to their perceived similarities and differences. Similarly, when asked to complete a Cloze passage, subjects were required to choose an appropriate word based on the syntactic, semantic and orthographic attributes, i.e. the attributes would indicate to which category the word must belong. To repeat, in a Cloze passage such as:

Would____please____me____drink____water?

readers demonstrating superior non-verbal abilities are better able to reduce uncertainty through the immediate recognition of multiple attributes thereby reducing the number of possible word categories. Finally, it was noted that this ability to categorize based on identifiable attributes is

not easily assessed. The difficulty would appear to be one of testing categorization ability without testing potential intervening variables associated with verbal or linguistic ability.

It has been suggested that the right brain may play a greater role in categorization ability. Pendse (1978) noted that the non-verbal hemisphere may possess a greater number of optimal categories into which to breakdown information, thus facilitating the categorization process. In addition, Bisiach et al. (1975), having noted the right brain involvement in perceptual categorization, stated,

> The possibility can...be envisaged that generalization processes (within categories) and discrimination processes (between categories) are better performed by the right hemisphere (p. 119).

In view of the role of categorization and the apparent involvement of the non-verbal hemisphere in the processing visual material it might be hypothesized that basic categorization ability is a primary function of the right or non-verbal hemisphere with the left or verbal hemisphere serving a secondary role.

CHAPTER II

RESEARCH DESIGN

In the following sections the sample, instruments and procedures which were used to test the hypothesis, as stated in the previous chapter, will be presented.

The first section will include a brief description of the research instruments used in the study, the Wechsler Intelligence Scale for Children - Revised and the Halstead - Reitan Category Test. Following this description, testing and sampling procedures will be outlined, as well as the statistical operations which were used to analyze the data.

I. Research Instruments

Two research instruments were selected to test the hypothesis, the Wechsler Intelligence Scale for Children - Revised, and the Halstead - Reitan Category Test. In this section, each instrument will be discussed in terms of appropriateness relative to the purpose of the study, its validity and, finally, its reliability as determined by a review of related studies.

a) Wechsler Intelligence Scale for Children - Revised (WISC-R)

To test the relationship between categorization ability and right hemispheric strength, it was necessary to determine the degree of verbal of non-verbal hemispheric functioning demonstrated by each subject. Because no "direct" measures were available to the researcher, an indirect measure had to be selected. The reader should be reminded that an indirect measure is susceptible to interhemispheric "noise" and therefore does not afford a precise indication of relative strengths. Recognizing this possible limitation, the Verbal and Performance Scales of the WISC-R were used to

provide measures of the degree of right and left hemispheric ability.

The WISC-R is a downward extension of the original Wechsler - Bellevue scale designed to test degree of intellectual ability (Littell, 1960). Although the WISC-R follows the same basic format as the Wechsler - Bellevue, many of the test items have been modified to make the test more adaptable to children from 6 to 16.11 years of age (Littell, 1960; Lezak, 1976). The WISC-R is composed of twelve subtests which are divided into two groups, verbal and performance. The Verbal scale consists of six subtests including Information, Similarities, Arithmetic, Vocabulary, Comprehension and Digit Span. The remaining six subtests which consitute the Performance scale are Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding and Mazes.

According to Gardner (1979), differences in scores obtained on the Verbal and Performance quotients of the WISC-R have recently been shown to provide useful information related to minimal brain dysfunction. To illustrate, it has been found that a low score on the Verbal scale may result from a left hemispheric deficiency, while a poor score on the Performance scale may indicate right-hemispheric impairment (Reitan in Ellis, 1966; Reitan and Davison, 1974; Gardner, 1979).

Gardner noted that, as the left hemisphere has been shown to be responsible for certain language functions, linguistic impairment would likely reduce one's score on such verbal subtests as Vocabulary, Similarities and Information. Conversely, the right hemispheric involvement in determining spatial relationships could interfere with the Block Design, Picture

Arrangement, Picture Completion, Object Assembly and Mazes subtests of the Performance scale (Gardner, 1979, p.347).

The majority of studies designed to test the reliability of the Wechsler scales in determining the existence and location of brain dysfunction have been conducted with the original Wechsler - Bellevue scale (Reed and Reitan, 1963; Reitan, 1966; Reitan and Heineman, 1968). As the Wechsler - Bellevue has been shown to be significantly related to the WISC-R; with subtest correlations in the .80's and .90's (Littell, 1960), it is felt that results from these studies may provide information with regard to similar use of the WISC-R.

As noted previously (Gardner, 1979), results from selected clinical studies appear to demonstrate that differences in the Verbal and Performance scales of the Wechsler intelligence scales provide effective measures of unilateral brain dysfunction (Balthazar and Morrison, 1961; Reed and Reitan, 1963; Reitan, 1966; Reitan and Heineman, 1968; Russell, Neuringer and Goldstein, 1970). In one particular study designed to compare results obtained on the Wechsler - Bellevue scale for adults and the WISC with neurophysiological measures of brain dysfunction, Reitan noted that,

> ...results indicated that lateralization of brain lesions has a striking effect on rank-order of...subtest means and that consistent relationships are obtained across a wide range of structural, electrophysiological and behavioral criteria of lateralized brain dysfunction (1966, p. 178).

In a similar study conducted with Wechsler - Bellevue and the WISC, Balthazar and Morrison (1961) noted a significant relationship, at the .005 level (x^2= 39.63 with Yates Correction applied p = .005), between

the Wechsler classification of subjects and the electroencephalographic classification.

While it would appear that the Wechsler scales may provide useful information concerning unilateral brain dysfunction, Gardner (1979) warned that this method of classification would not necessarily be effective for all children, i.e. those suffering bilateral or diffuse deficits. As the existence and localization of brain damage is not under investigation in the present study, it is felt that the Verbal and Performance scales of the WISC-R provide effective measures of relative right and left hemispheric abilities.

b) Halstead - Reitan Category Test

In brief, numerous studies appear to indicate that the right hemisphere may be involved in the process of categorization. In the previous chapter, a review of these studies was presented and it was noted that the non-verbal hemisphere appeared to be involved in those tasks which required categorization ability, i.e. 'match-mismatch', Cloze procedure. Apparently, when subjects were asked to categorize words and pictures as either belonging (match) or not belonging (mismatch) to a particular category, or when subjects were requested to complete a Cloze passage which requires the ability to deal with multiple attributes either successively or simultaneously, notable right brain participation was found.

This basic ability, the ability to utilize multiple attributes either simultaneously or successively, to subsume certain attributes, to

recognize similarity of attribute groupings, and to shift from inappropriate to appropriate attributes is not easily assessed. As was noted earlier, according to Flavell,

> ...special testing is required to diagnose hidden gaps in this understanding. The child's ability to bandy about classification-relevant phrases (e.g. "dogs are animals", "some of these are red" etc.) either under ordinary questioning or in spontaneous discourse is likely to be a most unreliable guide (1963, p.306).

This suggests the appropriateness of a language-free test, one in which the subject's categorization abilities would be camouflaged by verbal gymnastics. As Donaldson has stated, in her review of Piaget and Inhelder (1959),

> It might be too inadequate a summary of the book to say that it consists in an attempt to show that in the absence of special inquiry, the child's ability to handle language may grossly mislead us as to his ability to handle classificatory concepts (1960, p. 182).

In an effort to avoid any interference in terms of linguistic ability and to obtain a clear measure of the ability to identify and categorize on the basis of single and multiple attributes, the instrument selected to measure the dependent variable, defined in terms of categorization ability, was the Halstead - Reitan Category Test.

Developed originally by Halstead to test conceptual ability in adults, the Category Test has since been modified by Reitan (and Heineman, 1968) to provide measures of categorization ability in younger and older children. In the present study, the Intermediate Category Test designed for children from ages 9-14 was used.

The same basic principles are employed in the Intermediate Children's Category Test as are in the original Halstead test. The Intermediate Test is, however, organized more simply than the adult test, containing 168 items instead of the original 208 items. The items are divided into seven groups of pictures, each of which has a single principle or attribute running through the entire group from beginning to end. The attribute shift from group to group, i.e. from size to colour, requires "the ability to interpret the same non-verbal stimulus in more than one way" (Hamen, 1981, p. 127). The subject is required to abstract the principle employed in each item based on multiple attributes such as size, shape, number, brightness and colour. Items become increasingly more difficult in the final group of pictures where the subject is first required to identify the relevant attribute and then make an attribute shift from one picture to the next, a task presumably analagous to the shift from syntactic to semantic or from semantic to orthographic attributes. Each item contains four pictures which are presented to the subject on a projection apparatus. The subject indicates his or her response by depressing one of four levers which correspond to the four alternatives presented on the panel. A correct response is reinforced with the sound of a bell while a buzzer indicates an incorrect response. The score for each subject is determined by the number of incorrect responses (Knights and Tymchuk, 1968).

In brief, Reitan and Heineman (1968), noted that,

> The Category Test is a relatively complex concept formation test which requires fairly sophisticated ability in noting similarities and differences in stimulus materials, postulating hypotheses that appear reasonable with respect to

> recurring similarities and differences in the simulus material, testing these hypotheses with respect to positive or negative reinforcement (bell and buzzer), and adapting hypotheses in accordance to the reinforcement accompanying each response (p.105).

The Category Test is used extensively in neuropsychological assessment. Its wide use and acceptance appear to indicate its validity as a test of concept formation ability (Knights, 1982). While the test is included in the Halstead - Reitan Neuropsychological Test Battery designed to detect brain damage in children, Knights and Tymchuk (1968) have pointed out that an impairment in abstract thinking ability can result from poor learning as well as from cerebral dysfunction.

To illustrate, Knights and Tymchuk (1968) conducted two experiments in order to investigate the relationship between Category Test scores and various learning disorders, e.g. Known Lesions, Epileptics, School Problems, Emotional Problems, Retardates and Normals. Their results indicated that the category error scores produced significant differences ($F = 2.46$; $df = 5,234$; $p < .05$) among Normals, Retardates and other groups, although the test did not discriminate between children with brain damage and those with social adjustment problems. Second, it was found that the category scores are significantly related ($F = 2.68$; $df = 8,126$; $p < .01$) to degree of intellectual impairment. These results appear to be consistent with previous findings indicating a significant correlation (.33 to .63) between Full Scale IQ scores on the WISC and the Category Total Score (Knights and Tymchuk, 1968).

The authors, in apparent agreement with Reed and Reed, suggested

that the level of abstract thinking may be a function of "the level of intelligence rather than illustrating specific (neurological) impairment..." (Knights and Tymchuk, 1968,p.412). In conclusion, it is stated that,

> The Category Test is not a test of brain damage but a test of abstraction ability...which is sensitive to impaired abilities in children, whether it be related to adjustment problems or cerebral dysfunction (Knights and Tymchuk, 1968, p.413).

2. Research Methods: The Design

Due to the nature of the present investigation, i.e. the research instruments used and the data collection procedures applied, a quasi-experimental design was employed. According to Stanley,

> ...there are many natural social settings in which the research person can introduce something like experimental design into his scheduling of data collection procedures (e.g. the when and to whom of measurement) even though he lacks full control over the scheduling of experimental stimuli (the when and to whom of exposure and the ability to randomize exposures) which makes a true experiment possible. Collectively, such situations can be regarded as quasi-experimental designs (in Keith, 1972, p.73).

In view of the difficulty encountered in obtaining the testing apparatus necessary for the Halstead - Reitan Category Test and in providing the required testing conditions, this type of design appeared to be most appropriate for this study. All children referred for psychological testing at the Children's Hospital of Eastern Ontario (CHEO) are administered the WISC-R and the Category Test as part of the basic neuropsychological assessment. In this manner, the researcher was able to determine the selection criterion, and choose the sample from a relatively large

number of children from Eastern Ontario and Western Quebec.

At CHEO, the WISC-R and Category test are administered by two registered psychometrists. Standardized procedures are followed in the administration of both tests. Due to the widespread use and acceptance of the WISC-R it was not deemed necessary to include a description of those procedures here. Standardized procedures for the administration of the Category Test can be found in Appendix I.

3. The Sample

Eighty-five junior-grade children who were referred to the Psychological Assessment Unit of the Children's Hospital of Eastern Ontario as either in-patients or out-patients were selected on the basis of age. Basically, the children who receive testing comprise two main groups: a) Those children who are referred as out-patients by family physicians and/or school psychologists and b) those children who are admitted to the hospital with known physiological impairment, e.g. epilepsy, head injury etc. Referrals to CHEO come from a relatively large geographical area covering Eastern Ontario and Western Quebec.

The sample was selected from the population on the basis of age. According to the theories of Bruner and Piaget, intellectual development is characterized by an increasing ability to categorize objects and events which one encounters in one's world. As this ability is said to become more efficient with age, it was decided to select those children who ranged in age from ten years to ten years, eleven months. Subjects admitted for testing with head injury were excluded from the study. Of

the eighty-five subjects selected, sixty-eight were males and seventeen were female.

4. Plan For Statistical Analysis

The data were analyzed using a BMD P6R computer programme for partial correlation and multivariate regression analysis. Three variables were included; the dependent variable consisted of the scores derived from the Halstead-Reitan Category Test; scores derived from the Performance scale and the Verbal scale of the WISC-R constituted the two independent variables.

The formula for partial correlation, as described by Keith (1972, p.68) is as follows

$$r_{12.3} = \frac{r_{12} - r_{13}r_{23}}{(1-r_{13}^2)(1-r_{23}^2)}$$

A partial correlation analysis was conducted in order to examine the relationship between categorization ability and the Performance scale of the Wisc-R, with the Verbal level held constant or partialled out. The analysis also enabled the researcher to examine the relationship between the Verbal scale and categorization, with the Performance level held constant.

5. Summary

In summary, two research instruments were selected to test the hypothesis: The Wechsler Intelligence Scale for Children - Revised and

the Halstead - Reitan Category Test. The Verbal and Performance scales of the WISC-R were used to provide measures of relative left and right hemispheric abilities. The Category Test was employed to test the dependent variable, defined as categorization ability.

Subjects included eighty-five children referred for psychological assessment at the Children's Hospital of Eastern Ontario. The sample was selected on the basis of age. Of the eighty-five subjects, sixty-eight were male and seventeen were female.

Data were analyzed using a BMDP P6R programme for partial correlation and multivariate regression.

CHAPTER III

PRESENTATION AND DISCUSSION OF RESULTS

In this chapter, the results of the analysis will be presented and discussed. In the first section, the data from the partial correlation will be presented. The second section will include a brief summary of the theoretical rationale and the third part, a discussion of the results as they relate to the existing literature.

1. Presentation of the Results

The analysis of the data indicated that categorization ability is more closely correlated with the non-verbal hemisphere than it is with the verbal hemisphere. When verbal abilities were partialled out, a T value of -2.8929413 was found to exist between non-verbal scores on the WISC-R and categorization abilities, a value which was found to be significant at the .01 level. Conversely, when non-verbal abilities were partialled

TABLE I

PARTIAL CORRELATIONS

Independent variable	Partialled-out variable	T value	r_{crr}	$p < .01$
Non-verbal	verbal	-2.8929413	-.448	.007*
Verbal	non-verbal	-2.21655551	-.411	.04

out, T value of -2.21655551 was found to exist between verbal scores derived from the WISC-R and categorization abilities, a value which was found to be significant at the .05 level but not at the .01 level.

2. Hemispheric Differentiation and Categorization: A Recapitulation

As noted earlier, a major concern in recent literature has been the question of the relationship between cerebral lateralization and learning. Apparently, certain intellectual functions are localized in either the right or left cerebral cortex. It has been suggested in the literature that, for the majority of adults, language centres are located in the left brain, while the ability to determine visuo-spatial relations is a function of the right brain.

Numerous studies have demonstrated that certain linguistic abilities are performed better by the left hemisphere. Results from these same studies, however, have also indicated that the right hemisphere is involved in the processing of visual verbal material.

A review of related research suggests that right hemispheric involvement in language processing depends on the task at hand. For example, it has been noted that when subjects were asked to classify words and pictures as belonging (match) or as not belonging (mismatch) based on certain identifiable attributes, the non-verbal hemisphere appears to be able to process the items faster and with greater accuracy than the verbal hemisphere. Similarly, when subjects were asked to complete a Cloze passage, supplying a missing word using syntactic and semantic clues, it was noted that those

with stronger non-verbal abilities seem to be more readily able to reduce the uncertainty regarding the possible alternatives which can be applied to each space. To repeat, in a Cloze passage such as "Dick _____ home after school", readers demonstrating superior non-verbal abilities are better able to reduce uncertainty through the immediate utilization of multiple attributes thereby reducing the number of possible word categories.

Finally, it was noted that this ability to categorize based on identifiable attributes is not easily assessed due to the potential intervening variables associated with linguistic ability.

In view of the apparent involvement of the non-verbal hemisphere in those tasks requiring categorizaiton ability the research hypothesis was stated as follows: Basic categorization ability is a primary function of the right or non-verbal hemisphere with the left or verbal hemisphere serving a secondary role. As indicated in the presentation of the results, this hypothesis has been supported. It has been found that categorization ability may be primarily a function of the non-verbal hemsiphere, with the verbal hemisphere playing a secondary role.

3. Discussion of the Results

The results of the analysis, designed to test the research hypothesis, would appear to indicate that categorization ability may be related to both the Verbal and Performance scales of the WISC-R. As stated in the hypothesis, the results suggest that categorization ability may be primarily a function of the right or non-verbal hemisphere, with the left or verbal hemisphere

playing a secondary role.

In this section these results will be discussed in terms of the research problem and hypothesis identified in Chapter I. In addition suggestions will be made for further research in the area.

In order to test the hypothesis, measures for a total of eighty-five subjects were obtained for the Verbal and Performance scales of the WISC-R and for the Halstead-Reitan Category Test. The two subscales of the WISC-R were selected to determine the degree of relative right and relative left hemispheric abilities for each subject. It should be noted that for left-handed subjects those abilities measured by the Verbal and Performance scales of the WISC-R may be reversed in terms of cerebral lateralization, i.e. the Verbal scale may indicate right brain abilities and the Performance scale may be an indication of left brain functioning.

As a means to provide an accurate measure of the variability in category scores due to right brain activity, it was deemed necessary to determine the extent of the relationship between the dependent variable and left brain functioning. As was noted earlier, it would appear that the process of categorization requires some form of verbal mediation. According to Bruner (1957), category formation, i.e. the identification of those attributes necessary for category membership, is followed by the process of labelling. A verbal label thus facilitates category recall and the recognition of other elements which might fit into the established category. Similarly, Dechant (1970) has explained,

> ...that the child must learn to categorize. He must group his experiences into classes. Abstraction isolates the

> basic characteristics, and categorization applies it to more objects. The word of verbal symbol, in turn, is the verbal expression of a concept (abstracted attributes necessary for category membership). (p.370).

As such, a category could be defined as a labelled abstraction, whose meaning is derived from its linguistic context.

In other words, a child may have a rudimentary understanding of the word "blind". To him, it may simply be a word used to describe some animal or person, a blind dog or a blind man. To another child the word may have been encountered only as a noun, a word synonymous to or belonging to the category of words having to do with a window shade. Both children, however, encounter similar problems differentiating between "a venetian blind" and "a blind Venetian" (Smith, 1971). It is difficult to understand how the differentiation process can be accomplished successfully without some form of linguistic mediation, without the child being able to transform the words into parallel or equivalent linguistic structures by recognizing that in each case the word "blind" belongs to different linguistic categories. In both cases, the meaning of "blind" is not determined solely by the word itself but, rather, from the context in which the word is found, i.e., its semantic and syntactic attributes. It is the attributes which determine the category to which the word is assigned.

Chomsky (in Logan, 1977), extending the behaviorist S - R (stimulus - response) theory, has also noted the likelihood of verbal mediation. He has suggested that a child achieves understanding by transforming the stimulus into a form more compatible with his existing category structure:

As such, the child will evaluate the meaning of the stimulus relative to his previously formed category. To illustrate, according to the theory of S - M - R (stimulus - mediator - response), Victor, upon encountering the phrase "You must book your holiday one month in advance", would refer to his existing category of 'book' and adjust that category to fit the new syntactic and semantic attributes which he encounters. In this manner, his category of 'book' will be expanded in order to accommodate the newly identified attributes.

At a more basic level, Vygotsky, Luria and Sokolov (1972) have noted that verbal mediation in children may occur through inner speech. As the term suggests, inner speech is simply the "internal-projection" of external speech. To illustrate, when presented with a panel containing four objects with various attribute similarities and differences, the objects will be identified and compared according to the child's abstracted labels of "size", "shape", "colour", etc. In this manner, the process of attribute identification is facilitated through the use of labels or verbal symbols. Given the existence of verbal mediation at even the most basic level of categorization, a relationship between the dependent variable and the left or verbal hemisphere was expected.

A partial correlation was used to analyze the data. As such, the researcher was able to partial out the effects of each independent variable in order to arrive at the variability attributable to each of the independent variables.

Results from the correlational analysis supported the research

hypothesis. Basically, it was found that although categorization ability is related to both the Performance and Verbal scales of the WISC-R, a greater relationship would appear to exist between the dependent variable and the Performance scale of the WISC-R than between categorization ability and Verbal scale.

The relationship between categorization scores and right hemispheric ability has been previously noted by Knights and Tymchuk (1968). According to their results, categorization ability correlates more highly with Performance IQ than with Verbal IQ. Results in the present study appear to corroborate these findings. It might be recommended that, in future research designed to investigate the relationship between categorization ability and right brain functioning, a more direct method of determining the hemispheric localization of specific functions be used. In Chapter I it was noted that much of the research done in this area was conducted using "indirect" methods of investigation as opposed to the "direct" methods, i.e. clinical procedures with brain-damaged patients. While the clinical procedures appear to provide a much more accurate measure of cerebral lateralization, it has been suggested that patient availability makes this type of testing difficult. Advances in CT, PET and NMR scanners, however, may facilitate this type of investigation in the future.

In addition, one might suggest conducting a similar study with a larger sample from a more normally distributed population where data could be analyzed using an analysis of variance. This would enable the researcher to utilize what might be considered to be a more robust analysis (Keith, 1972).

In brief, then, it would seem that the ability to categorize based on multiple attributes may be primarily a function of the right cerebral hemisphere with the left or verbal hemisphere serving in a mediating capacity. These results were expected due to the nature of the tasks required of the subjects in those studies where large right hemispheric involvement was noted in processing visual verbal material. To repeat, it would appear that the right brain may be primarily responsible for the ability to identify multiple attributes and categorize based on these attributes. Returning, once again, to the Cloze passage

"Would_____please_____me_____drink_____water?

it could be stated that the ability to fill in the blanks based on the syntactic, semantic and, possibly, orthographic attributes, is a function of the non-verbal hemisphere. Right hemispheric involvement on a Cloze task was also noted by Hamen (1981). The reader is reminded that the common denominator in those studies noting superiority of the non-verbal hemisphere would appear to be categorization ability.

For example, right brain involvement may not have played as prevalent a role in those studies where the ability to process visual verbal material was measured by tests of oral reading ability, word identification etc. It may be noted that the Woodcock Mastery Reading Test seems to be unique in measuring this ability to "interpret stimuli in a variety of ways" (Hamen, 1981). As indicated in Appendix III, for most reading tests, i.e. (PIAT), a higher correlation may be found with the Verbal scale than with the Performance scale of the WISC-R. Thus, it has been assumed that reading

ability is almost exclusively verbal in nature. It might be suggested, at this point that, had Vamen used the WRAT or one of the similarily constructed reading tests, her results and conclusions could have been considerably different from those obtained and presented.

As was stated earlier, the relationship between categorization ability and the Verbal scale of the WISC-R was expected due to the general agreement in the literature that some form of verbal mediation is required in the categorization process. To repeat, Bruner has suggested that the final stage in categorization is labelling, that is, those objects or events with common attributes are grouped together under one label. In the early stages of development, this verbal mediation may exist in the form of inner speech. In other words, the child may simply internalize the label that he has acquired through external speech. For example, when first learning the word 'book', Victor was simply internalizing the word he heard every time Dr. Itard showed him a book. At a higher level of abstraction, i.e. "I want to book a flight to Florida", the meaning of the word 'book' is derived from the syntactic and semantic context in which it is found. The verbal mediation or labelling process could account for the relationship between categorization ability and the left or verbal hemisphere.

To recapitulate, the results of this study may provide some insight into those obtained in the Vamen (1981) investigation. Quite simply, it would appear that the ability to categorize based on the identification of multiple attributes is likely to be primarily a function of the right or non-verbal hemisphere with the left or the verbal hemisphere playing a secondary role.

4. Summary

In this chapter, the results of the partial correlation analysis were presented. In brief, it would appear that the ability to categorize based on multiple attributes may be primarily a function of the right cerebral hemisphere with the left or verbal hemisphere serving in a mediating capacity.

A brief summary of the theoretical rationale upon which this study was based was presented and the results of the analysis were discussed in terms of the existing theory. It was noted that the results of the present study appear to corroborate those found in previous studies, where the non-verbal hemisphere was found to be superior on those tasks requiring the ability to categorize. In addition, the relationship between the verbal hemisphere and category scores was discussed. According to the literature, some form of verbal mediation is required in the process of categorization, whether in the form of inner speech or subvocalization of identifiable attributes. Finally, some suggestions were made for further research in the area.

CHAPTER III

SUMMARY AND CONCLUSIONS: IMPLICATIONS FOR READING

A great deal of recent research appears to have been conducted in order to investigate the relationship between cerebral lateralization and learning. Clinical studies involving brain-damaged patients have cast some light on the hemispheric localization of various intellectual functions. Results from these studies have suggested language to be primarily associated with the left brain and visuo-spatial perception to be related to the right brain.

In the first chapter of this report an attempt was made to determine the hemispheric localization of certain intellectual abilities. For example, there appears to remain little doubt that speech production is primarily a function of the left brain in the majority of right-handed adults. An overview of related research, however, seems to indicate that each side of the cerebral cortex is capable of processing visual verbal material. It would appear that the demands of the task at hand determine the extent of the involvement of the right or left brain. To illustrate, it has been suggested that the left or verbal hemisphere may process information in order to communicate, while the non-verbal hemisphere may process material when no communication is required.

It has been noted that the research appears to be flawed by a seering myriad of operational definitions of visual verbal comprehension. Upon closer investigation however, it became apparent that those studies which appeared

to indicate a right brain superiority in the processing of written material shared a common denominator: in each case the task required the ability to categorize. The research question was stated, therefore, as: Are basic categorization abilities a primary function of the right or non-verbal hemisphere with the left or verbal hemisphere serving a secondary role?

The current study evolved from a recent investigation of reading comprehension, as measured by the Cloze technique, as a function of relative hemispheric strengths (Wamen, 1981). Briefly, it has been shown that a Cloze passage such as

Would _____ please _____ me _____ drink _____ water?

where the subject is required to supply the deleted words, tests a subject's ability to reduce the number of possible alternatives by predicting a category of words using syntactic, semantic and, possibly, orthographic attributes. Should the reader approach the second space, in the above example, testing attributes consecutively, he might syntactically reduce all possible alternatives to the category of verb, then to the subsumed category of transitive verb. Then, making a primary attribute shift, the number of possible alternatives would be reduced, semantically, to the word or category of words which will convey the most appropriate meaning. As was noted earlier, results in the Wamen study indicated that the better readers, when tested using the Cloze technique (Woodcock Mastery Reading Test), deronstrated superior right brain abilities when compared with older reading-handicapped subjects. These findings have implications in terms of clarifying the nature of reading comprehension as defined in

psycholinguistic theory.

Implications for Reading

That which follows is a discussion of categorization ability as it relates to reading comprehension. In addition, studies related to the psycholinguistic theory of reading will be reviewed.

There appears to be general agreement among theorists that "comprehension is the main goal...or aim of reading" (Lamberg and Lamb, 1980,p.56), and that, without comprehension one is not reading (Stauffer, 1975,p.56). Expressed more precisely, Smith (1971, 1973) has viewed reading comprehension as a process of reducing the degree of uncertainty which one encounters in one's reading. According to Smith and Goodman (1968), a child attempts to obtain meaning from print in much the same manner that he attempts to understand his environment.

A child's effort to understand his environment has been described by Piaget (1959; Ginsburg and Opper, 1969) and Bruner (1957; Bruner, Goodnow and Austin, 1956; Bruner, Olver and Greenfield, 1966), who have suggested that cognitive development is predicated upon the ability to reduce the complexity of one's world through the process of classification or categorization. Apparently, imposing structure on experience enables the child to adapt more readily to his world by assimilating new events into his current structure or accommodating his existing structure to meet environmental demands. According to Lamberg and Lamb (1980), individuals

> ...observe, compare and contrast, and then categorize particular experiences. They arrive at generalizations which allow them 1) to group specific experiences together, or categorize them on the basis of common characteristics and 2) to distinguish these experiences from others. As individuals learn and encounter more and more experiences, the categories are continually revised and expanded (p.40).

Essentially, the process of categorizing objects or events according to their perceived similarities and differences allows the individual to respond to different members of the same class in a similar fashion, for class membership implicitly suggests a degree of equivalence. In this manner the complexity of one's environment can be greatly reduced. Bruner has gone one step further stating that

> ...all perceptual experience is necessarily the end product of a categorization process...for whatever is perceived is placed in and achieves its meaning from the class of precepts with which it is grouped (Bruner et al., 1957, p.124).

According to Bruner, then, the process of categorization not only reduces complexity by allowing the individual to deal with generalizations, but is absolutely necessary if a visual stimulus is to be identified, for identification occurs only when the stimulus can be grouped into a particular category. Furthermore, the number of categories into which the stimulus might be allocated is determined by the experience and expectations of the individual (Holmes, 1973).

For example, the young child, upon first encountering an orange, may assume that all round objects of a certain colour are oranges. As the child becomes acquainted with other objects which are similar but not

identical, however, he will clarify the attributes determining the category of 'oranges'. What may initially be defined in very concrete terms such as orange colour, round etc., may then be defined according to a particular taste and smell and finally, in more abstract terms such as citrus fruit, grown in Florida, etc. With experience the child is able to identify and define the attributes necessary for an object to be included in the category of 'oranges', always increasing the number of recognizable and relevant attributes, always reducing the degree of uncertainty as to whether or not newly-encountered objects belong or do not belong to the category 'orange'.

Very briefly, it has been noted that categorization ability is basic to the process of adapting to one's environment. Apparently, it is the ability to impose structure on the outside world by grouping objects and events together based on their identifiable attributes which allows the individual to cope with the complexity of his surroundings. According to Bruner and Piaget, the process of adaptation is a developmental process, which becomes increasingly more efficient with age. As thought processes progress from the concrete to the abstract the individual is able to deal with an increasing number of attributes simultaneously. Thus, the orange is no longer simply a round object that is good to eat but, rather, a citrus fruit that grows in certain parts of the world, a source of vitamin C, etc. Having identified those attributes which make an orange an orange, one is able to apply this information to other objects. The situation becomes more complex or abstract when one encounters terms such as 'orange car' or 'Orangeman'. Stauffer (1975) has stated that,

> Levels of abstraction might best be defined as a means of grouping or categorizing concepts by an ever more definitive recognition of attributes. Symbols acquire meaning by constant association with their referents and their essential attributes...Some symbols refer to referent attributes that are readily identifiable; for example - ball - size, shape, weight. Others refer to attributes that seem to have a capricious variety of associations; for example, smile - bright, fleeting, shy (p.117).

As thought becomes more abstract, more removed from the concrete, verbal symbols represent increasingly more complex ideas.

According to Stauffer, "the primary purpose of symbols is to communicate meaningfully" (p.116). It is important to note that symbols or words do not themselves possess meaning. Rather, the symbol or word becomes meaningful inasmuch as it represents an object, event or idea encountered through interaction with the environment. In other words, the word symbolizes the category, e.g. the word 'orange' represents a group of objects with similar identifiable attributes. At a higher level of abstraction, the words 'citrus fruit' represent a category which subsumes the orange, grapefruit and lemon categories.

Stauffer (1975) also pointed out that "when pupils are learning to read, they are learning a new set of symbols (printed words) to stand for another set of symbols (spoken words) that stand for their mental constructs (p.118). As Smith noted, however, while one is dealing with a new set of symbols the process of achieving understanding is the same. In his words,

> Reading for comprehension or identification of meaning involves the allocation of visual information into category structures that represent meaning to the reader (1971, p.77)

In this manner, Smith has viewed reading as a process of categorization. Just as the child attempts to understand his world by imposing structure on the objects and events which he encounters in the environment so, too, does he attempt to obtain meaning from print. Smith suggested that

> In reading, categories exist at many different levels, the level of letters, words, sentences, ideas. These categories are identified, in turn, by different orthographic, syntactic and semantic attributes; that is, they may be characterized by their letters, grammatical relationships or by their meaning (Logan, 1977, p.51).

In order to read, then, the child must be able to deal with multiple attributes, i.e. orthographic, syntactic and semantic attributes, simultaneously or successively. To illustrate, Stauffer (1975, p.118) has refered to the word 'stand'. He described children reading a story where 'stand' is used as a noun to mean a stall or booth for business. While the children had previously learned that the printed symbol 'stand' meant to support oneself on one's feet in an erect position, they apparently had no difficulty making the shift in meaning as the story context (syntax and semantics) and the picture context (illustrations) helped convey the idea. A basic understanding was achieved although they were vague about the definite and potential attributes that would help them put 'stand' in a verb or noun category. Nonetheless, in future reading the children would be able to determine meaning or identify the category based on the syntactic attributes, or word position, e.g. You stand up (verb) as opposed to lemonade stand of newsstand (nouns).

The process increases in complexity as children learn more abstract

meanings such as to 'take the stand', to 'stand accused', to 'stand firm', to 'stand the cold', to 'stand up for your rights' or to 'stand a chance'. Recognizing that 'stand' could belong to many different word categories, the reader must identify multiple attributes. While the syntax will indicate whether 'stand' is a verb or noun, much more will be needed in order to detect the subtle semantic differences in the phrases mentioned above. The reader must achieve comprehension by chunking the visual information into larger units that are meaningful to him (Smith, 1973; Stauffer, 1975; Logan, 1977). In other words, the reader will identify the semantic attributes by grouping together the words, 'stand up for your rights' and , in so doing, be able to distinguish the meaning from other phrases such as 'stand up for an hour'. Thus, comprehension is achieved not by the simple recognition of words but by the recognition of meaningful word patterns (Carroll in Lamberg and Lamb, 1980, p.5).

Of primary importance in the psycholinguistic theory is the idea that the reader's prior knowledge, or existing cognitive structure, contributes more to reading comprehension than what is actually written on the page (Hayes, 1979). Because whatever is perceived achieves its meaning from the category into which it is placed, comprehension is said to precede word identification (Smith, 1973). By relating the visual information in a line of print to what is already known, the reader is able to reduce word uncertainty, i.e. the number of possible word categories, and, in turn, to predict or anticipate what may follow (Holmes, 1973).

In a similar manner, Goodman (1968) has viewed reading as a process

of selection and prediction, where the reader predicts what will follow based on his experiences and cognitive development and then selects the graphic cues necessary to confirm his predictions (Hayes, 1979). The number of graphic cues required will depend upon the degree of uncertainty that the reader brings to the task. In other words, reading ability is determined by the amount of information and organization 'behind the eye'. Whereas the efficient reader uses the syntactic and semantic cues from within his existing cognitive structure as primary referents, relying on graphic cues only to verify his predictions, the poor reader uses graphic cues as primary referents (Hayes, 1979).

To return, once again, to Stauffer's example, be noted that when the children first encountered a new meaning for the word 'stand', they were able to achieve comprehension based on the story context (syntax and semantics) and the illustrations. At this point, the readers were relying heavily on the graphic information on the page. Having adapted their cognitive structure to accommodate a new meaning for the word 'stand' (a place where things are sold such as a lemonade stand or a newsstand), in future reading they would require only minimal graphic information in order to assign the word to one of two pre-established categories.

To explain further, Smith (1973) investigated reading in terms of mediated and immediate categorization processes. In addition, each of these processes was examined in terms of word identification and comprehension. Briefly, immediate word identification involves assigning a word to a category based on only a few distinctive features, whereas mediated word

identification means progressing from the distinctive features to individual letter identification and, finally to word identification. Similarly, immediate comprehension occurs when understanding is achieved based on the distinctive features in the test, while mediated comprehension relies on graphic cues and word identification. It could be stated, then, that letter identification is not necessary for word identification and word identification is not necessary for comprehension. According to Smith, only the immediate method of reading comprehension is truly efficient. In more concrete terms, the proficient reader is able to predict word categories by their syntactic, semantic and orthographic attributes and requires only minimal graphic cues in order to verify his predictions.

In summation, it would appear that degree of reading efficiency may depend on the ability to relate incoming visual stimuli to existing cognitive structure. In psycholinguitic theory reading is viewed primarily as a process of categorization. Apparently, comprehension is achieved through the chunking of visual information into larger units that are meaningful to the reader. The reader with a large number of categories at his disposal, or with the ability to determine categories by their relevant attributes, will be better able to recognize and identify language redundancy and, thus, to predict or anticipate what will follow. The ability to anticipate requires that the reader use only minimal graphic cues to verify his predictions.

The psycholinguistic approach to reading appears to have gained considerable support in the literature. It has been shown, for example,

that when reading in order to identify meaning, words are the smallest units employed by the skilled reader (Kolers, 1973; Mason, 1978; Friedrich, Schodler and Juola, 1979). Apparently, letter and syllable identification lead to a decrease in comprehension and an increase in the time required to process visual information (Friedrich et al., 1979). According to Kolers (1973), skilled readers perceive familiar words as wholes or symbols, and operate on them in terms of their meaning and their relations to other symbols. Mason (1978) found that reading ability was related to speed of word recognition or, more specifically, to skilled use of visual code rather than phonological encoding. In brief,

> For the reader to focus on the meaning, most words must be processed quickly and easily. The non-fluent reader, who laboriously and slowly tries to analyze words, often loses the train of thought and quite often is unsuccessful in figuring out the words; he or she becomes bogged down with the letters and their discrete sounds (Lamberg and Lamb, 1980, p.9).

In short, it would appear that superior reading comprehension may be predicated upon the ability to categorize visual information into larger meaningful units. Indeed, in one study designed to investigate the relationship between Piagetian classification ability and reading, it was found that the good classifiers had higher achievement on comprehension test items (Gillet, 1978).

To summarize, an attempt has been made to establish the significance of categorization ability as it relates to the reading process. In view of the general agreement among theorists that verbalizing printed material without comprehension does not constitute reading (Tintz, 1980, p.249), focus in this section has been placed on reading comprehension. First, it was shown

that the ability to adapt to or understand the environment is predicated upon the ability to impose structure on experience. Pechant has noted that

> ...the child must learn to categorize. He must group his experiences into classes. Abstraction isolates the basic characteristics, and categorization applies it to more objects. The word of verbal symbol, in turn, is the verbal expression of a concept (Hogan, 1977, p.38).

It was also noted that children attempt to obtain meaning from print in much the same manner as they adapt to their environment. When reading, the child recognizes symbols on the printed page that trigger understandings he has developed about life (Harris and Smith, 1980). Important here is the notion that comprehension precedes word or letter identification. According to Lamberg and Lamb (1980),

> Even at the literal level, readers must bring some experience to the text - at the very least, their knowledge of the spoken language. At higher levels, comprehension is possible only if readers have access to information and ideas beyond that which is in the text itself (p.58).

As Goodman suggested then, experiential background and knowledge of language redundancy enable the reader to predict what he will encounter in the text, thus requiring only that he select minimal graphic cues in order to confirm his predictions. It has been found that the efficient reader achieves comprehension through the recognition of meaningful word patterns, as opposed to individual letter and word identification. In this manner, the reader relies on the syntactic (how the words work together) and the semantic (the idea the word pattern represents) attributes. This might best be illustrated with the popular example of the 'blind Venetian' and

the 'Venetian blind' (Miller, in Smith, 1973, p.13). While the letters and words in the phrase are identical, the meanings are completely different. As such, the reader must rely on the syntactic and semantic attributes in order to understand, for the graphic information alone is, at best, somewhat confusing.

The truly efficient reader, then, is able to employ what has been referred to as "immediate comprehension" or previously acquired categorization abilities which he brings to the reading encounter; that is, for the fluent reader, comprehension accompanies or precedes word identification. Anticipating word categories by their syntactic, semantic, orthographic and phonological attributes, the proficient reader can predict, by reducing the number of possible alternatives, the next word or category of words to be read.

The results in the present study have demonstrated that the right or non-verbal hemisphere may be primarily responsible for the the ability to categorize which, according to psycholinguistic theory, is basic to the reading process. In addition, it has been suggested that the linguistic nature of written material and the apparent necessity of verbal mediation in the categorization process indicate the importance of some left hemispheric involvement. Clearly then, reading for comprehension requires the participation and co-operation of both hemispheres.

If one accepts that reading is a bilateral activity, it would appear reasonable to suggest that the teaching of reading should be directed towards the enhancement of those abilities associated with both the left and right

hemispheres. Traditionally, however, the emphasis in the classroom seems to have been on those skills normally associated with the left cerebral cortex, e.g. letter and word identification (Hunter, 1976). Interestingly, it is these skills which, according to psycholinguistic theory, are not of paramount importance in efficient reading (Smith, 1971, 1973; Holmes, 1973; Kolers, 1973). In Smith's view, letter and word identification play minimal roles in passage comprehension. Furthermore, emphasis on these skills may slow down the reading process and may, consequently, inhibit understanding.

While it is recognized that word and letter identification are required in the reading process, it has been shown that these abilities do not necessarily differentiate between poor and efficient readers (Logan, 1981). According to Logan,

> That which distinguishes consistently between good and poor readers is not their ability to cope with individual words, but their ability to combine them, to "chunk" them into units of meaning... (1981, p.3).

It would appear then, that true reading efficiency is dependent upon the visuo-perceptual skills associated with the non-verbal hemisphere. It is suggested, therefore, that greater emphasis should be placed upon the development of these skills in the classroom.

More insight into what classroom activities might enhance the development of right-hemispheric abilities can be gained from tests designed to examine them. To illustrate, the Performance scale of the WISC-R includes the Picture Completions, Picture Arrangement, Block Design, Object Assembly, Coding and Mazes subtests. As these tests have been shown to provide a measure of the degree of hemispheric ability, activities based upon the

tests should promote the development of these skills.

As one example of the seemingly endless range of possibilities, one might suggest that greater emphasis be placed upon physical education in order to enhance body orientation and spatial relations skills. Apparently, familiarity with one's body, one's 'space', enhances the understanding of such principles as magnitude, direction and relativity (Witkin et al., 1974). The opportunity to physically interact with the environment provided in physical education may, therfore, permit the development of these visuo-spatial skills which have been shown to affect reading ability.

Conclusions

The intent of the present study was to determine whether categorization ability is primarily a function of the right or non-verbal hemisphere, with the left or verbal hemisphere playing a secondary role. Indeed, the results were interpreted as indicating that this may be the case, although further research in the area is certainly warranted.

In terms of pedagogical implications, discussion was centered on reading comprehension as it is defined in psycholinguistic theory. In view of the psycholinguistic approach to reading and the results obtained in the study, it has been suggested that reading is a bilateral activity, requiring the participation and co-operation of both cerebral hemispheres. As such, the author concluded that greater emphasis in the classroom should be placed on enhancing right hemispheric abilities as, traditionally, emphasis has been placed on the development of those skills associated with

the left brain.

While the primary focus of this report has been on the comprehension of visual verbal material, it is felt that the implications could conceivably be generalized beyond. As Bruner and Piaget have suggested that intellectual development is predicated upon the ability to categorize that which one encounters in one's environment, the possibility exists that the enhancement of those skills demonstrated by the right hemisphere may ultimately facilitate the process of adapting to an ever-changing world.

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APPENDIX I

Category Test

Young and Intermediate

Description

The Category Test, designed by Halstead, and modified by Reitan is a relatively complex test of concept formation requiring non-verbal abstract reasoning ability. The level of performance is related to effective reasoning skills and judgement. A projector is used to present the slides comprising the test. The child is required to abstract principles in each subtest based on variables of size, shape, number and position. Each of the first subtests involves a specific principle to be determined by the child and the last subtest consists of selected slides presented in the preceding subtests, introducing a memory component. A bell and buzzer provide immediate feedback regarding responses.

There are two Category Tests, one for Young Children and one for Intermediate Children.

Administration and Scoring

The child is seated directly before the screen in a somewhat darkened room and is told:

For Intermediate Children

On the screen in front of you, you are going to see pictures of different geometrical figures and designs. Something about the picture on the screen will make you think of a number, between one and four. On the keyboard in front of you, the keys are numbered; this is one, two, three and four. You are to press down on the key which has the same number as the number you think of when you look at the pattern on the screen.

For example present the first slide what number does this make you think of? Which key would you press?

On hearing the bell That's the bell, which means that you got the right answer. Try another key and see what happens when you get the wrong answer.

On hearing the buzzer That's the buzzer, which means that you got the wrong answer. This way you will know each time whether your answers are right or wrong, but for each picture on the screen, you may press down on only one key. If you make a mistake, we'll go right on to the next one.

Presenting the second slide Now, which key would you pick for this picture?

Following subtest 1 That was the end of the first subtest. This test is divided into 6 subtests and in each subtest, there is one idea or principle which runs throughout the subtest. Once you have figured out the idea or principle in the subtest, by using this idea, you will get the right answer each time. Now we are going to begin the second subtest and the idea in it may be the same as it was in the last one or it may be different. I want you to figure it out. Proceed with subtest 2, and when the first slide with circles is reached You will notice that first you saw squares, then lines, and now circles. Even though the patterns change, you should continue to use the same idea to get the right answer.

Following subtest 2 That was the end of the second subtest, and as you probably noticed, you don't necessarily have to see a number to have a number suggested to you. You saw squares, circles and other figures. Also, in each of the subtests, there was only one idea or principle which ran throughout the subtest. Once you figured out the right idea, you continued to use it to get the right answers. Now we are going to begin the third subtest and the idea in it may be the same as it was in the last one or it may be different. I want to see if you can figure out the right idea and then use it to get the right answer. Remember, the idea remains the same throughout the subtest. I'll tell you when we complete one subtest and are ready to begin a new one.

Following subtests 3 and 4 That was the end of the third (fourth) subtest and now we are going to begin the fourth (fifth). The idea in it may be the same as it was in the last one or it may be different. I want you to figure it out.

Following subtest 5 That was the end of the fifth subtest and now we are going to begin the last one. In this last subtest, there is no one idea or principle which runs throughout the subtest because it is made up of pictures you have already seen before. Try to remember what the right answer was the first time you saw the picture and then give that same answer again.

Record responses correct (√) in the right hand column or incorrect (X) in the left hand column. The middle column may be used for noting the incorrect response. The score is the total number of errors. Perseveration of response is noted.

The child may be told to:
Watch how the pictures change.
Look carefully at the picture.
The picture tells you which key to pick. How does it tell you?

Any comments are indicated on the record form as to where in the test the comments are made.

APPENDIX II

Raw Data

Subject	Sex	Age	Verbal IQ	Performance IQ	Category test	WRAT * (reading)
1	M	10.7	105	91	69	82
2	M	10.2	106	84	79	84
3	M	10.6	74	91	57	70
4	M	10.0	97	102	59	88
5	F	10.6	72	109	49	74
6	M	10.6	84	87	69	91
7	F	10.7	96	100	32	82
8	M	10.4	81	68	51	94
9	F	10.5	74	68	67	92
10	M	10.4	68	104	61	76
11	M	10.4	82	96	58	-
12	F	10.10	87	93	53	88
13	M	10.2	85	109	35	64
14	M	10.0	91	92	51	84
15	M	10.3	84	98	70	78
16	M	10.7	84	87	55	104
17	M	10.10	112	114	22	91
18	M	10.7	77	82	56	90
19	M	10.9	82	82	68	67
20	M	10.7	100	81	54	101
21	M	10.7	85	105	18	82
22	M	10.3	97	103	60	-
23	M	10.2	81	90	97	80
24	M	10.10	113	133	39	116
25	M	10.0	120	132	32	121
26	F	10.8	82	78	53	80
27	M	10.5	103	70	76	103
28	F	10.6	88	78	53	-
29	F	10.10	70	105	61	-
30	M	10.1	91	118	24	-
31	M	10.9	85	96	71	73
32	F	10.7	105	102	48	109
33	M	10.4	115	108	31	143
34	M	10.9	139	117	36	118
35	M	10.9	102	108	54	89
36	M	10.4	95	115	78	-
37	M	10.2	106	102	57	94
38	M	10.9	88	96	64	96
39	M	10.0	77	65	107	52

* Scores on the reading subtest of the Wide Ranging Achievement Test were not available for all subjects.

APPENDIX II

Subject	Sex	Age	Verbal IQ	Performance IQ	Category Test	WRAT (reading)
40	M	10.1	112	121	37	121
41	M	10.5	98	98	60	94
42	F	10.6	70	74	78	108
43	M	10.5	82	64	77	112
44	M	10.11	105	114	58	115
45	M	10.0	96	90	40	108
46	M	10.7	106	104	63	118
47	M	10.11	117	102	37	138
48	F	10.1	94	100	61	115
49	F	10.6	97	113	54	115
50	M	10.7	92	75	74	-
51	M	10.2	106	112	48	-
52	F	10.2	84	95	69	99
53	M	10.0	105	88	66	110
54	M	10.8	75	100	64	113
55	M	10.4	91	104	65	-
56	M	10.6	100	93	58	80
57	F	10.10	91	95	59	103
58	M	10.7	98	108	17	114
59	M	10.6	92	103	29	100
60	M	10.1	95	104	60	-
61	M	10.7	100	115	71	120
62	M	10.10	105	108	48	109
63	M	10.10	87	80	59	92
64	M	10.1	97	111	39	88
65	M	10.7	105	121	57	104
66	M	10.11	80	95	42	101
67	M	10.3	75	82	74	-
68	M	10.5	96	111	74	82
69	M	10.3	77	106	89	84
70	M	10.4	88	128	33	-
71	M	10.0	114	123	62	-
72	M	10.7	88	102	45	124
73	M	10.6	92	109	52	103
74	F	10.9	96	121	42	74
75	M	10.2	68	114	83	122
76	M	10.10	75	90	64	52
77	M	10.3	92	92	57	70
78	M	10.1	114	95	40	101
79	M	10.4	108	120	34	109
80	M	10.7	101	108	64	106
81	M	10.2	136	124	42	107
82	F	10.8	85	88	57	80
83	M	10.10	81	80	28	91
84	F	10.1	118	112	38	118
85	F	10.7	111	111	32	109

APPENDIX III

Correlations of WRAT Reading Abilities with Verbal and Performance Scores (WISC-R)

Independent Variable	Dependent Variable	Pearson Product-Moment R
Performance	Reading (WRAT)	.2037
Verbal	Reading (WRAT)	.6157