THE IMPLICATIONS OF THE LATERALIZED BRAIN MODEL FOR EDUCATIONAL PRACTICE: A CRITICAL ANALYSIS OF THE RESEARCH BASE

by

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THE IMPLICATIONS OF THE LATERALIZED BRAIN MODEL FOR EDUCATIONAL PRACTICE: A CRITICAL ANALYSIS OF THE RESEARCH BASE

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ABSTRACT

Following the split-brain operations on humans in the mid sixties, much research in neuropsychology, neurophysiology and experimental psychology was published assigning different and complementary characteristics to each of the brain's two cerebral hemispheres. Through the writings of a few foundational researchers and many popularizers these ideas have been presented to school personnel as relevant and efficacious for educational policy and practice.

This exploratory thesis addresses a number of questions. First, what is the current status of the claims with respect to hemispheric specialization? Secondly, what are current claims of educators regarding the usefulness for them of research into hemispheric specialization? Thirdly, are the educator's claims based on the foundational material accurate ? Broadly stated, the thesis asks what is the "goodness of fit" between the two bodies of literature? In addition, the question of the educators' motivations in attending to this neuropsychological research is considered.

Critical reviews of both sets of literature are presented. As neuropsychology burgeoned, the number and variety of claims/counterclaims has markedly increased; however, this review suggests that the main thrust of it has not changed. The educational claims, although not all-inclusive, called for significant changes in curriculum development and teaching practices. A comparison of educational claims with the claims of

neuropsychologists suggests that the educators were reasonably faithful in the adoption of the main conclusions.

Although the educators did not significantly distort the neurological conclusions, these did serve their interests in justifying a personal preference for specific teaching practices or for the inclusion of particular curricular material. A case is argued that the citation of this neuropsychological research by some groups in education is seen as a means of supporting individualized instruction, multi-modal learning, creativity and humanistic values and was a reaction to a behaviorist orientation in educational research and practice. The counter-reaction on the part of other educators can also be understood as in part reflecting their previously held educational philosophy.

The current limited educational and psychological research, which tests proposed claimed attributes of both hemispheres in the presentation and teaching of specific subject matter, does indicate that learning generally improves in regular and special class populations. Recommendations are made which include ongoing teacher training in the complexity of the hemispheric specialization model.

QUOTATION

As a consequence of the twentieth-century abandonment of synergetical thinking, both scholars and the public in general have been so disintegrated by ultraspecialization as to be not only helpless to alter public policy but also uninformed regarding comprehensive evolutionary trends underlying the forces at work around the planet.

R. Buckminster Fuller

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CHAPTER 1

INTRODUCTION

The Study

The practice of education in public schools has been largely rationalized from segments of the fields of psychology, sociology, philosophy, organizational science or composites of these fields. Typically education derives support for teaching practices from specific sub-sets of these fundamental disciplines. For example, the theory of operant conditioning in psychology has derivative educational practices, such as behavior modification (sometimes termed "applied behavior analysis" and "precision teaching".) Similarly, the educational conceptions of moral reasoning as enunciated by Kohlberg (1973), had its origins in Piaget's theories of cognitive development, including moral development as part of general cognitive psychology. Many so called "humanistic" or "person-centered" approaches to educational practice are derived from the client-centered psychology of Rogers (1961) and the psychological theories of Maslow (1968), especially from the hierarchy of need satisfaction construct.

In applying the term education, it may be helpful to differentiate the philosophical notion, "the process of

education," from and that of its usual subset "public school teaching" which draws on foundationaldisciplines such as psychology and sociology. Public school is said to be the place where this confluence of diverse disciplines culminates. In referring to the philosophical process of education Hirst and Peters (1970) stated " The more recent and more specific concepts links such [educational] processes with the development of states of a person that involve knowledge and understanding in depth and breadth, and also suggests that they are desirable" (p. 25). Education is analogous to the concept of "reform". (Peters 1966); there are numerous ways to achieve the ends in reform- "preventative detention, reading a bible or devotion of a loving wife" (p. 1). Accordingly the subset "public school teaching" and those disciplines which it draws to itself to achieve its particular aims, is but one means of attaining the "educated person." For the purposes of this paper, concern is focused on the subset, "public schooling" and in particular, on classroom practice,because this level is the basic unit of current school organization.

In order for a theory from a "fundamental" discipline to be translocated to educational practice, especially in public schools, there must obviously be processes which move the idea from the discipline to the field of education. This appears to happen in many ways. Educational researchers often take ideas from other disciplines and assess their significance for concepts of learning and teaching. Teacher trainers then apply

the concepts to the training of practicing teachers. In addition teachers train each other through "professional development" activities. Hence a complex network of idea transmission may operate to move a finding or claim from a foundational discipline to a teacher in-service and finally to actual teaching practice. It is rare that seminal information appears in a form which is readily accessible to the practicing teacher. Articles which appear in teacher journals often entail an interpretation of interpretations. Thus what ultimately appears in a teacher's journal or is presented directly to them through in-service may be information that is distorted, popularized or which has been chosen selectively from a large body of information according to a set of explicit or implicit criteria.

Classroom teachers who read professional journals or attend professional seminars and workshops must rely on the judgment, competence and integrity of the editorial boards, the authors, or conference presenters and colloquium committees. They have no other readily available means of verifying what is written or said . In other words, intense questioning on the theoretical basis of the article/ presentation at hand is not routinely done by the recipients of this information.

Since the mid-70's, professional teacher oriented journals serving education groups have begun to discuss ideas and findings from the fields of neuroscience (neurophysiology and neuroanatomy), medicine and experimental psychology in terms of their implications for teaching. Of particular significance

among these has been the concept of hemispheric specialization or brain lateralization in which the two hemispheres of the human cerebral cortex are regarded as differing significantly in the ways that they process sensory information and perform cognitive processes. A number of claims are made in the articles alleging that recent brain research requires a reconceptualization of teaching practice in an effort to develop "brain-congruent" approaches. Some of the articles' authors are fairly conservative in their interpretations. Others make quite sweeping generalizations.

The appearance of findings from brain research in professional journals of education and at teacher conferences and workshops provides an opportunity to examine the process of information transfer from the neurosciences research laboratories to the classroom teacher. It is the purpose of this dissertation to examine that process critically. Specifically, the dissertation seeks to: (a) determine the nature or status of current research concerning the human brain with particular reference to the lateralized brain concept; and (b) to examine the degree of match between the "foundational research" and the interpretive literature - the literature which attempts to communicate the findings of brain research to classroom practitioners.

The hypothesis under investigation is that the process of information transfer from a foundational area of research to teaching practice is both <u>partial</u> and distorted. During the

process of interpretation, selection, bias, emphasis, restatement and simple lack of understanding all affect what ultimately reaches the practitioner.

This dissertation, examining and chronicling a set of ideas crossing among disciplines, could be useful for at least two reasons. First, the process of transference and interpretation reflects pressures upon teachers and professional educators and the previous history of educational ideas. Why, concomitant with this issue at this time, is particular interest being paid to brain research in terms of teaching practice? This question necessitates considering the sociology of knowledge and is addressed in Chapter Five.

Second, by examining the basic research and the interpretations and claims of popularizers, it is possible to address the question of whether there is in fact an emerging, empirically sound basis for a restructuring or revising of educational practice.

The dissertation has six chapters. The neuropsychological/experimental psychological and educational literature will be reviewed in Chapters Two and Three respectively. For the purposes of clarity and accessibility each chapter has been initially divided into time segments five years in length, but each also develops themes and issues. Each segment of Chapter Two reflects the "state/wisdom of the art" during that period and reports the basic claims made by researchers in the era .Chapter Three examines educators'

interpretations of the foundational literature. The purpose of Chapter Four will be to examine the" goodness of fit" between the two bodies of literature: the degree of match between the foundational areas and the field of education. Chapter Five will discuss the processes that may influence the information transfer between the two fields and in addition it presents interpretations of the data. Chapter Six concludes the paper examining the implications of the previous chapters while suggesting tentative conclusions.

During my research I was fortunate to interview some of the foundational researchers in neuropsychology and related disciplines in North America and Britain. My intention is to convey to the reader a sense of the neuropsychological "culture" by presenting the researchers' opinions where appropriate. A list of those interviewed is in Appendix A.

Delimiting the Study

There are specific issues arising in the literature which although seminal in nature are beyond the scope of this paper. Philosophical issues raised by Sperry (1982) and McKay (1980) concerning the origin and nature of the human mind and brain will not be dealt with. In addition the origins of hemispheric specialization (Corballis and Morgan, 1978) and brain asymmetries as revealed through experimental psychology with animals (Hamilton, 1977) will also not be discussed here.

Pathology due to supposed undeveloped lateral asymmetry (Galin, 1974) such as psychosis and schizophrenia will not be discussed although the suspected causes of dyslexia will be included. Because the author's background was more educationally then psychologically based, preparation in neuropsychology was made by enrolling in neuroanatomy and neurophysiology courses as well as interviewing 20 prominent neuroscientists active in research of hemispheric specialization in North America and Great Britain.

The large amount of material published in neuro- and experimental psychology have made these fields quite unwieldy for the lay reader trying to gain an overview of their present status and future trends. This proliferation of research appears to be the result of many single articles having been written by workers who are not specialists in the field. It is quite easy to replicate some of the initial work by simply using a dichotic listening tape recorder or a visual tachistiscope system. Hence the literature contains a large number of replication studies often representing the only article published in the field by a given author.

The abundance of "replication" studies has meant that it was essential to develop criteria which could discriminate relatively minor studies from work which made important contributions to the field. The criteria used in this study were:

1. those articles written by reputable and prominent

foundational researchers in the field.

2. those articles that were cited in later years by other authors (the Social Science Citation Index was used to determine this factor).
3. articles on relevant themes that used peer commentary on a the targeted article.
4. data that were published up to August 31,1983.

Summary

This chapter set out to introduce a comtemporary phenomenon - namely, the translocation of information from the neurosciences, specifically the lateralized brain model, to public school educational practice. The goals of the thesis will be to determine the status of current research, with regards to the lateralized brain model, to examine its adaptation to public educational practice and to assess the match between both. Additionally the thesis will assess whether a restructuring of educational practice based on the recent work of the lateralized brain model is warranted for consideration. It is the hypothesis of this thesis that in the adaptation process, there was distortion, bias and selective reporting of the initial neuroscientific data, resulting in a partial and distorted impression of its use for educational practice.

CHAPTER 2

A REVIEW OF THE NEUROPSYCHOLOGICAL LITERATURE

The function of this chapter is to inform the reader of the origins of the concept of cerebral hemispheric specialization, that is, the idea that each of the two hemispheres (right and left) have different functions for the processing of sensorial and cognitive information.

A Concise History of Cerebral Lateralization Until the Split Brain Studies

This section will trace the approximately 150 year old history of hemispheric specialization and highlight the main investigators responsible for its naissance, development and movement.

Reviews by Gibson(1962) , Critchley(1970),Bogen (1969 a + b) and Springer and Deutsch(1980) describe the historical events in the initial stage of research localizing specific brain functions. Until the middle 1800's the brain was viewed as a whole unit rather than having localized sites responsible for specific faculties. Prior to this time however the cessation of these faculties did prompt questions such as that asked by Aristotle, "Why is it that of all animals , man alone is apt to become hesitating in speech "(Critchley, 1970,p.53). As well, the German poet Goethe had described at first hand the case of

his grandfather's right-sided lameness and impaired speech (Critchley, 1970, p.59).

The first serious attempt to localize cerebral functions was made by Franz Gall (1758-1828), an anatomist and author of a system commonly known as "phrenology". He related the shape of areas of the skull to underlying brain tissues and hence to emotional and mental/moral characteristics of the individual. The character of a specific individual could be derived from palpation of the head (Penfield, Rasmussen 1950, p.1). For various reasons, some dubious, Gall was able to assign the site of speech within the frontal lobes.

In 1836 a French physician, Marc Dax, read a paper "Lesions of the Left Half of the Brain Associated with the Loss of Signs of Thought" at Montpelier Medical College. This paper was based on the observation of 140 patients over a 36 year period. The Dax paper concluded that each hemisphere was mainly related to the opposite side of the body and that speech was in the domain of the left hemisphere. The paper was described as an "unqualified flop," arousing virtually no interest among those who heard it and it was forgotten soon after Dax's death in 1837 (Springer/Deutsch, 1981, p.1). However, it was resurrected later because of subsequent events.

Modern concepts of hemispheric specialization began with the study of "aphasia," the loss of speech and/or understanding of speech due to brain injury. Medical professionals were divided between those who did and did not believe in cerebral

specialization. Among the believers was a French physician, Jean Baptiste Bouillaud, who accepted Gall's opinion that the frontal lobe contained the speech center. He offered a substantial prize to anyone who could produce the brain of a patient who had lost the ability to speak without a lesion of the frontal lobes. In 1861 , Paul Broca, presented two cases with autopsy supporting the idea that the loss of speech was due to a lesion in the left frontal lobe. This syndrome (loss of speech with retention of other intellectual abilities) came to be called "aphasia." It is interesting to note that Broca himself did not emphasize the laterality of the lesion until 1864. In 1864 the son of Marc Dax, Gustav, claimed that Broca had "pilfered" the idea from his father without acknowledging Dax's work. Broca protested saying that he had never heard of the elder Dax's article . The literature then abounded with versions of the Broca-Dax controversy. Broca also considered the relationship of the hemisphere that controlled speech being on the opposite side of the preferred hand.

In 1870 the German investigators, Fritsch and Hitzig, applied electric current to the left and right cerebral cortices of a slightly anaesthetized dog evoking the movement of the limbs on the opposite side of the animal's body. The American physician, Dr. Robert Bartholow, in 1874 became the first to apply electrodes to the brain of a dying patient thus obtaining contralateral limb movements (Gibson p. 128).

In 1874 the German neurologist Karle Wernicke announced that an area in the back part of the left temporal lobe was responsible for the understanding of speech . The symptoms which resulted from a lesion in this area were primarily an abundance of mispronounced words and a deficit in verbal comprehension. This came to be called Wernicke's aphasia. Both Broca's and Wernicke's areas, as presently understood, are almost always in the left hemisphere.

Meanwhile the British neurologist, John H. Jackson, working primarily with epileptic patients at the National Hospital for the Paralyzed and Epileptic confirmed the left hemisphere's dominance for language by observation of patients with strokes and tumour. Jackson coined the term "propositional" hemisphere referring to the left hemisphere as the "leading hemisphere" with respect to speaking, writing and related abilities of the left hemisphere. At the turn of the 20th century Liepmann introduced the concept of apraxia, which was defined as an inability to perform purposeful movements on command, for example, the imitation of brushing one's teeth. Liepmann cited injuries or lesions of the left hemisphere as responsible for such incapacities (Bogen 1979) . Leipmann's and others' work led to the concept of the critical role played by the left hemisphere not only in language functions but also purposeful actions in general. As for the right hemisphere Jackson (as quoted by Milner 1971) attributed to it a leading role in visual ideation. However, by the turn of the last century the notion of

the left hemisphere's superiority and the right's relatively minor role had been firmly established.

Lesions and the Right Hemisphere

A major comprehensive study of cognitive loss from brain injury culminated in the publication of Weisenberg and McBride's (1935) classic, Aphasia: A Clinical and Psychological Study. Two hundred aphasic and non-aphasic subjects were administered an extensive battery of tests resulting in the following summation of clinical findings;

1. unilateral lesions in the left hemisphere produced disturbances in language.
2. "right-sided cerebral lesions without aphasia show certain changes in mental functioning but are not comparable with those characterizing aphasic disorders" (P. 453).
3. the site and size of the lesion were correlated to the extent of resulting difficulties in the patients' expressive and/or receptive faculties.

The role attributed to the left-hemisphere in well-lateralized right-handers by Weisenberg and McBride was not new, except for the added details about the site and extent of damage. However, in the mid thirties, the role of the right hemisphere had not yet been recognized. As Zangwill (1961) has pointed out, Jackson's idea of the right hemisphere's role in perception "had little influence and ... was almost wholly

forgotten"(P.60). The right hemisphere had a reputation as only having a compensatory or secondary role - in the neurologist Henschen's words; "..in every case, the right hemisphere shows a manifest inferiority as compared with the left and plays an automatic role only." Henschen's idea was that the right hemisphere was possibly "a regressing organ although it is possible that the right hemisphere is a reserve organ." (Henschen 1926 as cited in Bogen 1969(B),P.136).

In a comprehensive article Zangwill(1961) summarized the research of Hecaen,Humphrey & Zangwill and their co-workers; Zangwill concluded by assigning to the left-hemisphere a dominant role in language; to the right hemisphere he tentatively assigned dominance in visual-spatial judgement and perhaps "also for certain aspects of pictorial comprehension and topographical skill "(P.60). Two other findings were notable in this period. First, unilateral neglect(the ignoring of one-half of the body) is more prevalent in cases of right hemisphere lesions (affecting the left side) than vice-versa (Zangwill 1961). Secondly, from the research of Hecaen & Angelergues(1962) and DeRenzi & Spinnler(1966), the right hemisphere was found to have a distinct function in the recognition of faces. Hecaen(1962) summarized the state of affairs to that time: left anterior temporal lesions could produce language disorders; left posterior temporal lesions could produce not only comprehension difficulties but may include an inability to compute (acalculia); alexia (inability to read) may occur with

even more posterior left sided lesions. By contrast, right hemisphere lesions yield visuospatial disorders. It is interesting to recall that the description of the grosser differences between left and right hemispheres was not new - Jackson had suggested the left hemisphere as being the "leading hemisphere"for speech and the right for visual ideation in the 1870s. What is important is that these further studies of missile wounds and brain lesions confirmed the earlier findings.

Milner's research using patients with temporal lobectomies found that those patients with right hemisphere lobectomies were impaired on parts of the Seashore Test, including tests of tonal memory and timbre discrimination(Milner 1962). A few years later Kimura(1964) used dichotic listening for digits(numerals) and melodies with normal subjects. Whereas there was a right ear advantage (REA) for digits,there was a LEA for melodies in right-handed subjects. As emphasized by Milner (1958)the composite picture was one of hemispheric specialization in which the left-hemisphere was responsible for processing verbal material and the right hemisphere for non-verbal material. As a note of interest,Milner was Zangwill's student at Cambridge while Kimura trained under Milner at McGill. Thus the concept of the non-verbal/verbal hemispheric specialization of the left and right hemispheres was passed along three "generations of researchers of hemispheric specialization." While alll three researchers worked with lesion patients, Kimura was apparently the first to also use normal subjects.

Doreen Kimura's pioneering research at this time was important for two reasons. First, she was the first person to employ dichotic listening (based on the Broadbent model, 1954). This is a technique which uses a tape recorder to assess hemispheric specialization by sending simultaneous input to the two ears. Second, she was one of the first researchers investigating hemispheric specialization to use normal subjects instead of brain-injured or lesion patients. In her first paper (Kimura, 1961 b) she employed patients who were brain-damaged or who had had their temporal lobes removed (temporal lobectomy). Her second paper (1961) used normal subjects and found that the right ear (left-hemisphere) was better able to recall the sequence of verbal stimuli than the left ear(right hemisphere), i.e. there was a right-ear advantage (REA) for those subjects who were clearly right-handed.

Furthermore , she explained the results with the explanation that the neural pathway between the test ear and its opposite (contralateral) auditory cortex is stronger than that between the test ear and the auditory cortex on the same (ipsilateral) side.

In a most important piece of research, Wada & Rasmussen (1960) were able to delineate which hemisphere was the dominant (i.e. having the language center) by the injection of sodium amytal into the carotid artery. It became possible for the first time (Branch et al, 1963) "to compare the two cerebral hemispheres in a single patient for their participation in

speech"(P.399). In the years following its development, this test was used to aid surgeons to excise non-critical cortical areas and to determine the location of the language centre in either left or right-handed persons.

Thus by the early 1960's certain specializations (and associated dysfunctions) had been clearly described.

Left Hemisphere and Non-Linguistic Aspects

Interesting research was published by Efron(1963 a,b) during this period. His first paper suggested that the conscious comparison of time (temporal sequencing) is a function of the dominant (for language) hemisphere. In his second paper Efron noted(Efron 1963 (b)) that aphasic patients are deficient of any temporal order.He considered that aphasia might not be a language disorder, but "an inevitable consequence of a primary deficit in temporal analysis- in placing a primary time-label upon incoming data.....aphasia would be an epiphenomenon "(P.419).

To my knowledge, this is the first criticism of the concept of the fundamental characteristic of the left hemisphere as that of language. Instead, Efron suggested that there might be an even more basic characteristic of the left hemisphere and that language mightbe one possible derivative of that characteristic.As this chapter will chronicle, many other researchers came to natuarlly question the verbal/visuospatial

dichotomy first outlined by Jackson and extended by Zangwill, Hecaen, Milner and Kimura.

Initial History -1964-69

Split Brain Beginnings

The two hemispheres of the brain are not only united by a common brainstem that descends into the spinal cord but also by a major cross-bridge in between the hemispheres. The main function of this 200 million nerve fibre cable is to transmit information between the hemispheres. Erickson emphasized in 1940 that the spread of epilepsy in monkeys from one hemisphere to the other hemisphere occured via the corpus callosum. It had been noted by two other researchers that corpus callosum damage in human epileptics reduced the incidence of seizures (Van Wagenen and Herren 1940). Such observations prompted the pioneering surgery by Van Wagenen and the post surgical investigations by the neuropsychologist Akelaitis. The operation involved cutting the human corpus callosum (called a commissurotomy or a split-brain operation) as a means of dealing with epilepsy which was resistant to to medical management.The surgery tended to alleviate the epilepsy of those patients with variation from patient to patient. Akelaitis looked for disconnective deficits ascribable to the callosal section but in

general did not recognize any.

Akelaitis' work indicated that the patients in his series suffered no post-operative deficits such as apraxia, agnosia (inability to recognize) or agraphia (inability to write) (Gazzaniga 1970, p. 74).

As was later shown, Akelaitis'negative findings were attributable to the different surgical procedures (i.e. the incompleteness of the sectioning)and secondarily to the primitiveness of the psychological tests given. With more complete surgery techniques and more appropriate psychological tests, these disconnective deficit syndromes were found in the animal studies of Sperry and Myers (in the mid-fifties) and subsequently in the California (Vogel and Bogen series) series of human split-brain patients beginning in 1962.

Sperry and Myers

Beginning with the work of Sperry and Myers in the mid 50's, a new phase of " split-brain" operations began.These were made possible by advanced surgical techniques and by instruments developed by these two researchers.

Their experiments with cats produced the critical finding that the transfer of visual information occurred in spite of the cutting of either the optic chiasm or the corpus callosum,whereas if both were cut transfer did not occur. (Sperry 1961, Myers and Sperry 1958) The optic chiasm is the

crossing which brings the visual information from one eye to the visual cortex of the opposite hemisphere. When the chiasm was split information could be restricted to one hemisphere. In this circumstance the corpus callosum was responsible for the transfer of information. Their two major findings were the following: a) when the optic chiasm alone was split the cat still retained the ability to perform with the opposite eye a previously learned discriminative visual task because of its intact corpus callosum (i.e. a transfer did occur); b) however, with the corpus callosum sectioned performance with the second eye was deficient. "The corpus callosum is shown to be instrumental in laying down a second set of memory traces or engrams in the contralateral hemisphere, a mirror-image duplicate or weak carbon copy of the engram on the directly trained side . . . "(Sperry 1961, P. 1749). When the optic chiasm and corpus callosum were both sectioned prior to training there was no transfer of information from one hemisphere to the other. In fact Trevarthen (1962) was later able to train split-brain monkeys to perform two contradictory tasks simultaneously, one for each eye.

Sperry's remarks on this work with cats and the later work with monkeys reflect an expanding grasp of the dual nature of the hemispheres and called into question Akelaitis' negative results. "It was as if each of the separated hemispheres had complete amnesia to the experience of the other, as if each had its own independent perceiving, learning and memory

systems"(Sperry 1962).

The first human commissurotomy (of an eventual 16 till 1969) following the Van Wagenen/Akelaitis team was performed by Bogen and Vogel (1962) on a war veteran suffering from epilepsy. He was the first to be tested in the light of the split-brain animal results. The patient was seizure-free for at least six months post-operatively although psychological and physical syndromes were noted (Gazzaniga, Bogen and Sperry 1962). Specifically, the patient had in his left hand an apraxia, anomia and agraphia- no such problems existed in the right hand - (apparently because the right hand is more directly connected to the left (dominant for speech) hemisphere whereas the left hand is connected to the mute right hemisphere). Similar results occured when visual stimuli were presented tachistiscopically to the left visual field (LVF),(which is connected to the right (mute) hemisphere). Although visual stimuli in the LVF were recognized as evidenced by appropriate reactions, they could not be named or verbally described. (The tachistiscope is a device that allows the investigator to control precisely the duration for which a visual stimulus is presented on a screen). As well motor apraxia (inablity to plan and carry out motor activities) was present affecting the left hand. As described by the authors, "it was as if the control of the left hand was strongly centered in the minor hemisphere at such times and hence isolated from the main intent and previous directorship of the dominant hemisphere." (P. 1767) It appeared

that each separated hemisphere was unaware of the other's activity. As in the cat experiments there was no transfer of learning between the hemispheres.

A cautionary note is worth mentioning at this point. It is difficult to know the extent of prior damage to the patient's cortex. Since the patient's brain was not fully intact before the operation, lateralized functions may have been exaggerated or diminished. This factor will be raised later when the issue of generalizing from the work of split-brain or lateralized lesion subjects to normal subjects will be discussed.

Up to this time, 1962-64, there was little written about the commissurotomy studies except in the more specialized journals. Sperry's Scientific American article in 1964 popularized for the scientific and lay communities what was occurring in the " split-brain" work with cats and human subjects. This paper is cited the most frequently in chapter 3, by those attempting to interpret split-brain work to educators.

Summary

The period from 1955-1964 was a productive one. The work by brain researchers Hecaen, Zangwill and their co-workers on lateralized brain lesions led researchers to relate specific syndromes to each hemisphere. Right hemisphere functions once considered mostly non-existent slowly came into view. It became clear that there was hemispheric specialization - notably the

asssociation of the left with verbal/ language processing and the right with visuo-spatial abilities. Milner's and Kimura's work on auditory function extended the hemispheric specialization nction beyond the concept of "visuo-spatial", and included investigations with lesions and normal people. In the beginning of the sixties, an attempt was made once again to use commissurotomies as a means of dealing with intractable epilepsy. Successful operations were performed. Unlike Akelaitis' post-operative investigations, those at CalTech, with the aid of more advanced investigative techniques, discovered the results of disconnecting the two hemispheres in these patients. Also notable was Efron's (1963 a,b) suggestion of a more basic feature underlying hemispheric specialization ,a foreshadowing of further developments over the next 19 years.

The Split Brain Investigated Further

Throughout the period 1964-1969,stimulating experiments yielding information about hemispheric specialization continued to be those using the post-operative psychological testing of the commissurotomy patients. This section will describe some of these findings as well as the characteristics to be ascribed to each hemisphere. The psychological investigative work was reported by the original researchers represents a primary source. It is from these sources that I will draw the data for this section and in particular from their 1968/1969 review

papers. Recalling that Sperry (1964) wrote an article to the scientific and intelligent lay community in Scientific American which initiated much interest in the split-brain, his colleague Gazzaniga (1967) continued this form of reporting with another paper in Scientific American which further discussed the findings of the research with split-brain patients.

The group of psychological effects resulting from the cutting of the cerebral commissures became known as the 'syndrome of hemispheric disconnection" (Sperry et al 1969). As noted by the authors, the specific effects of commissurotomy could only be detected with sophisticated psychological testing unavailable to Akelaitis in the 40's. The initial findings for example from Bogen and Gazzaniga (1965), supported the existent dichotomy of left/verbal and right/visuospatial activites, but qualifications" soon appeared. The syndrome of hemispheric disconnection involved the following basic neurophysiological information: the left hand and left side of the body were connected predominantly contralaterally to the right hemisphere while the right hand was mainly connected to the left hemisphere. In right handed people the left hemisphere was dominant for linguistic abilities and speech production. When the two "brains" were disengaged through surgery, a crucial connection between the hemispheres was severed resulting in the following phenomena: if the right-handed patient was given the task of palpating an unseen object, when the right hand felt the object the patient could name it whereas when it was held in the

left hand it could not be named -this was called a "unilateral left- handed anomia". By contrast in normal intact brains the informaticn just received by the mute right hemisphere would be transferred via the callosal route to the verbal hemisphere and the answer would be forthcoming. Similar phenomena with split-brain patients were seen when stimuli were presented tachistiscopically: stimuli presented via the the right visual field (RVF- left hemisphere) could be vocally identified while those presented to the left visual field (LVF-right hemisphere) could not be verbally labelled although the patient could retrieve with his left hand the appropriate objects. The right hemisphere had an anomia (an inability to name familiar objects) because it was mute;but as the authors pointed out the right hemisphere can percieve, recognize, learn and remember.

In part 1 of a comprehensive review paper Bogen (1969 a) detailed part of the syndrome as experienced by 8 split-brain right-handed patients: a left-handed and right-handed dysgraphia and dyscopia (the inability to write and the inability to copy a figure, respectively). The patients were unable to copy with their right hand (connected to the left hemisphere responsible for speech and language) and could not write verbal material with their left hand (connected to the right hemisphere specializing in visuo-spatial activities). As Bogen pointed out "the data here are clearly in line with a belief in segregation of certain functions to either hemisphere" (Bogen 1969a). The left-handed agraphia leads to an interesting hypothesis: whilst

left-handed agraphia is typical in right-handed patients, in some patients recovery is evident - they eventually can write verbal material with their left hand. What is the mechanism by which this occurs? Bogen suggested that in normal intact brains, there is an inhibition of the linguistic functions in the non-specialized hemisphere allowing the specialized hemisphere's dominant role in performing that function. For right-handed subjects there is an inhibition in the right hemisphere for linguistic/verbal material. When the callosal commissures are severed, some of the inhibition is relaxed, permitting the emergence of previously non-evident linguistic functions.

Bogen(1969 a) notes the study by Smith (1966) who reported that after a left dominant hemispherectomy, the right hemisphere "can sing, utter simple familiar or exclamatory words and has found receptive language impaired less than the expressive". Sperry et al (1969)reported the existence of an elementary vocabulary (mostly object-nouns) in right hemisphere studies of their commissurotomy patients. They considered the possibility that this was because the patients had acquired language bilaterally due to early cerebral reorganization early in response to the early damage.The question of R.H. language is still being actively debated (Gazzaniga 1983 a,b;Levy 1983,b; Zaidel 1983, c) The main point to emerge from these split-brain studies was the authors' claim that the right hemisphere possessed distinctively human attributes including emotion and sensitivity. This appears to be the first mention in the

literature concerning emotions and laterality. The article does not suggest that the right hemisphere is specialized for emotion, but just suggests its presence in that hemisphere . As Sperry et al (1969) concluded:

> "... [right hemisphere] results ... suggest the presence of conscious awareness and intellect at a level characteristically human with fairly high order mental processing including abstract thinking and reasoning (p.286)."

A key paper derived from work with this series of California patients also claimed that each hemisphere employed a different processing strategy (Levy-Agresti and Sperry, 1968).These authors suggested that the right hemisphere "is specialized for gestalt perception, being primarily a synthesis in dealing with information input. The speaking, major hemisphere, in contrast, seems to operate in a logical, analytic/computer-like fashion"(p.1151). They suggest the possibility that this lateralization results from a "basic incompatability of language functions on one hand and the synthetic perceptual functions on the other." The data and information background given in this important paper was minimal; the entire report appeared as four paragraphs in the Proceedings of the National Academy of Science as a note . Yet in later years these attributes (logical/gestalt) would become perhaps the most popular characteristics of hemispheric specialization.

The Dual Mind

As was the case with the monkeys described by Trevarthan's study (1962) , the commissurotomy patient sometimes did two tasks simultaneously with no interference from the other hemisphere (Gazzaniga 1968, Sperry et al 1969). Such results reinforced the foundational authors' speculation about the dual nature of man's mind,stimulated originally by the split-brain animal experiments. For example, when a patient was observed to pull down his pants with one hand and to pull them up with the other (Gazzaniga 1970),it could be inferred that there was a conflict of interest in the mind , that a unifying mechanism for motor control was not operative.

In one of Sperry's (1968) major reviews and two of Bogen's (1969 b,1969) most influential writings, Sperry and his colleagues showed from studies of a series of commissurotomy patients that each cerebral hemisphere had "its own and private sensations, perceptions, concepts, its own impulses to act, with related volitional, cognitive and learning experiences. As well each has its own separate chain of memories.... inaccessible to the recall of the other" (Sperry 1968, p.724). The elaboration of characteristics unique to each hemisphere was thus broadened beyond the work with the brain-lesioned and hemispherectomy patients by combining hemispheric specialization with the notion of a dual system of conscious awareness, that is, that each hemisphere could function independently.

Bogen (1969a,b) and Bogen & Bogen (1969) wrote a series of three papers of which the last two would be cited frequently in the next thirteen years as demonstrating what we might paraphrase " a neurosurgeon's view of creativity and a neglected right hemisphere." These papers will be examined in detail.

Bogen (1969 b) summed up the history of hemispheric specialization from Jackson to Weisenberg and McBride to Hecaen, spanning over one hundred years. He concluded that the two ideas of this period delineating complimentary hemispheric specialization and hemispheric independence should be combined. He went on to define the right hemisphere as being predominantly "appositional" in parallel to Jackson's notion of the left hemisphere as " propositional" that is, leading in verbal/linguistic activity. Bogen said of the term "appostional",

> it implies a capacity for apposing or comparing of perceptions, schemes, engrams etc. but has in addition the virtue that it implies very little else. If it is correct that the right hemisphere excels in capacities as yet unknown to us; the full meaning of "appositional" will emerge as these capacities are further understood. The word "appositional" has the essential virtue of suggesting a capacity as important as "propositional", reflecting a belief in the importance of right hemisphere function(p.143).

What is asserted here is the importance of the right hemisphere's status- one which, as Bogen points out, is open to "capacities yet unknown". This independent status of the right hemisphere is in contradiction to the opinion of the Nobel Prize Winner, Sir John Eccles, who believed (at that time) that it was only the dominant (left) hemisphere that was truly human and had

consciousness since it had linguistic and speech capabilities (Springer and Deutsch p.182). Eccles,(1981) has since changed his mind believing that the minor hemisphere now has "a limited self-consciousness".

In this paper, Bogen made a distinction rarely evident in either the neuropsychological or educational literature. He distinguished both his historical review and his research data from his personal beliefs in the duality of "mind".

> I <u>believe</u> (with Wigan) that each of us has two minds in one person" p.156
>
> Having <u>believed</u> for several years in the duality of mind I have collected a variety of related opinions from various sources(p.158). (emphasis mine for both quotes)

Table 1(a) represents Bogen's collection of previous dichotomies arrived at largely in the absense of a knowledge of hemispheric specialization. The reader is referred to Table 3 to Bogen's collection of attempts to describe in a dichotic fashion the emerging facts about hemispheric specialization.

TABLE 1 - Dichotomies without Reference to Cerebral Lateralization

(as adapted from Bogen 1969,b)

SOURCE	LEFT HEM. TRAIT	RIGHT HEM.TRAIT
C.S. Smith	Atomistic	Gross
Price	Analytic or reductionist	Synthetic or concrete
Wilder	Numerical	Geometric
Head	Symbolic or systematic	Perceptual or non-verbal
Goldstein	Abstract	Concrete
Bateson and Jackson	Digital	Analogic
J.Z. Young	Abstract	Map-like
Pribram	Digital	Analogic
W. James	Differential	Existential
Hobbes	Directed	Free or unordered
Freud	Secondary process	Primary signalling
Pavlov	Second signalling	First signalling
Sechenov (Luria)	Successive	Simultaneous
Levi-Strauss	Positive	Mythic
Bruner	Rational	Metaphoric
Akhilinanda	Buddhi	Manas
Radhakrishnan	Rational	Integral

In regards to this list of dichotomies Bogen commented: "They are intended here in the hope that they may be of interest and perhaps a little enlightening in an appositional sort of way."(p. 158) It is important to notice the cross cultural references made at the bottom of the chart. As well as stating his personal beliefs, he provided a list of basic dichotomies, whose pertinance to cerebral laterality varied from direct relationship to vaguely peripheral. Much that would be quoted and referred to in later years by educators would be derived from this chart.

The next influential paper (Bogen and Bogen 1969) dealt with the issue of creativity and the corpus callosum. The proposal was that the presence of two independent problem-solving organs increased the prospects of a successful solution to a novel situation. No longer should one think of the hemispheres as major or minor; rather they should be considered as complimentary to each other,each with its own strategy of problem solving , (reminiscent of Levy-Agresti and Sperry (1968)) "... specialization of the hemispheres for different modes of thought greatly increases the flexibility and creativity of the ensemble."(Bogen and Bogen , 1969 p.194) The corpus callosum then serves interhemispheric communication and takes the role of the chief mediator in a creative process.

Quoting Ruesch and Kees (as cited by Bogen & Bogen 1969)

> "The writer depends necessarily upon evoking non-verbal images to verbal means."

Quoting Jung (as cited by Bogen & Bogen 1969)

> "... every creative person is a duality or a synthesis of contradictory aptitudes."

Quoting Henry Moore (as cited by Bogen & Bogen 1969)

> all good art has contained both abstract and surrealist elements, just as it has contained both classical and romantic elements- order and surprise,intellect and imagination,conscious and unconsciousness.

These quotes draw to our attention what the highest function of the corpus callosum is said to be - responsibility for the creativity of an individual. Bogen raises the issue of the right hemisphere's position in the creative process - he cites the possible inhibitory action of the left hemisphere upon the right: "it is the inhibitory effect, on the appositional source, of an excess of propositional thinking "(p.201). He continues to say:

> Creativity requires more than technical skill and logical thought; it also needs cultivation and collaboration of the appositional mind. If the constraint of an intellectual ideal can make man a unilateral being, ... a better informed and foresighted community will survive toward a more harmonious development of the organism by assuring an appropriate training and a greater consideration for the other side of the brain (p.202).

Further Bogen quotes Sperry suggesting that,if deeper brain centers which discharge in very special activities are not exercised , especially during maturational stages when the neurons seem to be particularly dependent on use, repression (atrophy)of these neurons may occur,"leaving profound functional deficiencies in the integrative machinery" (p.201).

Bogen's position is clearly one of establishing a balance between hemispherical activites -- of raising the idea of hemispheric complementarity and of linking it to creativity.

However, it is important to note that although these ideas may be attractive, they represent a most interesting speculative argument that remains unproven to this day.

1964-1969 Overview

The period, 1964-1969 was highlighted by the continued exploration of the psychological syndromes found in the commissurotomy patients. Investigation also continued with brain-lesioned patients. Work started by Kimura with normal subjects flourished with numerous investigators using undergraduate students as subjects. Both the lesion and normal research was designed to either examine or to expand the known hemispheric specializations of left/verbal -- right/visuospatial, which we consider next.

Investigation of Patients with Brain Injuries:1964-1969

The role of the right hemisphere was further investigated by a number of researchers using brain-lesion patients including those with temporal lobectomy.

Milner's (1965) work with seventy-nine patients having bilateral hippocampal/frontal lesions and unilateral lesions showed distinctive hemispheric differences on visually guided maze learning. As expected, patients with bilateral hippocampal lesions showed the most difficulty on the task while those with right temporal lobectomies including the hippocampus had a significant deficit. On the other hand, those with lesions of

the left hemisphere obtained normal scores. Milner stressed the anterior and posterior regions of the right hemisphere as each contributing in differing ways to the performance of the task. This is important because one cannot assume that any sort of unilateral damage will affect the subject in the same way. Warrington et al (1966) showed that patients with right hemispheric damage may have difficulty incorporating spatial information into drawing, while those with left hemisphere lesions had difficulty in planning the drawing process leading to simplified versions of the model. The suggestion was made by the authors that a number of processes are involved in drawing. An important work by DeRenzi (1968) with brain lesioned subjects showed that when time allows, the retention of non-verbal material shown tachistiscopically to subjects can be enhanced through verbal identification or labelling. Thus a verbal label will enhance recall of a visual stimulus. In keeping with the verbal/visuospatial paradigm, patients with right hemisphere lesions who tachistiscopically were shown non-verbal material to the affected hemisphere (via the left visual field) were most impaired - whereas patients with left hemisphere lesions shown verbal material through the right visual field did significantly less well. The article reinforces the importance of dual encoding for memory retention versus input from solely one modality. In a later study Milner (1968) found that patients with right temporal lobectomy had a mild impairment in the perception of complex visual patterns when tachistiscopically

presented; this was accentuated with the retention of the perceived material, the difference implying that the right hippocampus which was also invaded contributes considerably to memory.

Concerning "prosopagnosia" (as described above) , Milner stated that the "underlying defect in prosopagnosia is still a matter of conjecture, but the impairment on face recognition tasks seen after right temporal lobectomy clearly reflects a more general difficulty in distinguishing and remembering intricate visual patterns that share many structure attributes"(p.204). Newcombe's (1969) classic , Missile Wounds of the Brain: A Study of Psychological Deficits, reported a study of 153 brain damaged men who suffered missile wounds during the Second World War. Her findings reinforced the existing paradigm of hemispheric specialization: wounds to the left hemisphere resulted in lower test scores in verbal learning, reading, writing,spelling and retention of verbal material. These deficits were not seen with wounds to the right hemisphere. Injuries to the right cerebral cortex produced impaired spatial orientation, poor visual pattern recognition and matching, maze learning and visual closure tasks. This particular population was important because there was minimal if any possibility of cerebral damage prior to the specific war injury.

The role of the right hemisphere often considered to be mute or even for some invesigations to be "monkey-like," was the

subject of much research in the sixties. However, as will be seen from investigations of split-brain subjects, the right hemisphere is revealed to contain some language abilities.(see Appendix B)

Another element of the research with brain damaged patients was the work of Carmon and Bechtoldt (1969) who found that the right hemisphere was dominant for stereopsis (the ability to perceive depth).

In an oft-cited paper Semmes (1968) postulated that the neuronal structure of the left and right hemispheres was different. Hence a well placed small lesion in a focally-organized hemisphere (the left) would cause a specific deficit whereas a lesion to the same area in the homologous area in a diffusely organized hemisphere(the right) could have either a more general effect or no effect at all. She supposed that hemispheric specialization might result from a difference in intra-hemispheric neuronal organization and that the verbal/visuospatial dichotomy could be a subsidiary reflective of such a difference in neural organization.

The Research with Normal Subjects

In the mid sixties the main methods used to investigate hemispheric specialization in the normal population were tachistiscopically presented stimuli,dichotic listening, the electroencephalogram (EEG) and conjugate lateral eye movements.

Tachistiscopic Investigation

Tachistiscopic presentation of either linguistic or non-linguistic stimuli were made to right-handed normal subjects via the left or right visual field by Kimura (1966). The verbal stimuli (letters) were more accurately identified in the right visual field (RVF going to the left-language dominant hemisphere), whereas the nonalphabetized stimuli were better perceived in the left visual field (right hemisphere). Also demonstrated was the left hemisphere's involvement not only in identification of verbal stimuli, but also of non-verbal stimuli which evoked conceptualization (Kimura 1966).

In a later paper by Kimura (1969) employing a non-verbal task, subjects were asked to locate dots presented to one visual field or another on a reference card containing a set of possible locations. Although Kimura found men to be more superior in their left visual field than women, there was no overall difference in accuracy between the sexes. She suggested that the female subjects had failed to show a strong LVF preference since they may have used other means of coding the information.

Two issues were raised by this study. First, the left field superiority for dot localization is highly correlated with the right hemisphere's dominance in tasks requiring visuospatial activities. Second, in some of the experiments, a male

superiority for visuospatial tasks was evident. Although Kimura remarked that more systematic investigations were necessary to ascertain this fully, her results gave impetus to the idea of sex differences in laterality. In an earlier paper, Kimura (1967) pointed to sex differences in cerebral dominance - five year old girls showed a significant left hemisphere right ear effect as compared to five year old boys. Boys seemed less lateralized for speech development (p. 169). However a third and inextricably linked issue arises here. Could it not be that sexes and/or individuals do in fact have different strategies for solving the same problem whether by using left or right hemispheres or combinations thereof? For example, it was mentioned in the dot localization experiment (above) that males utilized a Left Visual Field (LVF) (referring to a visuospatial reference point) whereas females made use of a verbal component (i.e. "the dot is at 5 o'clock"). Thus what may be called by some "contamination" of an experiment (the use of different non-expected means of arriving at the answer) may be an important illustration of our human differences in problem solving.

Dichotic Listening

The findings with normal people on dichotic listening tasks featured a left hemisphere - right ear advantage (REA) for verbal material whether it be concrete, abstract, functional or nonsense words. In a most widely cited paper, Shankweiler and Studdert-Kennedy (1967) questioned whether all phonetic elements

in speech are processed in the same way and/or in the same location. Their results indicated that consonant-vowel (CV) syllables were identified with greater accuracy by the left hemisphere (REA) than vowel sounds by themselves. It is suggested by the authors that the left hemisphere operates at the level of "speech sound structure." In other words the L.H. is sensitive to sounds that are part of speech. Kimura's (1967) findings also indicate the L.H. role in processing the sub-units of speech. She suggested that the L.H. was processing these parts of speech due to "their articulability rather that to [a] conceptual context" (p.177).

Electrical Approaches

At this time (1964-69) other sophisticated techniques were being utilized to examine the prevailing paradigm. Using an electrophysical technique called Average Evoked Potential, Buchsbaum and Fedic (1969) reported differentiated physiological correlates for varied stimuli. When presented to ten normal right-handed subjects, verbal stimuli had different wave forms than non-verbal stimuli. This was consistent with the emerging hypothesis of hemisphere asymmetry for cognitive behavior.

Conjugate Lateral Eye Movements

Bakan's (1969) work involved the phenomena of conjugate lateral eye movements. This research is based on the following observation: when a normal subject is asked a question, both

eyes move in either the right or left direction. When one direction would predominate after many questions, subjects would either be classed as "right movers" or "left movers". It was hypothesized that left or right eye movements were an index of contralateral hemispheric activation (thus right eye movements would indicate left hemisphere involvement and vice-versa). Bakan's studies of "right-movers" showed them to employ linguistic, conceptual, linear (left hemisphere) strategies while "left-movers" used non-verbal , visuospatial, global (right hemisphere) strategies. He was also able to show that the left eye movers (those utilizing initially the right hemisphere) had greater susceptibility to hypnosis, were more interested in humanistic pursuits, had poorer math performance, and had clearer imaging ability. (Bakan, 1969)

Conclusions of the 1964-1969 Period

At the close of this period of research with normal subjects utilizing dichotic listening and tachistiscopic investigation,the paradigm of left and right hemispheres being responsible for processing verbal and visuospatial activities respectively remained largely intact. There was some evidence as well suggesting a sexual difference in the development of cerebral asymmetries.

Patients with either unilateral lesions, hemispherectomies or missile wounds experienced deficits which were consistent with the same specialization paradigm. Some findings of this

period are noteworthy: (1) there was some elementary language comprehension in the minor supposedly "mute" (right) hemispheres of right handers,(2) strategies which use one or the other hemispheric process required consideration as well as the processes usually employed for particular stimuli ; (3) the proposed focal/diffuse neuronal organization might subsume the verbal-visuospatial dichotomy; (4) dual "engrams" or memory encoding requiring both hemispheres aids retention of the perceived material.

The Investigative Period 1969-1974

Commissurotomy Investigations: 1969-1974

Research with the original split-brain patients continued to be investigated (Levy, Trevarthan and Sperry,1972; Levy 1974; Zaidel and Sperry 1973; Zaidel and Sperry 1974) . This work, described below,could be characterized as a process involving the continued development of procedures and tools to ascertain psychological anomalies in these patients.

A most interesting finding by Gordon, Bogen and Sperry (1971) was the lack of the "hemispheric disconnection syndrome" (as described in the 1964-1969 split brain section) in two patients whose corpora callosa were all but one-forth severed, sparing the posterior portion. It appeared that because of this spared area effective cross-hemispheric communication was

maintained. What remained to be determined was the function of the severed anterior 3/4 . Also of interest were research findings suggesting individual hemispheric strategies .In an experiment by Levy, Trevarthen and Sperry (1972) using split faces (chimeric figures as stimuli) the following was noted: if a face was recognized by its physical features (non-descriptive patterns), the right hemisphere was considered dominant, while if physical features were noted and then internally coded a left-hemisphere verbal superiority was considered prevalent. In other words a particular hemispheric activation would be considered to have occurred depending upon the strategy used for information processing. Sperry (1974) has pointed out that when the right hemisphere deals with a face perceptually (without a verbal label), it perceives it as a whole unit, while the left-hemisphere focusses on specific salient features to which verbal names can be easily attached. This experiment was among several during the early seventies whose findings further questioned the usefulness of the verbal/visuospatial dichotomy to distinguish left from right hemisphere specialization. The usual expectation that facial stimuli would be processed by the R.H. (visuospatial) might not be the case if the subject had another means (eg. verbal) of encoding the facial information. The dominant hemisphere for a specific activity then was dependent upon which strategy was the more appropriate for the task or which strategy the subject chose. Similar findings were reported for commissurotomy patients who took the Ravens

Matrices, a non-verbal intelligence test requiring perceptual and spatial reasoning. Even though the results showed a left hand-right hemisphere superiority overall (as would be expected on a visuospatial test), the left hemisphere did score above chance indicating that either hemisphere could perform the task depending upon the strategy used. A visiting team from the Montreal Neurological Institute tried to control for such verbal encoding by having the patients perform tactile tasks (without sight) with wire figures which would be most difficult to encode (Milner and Taylor, 1972). In this case the results did show a right hemisphere superiority for perception of spatial patterns. Also noted was the right hemisphere's superior tactile memory ability suggested by its being able to recall a spatial pattern after a two minute delay.

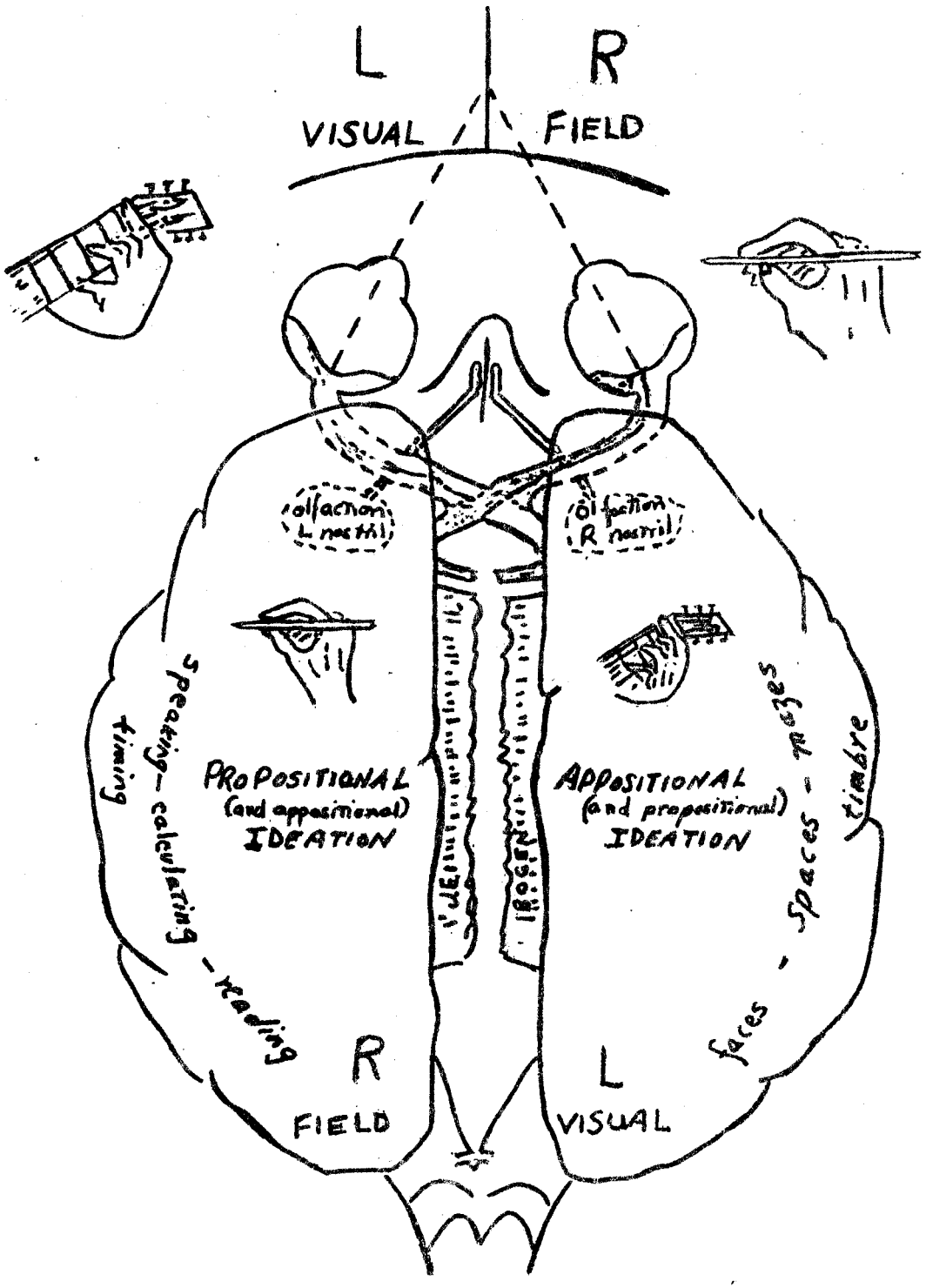
General memory was also quite evidently impaired with these commissurotomy patients (Zaidel and Sperry 1974). These authors suggested "that inter-hemispheric commissures are important in memory especially in the initial grasping and sorting for storage of perceived information and at later stages in the retrieval and read-out of contralateral or bilateral engrams" (p.270). An overview of Sperry's (1974) delineation of hemispheric asymmetries for the right-handed commissurotomy patients is tabulated in 2(A),while Bogen's visual representation summarizing lateralized lesion cases as well as the commissurotomized patients is in table 2(B). "However," Sperry stated, "it yet remains for someone to translate in a

meaningful way, the essential R/L characteristics in terms of brain process....(P. 11)"

TABLE 2(A) - Sperry's View of Hemispheric Specialization - 1974

Left Hemisphere	Right Hemisphere
speech/ writing/ calculation	- unable to respond in speech or writing in most situations - can't perform simple additions past twenty
most agressive, executive leading hemisphere in the control of motor system;	- quite inaccessible to investigation - it is a conscious system in its own right; perceiving, thinking, remembering, reasoning, willing and emoting all at the human level. - spatial patterns, relations and transformations
analytic/fragmentary	- holistic, uniting
abstract, sequential rather than symbolic reasoning	- orientational - concrete

TABLE 2(B) - A Summary of Hemispheric Specialization according to Bogen- 1975



Adapted from Bogen, 1975.

process... (p.11)"

In terms of the philosophical issue of the role of the hemispheres Milner (1974) supported a claim stated previously by Broadbent that "the efficient solution for most tasks requires the concerted action of the two hemispheres of the brain "(p.78). When this is compared with Bogen's cerebral duality position,we find ourselves in the midst of an emerging major question in the field having to do with whether and when the hemispheres work in unity and/or as separate entities. Is there a continuum of interaction from synchrony to near independence or is there some non-continuous alternative between the hemispheres?

Brain-Damaged Studies-1969-1974

The continued investigations of Milner(1971, 1974) and her associates concerning the neuropsychological implications of cortical damage were representative of the general clinical field at this time. Their study on the frontal and temporal lobes yielded an enrichment of the simpler paradigm of hemispheric functioning: "left frontal and temporal lobes share the overiding verbal functions, while the right frontal and temporal lobes manifest the still poorly defined non-verbal specializations of the opposite side"(Milner 1971, p.276).

Experimental Methodology -1969-1974

The studies cited below are representative of the continued trend in experimental and neuropsychology to determine the variabilities and parameters of dichotic listening, visual half field tachistiscopic studies and physiological measures. The existing paradigm of all verbal material being processed in the left hemisphere and all visuospatial in the right began to shift as factors such as task analysis, attentional bias, level of subject's proficiency at task,strategy and other factors were manipulated.

Dichotic listening

As mentioned earlier(Kimura 1961), a right-ear advantage (REA) was associated with left hemisphere (LH) activity, usually for verbal material. Conversely a left-ear advantage (LEA) was related to right hemisphere (RH) processing of non-verbal material. The experiments described below, however, showed the manipulatable complexities of this testing situation.

Spellacy and Blumstein (1970) presented consonant vowel consonant (CVC) nonsense syllables (although they are nonsense syllables they are still considered a linguistic stimulus because of the phonologic content) dichotically to 116 right handed subjects. Half of those subjects were advised that a non-linguistic stimulus would be heard, while the other half were told that the stimulus would be linguistically based. As per their prediction, the former group who were advised of a

non-linguistic stimulus showed a significant LEA-RH superiority, while, as anticipated, the language-expectant group did have the usual REA-LH effect. Thus personal expectation changed the ear advantage and the processing hemisphere. Similar results were obtained when subjects listened to the same melody but had different instructions as to task requirement. (Bartholomeus, 1974). For those subjects who were specifically listening for a letter sequence, a significant REA was obtained; those listening to the melody had a significant LEA, while those listening to sung voices had no significant ear preference. In an earlier work Studdert-Kennedy and Shankweiler (1970) secured a significant REA by presenting CVC syllables to subjects- a reduced but significant REA was obtained for a final stop consonant (b,d,g,p,t,k) while no significant REA was obtained for medial vowels. These findings, combined with Bartholomeus' (1974) work, pointed to an essential feature of the left hemisphere - its ability to extract linguistic features.

Another variable manipulated in dichotic tasks was the emotional tonality accompanying a linguistic phrase. In such an experiment Haggard and Parkinson (1971) found a LEA instead of the usual REA. An exception to a LEA for tonality occurred when the intonation pattern of words was specific to the meaning, (as in Thai), in which case a REA was evident, the tone being processed as an intrinsic part of the meaning. (Van Lancker and Fromkin, 1973).

A most popular and widely cited study of strategy effects on a stimulus was shown with musicians and non-musicians who were given a melody comparison task (Bever and Chiarello 1974). Naive listeners (non-musicians) had a LEA-RH effect, while trained musicians recorded a REA-LH advantage. It was suggested that the non-musicians were utilizing a gestalt or holistic approach to listening (a supposed right hemisphere task) while the experienced musicians utilized an analytic process (assessing chords, instrumentation, etc.).

Tachistiscopic Studies-1969-1974

Reaction time studies using visual half fields were also used as evidence of hemispheric asymmetry (Geffen et al 1971, Rizzolatti et al 1971). The findings were consistent with the existing paradigm that verbal stimuli presented to the RVF-LH were detected more quickly than if presented to the LVF-RH, with the opposite being true for non-verbal stimuli (such as whole faces).

This period was marked by a shift away from the stimulus material determining the particular hemisphere used to an information processing approach where the focus was understanding the particular processes used by the subject. In a tachistiscopic experiment by Seamon and Gazzaniga (1973), stimuli which by their nature could be stored in memory either through a verbal coding strategy or an imaginal one were presented to subjects. Depending on how the initial coding

instructions were given, the subjects could either have a verbal (L.H.) or imaginal (R.H.) code for the initial stimulus. This finding was noteworthy because it added depth to the idea of the individual existence of different processing strategies with the same initial stimulus.

Physiological Measures-1969-1974

Inquiry continued during this period with a proliferation of electrcphysiological techniques aimed at investigating and experimenting with hemispheric asymmetries. Using the concept of verbal/non-verbal distinction, stimuli were presented either to visual fields or to auditory channels while neuro-electrical recordings of the brain's activity were made. This could be accomplished using an electroencephalogram (E.E.G.) over an extended period or by recording the average evoked potential during a brief exposure to the stimuli. The ingenious use of cerebral blood flow as a measurement of hemispheric activation was also highlighted at this time. (Lassen and Ingvar, 1972)

The early electrophysiological studies of Buchsbaum and Fedio (1970) and Morrell and Salamy (1971) utilized tachistiscopic and auditory stimulation respectively as a means of investigating cerebral specialization. The results of the measurement of neuro-electrical activity using evoked potentials showed left hemisphere activity for speech and linguistic abilities. Similar findings were reported by Wood, Goff and Day (1971) using dichotic listening tasks. The latter writers

concluded that their experiment provided strong "support for the idea that a unilateral mechanism is specialized to perform those linguistic processes necessary for speech perception" (p.1251). Davis and Wada (1974) noted some technical problems associated with the evoked potential studies which could bias the asymmetries. They also cited the more global issue of attaching hemispheric asymmetry to a difference in electrical amplitude. The question posed was whether electrical activity over the left hemisphere actually indicated specialization for that specific task "... terms like ' left and right speech-dominance' and'hemispheric asymmetry' although conceptualized from a neurological viewpoint, have been only vaguely defined in terms of brain function and experimental evidence" (p.1).

E.E.G.-1969-1974

The recording of hemispheric asymmetries using the E.E.G. was investigated by Galin and Ornstein (1972) and Doyle,Ornstein and Galin(1974) at The Langley-Porter Institute in California.As an introduction to the reader, the major states of electrical activity are "Alpha" (8-12 cycles per second) occuring usually when the subject is resting, while "Beta" is considered characteristic of the active cortex at 13-80 cycles per second.

Three major factors differentiated the work of these researchers from previous E.E.G. research. First, they chose to use a resting baseline of brain activity, after which the subject would engage in a task. In other words, a subject before

the task would be in the electro-physiological "resting" state of"Alpha". Secondly ,a task which was known to depend on one of the two specific cognitive modes (verbal or visuospatial) would be given to the subject. This would necessitate the brain moving from its initial resting "Alpha" state into the set "activity." Thirdly, the electrodes would be placed on the temporal and parietal points which are most sensitive to cerebral asymmetries. A critical expectation of their model was clearly stated:

> "Our opinion is that in most ordinary activities, we simply alternate between cognitive modes rather than integrating them. These modes complement each other but do not readily substitute for each other. (Galin and Ornstein, 1972, p. 413)"

Although this expectation was not particularly confirmed, the crucial expectation that there was an electrical correlate of cognition has apparently been repeated and confirmed. The results of their studies using EEG measurements confirmed their predictions. The right hemisphere became active (i.e. moved out of Alpha) for visuospatial tasks, while the left hemisphere became active for verbal tasks thus indicating task-specific asymmetries.

Cerebral Blood Flow

As shown through the processing work of Ingvar and Risberg (1967) changes in neuronal tissue through increase or decrease in blood flow could now be monitered. This clinical procedure entails the injection of a radioisotope Xenon 133 or the

inhalation of an air-xenon mixture. With detectors near the surface of the head, changes in blood flow could now be detected during physical and mental activities. In 1974, for the first time, a topographical display of regions activated by speech and reading in the dominant hemisphere was obtained (Ingvar and Schwartz 1974). This blood flow technique was an independent source for the mappings of the language area supplementing the many lesion studies as well as the exploration with electrical stimulation by Penfield and Roberts (1959). To quote the authors:

> "... that by means of the rCBF technique the cerebral correlates to the highest functions of man's brain are now acessible to a new form of quantitative analysis." (Ingvar and Schwartz,1974,p.287)

Conjugate Lateral Eye Movements (CLEM) and Cerebral Organization- 1969-1974

Based on the work of Day (1964) and Bakan (1969) work in CLEM continued during this period. Kinsbourne (1972) found that when right-handers solved verbal problems, not only did their eyes move to the right(as previously reported) but their heads turned right as well, this movement being contralateral to the activated hemisphere. When given numerical and spatial problems, subjects looked and turned left indicating a right hemisphere activation. Similar findings were obtained by Kocel, Galin, Ornstein and Merrin (1972).

> "Several blind men attempt to investigate an elephant. One who has the trunk says, "It is long and soft and emits air." Another, holding the legs, says, "It is massive, cylindrical and hard." Another, touching the skin, "It is rough and scaly." (Ornstein 1972, p.25).

Such was Ornstein's position on our limited capacity for viewing ourselves and our environment. In his book, The Psychology of Consciousness, he challenged some of the basic paradigms about human classical "ways of knowing." Ornstein's concern was with the high status given to "verbal rationality" and a more limited acceptance of "other ways of knowing." Quoting Jacob Needleman, Ornstein suggested that we have been subject to a "radical underestimation" of our lives due to the strong reliance on "one way" of knowing. In relating the above to brain functioning he stated that this present culture's reliance is on the left hemisphere's analytic, logical, verbal and mathematical function at the cost of limited utilization of the right hemisphere's faculties, which he characterized as being specialized for "holistic mentation ... orientation in space, artistic endeavor, crafts, body image, recognition of faces ... more holistic and relational" (p 68.) It was Ornstein's opinion that Bogen's three review papers (1969 a,b;Bogen and Bogen 1969) contributed greatly to understanding the different specializations of both hemispheres. What is important to note here is that Ornstein accepted without reservation all the information in these articles by Bogen (1969a,b;Bogen & Bogen

1969), some of which was explicitly stated to be speculative in nature. Ornstein made liitle distinction between verifiable neurological asymmetries and inferential or supposed hemispheric characteristics.

Ornstein stated that the concept of a major/minor hemisphere (left/right) was more of a societal nomenclature than a neurological one. The thrust of his concern was directed at the cultural dominance of speech residing largely in the left hemisphere and minimal cultural appreciation for other than the spoken and written word.

In regard to public school education Ornstein wrote :

> We deemphasize and even devalue the arational, nonverbal modes of consciousness. Education consists predominantly of "readin', ritin', and rithmetic, " and we are taught precious little about our emotions, our bodies, our intuitive capabilities. A strict emphasis on verbal intellectual knowledge has screened out much of what is or could be legitimate for study in contemporary psychology. (p.26)

New Dichotomies Suggested During 1969-1974

During this period three new characteristics of hemispheric specialization were added to the already considerable list. Egeth and Epstein (1972) suggested that the R.H. was specialized for "difference" detection while the L.H.'s concern was for sameness.

Nebes' (1972, 1973) work with the California split-brain patients indicated that the disconnected right hemisphere was markedly superior in generating a conceptual whole from incomplete or fragmented information - i.e. a closure operation.

In a widely cited finding Cohen (1973),using neurologically intact subjects,tentativly suggested that the left hemisphere used a serial method of analysis while the right used a parallel method. This idea was based on Levy-Agresti and Sperry's (1968) analytic/holistic dichotomy and Nebes (1971) closure capability of the R.H.. Cohen's dichotomy was limited specifically to linguistic material. When shapes were tachistiscopically presented she found that both hemispheres processed the information similarly.

Egeth and Epstein's (1972) and Nebes' (1972, 1973) findings contributed to the understanding of hemispheric asymmetries by delineating the characteristics of each hemisphere. Yet Cohen (1973) suggested that the serial/parallel dichotomy was the underlying dichotomy upon which other characteristics such as language and visuospatial processes were built.

Foundational Authors' Publications in Lay Journals-1969-1974

During this period, more general review articles on the nature of brain organization and hemispheric specialization were published by a number of major brain researchers for the scientific community and intelligent lay public in Scientific American . An introduction to the functional organization of the cortex by Luria (1970) was followed with articles by Geschwind and Kimura . The focus of the article by Geschwind (1972) was on the left hemisphere's language capabilities and subsequent disorders (aphasias) due to disease or accident while Kimura's

(1973) descriptions of her work using dichotic and tachistiscopic paradigms focussed on the verbal/visuospatial hemispheric asymmetries. Although the authors had access at that time to coexistent information which might have questioned the clear predominant dichotomy, they did not choose to include it. Whether this was due to its tenuous nature (i.e. some evidence from split-brain patients may not have been considered readily applicable to" normals"), or to the authors' belief that the existent predominant model was so well established as to render other factors insignificant , is not clear. They might have chosen to write what was clearly known and perhaps did not wish to use this particular forum for more finely-tuned points. Lay journals usually deal in broad brush strokes to paint their pictures. Thus at the end of this period (1974), those not reading the more technical journals (Neuropsychologia, Cortex, Brain, etc.), where details concerning the nature of specialization were debated, would be left with the dominant idea of hemispheric capacities established in a rudimentary form more than one hundred years earlier.

Summary-1969-1974

The research findings cited in this chapter led to the following conclusions concerning hemispheric specialization up to 1974:

1. Although each hemisphere held an executive functional strategy (left/verbal - right/visuospatial), the hemisphere

which was used was not only dependent on the nature of the stimulus (verbal/visuospatial), but also on the particular strategy chosen by the research subject.

2. The dominant concept of strict hemispheric specialization was reduced by studies which found that certain aspects of music were found to be localized in the verbal hemisphere (left) while the right was found to have some verbal comprehension.

3. Cohen (1973),following the impetus of Levy-Agresti and Sperry (1968) and Nebes (1971) who suggested that the basic hemispheric dichotomy was not a linguistic/visuospatial one, put forth the view that it was characterized by serial versus parallel processes. It is worth noting that, while by 1974 the analytic/gestalt and serial/parallel dichotomies were the two major hypotheses that challenged the dominant dichotomy, neither theory was being seriously debated.

4. Two additional concepts which emerged at this time continue to be debated and argued still. These are :

   a. The position urged by Bogen and elaborated by Ornstein that there is a significant degree of hemispheric independence, the two hemispheres working differently, this being called hemispheric complementarity.

   b. The view of researchers such as Milner and Kimura, who in addition to shunning questions of the educational significance, viewed the continual interplay between hemispheres as the normal state of affairs. This

position was described as "dual functional asymmetry."

The Recent Period-1974 Till the Present

This section will serve four purposes. First,it will provide current information about a number of specific topics. These will include R.H. language, the asymmetry of music and the subsequent review, replication and criticism of claims that challenged the verbal/nonverbal dichotomy--(diffuse/focal, serial/parallel, analytic/gestalt). Secondly, new themes will be described and their present status outlined.These include lateralization of emotion/imagery,"cultural" hemisphericity and dyslexia. Thirdly, the challenge presented to the existing model of verbal/visuospatial asymmetry in right handers with the introduction of such variables as age, sex, individual cognitive style and handedness and cultural orientation will be reviewed. In addition, methodological weaknesses in the tools used to detect hemispheric asymmetries will be discussed. Fourthly, new concepts of hemispheric specialization that have been recently developed will be outlined.

The Status of the Hemispheric Specialization Dichotomies

Research in hemispheric specialization over the last twenty years has resembled the quest for the Grail-- i.e. the ultimate search for the nomenclature that could best characterize the processing capabilities of each hemisphere. With the appearance

of seeming incongruities in the older,stable verbal/visuospatial model , this period has seen a search for the most all-encompassing base dichotomies. This section will examine the dichotomies suggested in this period, specifically:

1. temporal and sequential processing (Efron, 1963)
2. analytic/holistic (Levy and Sperry, 1968)
3. focal/diffuse (Semmes 1968)
4. serial/parallel (Cohen 1973)

A recent review of the hemispheric specialization literature by Bradshaw and Nettleton (1981), accompanied by peer commentaries based on the target article as well as other review articles, will be used in examining the present claims of cerebral dichotomy.

(i) Temporal and Sequential Processing

In his review of the literature Allen (1982) stated that most contemporary researchers believe that both hemispheres do some temporal processing while the orginal thesis stated by Efron (1963) considered this to be in the L.H.'s domain. However this remains a moot point. Allen's review of the literature revealed four researchers in agreement with Efron's original thesis, while there were four against. Moscovitch (1979) summarized the case of those against the initial thesis stating that although sequential/temporal features have a critical role in language (L.H.), they alone cannot account for language production because lexicon and contextual factors considered to

be right hemisphere attributes are also critically important. Both Moscovitch (1979) and Cohen (1982) cited the case of braille readers who used their left hand (R.H.) to read, considered a sequential/temporal task. Thus even if temporal/sequential processing was in the domain of the L.H., it would not extend to haptic (tactile) information. To suggest that the basic nature of the left hemisphere is suited solely to temporal/sequential processing is premature although it may be an intrinsic component of the left hemisphere's operation.

(ii) Analytic/Holistic

This dichotomy originated with Levy-Agresti and Sperry (1968) and was later confirmed through the work of other researchers including Nebes (1971). Bertelson (1982) has suggested that the dichotomy is most popular because of its inclusion of other distinctions such as digital/analogic, focal/diffuse, serial/parallel and propositional/appositional. Yet there is a vagueness about it yielding a poor operational definition which is open to misapplication and distortion. Cohen (1982) has stated that although the left and right hemispheres may have this dichotomy the question is whether this definition explains anything more than the different ways in which items can be remembered and reconstructed from memory - i.e. is a global assumption valid? Continuing on this theme, Moscovitch(1979) has suggested that perhaps other explanations besides the analytic/holistic one may be appropriate. According

to the analytic-holistic viewpoint, the left hemisphere is considered to be slow in processing information because of its analytic nature, resulting in a feature-by-feature examination. The right hemisphere alternatively is considered to be the quicker one because of its overall gestalt, panoramic processing. In citing the experiments with split-brain patients (Zaidel & Sperry (1973) and Levy(1974)) involving tactile materials, Moscovitch suggested that beyond the analytic/holistic explanation of the L.H. being unable to process nonverbal tactile information as quickly as the right, that another possible explanation was that the left hemisphere's "non-verbal memory is so poor it cannot store that information for a sufficiently long time to make the necessary match unless it can encode the information verbally" (Moscovitch, 1979, p.415). Bertelson (1982) had concerns with the dichotomy,namely that the terms were vague and did not easily lend themselves to operational constructs. As well, the terms could not be clearly differentiated from other definitions. While these incongruities have raised concerns about globally considering each of the hemispheres as analytic/holistic, it is possible that these may be aspects of their processing capabilities.

(iii) Focal/Diffuse

Semmes (1968) argued for a left hemisphere that consisted of a neural substrate that was focal or specific in nature, while the R.H.'s functions were neuronally more broadly

(diffusely) separated. Recent neuroanatomical research seems to support Semmes' view. The Gur et al (1980) study which found that there was a greater proportion of grey to white matter in the left hemisphere than in the right was congruent with Semmes' notion. In accordance with this dichotomy the organization of the left hemisphere is viewed as emphasizing processing or transfer within a region of the hemisphere (left) while the right's movement is across regions. There has been some research on this hypothesis but with conflicting results. As Allen (1982) has suggested, this hypothesis is best regarded as "intriguing speculation."

(iv) Serial/Parallel Processing

The terms serial/parallel were popularized from Cohen's (1973) original research. Investigators have sensed the interchangability of serial processing with other nomenclatures such as temporal, executive, planning and decisional processing, but, as these terms are somewhat vague, the explicit relationship has yet to be investigated.

Although Cohen's (1973) formulation of this dichotomy was initially to apply specifically to alphanumeric information, it was soon generalized as the processing model for all perceived stimuli. (Allen, 1982). Two researchers who found similar processes hypothesized that both serial and parallel were actually localized in one hemisphere (Seamon 1974 and Seamon and Gazzaniga, 1973 as cited in Allen, 1982). Cohen (1982) herself

stated that her initial results were difficult to replicate while White and White (1975) as cited in Moscovitch (1979) found that letters and shapes were processed in parallel regardless of which visual field received them. Bradshaw and Nettleton's (1981) view, of course, is that serial/parallel are subsumed along with focal/diffuse under the more general analytic/holistic dichotomy, but their view too is not without bias. (Bradshaw and Nettleton, 1981).

Summary

In spite of the incongruities of the research findings, poor methodology, and in some cases, an unwillingness or unawareness of mitigating factors such as sex, handedness, family sinistrality, task practice effects, etc., many researchers during this period were still maintaining the notion of information processing that was fully lateralized in one hemisphere or the other - language being the most prominent of lateralized characteristics.

As Cohen (1981) noted, there seemed to be a haste to replace the older verbal/visuospatial model with the Bradshaw and Nettleton (1981) all-inclusive dichotomy of analytic versus holistic. The points below will address the consequences of this seeming haste to narrow human performance into two modes.

1. The definitions of such terms as holistic/analytic or serial/parallel processing are broad and general and can be easily manipulated to fit the meaning the researcher has in

mind. They can have little more than a speculative value due to their poor operational definition.

2. As mentioned, there was the clear tendency to use the disparate characteristics of hemispheric specialization and have them globally represent each hemisphere. This resulted in the upgrading of a processing ability to represent a cognitive style which then became a fixed description of the unique functioning ability of the hemisphere. Thus although the R.H. was said to have "holistic thinking capabilities", it now became the nomenclature used to describe this area of the cortex. As Segalowitz (1983) has remarked, this description led to even further extrapolations - holistic thus became "irrational," "creative" and "intuitive."

3. Because clear dichotomies were set, most of the evidence pointing to hemispheric asymmetry (which as Moscovitch (1979) stated was descriptive or anecdotal) was "assigned a hemisphere" in a post hoc fashion or through default. This process Cohen (1981) has described as "shoe-horning." The Nebes' (1971) study serves as an example of the present confusion over hemispheric properties. The task of forming a gestalt from incomplete information, in this instance the task being to have a portion of an arc form one circle from a group of varied circumferences, was considered by Nebes to be a R.H. operation. But as Marshall (1981) stated in his commentary to the Bradshaw and Nettleton (1981) article;

> "had the data gone the other way, we can be sure that the task would have been described as

> implicating the ability to decompose circles into their constituent arcs (an analytic operation) followed by computing a relationship between a stimulus arc and internally segmented circle" (p. 73) - (a left hemisphere operation)

4. There appeared to be a "band-wagon" approach in which, once hemispheric processes were allotted to a specific hemisphere, the dichotomy fullfilled itself and the search for alternative explanations, dichotomies or other models ceased.
5. Because of the above point, numerous dichotomies were left unresolved.
6. When attempts are made to group characteristics of hemispheric asymmetries, there will inevitably be a loss of detail and future predictive power.
7. In slotting performance results into a dichotomy, many researchers have not concentrated on understanding the underlying processes implicit in a specific task. However, relying solely on the results and not the subject's strategy, which may yield great variation in the results, may account for the unexplained variance in visual half-field and dichotic listening data.

To give a sense of where the field is, one merely has to read the mixed reaction to Bradshaw and Nettleton's arguments for an analytic/holistic dichotomy. The writers in the peer commentary were obviously divided in their acceptance of such a new and all-inclusive nomenclature - nine in agreement, nine against.

The Effect of Individual Differences on Laterality

In an comprehensive review Levy (1980) described those who she considered to definitively have a classical verbal/non-verbal, left/right dichotomy as

> "adults, right-handed, right-eyed males, with non-inverted hand posture during writing; who have no left-handed relatives, were free from birth stress, whose sensory functions are intact, who suffer no psychotic illness and who were reared in a relatively normal environment. Such individuals probably constitute no more than fifteen percent of the population. The remaining eighty-five percent of us manifest various deviations from this standard pattern either in direction or degree of hemispheric lateralization, intrahemispheric organization, plasticity of one hemisphere, to assume the other hemisphere's function, or in dominance relations of the hemispheres with respect to behavioral control. Far from being a species-specific trait, the standard lateralizing pattern is but one among many in the human population." (p.259.)

This section is concerned with those human internal and external factors which restrict the utility of the existing paradigm. A person's sex, handedness, and individual cognitive style may all affect their hemispheric specialization. Externally, the subject's cultural background, present orientation, and factors of prior "priming" or "attentional bias" instigated from an exterior source may all affect the subject's response pattern from a "supposedly" fixed set congruent with the existent dichotomies model. Coupled with these factors is the unreliability/variability of methodological tools used in ascertaining hemispheric specializations. It is the aim of this section to provide an overview of these issues, giving rise to Levy's opinion "that the standard laterality pattern is but one

among many ...". As we shall see, these many variations are in fact minor as compared with the principal facts of hemispheric specialization in the vast majority.

Sex-Related Differences

Contrary to Buffery and Gray's (1972) finding that women were generally more lateralized then men, Bryden's (1982) summation showed that men were more lateralized than women, specifically on verbal measures. Because he felt that measures of right hemisphere functioning were not as consistent as measures for the left, he concluded that it was too premature to suggest spatial superiority. Interestingly, Allard (1980), as cited in Segalowitz (1983), had shown that the supposed spatial infericrity in females disappeared when the task could be practiced. The basic finding that cognitive processes were less lateralized in females than males was supported by McGlone's (1978,1980) work with neurologically impaired patients. In Hecaen's studies of aphasics he had shown that more men had language in the L.H. than women (95% vs. 79%). However, of the group of men and women having L.H. language, both sexes were equally lateralized as to cognitive functions.

Evidence from Levy's (1974) work demonstrated that verbal tachistiscopic and dichotic tests placed males in a stronger position than females (i.e. males were more lateralized). As well, the pioneering anatomical work of Geschwind and Levitsky (1968), Wada, Clark and Hamm (1975) and Witelson and Pallie

(1973) showed the temporal planum to be larger on the left than on the right in adult males. In infants this area increases more with age in males than females. Although the larger size of a neuroanatomical region may result in an increased cognitive performance capacity for that area, at this time it is only speculation that this is the case.

Thus considering the evidence of: (a) tachistiscopic /dichotic listening studies with normals; (b) brain damaged studies; (c) anatomical differences with normals, there is a strong argument for male/female differences in verbal functions with the spatial evidence being weaker. However, as suggested by Bryden (1982), a major challenge to this whole concept of sexual differences in hemispheric specialization may be the approach that men and women take to the same problem. Thus men and women may be lateralized in the same neuropsychological fashion, yet strategy effects may be the fluctuating factor. Women, although said to be less lateralized at spatial functions, may be encoding the information verbally, thus resulting in a seemingly less lateralized R.H.. In his peer commentary to McGlone's (1980) target article, Bryden (1980) suggested the need for other parameters to be taken into account before the reliability of sex differences was to be accepted. Such factors would include overall cognitive skills, achievement, practice, memory load, novelty, motivation, hand performance, familial sinistrality (left-handedness) and the subject's attention and informational processing strategies.

Studies on laterality differences with boys and girls have also shown mixed results (Bryden 1982). Methodological concerns and strategy effects have cast doubt on some of the studies showing asymmetrical differences. It was suggested by Bryden (p.235) that if the developmental literature on hemispheric asymmetries were moving in any direction it would be toward indicating a greater bilaterality for both language and spatial processes in females.

Although McGlone's (1980) review article concluded that the male brain was more asymmetrically organized than the female brain, other effects and factors weakened the general laterality concept. Bryden suggested that(1980) there seemed to be more similarities between female/male brains than supposed differences. Kimura (1980) raised an interesting notion by suggesting the possibility of intrahemispheric differences in the male and female in the L.H. for speech,but this has not been investigated. McGuiness's peer commentary on McGlone's (1980) article would be most appropriately stated here.

> "Because of all these problems, my conclusion would be even more cautious than McGlone's. Until better controlled studies are carried out with larger populations, nothing can be concluded from the evidence. Meanwhile it would be of benefit to scrutinize all task and response parameters in the studies demonstrating hemispheric effects in males." p.244

Handedness

The concern in many studies has been with the typical right handed male and his functional brain organization where a

particular type of response has been observed. However, where display of performance and cognitive characteristics is quite different for the left-hander (sinistral), a cohesive singular typical mode of reponse for such subjects has not been evident. The chief difference for the sinistral population has stemmed from the greater incidence of right hemisphere or bilateral representation of language in the left-handed group - 4% of the epileptic right handed population vs. 30% in the left-handed. (Rasmussen and Milner, 1977). In a clinical population, for example, this would be demonstrated as a decreased incidence of aphasia or quicker recovery where there was left-hemisphere damage. It has also been suggested that stuttering was a result of bilateral representation of language (Jones, 1966). When one of two speech centers of four stuttering patients was excised (sodium amytal tests had been administered to determine in fact that two language centers were present), the stuttering ceased.

Levy (1969) hypothesized that left-handers (who as a group have a greater incidence of bilateral representation of speech), would be impaired on visuospatial tasks. This would be due to the verbal and visuospatial centers of the right hemisphere being in competition for space, with the verbal centre succeeding in squeezing out the visuospatial. Her hypothesis was supported-- left-handers as a group scored significantly poorer on visuospatial subtests of the Weschler Adult Intelligence Scales (WAIS) while both groups scored similarly on the verbal subtests. Although one study was replicated with a large group,

failure to subsequently replicate the results occurred three times (Springer and Deutsch, p.120). A preliminary estimate of spatial representation in the right hemisphere of right handers has been 69.3%, but in left handers there is an increased bilateral representation and reduced right hemisphere representation. Bryden suggested that although there was complementary specialization, it could be assumed in left-handers. Thus, in conclusion, as suggested by Bryden (1982), "left handers are less likely to demonstrate clear-cut cerebral organization than right-handers" (p.173). This is another factor that would alter the usual paradigm of cerebral specialization.

Other Lateralities

Although most people have a preferred eye for sighting (67% of the population show a right-eye dominance), Porac and Coren (1976), as cited in Bryden (1982), stated that little evidence was available indicating a functional relationship between eye preference and handedness or cerebral lateralization. They also noted that " footedness" or "earedness" were also not reliably related to either handedness or cerebral dominance.

Neuroanatomical Asymmetries

Beyond the behavioural and electrophysiological measurements suggesting differences in brain laterality, anatomical asymmetries have been observed in human and animal brains. The review by Goldberg and Costa (1981) on anatomical differences will be used here.

Early studies by Geschwind and Levitsky (1968) have shown that an adult's left temporal lobe upper surface (temporal planum) is one-third longer than the right. A larger left temporal planum is also found in infants (Wada, Clarke and Hamm, 1975; Witelson and Pallie, 1973). Specific anatomical regions responsible for the processing of language (the secondary auditory centre, the oral kinesthetic and oral-kinetic) have been shown tc have greater left hemisphere representation.

Outside the speech areas, the left occipital lobe is wider than the right in right handers, while in left handers, it is less pronounced. Studies suggesting a greater representation of the left's postcentral gyrus and superior parietal has also been reported. In brief, it can be summarized that the sensory and motor-specific areas are greater in the left hemisphere. Anatomical differences have shown that the right hemisphere has greater areas of associative cortex (temporoparietal and prefrontal), which areas are implicated in the most complex levels of processing and decision making, and which,with their interconnections, form one functional system. At the level of the cranium, Lemay has found asymmetries in the fossil skulls of

early humans and primates, strongly suggesting that asymmetries have developed over millions of years. (Marx, 1983). These physically larger areas are said to be a result of a difference at the cytoarchitectural (neuronal) level. This cellular bias toward the left hemisphere can be observed predominantly in specific language areas. Dendritic length and the complexity of the dendritic network were found to be greater in the left hemisphere, specifically in the main speech centre (Marx, 1983).

While neurotransmitters such as dopamine have been observed to be in higher concentration in the left than in the right hemisphere of some adults, the reverse was true for others. Particular dopamine concentrations were also noted in specific areas of each hemisphere contralateral to the subject's preferred hand (Marx, 1983). In summary, the accumulating evidence from neuroanatomical and neurochemical investigations strongly suggest the genetic innate pre-eminence of the left hemisphere for executive speech and motor functions for the typical right-handed person.

Strategy effects altering hemispheric asymmetry

> .... we have become too accepting of the relation between behavioural laterality and cerebral organization. We have too often forgotten that our tasks are administered to active, thinking subjects who have their own particular strategies for dealing with the demands that are put upon them. Thus many of the differences that have been attributed to differing patterns of cerebral organization may, in fact, be manifestations of different ways of dealing with the tasks. Such an argument does not deny the existence of

hemispheric asymmetry; rather, it claims that many of the procedures used for assessing asymmetry are subject to other sources of variation." (Bryden, 1978, p.119).

Bryden's contention has been borne out by data from other sources. This section will discuss these different possible strategies that Bryden speaks of. The basic model accepted at this time, termed the Structural Approach (Bryden 1978) or the Absolute Specialization Model (Cohen 1982) originated with Kimura's work (1966, 1967). It showed that each of the hemispheres was specialized for processing only certain types of materials. For example, the model suggested that information or stimuli received on the right side (right ear, right eye, right hand or foot, etc.)was processed by the left hemisphere. It was to be concluded that there was a right-sided superiority for those tasks involving stimuli that the left hemisphere dealt with more proficiently. (Bryden, 1978 p.119). The points raised below however question this basic assumption.

Attention

Attentional strategies are those which are under the volitional control of the individual. Should a subject know that he/she is doing poorly on a tachistiscopic or dichotic listening test, specific attention may be directed to the poorer eye/ear. The key point here is that this response is under the subject's control and is independent of hemispheric effects (Left Ear Advantage for music for example). Secondly, there may be a handedness effect involved which is also independent of

hemispheric asymmetry: i.e., right handers who have speech in either the right or left hemisphere are more right dominant than the left-handers. In other words, handedness has an effect over and above speech lateralization. (Bryden, 1978). Thus, where a subject places his attention is due to a number of variables: (i) the task itself (e.g. music creating a LEA), (ii) the handedness of the subject, (iii) where the subject consciously chooses to place his attention and (iv) "the moment to moment shifts in the demand as the task is being performed" (Moscovitch, 1979 p.423).

Priming

Irrespective of Kimura's structural model, Kinsbourne (1970, 1973) postulated a theory which stated that the right and left hemispheres became active if they were expected to be engaged in non-verbal/verbal activities. This in turn caused a selective attention bias toward the sensory field contralateral to the activated hemisphere. Thus, if a subject were told that she would hear a verbal stimulus, the left hemisphere and thus the right auditory field would become activated. This resembled the Spellacy and Blumstein (1970) experiment discussed earlier. In reviewing the subsequent studies based on Kinsbourne's work, Moscovitch (1979) concluded "... attentional influences may be present but they are weak and unreliable and show their greatest effect for material that is not strongly lateralized" (p.424). Replication of Kinsbourne's initial work has been inconsistent.

Following the work of Kinsbourne, Hellige and Cox (1976) found that when two to four words were kept in memory (left-hemisphere) and concurrently a polygon shape was processed, it was the left hemisphere that processed the shape, contrary to the usual right hemisphere's predisposition for non-verbal material. However a larger load of six words placed processing of the shape in the domain of the right-hemisphere. As an explanation Hellige posited that a moderately active L.H. is more efficient at certain stages for visuospatial processing than the R.H. which may be at a lower level of activation.

As Bertelson (1982) remarked when discussing Hellige's work (Hellige et al, 1979), intrahemispheric competition can also result in an overflow to the less competent hemisphere, "specifically that loading the left hemisphere with a word rehearsing task shifted the pattern of performance on letter recognition from the left hemisphere to the right" (p.192). These often cited studies of Hellige's (1976, 1979) have shown dramatically the "non-fixed" nature of hemispheric specialization and have contributed to the loosening of the seemingly tenacious grasp of the absolute specialization model.

Individual Cognitive Style

In keeping with the spirit of Bryden's opening remarks to this section, it seems clear that as individuals we have our own style of dealing with problems. Whether one looks at problems in an overview/gestalt manner, in a linear/sequential fashion

("figuring it out"), through visualization/imagery or drawing, the variabilities of the human being will continually elude those who search with limited tools or who have a binary preconception of cognitive functioning. Levy (1983) in a recent article suggested that another factor to be considered in the perceptual variation among right-handers is the individual's own level of arousal. This level of arousal may be affected by emotion, personal learning style or personal disorders. Arousal seems to be a more intrinsically personal and constant factor than Kinsbourne's notion of attentional bias or priming which may vary with the task or stimuli.

Limits of Behavioural Measurements of Hemispheric Specialization

Dichotic Listening

Bryden (1983) has recently posed a most interesting question that requires questioning some basic assumptions regarding the reliability of the dichotic listening paradigm. Specifically, if the incidence of left-hemisphere speech in right handers is 97% - 99%, why does the incidence of right ear superiority (left-hemisphere activation for verbal material) tend to be between 75% and 85%? As suggested above, there would seem to be other factors that mediate in the process that were not considered in the original hypothesis. The extraneous factors which ultimately affect performance could include the following:

8. Where the subject "decides" he will place his attention - (i.e. one can will to which ear attention will be paid, or one can use a strategy which is personally initiated - "first the right, then left, then left again...".
9. A correlation between the ear to which the stimuli is presented and the resultant laterality effect as reported by Bryden (1978).
10. Short-term memory and order of reporting which may also mediate performance.

Also to be considered is the observation that non-verbal dichotic effects are generally less lateralized than those for verbal stimuli (Bryden 1978, p.132). Teng (1981) also placed a cautionary note on the usefulness of dichotic ear score differences, citing highly inconsistent results and a relatively large retest error variance. Factors possibly responsible for this variance are consistent with those suggested by Bryden (1978) above.

Tachistiscopic Lability

The tachistiscopic experiments have usually involved a controlled presentation of the stimulus to the subject, for example, time exposure, subject's gaze, available light, etc. Using faces as a stimulus, Sergent (1982) altered the initial flash of stimuli from the usual 150 milliseconds(msec) to 250 msec. with a resulting different asymmetry effect - L.H. activation in addition to the usual right. She contended that

both hemispheres were sensitive to faces but the left hemisphere's sensitivity arose under specific presentation conditions which were different than in the usual presentation method. Specifically her variables included an increase in stimulus time, no memory involvement in the task and the use of highly similar faces . She suggested that the L.H. is superior at processing faces when there are difficult discriminations involved and in identifications. Thus, as intended, Sergent drew attention to the fact that when elements of the tachistiscopic task presentation were altered, unexpected patterns of hemispheric activation resulted. This suggested that when a "set stimulus presentation" pattern is used, the tachistiscopic results may not "reflect the full perceptual capacities of the subject"(p.13). Bryden (1978) echoed the same caution.

Limitations of Physiological Measures of Hemispheric Acitivity

Although regional Cerebral Blood Flow (rCBF) (Lassen and Inguar, 1972) is responsive to changes in the hemispheric activity of the cortex, the technique does not allow activity to be analyzed in the deeper levels of the brain. It has also been suggested that blood flow is probably not responsive to rapid variations of the brain's activity. (Springer and Deutsch, 1981).

Electrophysiological Assessments

As with the behaviour measurements of laterality, there have been conflicting results and difficulty with the replication of the EEG and AEP (Average Evoked Potential)results. As Springer and Deutsch (1981) have suggested, this was due to three reasons. First, there was a failure to control for individual differences among subjects. Second, tasks were used which did not necessarily differentiate between left and right activity. Thirdly, there were differences among researchers as to the electrode placement and particular measurement of cortico-electrical activity. In a series of papers citing the work of Galin and Ornstein (1972, 1974) as well as the work of others using alpha wave production to differentiate hemispheric activity, Gevins et al (1979 a, b, c) criticized this work citing poor control for "non-cognitive factors" such as motor artifacts. In their own experiments these research teams were supposedly able to control for such extraneous factors with the results indicating "no task-dependent asymmetry." As Bryden (1982) suggested, even with arguments such as those of the Gevins team, there has been a growing body of positive findings which suggests the validity of using EEG measures to provide an overview of cerebral organization. Yet Bryden cautions about the prematurity of suggesting that differences in EEG measures definitely reflect differences in cerebral laterality. Galin et al (1982) also echoed the same hesitations and weaknesses with the general

model. For example, although there was an electrical reading from the scalp signifying activity, it was not known if this region of the brain was the focus of the activity or if it was being driven by another deeper or local area (a limitation of the EEG, like rCBF, is that only surface activity, rather than deep cortical areas, can be measured).

Citing the key disadvantages of dichotic listening, visual half-field, and reaction time studies as not giving precise and explicit information about the participation of specific brain regions during activity, Galin et al (1982) recommended the use of EEG recordings in addition to these other grosser behavioural measures. They expressed strong positive opinions about the future applicability of the alpha paradigm to differentiate specific hemispheric activity. It was their opinion that with a continual refinement of technique and a greater understanding of the electrophysiological interaction between regions, this research approach holds much promise.This is primarily because measurement of a subject's activity is not the result of a millisecond flash of stimuli but can be followed over a natural period of the task. As well, the EEG does not require the use of foreign substances in the body such as in CBF where an isotope is used. Thus it is non-invasive .

Of Fundamental Concern: Generalizing from Neurologically-Impaired Subjects

A major issue of concern for researchers has been the validity of using data from neurologically-impaired patients (specifically the split-brain series) to construct a model of the informational processing capabilities of the normal brain. The concerns have been based on the following issues;

1. The patients who were operated upon had intractable epilepsy, in some cases present since infancy. Some cerebral reorganization might consequently have taken place so that the results are not altogether representative of the normal person with an intact cortex.
2. The interpretation is complicated by the possiblity of post-operative cerebral reorganization.
3. The split-brain laterality studies were performed with a small number of individuals, sometimes only on one. To what extent is such data considered generalizable to all humans?

In response to these cautionary notes, Zaidel (1983 a) remarked that none of the patients had a language shift from one hemisphere to the other as had been suggested. They were remarkably free of damage such as global aphasia, visuospatial agnosia or unilateral neglect, as had usually been seen with lesion patients. Interestingly, he went on to comment that as varied as the patients were in respect to etiology and localizing symptoms, as a group they all exhibited the same general pattern of hemispheric specialization. Sperry suggested

(1982) that because of the complexities of communication across the intact commissure, R.H. capabilities were only recognized because of the research done with the split-brain patients.

Other positive results of the split-brain research included: (1) the split research that followed showed hemispheric capability without the inhibitory effects of the opposite hemisphere; (2)a broader understanding of the non-verbal R.H.'s information processes.

At present, after examining the split-brain literature, this writer concurs with Zaidel's (1983 a) comments concerning the homogeneous pattern of symptoms (e.g., a left handed anomia as reported by Bogen(1979) was exhibited in all of the split right-handed patients despite their varied neurological histories.) However a cautionary note is warranted on the wholesale acceptance of these findings because of the obvious general difference between hemispheric interactions in the normal brain and in those of the split-brain patient.

Yet Segalowitz (1983) emphasized a most interesting point. The popular media, in reporting the findings of the split-brain patients, straight away generalized them to normal intact individuals. In characterizing the press reports Segalowitz remarked, "the left hemisphere is characterized as linguistic, mathematical, scientific and logical while the right is characterized as responsible for music, art and dance appreciation, perception, sculpture and fantasy. Occasionally dreaming, poetry and sexual satisfaction are thrown in for good

measure" (p.57). What we shall see in the next chapter is that the educators did not generally follow the popular press in this regard.

A Recapitulation

Before moving to themes that have been developed after 1974, it may be appropriate to assess briefly what had occurred to this present date. The status of the verbal/visuospatial paradigm was jeopardized by the incongruities of R.H. language abilities and the musical abilities of the L.H. Personal/individual differences which had not been previously recognized as an intrinsic part of the testing procedure were now being noted as a major source of variability in performance. As well, technical strategy and methodology effects, which had resulted in test score variances, were noted, and in some cases researchers began taking them into account before making the usual laterality pronouncements. Weaknesses of the major diagnostic tools were also briefly examined. Hellige's work pointed out the abilities of a hemisphere to shift the processing load to the "non-specialized" hemisphere using a priming or overloading model. These new developments severely limited the functionality of the absolute model of hemispheric specialization. Evidence has shown that the lateralization of a given function is not complete in one hemisphere. A hemisphere that receives "alien" information for processing may handle it and not shift it via the corpus callosum to the more appropriate

one. As well, extraneous elements and intrinsic personal factors can alter the usual pre-determined patterns of hemispheric asymmetries.

Two major shifts occurred in the field during the mid-70's resulting from the inability of older theories to encompass the new findings.

First, the absolute model of hemispheric specialization yielded to a more fluid and spacious relative model. Because of more detailed investigations using sophisticated equipment and improved methodology, it was clear that both hemispheres had the capability of performing tasks once considered doable by only one of the hemispheres. The verbal and non-verbal dichotomy, for example, although still considered the major nomenclature for the left and right hemispheres respectively, was subject to shifts when variables such as sex, handedness, etc. were also considered. Investigations using EEG, Evoked Potential (EP) and blood flow studies confirmed activity in the supposedly dormant hemisphere during a task.

Second, it was recognized that regardless of the presented stimuli (for example, letters or music), each hemisphere might be specialized for a specific type of processing. For example, the major function of the left hemisphere may not be language per se as much as it might be an ability to process analytical information. Consequently the language process is best served under an analytic strategy. Thus, as chronicled in this paper, types of hemispheric processing (serial/parallel,

analytic/holistic etc.) have risen to a noted stature in the recent literature. In his Nobel Prize speech, Sperry (1982) still maintained the analytic/synthetic and sequential/spatial (Levy-Agresti and Sperry 1968) nature of the hemispheres. Other suggested dichotomies seemed to have been discarded either by time and research or by lack of them.

New Themes of This Period

Culture Hemisphericity

> In a culture where most individuals are exposed to intensive education of the left hemisphere potential for reading, writing, grammar, etc. we could reasonably expect a tendency for the propositional mode to dominate even when dealing with problems for which it is less appropriate. Conversely, persons raised in a non-literate culture emphasizing different training, in spatial skills for example, should exhibit a reverse tendency. (Bogen 1972, p.49).

Based on Bogen and Bogen's (1969) earlier work citing the left and right hemisphere as the propositional and appositional processes respectively of an individual's cerebral organization, Bogen suggested that different cultural groups were more prone to display one or the other of the methods of processing information. (Bogen et al, 1972). In a later paper Bogen (1982) states this idea:

> It is amazing how many students of the human condition accept the facts of hemispheric specialization without acknowledging the implications of cerebral duality, whereas many others ... readily recognize cerebral

duality but fail to consider how it is affected by hemispheric specialization. The potential value of these two ideas, in combination, as an intellectual tool in humankind's self-study has been as yet only meagerly realized ..." (p.13).

As stated in the earlier quote, highly literate societies were inclined to use the propositional (left hemisphere) approach while non-literate cultures utilized the appositional approach (right). To test Bogen's (1972) hypothesis four groups representing 1220 Americans were administered two specific tests designed to investigate either a left or right hemispheric predominance. The groups were urban blacks, urban/rural white and rural Hopi Indians. As the reseachers had suspected, the results showed that the Hopi and Blacks relied more on the right hemisphere (appositional processing) while whites showed a strong preference for the linear/sequential/left hemisphere (propositional) mode of information processing. An article published a number of years later by Zook and Dwyer (1976) criticized the Bogen et al (1972) study claiming that it revealed nothing beyond the known cultural differences. As the score on the verbal (left hemisphere) test differed among all the groups, while the "spatial test" scores were similar, the authors concluded that culturally deprived groups, as routinely examined, showed a depressed verbal ability due to a lack of educational opportunities. As well, all groups seemed to have developed similar right hemispheric abilities. When reporting this experiment, a question noted by Springer and Deutsch (1981) was that of the reliability of the tests used to examine specifically right and left hemisphere functions. As mentioned

earlier, it could be possible to silently verbalize supposed visuo-spatial tasks and thereby effect a contamination of scores. They noted that while specific differences relating to cultural hemisphericity may be present, tests are needed that are sensitive to small hemispheric changes.

Galin and Ornstein (1974) used conjugate lateral eye movements (CLEM) as a means of testing two supposedly different kinds of thinkers - lawyers and ceramicists. Results were not convincing. Although the lawyers' performance on the verbal (writing) task was better then on the spatial task, while the ceramicists' pattern was the reverse, there was little difference in actual eye movements between the groups. In a later study, graduate students in sculpture, psychology and law were tested on the assumption that an individual's cognitive mode (verbal/analytic versus spatial/holistic) was related to cerebral laterality. As could be expected, lawyers performed better on the verbal skills while the sculptors were better on the holistic tasks.This does not necessarily indicate innate capacities but more of the suject's method of negotiating his/her world.

Bakan's (1969) study using Conjugate Lateral Eye Movements (CLEM), as reported earlier, differentiated science/engineering majors (right movers activating the left-hemisphere) and humanities and literature majors (left movers utilizing the right hemisphere).

Two studies have been reported which have examined physiological correlates of hemispheric activation. A recent study by Dabbs (1980) (as cited in Segalowitz, 1983) revealed that blood flow to either side of the brain (a measure of activity) was different among university English and Architectural students. As suspected, in a resting position, blood flow increased in the left hemisphere for the English majors while the Architectural students showed a rise in the R.H.. Using an EEG, there was increased R.H. activity when stories were read in Hopi, rather than in English, to Hopi children. (Rogers et al, 1977). Although these findings may point to a language's ability to evoke more appositional or right-hemisphere thinking, the authors have cited other possible causes , among which are the facts that English was the language of instruction while the Hopi language was used for cultural and religious activities.

Testing Navajos and Anglo subjects with dichotic listening tasks ,researchers found the usual REA for the Anglo students while the native group showed the opposite. (Scott et al, 1979).

In addition to these experiments which suggested different strategies in processing information among various occupational groups, as well as different cultural modes, it is clear that other cultures utilize non-linear sequential means of dealing with information. Bogen (note 1) and Segalowitz (1983) reported the reference of Paredes and Hepburn (1976) to the Trukese islanders of the Pacific who traversed vast areas of ocean with

none of the usual navigational aids, relying mostly on "spatial relationships." "Our concepts of intellectual process ignore thought based on imagistic, noncausal and contextual logic. These... form the basis of qualitatively different thinking styles of non-Western peoples" (Segalowitz, 1983 p. 181).

Despite the limitations of these studies (methodological weaknesses, failure to repeat), they indicated a trend, albeit early in its development, towards an empirical and phenomenological understanding of cultural modes of cognition. They also pointed to the need for specific cultural institutions, like schools, to reflect in their structures and approaches the diversity of their clients.

Imagery and Hemispheric Laterality

The primary source of material in this section is the comprehensive reviews of the imagery literature by Ley (1979). The survey included research with unilateral brain-injured, epileptic and split-brain patients and with normals using EEG, Galvanic Skin Response (GSR), conjugate lateral eye movements (CLEM), dichotic listening and tachistiscopic techniques. The majority of studies on this spectrum of subjects and varieties of investigative tools were consistent in revealing the right hemisphere's predominance in the imagery process. It was noted by one research team (Davidson and Schwartz, 1976) that affect and imagery were inextricably linked and that one very easily conjured up the other. Research has also been reported

indicating the R.H.'s involvement in imaginable language.

Positing possible reasons for the R.H.'s superior role in the imagery process, Ley recalled Semmes' (1968) original focal/diffuse (left/right) relationship for describing hemispheric organization: "Such an organization would lead to a proficiency in integrating diverse units of information and a resultant specialization for behaviours requiring multimodal coordination, such as various spatial abilities" (Semmes 1968, as quoted in Ley 1979). Ley suggested that imagery processes would fall into this domain of the right hemisphere.

Paivio's (1971) hypothesis, which includes Ley's as one of its premises, postulates a dual coding memory system which is applicable to this discussion. He suggested that both a word and its evoking imagery were stored in short and long term memory. As Bryden (1982) suggested

> It is only a small leap to link this research [in cognitive psychology] to studies of hemispheric asymmetry and to argue that verbal memory is left hemisphere and visual memory right hemisphere. By this argument, concrete and easily imaged words should activate both left and right hemispheric processes and this should yield a smaller laterality effect than abstract material. p.82

In a recent review paper however, Bakan (1980) suggested that "raw" imagery (the initial ability to produce pictures or images) was a right hemisphere task, while the manipulation or refinement of that image (what he referred to as a 'cooked image') was a product of the left hemisphere. What appears to be the salient feature here is not the locus of imagery in the cortex, but rather that imagery forms an intrinsic part of a

dual encoding system.

Creativity and the Right Hemisphere

A further link has been offered between the creative process and the R.H., usually with descriptive anecdotes as the data source. Other reviewers have suggested that insights into the genesis of the creative acts of writers, musicians and scientists can be differentiated into two elements - the intuitive (non-verbal) followed bya translation of the initial impulse from the subconscious to the conscious (Gordon and Poze, 1981) into the written word, score etc. (Katz 1978)

> the committing to paper is done quickly enough for everything is, as I said before, already finished; and it rarely differs on paper from what it was in my imagination .(Mozart as quoted by Katz, 1978 p.253)

Einstein (as quoted by Blakeslee 1980) remarked:

> The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined (p.45)

The stages of the process leading to creative production are sometimes conveniently linked through supposition to support right to left hemispheric activity (Gordon and Poze 1981; Katz 1978; Hermann 1981,1982; McCallum and Glynn 1979). For example, Springer and Deutsch (1981) in their review of the literature refer to Koestler's (1964) work The Act of Creation and his suggestion that the creative act usually occurs without "conscious analytic intention" (Springer and Deutsch p.195). The

creative process itself, as described by Wallas (1926), had four stages: preparation, incubation, illumination and verification. An advocate of programs for gifted children, Gowan (1978) (as quoted by Khatena 1979) saw tools such as imagery, fantasy and meditation as vital to the relaxing (incubation) stage of the creative process.

As Gowan has stated;

> Incubation is the mental analogy of physical gestation in which an ovum is developed into a baby. Incubation is the process of metamorphosis and right hemisphere imagery is the vehicle through which incubation produces creativity" (Khatena 1979, p.4).

Koestler (1964) described creative thinking as the "type of thinking prevalent in childhood and in primitive societies which has been superceded in the normal adult by techniques of thought which are more rational and realistic" (Koestler 1964 as quoted in Springer and Deutsch, 1981). The following statement is a example of how this supposition has been derived:

> The other side of the brain, the R.H., is called the minor or mute side because it cannot verbalize what it knows. It houses spatial perception, holistic understanding, perceptual insight, tactile sensation, musical ability, visualization and some intuitive ability. <u>These are the bases of the creative impulse.</u> (Emphasis mine) (Garret 1976 p.239-240)

Those who claim that the R.H. is the seat of creativity have either taken highly selected points from the general literature or have extended them speculatively because the actual link is rarely written in the foundational literature. For example, the often quoted Ornstein (1972) stated that .... "The [right] hemisphere is primarily responsible for our orientation in

space, artistic endeavor, crafts, body image and recognition of faces" (p.68). The R.H. is also said to be specialized for synthesis, gestalt (holistic) patterns and visuospatial perception (Levy-Agresti and Sperry 1968; Bogen 1969). One could thus easily construe the R.H.'s role as the creative one.

Dimond and Beaumont (1974) administered a word association test first described by Jung and found that R.H. responses were less common (and thus they reasoned, more creative) than the left hemisphere's. They reported:

> We take the finding of greater variability and ingenuity in the R.H. to indicate the greater participation of the R.H. in the creative aspects of thought, attributing to it in this respect a specialized role. This role is seen as concerned with the more inventive exploratory and improvisatory aspects of mental activity (p.75)

(This experiment is rarely referred to or cited in the literature).

Rozak (1975 as cited by Morrow, 1979) suggested, "it is a staggering and not automatically warranted leap from the R.H.'s documented visual-spatial talents to assertions about the locus of art, metaphor, holistic insight and intuition." (Morrow p.75). The two experiments actually used to attempt to relate creativity to hemispheric specialization were not conclusive (Katz, 1978). Thus Katz (1978) stated "while this descriptive similarity [hemispheric specialization and its relation to creativity] is provocative it has yet to be proven in a scientifically adequate matter" (p.254). Morrow (1979) has stated, "A brillant and exciting interpretation, yes, but an interpretation, not an irrefutable scientific truth" (p.74). He

goes on to make a provocative point - if the R.H. is the creative one, are writers and poets like Twain, Carroll and Li Po devoid of creativity. Have not such figures as Dante, Lao Tsu, Frost and Tagore used language to evoke the most mystical, inspiring and creative insights?

This error in thinking by some educators has been based on the faulty premise that art (non-verbal) is in the right hemisphere and logical/linear thinking (verbal) is in the left. There is an inherent trap in this reasoning for it is not the task at hand but the process used by that individual to negotiate the task that determines the hemisphere used.

In what appears as a contrasting view to this, Levy's (1978) work with two split-brain patients led to the following summation:

> "The artistic capacities of the R.H. almost certainly result not only from its superiority in being able to generate representations of form, but also from its superiority in being able to generate the infinite variety of colours that fill the human perceptual world" (p.293).

But even though the R.H. is credited with having artistic capabilities (Ornstein 1972; Levy 1978) and an "inventive, exploratory and improvisitory" aspect (Dimond and Beaumont, 1974), it does not mean that these factors will be utilized in creative production. What does enhance creativity? Bogen and Bogen (1969) strongly suggested that it was the transfer of interhemispheric information via the corpus callosum. Referring to artists like Moore and Miro, the authors pointed out that access to all processes of each hemisphere and their synthesis

seemed to greatly enhance a person's ability to create. They further suggested that a person's undeveloped appositional characteristics (R.H.) were partly responsible for a lack of creativity. Thus even if the appositional was developed, a free interplay between both hemispheres was needed to manifest the creative. As Ornstein (1972) has stated;

> Our highest creative achievements are the products of the complementary functioning of the two modes. Our intuitive knowledge is never explicit, never precise in the scientific sense. It is only when the intellect can begin to process the intuitive leaps to explain and translate the intuition that scientific understanding becomes complete")p.28)

Parnes (1977 as cited by McCallum and Glynn 1979) also stated:

> "Integration of the special abilities of both the left and right halves is required for creativity" (p.15).

Torrance (1978, as cited by McCallum and Glynn 1979) has added:

> "...In creative thinking, it is especially important to understand the specialized functions of the right and left hemispheres, since almost by definition both kinds of functioning are required"(p.15).

Hemispheric Specialization and other Research Directions

The reader is directed to Appendix B for a further consideration and discussion of the following issues:

1. Right hemisphere language
2. Music and hemispheric specialization
3. The role of the hemispheres in diagnosing dyslexia
4. Emotions and hemispheric asymmetry.

Suggested New Paradigm of Hemispheric Specialization

Expanding on the previously suggested dichotomies of analytical/holistic (Levy-Agresti and Sperry 1968) and propositional/appositional (Bogen, 1969), Goldberg and Costa's (1981) new proposal was that the right hemisphere's processing superiority was for material which had no pre-existing "engram" or cognitive map, i.e. novel stimuli, while the left hemisphere's speciality was for previously laid down codes which form part of an individual's existing cognitive repertoire.

There had been a trend, initiated with the work of Moscovitch (1979), suggesting that it might be profitable to abandon the concept of the hemisphere as the basic unit of processing and replace it with numerous processes involved in a single task. The varied work described below seems to converge on this point. Allen's (1982) review of the hemispheric specialization literature and subsequent stimulating reformulation of the material shifted from previous conceptions. He abandoned the search for the metatheory and suggested that perhaps the basic unit was the "subprocessor" rather than the hemisphere, task or function. These subprocessors as described by Allen were "a finite and probably rather small number of entities ... which are utilized in the performance of all pyschological tasks and functions"(p.93). He was of the opinion that recent advances in non-invasive scanning devices such as Positron Emission Tomography (PET), EEG, Evoked Potential as, well as the invasive regional cerebral blood flow (rCBF), would

be able to differentiate such subprocessors. Allen has suggested that a General Systems Theory approach which could assume dynamically interacting, multiple linked subsystems, is compatible with the subprocessor paradigm. Friedman and Polson (1981) as well suggested that psychological tasks were composed of processes which in turn required differing subsets of mechanisms. Allen (1982) suggested that his and Friedman & Polson's theory interfaced at the level of "mechanism/ subprocessor."

This same expansive notion of hemispheric functioning was examined in Cohen's (1982) and Zaidel's (1983 a) work. Cohen, as others have suggested, showed that the "absolute model" of hemispheric specialization whereby a given cognitive function was completely lateralized to one hemisphere was not well supported. She stated that a more plausible alternative might be the "relative specialization model," which allowed that while both hemispheres could perform a task, one hemisphere was more proficient then the other. An even more promising model in Cohen's estimation consisted of a combination of a structural model (the relative specialization model as described above) and a dynamic one(that took into account Kinsbourne's and Hellige's notion of attentional and priming factors),which combination allowed for flexibility and subject variability. While she recognized the underdeveloped nature of this theory, she foresaw promise in its broad and encompassing base. Zaidel's (1983 a) work with the split-brain patients yielded two models which

"represent the limit cases of a continuum of models for laterality effects in the normal brain". These were: hemispheric competence representing the direct access model (or Cohen's "absolute model") and the callosal connectivity model representing callosal relay (relative specialization for Cohen). Zaidel's research showed that both co-exist and do represent different complex cognitive operations.

Like the previous researchers, Sergent(1982) argued for the bilateral representations of cognitive processes, but suggested that the primary focus of each hemisphere was not verbal/visuospatial or analytic/holistic.What differentiated them was the sensory or motor- spatial frequency or resolution. For example, when a clear and complete stimulus representation was achieved through either a longer-than-usual exposure or because of its familiar material, a L.H. advantage would emerge irregardless of the nature of the stimuli. On the other hand the R.H. would be sensitive to material of low resolution and/or unfamiliar material (reminiscent of Goldberg and Costa's (1981) work .

General Conclusions

The psychological functions and interactions of the cortex seem difficult to identify and map. Certainly a more dynamic version of hemispheric interaction as suggested by Cohen (1982) is evolving,encompassing the variabilities of individuals and including their cognitive style. This may include, as Moscovitch

(1979) has stated, a shift away from a metatheory of hemispheric asymmetry to a proposition of no-overall guiding principle, which suggests instead that perhaps many task-dependent subprocesses are involved .

What remains from these two decades of research is the recognition of H.H. functions otherwise concealed and possibly overwhelmed in the intact brain. From Sperry's Nobel Prize speech:

> Regardless of the remaining uncertainties concerning laterality, what does hold up is an enhanced awareness in education and elsewhere of the important role of non-verbal components and forms of intelligence (Sperry 1982 b p.1225)

The presence of contrasting and divergent cognitive processes within the two hemispheres permits the use of varying strategies for short/long term memory. It involves the interdisciplinary synthesis of cognitive, neurophysiological, neuro and experimental psychology, a blend which has not been too well advanced in the past. It is only recently that cognitive psychology textbooks (for example, Glass, Holyoak and Santa, 1974) have included chapters on laterality but the material remains to be fully assimilated into the field. As techniques such as Computer Assisted Tomography (CT), Positron Emission Tomography (PET) and Nuclear Magnetic Resonance (NMR) scans become perfected, the multidisciplined team, far beyond the single but adventurous researcher with a dichotic listening tape, may emerge as capable of displaying the unique individual human characteristics that

we possess and that are our human heritage.

CHAPTER 3

A REVIEW OF THE EDUCATIONAL LITERATURE

This chapter will examine the educators' interpretations of the neuropsychological literature beginning with split brain research in 1962. One purpose will be to chronicle the potential influence of the brain based information, specifically about hemispheric specialization, on school personnel. Specific issues will be: a) what information did this group receive about the nature of brain functioning through professional journals and/or by attendance at conferences?; b) what were they led to believe about possible alterations to curriculum, course content or instructional methodology which could better utilize known themes of cerebral processing? The chapter will be divided into two periods: the first, pre-1975, during which time Orton had substantial influence, and the second, post-1975 period.

Pre-1975 Influences - The Brain is Important

Initial interest in brain functioning had as a main focus the problem of reading disabilities. Following Orton's work (1937), research continued in an attempt to show a correlation between a lack of lateral dominance and reading disabilities (Harris, 1957). However, work by Zangwill (1962) and Belmont and Birch (1963) suggested that a development in lateralization of right/left discrimination and a reading disability "are independant manipulations of a more general underlying

disturbance in neurological organization and are not etiologically related to one another" (Belmont and Birch 1963 p.269). Similar findings by Cohen and Glass (1968) showed that although there was a significant relationship between poor directional understanding and reading problems in first grade studies, this relationship no longer appeared for these students in grade four. Though training and maturity were cited as factors responsible for learning the right/left distinction, some of these students remained poor readers even after developing directionality. Gazzaniga (1973) cited his work with split-brain patients and suggested that Minimal Brain Dysfunction (MBD) might be due to problems of information transfer between the two hemispheres.This might reflect a dysfunction with neuronal integration (originating from a lack of a cerebral dominance) rather than a specific neuronal disorder, such as a lesion.

Articles on these issues continued to be published specifically in special education journals such as Academic Therapy , Exceptional Children and The Journal of Learning Disabilities.

However, about 1973, a shift began to occur with authors starting to cite the neuropsychological writings of Levy, Sperry, Kimura and Milner:

> "that hemisphere cross-interpretation deficiencies must be added as another possible cause of learning difficulties" (Kershner and Kershner, 1973 p.392).

The titles of these easily accessible articles in special

education journals reflected this shift-- for example, "Recent Advances in the Neuropsychology of Some Specific Cognitive Functions" (Rosenthal, 1973) and "A Review of Measures of Lateralized Cerebral Hemispheric Functions" (McNeil and Hamre, 1974). The latter is a comprehensive review of the literature which familarizes the novice reader/practitioner with a brief and concise history of the general status of hemispheric specialization theory. Researchers faced with the enigma of diagnosis and remediation in a special needs population began to investigate causes other then those suspected by Orton and his followers.

There also began the trends of "humanizing" the regular classroom and being "creative" with one's class. The Journal of Creative Behaviour which was founded during the "humanistic period" of the late sixties often highlighted creative exercises for classroom use (see for example Treffinger and Gowan (1971) for a compendium of stimulating programs available during this period). Normal students at this time were not subjected to any change in school practice based on alternative or "appropriate" neurological theory. If any reference was made to the brain in regard to regular public education, it usually dealt with the speculative manipulability of learning and behaviour via neurochemical or neuroelectrical stimulation. An example of such an article was written by Seltz (1971) and appeared in the popular American teacher magazine, Grade Teacher, (now called Teacher).

Of major importance for the lay public was the chronicling of the split-brain work as well as articles on the localization of cerebral functions - both reported in the reputable Scientific American . As mentioned in Chapter 2, the major articles were:

1. The Great Cerebral Commissure (Sperry 1964)
2. The Split Brain in Man (Gazzaniga 1967)
3. The Functional Organization of the Brain (Luria 1970)
4. Language and the Brain (Geschwind 1972)
5. The Asymmetry of the Human Brain (Kimura 1973)
6. Cerebral Blood Flow (Lassen, Ingvar & Skinhoj,1978)
7. The Brain - September 1979 (an entire issue on recent brain advances by eminent neuroscientists)

It is noted that all are written by foundational researchers.

During this same fertile period, a most influential mass-market book appeared, The Psychology of Consciousness (Ornstein 1972). As described in Chapter 2, Ornstein combined the data of seminal researchers in hemispheric specialization with the speculative thought of eastern mysticism. He suggested, for example, that the western culture was left-hemisphere dominant, while the right -hemisphere was comprised of "eastern cultural" attributes and unique processing. Further, he speculated that our culture was underdeveloped in the more subtle nuances of life which emanated from the right hemisphere. It was his opinion that we had forfeited greater meaning for

linear detail resulting in a marked decrease in the quality of our lives. The book became one of the most often quoted sources for educators as judged by the citations in the educational articles from 1975. Ornstein's article in 1977 in The Instructor magazine, in addition to his book, provided educators with some powerful references for stating their cases concerning the lack of arts or creativity in public school classrooms. These two sources were the impetus for articles by Andrews(1980), Cassell(1978), Nelson (1977), Raina (1979) and Virshup(1976) among others.

Seminal Researchers Publishing in Popular Magazines

While it was a rare phenomenon during this period for pioneering neuroscientists to write for a national magazine, let alone for a national teachers' journal, a few did publish in these forums. It is important to mention these articles because they, in conjunction with the Scientific American papers, stimulated the publication of articles in education journals from 1975 on calling for public school reforms based on new neurological findings.

Sperry published "Left Brain, Right Brain" in The Saturday Review (1975) which provided information about the events preceding the split-brain operations, the operation itself and the subsequent neuropsychological findings. (The magazine cover for that issue was entitled "Inside the Brain - The Last Great Frontier.") Specifics from this article are cited to acquaint

the reader with the level of information available to the lay public during that period.

> "It's as if each hemisphere had a mind of its own" (Sperry 1975 p.30)
> "The left is highly verbal and mathematical, performing with analytic, symbolic, computerlike, sequential logic. The right by contrast is spatial and mute, performing with a synthetic spatio-perceptual and mechanical kind of information processing that cannot yet be simulated by computers" (p.31)

There were three specific points from this article that would be cited by educators in future years:

1. The coupling of human differences in left and right brains with the wide variation of genetic inheritance results in the temperaments and talents of each individual being truly unique - a brain's surface structure, cytoarchitecture and chemistry "would probably make these differences seen in facial features or in fingerprint patterns look relatively simple and crude by comparison" (p.33)
2. Modern society in general and the educational system in particular discriminate against an entire half of the brain because of very heavy emphasis on communication and early training in the" three R's". This results in little attention being given to the minor (right) hemisphere which has its own perceptual mechanical and spatial mode of apprehension and reasoning.
3. The conscious mind is not an epiphenomena of brain processes but is an integral and essential part of it. "It is something distinct and special in its own right, different from and more than its component physiochemical elements"

(p.33) Sperry thus breaks with the "long established materialistic and behaviouristic thinking which has ruled the neurosciences". He goes on to state that with the introduction of terms like mental imagery and visual, verbal and auditory imagery in recent years, the behaviouristic interpretations of brain functioning lose their credibility. Man regains his stature and dignity as the reductionist/behviourist vision of him proves to be false.

The reader of this same edition of Saturday Review might also have seen an article by Gardner (1975) on brain damage and its resultant specific dysfunctions.

In summary, by 1975 the lay public would have had exposure to the neurosciences at two levels. First, through the more technical magazines such as Scientific American and second, through national general reading material such as The Saturday Review. Additionally, there was coverage given by medical/science reporters on local newspapers - an example of which is the influential article in the New York Times Magazine (Pines 1973) which, in the writer's opinion, provided a fair and concise review of the research.

Foundational Researchers in Educational Journals

One of the earliest articles published by a foundational researcher in an educational journal was by Sperry (1972). The popular Claremont Reading Conference Yearbook considered it appropriate for that year's theme, "The Person in a Mass

Society." This article,'Hemispheric Specialization of Mental Faculties in the Brain of Man,' included a description of the differing attributes of each hemisphere as seen through the split brain patient. These in fact had been chronicled in previous neurological articles by Sperry(1969). This article was important for with it began a trend in the educational literature of suggesting differentiating individuals at a most fundamental level - the neuronal circuitry of the human brain.

A series of articles by seminal researchers (Nebes, Gazzaniga, Krashen, Bogen) also appeared in the UCLA Educator (1975), which devoted an entire issue to brain research findings. This issue would become another major reference source for educators who in later years would write about needed changes in school operations or subject matter (content and process). It may be useful to summarize the key points made by Gazzaniga, Nebes and Bogen with regards to their views of laterality and education.

Michael Gazzaniga: Review of the Split Brain

Gazzaniga spoke directly to the idea of individual cognitive style;

> Indeed, one of the intriguing possibilities deriving from split-brain research is the possibility that man can be explicitly specialized in a variety of aspects of mental life: superiority in the verbal area might not necessarily mean superiority in the visuo-spatial area - while the reverse may hold true. If this proves correct, it may well follow that a particular child might be able to solve a problem using verbal symbols with greater ease then using visuo-spatial ones, while another child might be better off solving the same problem using

visual-spatial relations.

He went on to discuss the results of such a process;

> .... [if] (s)he is being forced into a curriculum that emphasizes the verbal articularity modes of solving a conceptual problem, this child will encounter enormous frustration and difficulty which may well result in hostility toward the teacher and worse toward the learning process itself. (p.11)

Gazzaniga then called for a more comprehensive view of intelligent behaviour.

> .... the more we understand about the brain and the more we understand about various kinds of cognitive processing systems we use in our normal mental life, the more clearly we can understand the components of what is normally called "intelligent behaviour." (Gazzaniga p.11)

Robert Nebes: Man's So-Called "Minor" Hemisphere

> The right side of the brain probably processes information differently from the left, relying more on imagery than language and being more syntactic and holistic than analytic and sequential in handling data (p.16).

In regard to public school education:

> If there is any truth in the assertion that our culture stresses left-hemisphere skills, this is especially true of the school system. Selection for higher education is based predominantly on the ability to comprehend and manipulate language - a fact which may help explain why it took so long for science to come to grips with right hemisphere abilities. If the right hemisphere does indeed process data in a manner different from the left, perhaps we are short-changing ourselves when we educate only left-sided talents in basic schooling. Perhaps, when people talk about the inverse relationship between scholastic achievement and creativity, they are really talking about the effect of over training for verbal skills at the expense of non-verbal skills. Many problems can be solved either by analysis or synthesis;

> but if people are taught habitually to examine only one approach, their ability to choose the most effective and efficient answer is diminished. Increased understanding of how the minor hemisphere works will hopefully lead to better training in how to choose between and to use the skills of both hemispheres. (p.16)

Joseph Bogen: Some Educational Aspects of Hemispheric Specialization

Of the three articles, published in the UCLA Educator, Bogen's (which was later reprinted in the Human Brain (Wittrock 1977)) has been most frequently cited in the educational literature. Its contents therefore are important to note because its information is what teachers later selected as source material.

The article consisted of a discussion of the data from his three initial papers (Bogen 1969 (a),(b); Bogen and Bogen 1969) with specific emphasis on his notion of the propositional/appositional mind representing the left/right hemispheres respectively (Bogen 1969 (b)). As well, he reprinted a lengthened version of the chart of authors who have "postulated two parallel "ways of knowing" or two "types of intelligence" or "two cognitive styles," which had first been published in Bogen (1969 b) (its shorter version was cited in Chapter 2).

Specifically because of its popularity, it is important to be clear about Bogen's claim. Discussing the known role of the hemispheres Bogen stated:

> ... we can summarize to some extent the wealth of information already at hand. Figure 1 represents in schematic form such a summary omitting some of the more speculative notions ..." (my emphasis) (p.27)

Bogen summarized the hemispheres as follows:

Left	Right
speaking	faces
calculating	spaces
reading	mazes
timing	timbre (music)
propositional	appositional
and (appositional)	and (propositional)

(The reader is referred to Table 2B for a pictorial representation of these dichotomies.)

Yet he suggested that what distinguished hemispheric specialization was not the kinds of material that each hemisphere could process, but rather the way in which the material was processed, alluding to (though not specifically mentioning) some of the processing dichotomies presented in the prior chapter.

On the educational implications of the data and his speculative thought Bogen quoted Sperry:

> "The main theme to emerge... is that there appear to be two modes of thinking, verbal and non-verbal... and that our educational system, as well as science in general tends to neglect the non-verbal form of intellect.What it comes down to is that our modern society discriminates against the right hemisphere (Bogen 1975,P.29).

Continuing on the same theme, Bogen added:

> If our society has overemphasized propositionality at the expense of appositionality, more is involved than the adjustment difficulties of isolated individuals. It means that the entire student body is being educated lopsidedly (Bogen 1975,P.29).

In terms of human potential, Bogen (1975) remarked:

> Since education is effective in so far as it affects the working of the brain, we can see that an elementary-school program... will educate mainly one hemisphere, leaving half of an individual's high level potential unschooled. We are accustomed to hearing these days of the "culturally disdavantaged", those persons whose propositional potential has remained underdeveloped for lack of relevant exposure. There is likely a parallel lack of appositional development in persons whose only education consists of the 3 "R's". That is, just as the left-hemisphere potential may be underdeveloped, so too should we expect that right-hemisphere capacities can suffer educational neglect (P.27).

Sperry had earlier detailed the same argument in an article that appeared in the American special education journal, Academic Therapy (1975). In a Saturday Review article of the same year he outlined three central issues:

1. the basis for individuality is based on the neuronal structures of both hemispheres
2. the role of the right hemisphere in cognitive processing
3. the decreased status of behaviourism in the context of recent brain research.

General Conclusions from Educational Material in the UCLA Educator

The three authors, Gazzaniga, Nebes, and Bogen, as well as Sperry in his own articles, were consistent in expressing their thoughts about an educational bias towards the left hemisphere and its processes at the expense of the "so-called" minor hemispheres. Certainly a clear position about hemisphericity was stated, that is, the predominance of one hemisphere or style of processing information in schooling. This bias, as stated

explicitly by Bogen, did not arise from a student's c cognitive style, but rather from a cultural bias represented the intelligent, successful or useful individual in a particular way . As a consequence,other modes of processing information would not be honoured or reinforced.

General Summary

When the publications which influenced school personnel are examined, from the first Sperry (1964) article in Scientific American, the national magazines/newspaper reports of the early and mid seventies, to articles in professional educational journals and magazines by seminal researchers, a consistent theme is seen to be emphasized. The two hemispheres of the cortex are dissimilar in appearance, function and information processing strategy,and, individuals in the Western world have a dominant hemisphere or processing strategy for problem solving which is usually the left (for the right handed). The researchers speculated that this bias was culturally determined and perpetuated by institutions like public schools.

Articles such as "Left-Brain, Right Brain" (Sperry 1975), "Hemispheric Specializations of Mental Faculties in the Brain of Man" (Sperry 1972) and "Some Educational Aspects of Hemispheric Specialization" (Bogen 1975) contained only minimal reference to the synthesizing nature of both hemispheres. It is possible that educators were left with the impression that a single predominant hemisphere was all that was required to complete

cognitive tasks.

The Initial Educational Reactions 1975-77

How did the educational community react to the neuropsychological data, specifically to that provided by foundational researchers also making claims about the biased nature of educational policy and curriculum practices?

The result was an alarm sounded in widely-read teacher magazines and upper level administrative journals, claiming that educators were only teaching to half a brain (the left). "Educating for Both Sides of the Brain"(Samples 1975) and "Cerebral Symmetry (sic) - An Urgent Concern for Education"(Rennels 1976) were some of the first articles that introduced the subject to educators. Most of the subsequent articles repeated this common theme.

A key author during this period was Bob Samples who published three well-placed articles (1975 a,b;1977) and one book (1976). He, as so many other authors, would argue that educational instruction was directed mainly towards the left hemisphere's noted specializations.

Based on some of Ornstein's (1972) work, Samples (citing Ornstein's work) claimed the left hemisphere as rational, logical and linear, ordered and structured, constrained, acting like a digital computer, responsible for reading, writing and math. The right hemisphere specialized in the intuitive, metaphoric, capricious and holistic modes, "tumbling through

myriads of data simultaneously " (Samples 1975 (a) (b); 1977). He was clear and concise in his statement of what he considered as our western cultural predicament.

> The cultural ecology with its emphasis on structure, logic and linear conforming, overtly ... prejudices against the analogic, intuitive, wholistic functions or the right mind" (1977 p.688).

> a child develops and language becomes culturally predominant, the "undifferentiated, holistic world it perceives cannot be communicated holistically. It must first be chopped up and labeled. Language is the first linearity in a world controlled by logic, order, sequence and independent structure (Samples 1976 p.24).

He continued:

> It was clear, if left alone children tended toward more metaphoric-intuitive modes of exploration when confronted by a problem ... There would be prolonged periods of play, fantasy and sensory exploration. The children would literally play with the problem, make jokes about it. In the play-reverie phase, the children confronted the problems with their right hemispheres. At the same time they were trying out a constellation of solutions and partial solutions in this mode. When a teacher's (straight-forward) question burst in on them they snapped back into ... their left cerebral hemisphere and played back a straight forward tape. (Samples 1976 p.21)

Samples further suggested:

> "the capacity for expressing metaphoric knowing persists at all stages of cognitive maturity, yet in terms of prevailing teaching strategies and curriculum materials, appropriateness of its use is diminished throughout the school experience." (Samples 1977, p.691)

As a remedial approach for such a biased situation, Samples suggested not a denigration of the left-hemisphere, but the legitimization of the right's intuitive - metaphoric way of knowing - a balanced intergrated approach.

> "Effectiveness in education comes from a fully acknowledged commitment to the function of both

hemispheres" (Samples 1975(b), p.123)

What would be the results of both hemispheres being given equal opportunity? Samples (1977) suggested the following:

1. greater feelings of self-confidence, self-esteem - the power to further explore and self-initiate.
2. wide exploration of traditional content subjects and skills.
3. higher levels of creativity in content areas
4. the use of the right hemisphere could lead a proliferation of new possibilities and a greater tendency to synthesize thought qualities.

The essence of Sample's argument would be subsequently restated in educational articles. In brief, the issues raised and defined in the initial educational articles were as follows:

1. A definition of cerebral functional specializations with logic/metaphor and linear/wholistic as the major dichotomies;
2. A stressing of the fact that schools utilized only the left hemisphere in the teaching of subject matter (for example," List the 3 causes of" ... "name five rivers...");
3. Because of this biased teaching methodology there was a disservice to and underestimation of a student's innate capability and potential;
4. A curriculum emphasizing the right hemisphere was not the remedial answer, but rather, what was required was a balanced approach favouring both kinds of hemispheric processes.

5. The results of such an equally distributed "hemispheric weight" would not only enrich the student's academic life but the synthesis of left and right hemispheres would yield a more open and creative individual.

Many of the 40 papers examined in the category of 'general awareness articles' (1975-1982) echoed Samples' sentiments. Strategies for reaching such an end included a language experience teaching approach and affective teaching (Guckes and Elkins, 1981), the ability to move from one process to another at will (Konicek, 1975), employing divergent strategies and avoiding reductionist answers (Brandwein and Ornstein 1977), diagramming and modeling (Hunter, 1978) and using arts such as basket weaving, woodwork, colouring and crocheting (Ogletree 1978). Most agreed upon the use of visual imagery and the presentation of material to students in both a verbal and spatial/wholistic manner - a fail-safe mechanism assuring that no student was handicapped in initial classroom instruction. In her new book, Teaching for the Two-Sided Mind, Williams (1983) has suggested the use of metaphor, visual thinking, fantasy, multi-sensory learning and direct experience as a means of balancing the curriculum.

Specific articles in subject area journals stressed the cooperation between hemispheres in teaching a particular subject. Math curriculum in its present form was described as follows:

> a general school diet of traditional courses served up in uninspired fashions, with specific meals in

> mathematics consisting of algorithmic rules to digest and computational drills to swallow, would certainly prove unpalatable and malnourishing for a literally starved population of pupils (Elliot 1980 p.218).

To raise mathematics teaching to a "brain-compatible status" would involve:

1. the application of math to everyday problems;
2. predicting;
3. measurement;
4. computation;
5. geometry;
6. computer literacy; (Elliot 1980)
7. puzzles; (Wheatley 1977)

For the English teacher, Nelson (1977) stated that the left hemisphere was the scientist while the right hemisphere was the poet. As the right hemisphere was attaining a degree of legitimacy with current hemispheric research, those who taught English no longer had to be apologetic that their subject was non-precise and at times not logical. Wolfe and Reising (1978) offered English teachers strategies that were aimed at both hemispheres, using affective teaching methods. In art education, the validity of the artists' varied perceptions of themselves and their world yields a richness sometimes captured on canvas. Virshup (1976) suggested that a synthesis of the two hemispheres could offer a broadened perspective yielding this richness. Strategies were also suggested for teaching chemistry (Hildebrand 1980), biology (Iannazzi 1975), and music (Regelski 1977).

The reading teacher could also utilize some "whole-brain" strategies,for example, the use of imagery, the correct use of the questioning procedure, daily exposure to literature and writing (with emphasis on themes - a supposed right hemisphere interest) and diagnostic teaching (Fox 1979; Winzenz 1977). In a monograph (1980) and a recent book (1983), Rico introduced a method called "clustering" which supposedly utilizes the linear and non-linear functions of the left/right hemisphere(as did Buzan (1983)). Similar to brain-storming or "stream of consciousness," the student visually creates a web or labyrinth of related ideas on a central theme which are later used in creative writing or problem solving. Hudgens (1980) suggested that students at the junior college level who were not efficient readers (in her estimation caused by left hemisphere difficulties) might be more proficient in involving themselves in concrete experiences to increase their understanding of previous abstract learning. The arts would be at the core of such a program. Teaching staff would consist of artists, art educators, art therapists, guided imagery experts and instructors sensitive to multi-sensory learning. She felt that such a program might be most helpful to minority groups.

Imagery and Visualization

In the educational literature, the use of imagery, guided imagery, guided fantasy and visualization has received much attention. Many educators writing about these practices associated the use of imagery with the right hemisphere (Blakeslee 1980; Hagland 1981; Roberts and Clark 1976; Galyean 1981; Murdock 1983; Rose 1979; Brooks 1980; Vitale 1983; Raina 1979; Ostrander and Schroeder 1979; Houston 1982; Clark 1979; Beals 1981; Samples et al 1977; Buzan 1976; Gonzales-Mena 1977; Konicek 1975; Karlson 1978; Rennels 1976) while others linked it to the creative act itself (Ainsworth-Land 1982; Khatena 1978; Greeson 1981; Durio 1975). Meditation was also suggested as a means of facilitating the creative act (Gowan 1978; Grady and Luecke 1979; Karlson 1978; Myers 1982).

There were other educators (Galyean 1980) who, while not mentioning the right/left paradigm, used the term "whole brain" approach. Perhaps because they wished not to enter into the debate about the validity of descriptions of the dichotomies, they nonetheless alluded to the benefits of right hemisphere functioning and process. Morrow (1979), quoting the New Yorker film critic Pauline Kael, aptly described this position :

> "People who worry about the supposed division between emotion and intellect never leave one in doubt about the side they're on."

While Paivio's (1971) empirical support for dual encoding theory clearly enunciated the link between the right hemisphere and imagery, Durio (1975) discussed the role of the right

hemisphere's use of imagery in cognitive processes. However, the educators who wrote about this association only concerned themselves with anecdotal, suppositional and hypothetical statements. It is also important to note that the empirical evidence (which will be reviewed in the next section) was derived from work done in labs and classrooms under the guidance of cognitive psychologists and rarely by educators.

Empirical Research on Learning and Imagery

The cumulative data positively linking the use of imagery as a mnemonic aid to verbal learning has been abundant. Regardless of the cerebral focus of imagery (whether left or right or bilateral), imagery has been shown to be an effective tool in learning. Following the publication of Paivio's paradigm in 1971, extensive empirical research resulted in an attempt to explore its applicability. In his review of the literature on children's learning and imagery Pressley (1977) concluded:

> There is one fact about imagery and children's learning which is indisputably true: imposed pictures are almost always learned better than words. No more experiments are required to substantiate the positive effect of pictures on children's learning (p.613).

This was echoed in Greeson's (1981) literature review on imagery:

> It has been suggested that mental imagery serves to complement verbal symbolic processes by representing, in concrete terms, the more abstract verbal, perceptual and conceptual relationships involved in children's learning and thinking and there is considerable evidence that this is the case (8 references) p.216.

He went on to suggest:

> Furthermore, the facilitative effects of imagery processes have often been found to equal and even surpass those found in verbal processes, especially in concrete learning materials (four references). These results are noteworthy in that verbal skills and their relationships to children's learning and thinking have been stressed for many years by educators and psychologists while the development of imagery skills, has, for the most part been neglected or ignored (five references) p.216.

He recommended the use of imagery in augmenting education for children having difficulty with symbolic representation (math, letters/words), "especially those purported to have difficulty in the mastery and use of written language, such as retarded children and children from culturally different backgrounds" (p.216). Yarmey and Bowen (1972 as cited by Fox 1979) studied the effects of visual imagery on comprehension using forty-five normals and forty-five retarded children. It was found that comprehension scores were "nearly the same" when the children generated visual images corresponding to each sentence of the short story. "It seems that the right brain's facility for organizing material pictorially can significantly improve comprehension for both normals and handicapped children" (Fox p.12). The ability to use imagery as a means of improving learning appears to be a developmental phenomena. Pressley (1977) summarized the stages:

1. Nursery children cannot produce such images when requested.
2. 6 and 7 year olds can produce images of paired-associates (i.e. cat and mouse)
3. children eight years and above can apply visual imagery strategies to complex tasks such as prose writing.

Imagery has been cited as an aid in the creative thinking process and for the writing ability of gifted students (Hershey and Kearns, 1979), as well as an aid in curbing disruptive classroom behaviour (Gaylean 1980).

Yuille and Catchpole's (1977) review of imagery and children's learning concluded with two salient points. First, instruction in teaching children "how to learn" has not thus far been given. Educators and psychologists have devoted little attention to helping children acquire learning strategies, hoping that the child would discover her/his appropriate coding strategies spontaneously. Available evidence now supports the teaching of "a variety of learning and memory devices, including both verbal and visual techniques ...(p.436). Secondly, the child showed that she/he could judge the effectiveness of her/his coding strategy (and improve weak ones if necessary) by including immediate recall trials shortly after learning.

Creativity and Hemisphericity

Educators have claimed that creativity was associated with the right hemisphere (Ostrander and Schroeder 1979; Vitale 1983; Samples et al 1977; Clark 1979; Haglund 1981; Beals 1981; Gonzales-Mena 1977; Karlson 1978; Andrews 1980; Wheatley 1977; Kane and Kane 1979). These educators have also stated that the public school system has only been concerned with developing the so-called left hemisphere functions (i.e. "the three R's"). Their clear and explicit message was that schools disregarded

the specialized functions of the right hemisphere and thus negated creativity. The explanation in Chapter 2 (see creativity and the right hemisphere) showed this viewpoint to be based on a supposition which had not been supported by the foundational researchers. In reviewing the educational literature, this author has traced the basis of the right hemisphere/creativity claims. These can be summarized as follows:

a. There were educators who inferred from the original data. When they compiled the attributes of the right hemisphere which had been documented by foundational researchers (e.g. holistic, visuospatial perception, synthesis and gestalt) it was but a short step to then suggest that the right hemisphere was "creative." Usually no references were given for the ultimate claim of creativity. Rather, statements such as "there is evidence that the right hemisphere is the site of creative thought" (Wheatley 1977, p.38) were made.

b. The "sources" that were said to link the right hemisphere and creativity were usually secondary sources - i.e. writers who had interpretated the central research.

c. In some cases the educators misinterpreted the initial research. For example Kane and Kane (1979) stated that the right hemisphere was "creative" and cited Bogen (1969 b) as the source. However a careful reading of the source article reveals that creativity had not in fact been mentioned as an attribute of the right hemisphere. The authors must instead

have inferred this.

In some cases an author had reversed prior inaccurately stated information. For example in an earlier paper Reynolds and Torrance (1978) had written:

> Research conducted during the last several decades has shown the human left cerebral hemisphere to be specialized for primarily verbal, analytical, abstract temporal and digital operations (Bogen 1969; Gazzaniga 1970; Ornstein 1972). The same investigators have found the right cerebral hemisphere to be specialized for primarily nonverbal, holistic, concrete, spatial, analogic, creative and aesthetic function (p.247).

Later Torrance (1982) stated:

> The left hemisphere seems to be specialized for the logical, sequential processing of information and deals primarily with verbal, analytical, temporal and digital materials (Bogen 1969; Gazzaniga 1970; Ornstein 1972). The right cerebral hemisphere processes information nonlinearly, holistically ... for primarily nonverbal, concrete, spatial, analogic, emotional and aesthetic materials.

He went on to say:

> There seems to be a common notion that the right hemisphere is dominant in creative thinking. This may be due to a common failure to regard creative functioning as a process rather then a quick instance of insight or mental leap (p.29)

Thus within a four year period Torrance had departed from the notion of the right hemisphere as being the "creative one" and selectively forgot that he had held that view. While the sources which he quoted from in both articles remained the same, one has to question the accuracy of his first statement, "The same investigators have found the right cerebral hemisphere to be specialized for creative ... function" (p.247), when in fact it was omitted in the second article citing these same authors

(Torrance, 1982). The writer's investigation of the three source references indicated that creativity had never been mentioned as the sole property of the right hemisphere, although from Ornstein (1972) it could be inferred as such since he mentions the right hemisphere's role in the arts (he does in fact mention that creativity needs both hemispheres). Torrance (1982) did correct himself but the "common notion that the right hemisphere is dominant for creative thinking," (p.29) was a notion that he had participated in creating. A most interesting question would be why a researcher might do this. Was it an error, lack of clarity of interpretation of source material, or otherwise?

Another example of the misreporting of seminal researchers' findings was Rubenzer's (1979) claim that the right hemisphere was creative, referring to Bogen and Gazzaniga (1965) as the source. The closest these foundational researchers had approached "creativity" was to claim that the right hemisphere was responsible for visuospatial processes. The word "creativity" had not been mentioned.

In conclusion,it is seen that nowhere in the seminal research had "creativity" been considered a sole or special attribute of the right hemisphere. In fact Bogen and Bogen (1969) had clearly stated, as had other researchers (Ornstein 1972) and numerous educators, that creativity was a result of both hemispheres working in cooperation (see Table 1).

Recent Tests Measuring Hemisphericity

It appeared that the next step for educators was to design a test to investigate "who's who" in the classroom, for purposes varying from teacher-student matching to ascertaining the "gifted". Using the broad definition of hemispheric specialization, five different instruments have been developed to specify hemisphericity (i.e. a predominant use of one hemisphere over the other) in children and adults. A review of each test and the research derived from using the testappears below.

Your Style of Learning and Thinking (SOLAT) - Torrance et al (1977)

This test consists of a self administered questionnaire containing forty questions which, when scored, will indicate hemispheric preference for a right, left or integrated mode.

Zenhaursen and Gebhardt (1979 a) using the SOLAT and a test devised by Zenhaursen, the Style of Thinking questionnaire, found that graduate student subjects having " left hemisphere dominance" had an auditory advantage while a visual advantage existed in those subjects having a "right hemisphere dominance". In a learning task involving a finger maze, those graduate students classified as right dominant took fewer trials, less time, and made fewer errors than the left-dominant group. (Zenhaursen and Nickel, 1979b). In a study by Torrance and

Mourad (1978) graduate students who were classified on the SOLAT as "rights" (9) excelled over the "lefts" (5) on creative personality, a lack of acceptance of authority ,a lack of feeling of certainty, disciplined imagination, creative achievements, environmental sensitivity, lack of conforming, childlikeness, figural elaboration, figural creative index, verbal fluency and verbal originality. In a later study Torrance (1982) related the creative style or personality of students "positively and significantly .... to the right hemisphere style of information processing and negatively and significantly related to the left hemisphere style" (p.36). Results for the students' creative ability were less consistent. As Torrance remarked in his summary, the creative individual uses both hemispheres. This can be achieved by the two hemispheres functioning in a complementary fashion or by one mode inhibiting the other when appropriate, allowing "free reign."

Stellern, Marlowe and Cossairt (1983) administered an Adapted Children's SOLAT to seventy-six elementary students while their teachers rated the children on two learning/behaviour problem checklists. The right hemisphere students (38) scored significantly higher on the two teacher rated checklists indicating a higher risk status than the left (25) or integrated (13) students. It was concluded by the authors that those students who have a right hemisphere cognitive mode may become frustrated by a school's left hemisphere instructional predominance, the result being

frustration, distractability and acting out. Those students with a right hemisphere dominant cognitive mode also scored significantly higher on 3 tests requiring visual-motor integration, visuospatial ability and cerebral dominance than did those who were left hemisphere dominant (Stellern, Marlowe and Jacobs, 1983). When the relationship between a divergent thinking task (which the authors viewed as a measure of creativity) and hemispheric dominance (as ascertained by a dichotic listening task) was investigated, right-dominant preschoolers as young as four years of age scored significantly higher on the divergent thinking task than on the dichotic listening task. (Tegano, Fu, and Moran 1983)

In a further study a large group of high school students (N=353) were administered a learning style inventory and a self-administered questionnaire. The inventory, similar to the SOLAT, was developed by Zenhaursen, and is titled, The Differential Hemispheric Activation Test (Dunn, Cavanaugh, Eberle and Zenhausern, 1982). A statistically significant relationship was found to exist between an individual's learning style and hemispheric dominance: (as measured by the inventory) right-hemisphere dominant students preferred unconventional instructional approaches and settings while those with a left hemispheric preference did not. As the authors stated, "right preferenced students, because of their need for an informal environment and their ability to either block out extraneous sounds or to work with background sounds [as ascertained by the

learning style inventory], might perform more comfortably in either an open or an alternative program than in a conventional environment" (p.293).

Another researcher developed a similar self-questionnaire, the Hermann Brain Dominance Instrument (Herrmann 1981, Gorovitz 1982), comprised of 120 questions which would yield a hemispheric preference, not only of left and right cerebral hemispheres, but also of the more encapsulated limbic system. Details of the instrument's validation are unclear to this writer. Hermann claimed (Gorovitz 1983) to have collected 7000 pieces of individual data with 500 representing data from other cultures and languages. The instrument is now in its 15th edition since 1976. As well, the Japanese have recently published a new test for hemisphericity based on an individual's preference for tachistiscopically presented visual-spatial or visual-verbal stimuli (Ogura and Hatta, 1983).

The Cognitive Laterality Battery developed by Gordon (1980) also attempted to describe an individual's hemispheric cognitive style. This test battery is not a self-administered questionnaire as are the previous three, but consists of verbal and spatial tests (some adapted from the Weschler Intelligent Scales for Children or the Weschler Adult Intelligent Scales), validated on neurological patients. Gordon obtained norms for the test from 1000 public school children and adults. It is noteworthy that Gordon's test is not a list of presumed hemispheric abilities as in the previously mentioned test, in

which the patient/client chose between three alternatives.

From this writer's viewpoint, the three self-questionnaires seem to have a common problem. This is that the test designers have not documented (with any objective measures) their claims that their tests actually measure hemisphericity, *i.e.*, the construct validity of the tests has not been shown. In the instance where individuals have demonstrated a constellation of characteristics that displayed a common theme or *modus operandi*, such as one who relies on thinking and language, remembers names, favours logical problem solving and controls feelings, the leap was generally made that such a person was deemed left-hemisphere oriented, since the items were similarly related and of a "left-hemisphere" nature. Most of the research studies described above showed a positive relationship between the typical attribute and the task or measured performance; yet a jump in thinking is required to state a relationship between the task and actual activation of the hemisphere. Sayer and Bakan (Note 2) have shown that while neither the SOLAT nor the D.H.A.T. is significantly related to conjugate lateral eye movements (CLEM) the two questionnaires correlate with each other. It should be noted that while CLEM itself has come under criticism (Erlichman and Weinberger 1978; Owens and Limber 1983) it has been positively correlated to some objective neurophysiological measures such as cerebral blood flow(Gur and Reivich,1980). At this time the self-administered questionnaires linking specific "gross" cognitive characteristics to

hemisphericity must be approached cautiously while awaiting further verification. There are concerns about the shadow side of such tests in schools. First, the tool itself has not been validated beyond the rather popular traits that are ascribed to the hemispheres. Second, the level of interpretation and the subsequent results of placing children may be premature and represent yet another mechanism for labeling children.

Hemisphericity and Training Programs

It has been shown that it is possible to train a hemisphere or to modify an individual's preferred style of learning and processing information in a relatively short period of time. Significant improvements were also found with a grade eight math class (Brinkmann 1966) and an upper elementary math program (Young 1981) when specific programs aimed at improving spatial visualization (a proposed R.H. capability) were introduced. The research findings of Rhoades (1981) on spatial ability training concurred with his own review of the literature that spatial abilities could indeed be trained. Measures of testing spatial abilities included performance subtests on the WISC-R and Wide Range Intelligence and Personality Tests.

As well Reynolds and Torrance (1978) used the SOLAT with two groups of highly motivated students with superior educational achievement and ability.They found that for those students who received a "diverse array of learning and thinking experiences" a significant shift was noted to the "integrated

category" (where both hemispheres are utilized in a complementary manner). Another group of students who received intensive direct training in right hemisphere dominant styles of information processing showed a "substantial increase in the number classified as having right hemisphericity " (p.250). Although the SOLAT was previously critisized as having poor construct validity, the results of hemispheric training in this study are congruent with the above mentioned data.

A Review of the Empirical Research on Whole-Brain Learning

The previous section reviewed the empirical data arising from research using imagery as a variable in classroom teaching and involving the training of spatial abilities in students. Both sets of data have generally shown positive results. There is, however, undoubtedly an overlap between single variables such as imagery and "whole-brain teaching" in general. The review of the research below involves the use of "whole-brain approaches" to teaching in general with regular and special school populations. It is noteworthy that almost all of the research described is from doctoral dissertations over the last four years, accompanied by only three journal articles.

Two studies (Guyer and Friedman 1975; Hudgens 1979) attempted to show that remedial students (elementary grades and Adult Basic Education respectively) evidenced a left hemisphere deficiency and a right hemisphere superiority. Similar findings (Piatt 1979) were made in a "divergent" teenage population where

the results of testing indicated that over 80% of the students were either " right hemisphere" or "mixed brain dominant" and only 19% were "left hemisphere dominant". It was recommended by all three of the above authors that a brain-congruent approach be implemented in the respective settings to meet the specific needs of the individual students. Thus lecturing (a so-called left hemisphere task) may not be appropriate to "divergent youth " (Piatt 1979). It is also suggested that an appropriate match between a teacher's and student's cognitive style be given at least an experimental trial.

When experimental and control groups of normal students were each given classroom instruction the results were mixed. In a study of fifth grade science students (Kemp, 1978), two classes were considered control groups while the three remaining sections were divided into groups identified as El, Er and Ei; the group El was given instruction through so-called left hemisphere techniques (textbook orientated, verbal method with no demonstrations, activities or visual aids); the Er group was taught by methods involving the right hemisphere functions - there were more holistic and activity centered approaches with little verbal interchange; while the third, Ei, involved a method that integrated both approaches. The results after a treatment period of a month, indicated no significant differences among the groups.

> "no significant difference was found .... indicating that students can be taught by a method emphasizing the holistic activity centered, more non-verbal approach without lowering their ability to compete in a more

textbook orientated achievement test" (p.5430)

This quote raises an important issue. If a more "holistic" approach did not result in higher scores as might be expected, and secondly, if learning new techniques (such as an holistic method) did not result in higher grades, is there an impetus for a teacher to be trained in such methodology? In other words, why bother? A similar study with grade one children (Vigil 1981) revealed no difference on the WISC-R when two teaching methodologies were applied to different classrooms. However, when a "whole brain learning/teaching model" was applied to 10 experimental grade ten creative writing classes a significant treatment effect was noted. (Reedy 1981)

The classroom studies cited may be criticized for the following reasons:

1. the studies were all done over a short period of time and did not allow for a genuine training period in "other ways of seeing" or in learning to process information in novel ways;
2. the use of differential teaching methods should be attempted with a literate group of students (for example grade one is too early to evaluate the printed word and/or imagery methodology);
3. The questionnaires used to determine a hemispheric preference were suspect for the following reasons:
   a. they arose from a sterotypical notion of hemispheric specialization;
   b. they disregarded the fact of the possible use of

alternate strategies for the same task. For example a question which supposedly utilizes right hemisphere functions, (such as "Do you have a good sense of direction?"), may be actually utilizing the left hemisphere skills if the subject uses mnenonmic or verbal strategies to find his way to a specific location.. (e.g."make a right at the bridge and then a left at the park")

c. Also, as pointed out previously, there are other variables that relate to hemispheric specialization such as sex, handedness, field independent/dependent etc. which are not accounted for in these studies.

Summary

In this chapter, the events leading to the numerous educational articles concerning hemispheric specialization and learning have been chronicled. The direction taken by educators from the neuroscience information that was available to them was that the hemispheres were indeed specialized for specific processes and that most of the educational process favored the left-hemisphere. This bias of favouring the left hemisphere was seen by most writers to be a disservice to children in the learning process; the bias was also seen to be culturally determined factor. In other words,we live in a culture in which language (written and spoken) is accentuated and emphasized, where those "successful" in the culture have been so due to

their most proficient language skills. A credibility gap arose however when educators suggested that the right hemisphere was "creative," a claim that was not substantiated in the foundational literature. This inaccurate assumption led to the view that because the school system dealt mainly with the left hemisphere, and the right was generally subservient, that the school system did not foster "creativity" (a supposed right hemispheric process). This idea further contributed to the view that education was "lop-sided" and helped to create an unbalanced individual. The limited experiments in regular classes have shown mixed results with the use of an "holistic" curriculum. However, as has been shown, this may mainly be due to poor methodology. Special education experimental groups did, on the other hand, show significant differences. The results of trials with the use of imagery as a mediator in learning have been favorable.

There is an underlying dynamic here which needs to be explored. Was it the hemispheric specialization model that convinced educators that an "injustice" was being done to children? Did educators have these ideas before, or did the scientific explanation give credence to otherwise unsubstantiated claims. Why was the relationship between creativity and the R.H. established? Was there something culturally unique happening at this time which allowed these claims to be given a greater ear or more credibility? If the neuropsychological investigative period had come after the

Sputnik mission in 1957, would education have been considered a fertile field for the ideas of neuropsychology to be explored and experimented with? As will be shown in Chapter 5, at certain periods in a culture there is a predominant "climate" (what some call the Zeitgeist) which is either open or closed to specific information and ideas. Such was the case with the idea of hemispheric specialization which would be adopted because the information was precisely what certain segments of the culture and specifically the teaching profession needed.

CHAPTER 4

THE GOODNESS OF FIT EXPLORED

The aim of this chapter is to discuss a major question posed by this dissertation: what is the "goodness of fit" between the neuropsychological literature and the educators' interpretation of it? Specifically, were all the attributes ascribed to the left and right hemispheres by the foundational researchers accurately interpretated by educators? Were there omissions, exaggerations, suppositions and/or the creation of "new" characteristics by educators. These findings will be presented in tabular form. In assessing the match, a few guidelines have been implemented.

1. Even though the attributes of each hemisphere as suggested by the foundational researchers were subsequently challenged by fellow researchers (i.e. serial/parallel by Cohen (1973) questioned by White and White (1975)), these somewhat esoteric arguments are discounted for the purposes of the present task.
2. Coupled with this first point is the definitional problem ascribed to each attribute. What is "analytical" for example and how can it be delineated and translated into an operational definition? Some of the terms could be considered vague in this context. This limitation will be disregarded for this comparison.
3. As described in Chapter 2, there are variations of the basic

hemispheric specialization pattern which result from such factors as an individual's sex, handedness, etc. Although important to any discussion of hemispheric specialization they will alsc be disregarded. (The problem of assessing the field without such variables will be discussed in Chapter 5).

Thus, what will be examined in this chapter is the accuracy of the translocation of claims between two disciplines. Table 3 presents the claims as stated in the neuropsychological literature while Tables 4 (a) and (b) are the interpretation of those claims by educators. The neuropsychological claims are derived from the said articles or similar articles published by the same authors or those of the same research teams. It is from these sources that the original claims were popularized. The educational articles in Table 4 (a) are representative of the educational papers published during and after 1975 and were chosen by the following criteria:

1. cited often after their publication by other educators
2. published in a North American educational journal (with one exception The B.C. Teacher, which was chosen to represent a local author's understanding and translation of the source material to a teacher readership.)
3. authors whose articles cited foundational researchers as the source of their information; as well there was fidelity between the foundational research and the author's interpretation of the material;

4. whose authours were cautious in printing speculative, inferential or suspected attributes or processing characteristics;
5. whose authors recognized the foundational researcher's right to speculate beyond the known research base.

Table 4 (b) is comprised of those characteristics from the same educational articles used in Table 4 (a) which have been somewhat overstated or inferred in the foundational literature. There is a notation for each of these latter characteristics regarding its possible origin.

The article chosen (Haglund 1981) for table 5 is representative of a number of articles published that contain many speculative and amplified characteristics of the hemispheres and could be considered "caricatures " of the initial foundational observations. This table (5) has been provided to demonstrate to the reader the extreme limits of distortion of the foundational characteristics.

TABLE 3- Terms Applied by Neurological Reseachers to the Characteristics of the Human Cerebral Hemispheres(from Chapter 2)

Original Researchers	Left	Right
Humphrey and Zangwill (1951)	symbolic	fantasy and dreams; imaginative
Milner (1958)	verbal	visuospatial
Zangwill (1961)	symbolic	visuospatial
Efron (1963 a)	temporal	
Semmes (1968)	focal	diffuse
Bogen and Bogen (1969)	propositional	appositional
Levy-Agresti and Sperry (1968)	logical/analytic "computerlike fashion"	synthetic/ gestalt/ holistic
Cohen (1973)	serial	parallel
Sperry (1974)	sequential; fragmentary; abstract; speech;writing; calculation	unitary; dynamic; concrete

Attributes Not Usually Cited in Educational Articles

Semmes (1968)	focal	diffuse
Cohen (1973)	serial	parallel

TABLE 4A Hemispheric Attributes as Described by the Educators

Educators	Left	Right
Konicek (1975)	logical; analytical; linear propositional;	visuospatial; appositional; imagery; dream/fantasy
Samples (1975)	digital computer; logical; rational;	data simultaneously
Rennels (1976)	verbal; numerical; linear/logical/ rational;	spatial/ perceptual; fantasy; imagery
Hunter (1976)	temporal	visuospatial
Brandwein/Ornstein (1977)	language; rational; cognitive; sense of time;	spatial
Grady/Luecke (1978)	3R's; sequential/ linear; analytic;	simultaneous
Scotthorne (1981)	speech; logical; math; verbal; linear; detailed; sequential; analytical; 3R's; ordering; complex motor tasks;	spatial;holistic; simultaneous; emotional; synthetic; gestalt;faces; abstract patterns

TABLE 4B - Educational Articles Citing Unsubstantiated Hemispheric Attributes

Author	Left	Right
Konicek (1975)	thought [a]	none
Samples (1975)	constrained [b]	metaphoric [c]
		intuitive [d]
Rennels (1976)	Euclidean [e]	metaphoric [g]
	Geometry [f]	sensory [h]
		intuitive [i]
Hunter (1976)	none	none
Brandwein/Ornstein (1977)	none	intuitive [j]
		painting [l]
		sculpting [l]
		dancing [a]
Grady/Luecke (1978)	none	T.V. [m] art [l]
		meditation [k]
		visual [n]
		intuitive [o]

Scotthorne (1981)	controlled [a]	musical [q]
	intellectual [a]	artistic [k]
	active [p]	symbolic [a]
		intuitive [k]
		creative [b]
		spiritual [r]

The bracketed notation indicates the suspected origin of the claim.

a. inferred from foundational data

b. possibly from the psychologist

Neisser (1967) (p.297) when he mentioned 2 different forms of mental organization; the distinctions have been given many names:

rational vs. intuitive

constrained vs. creative

logical vs. prelogic

c. from Bruner (1962)

d. from Ornstein (1972)

e. Euclidean: a term probably referring to geometry. The left has no such documented role; in fact the R.H. through Franco and Sperry's (1977) research is credited with the control of geometrical form

f. see [e]

g. probably Samples (1975)

h. vague; halves of the body have afferent sensory pathways leading to the opposite hemisphere

i. from Ornstein (1972)

j. misquoted from Levy-Agresti and Sperry (1968)

k. initiated by Ornstein (1972)

l. from Ornstein (1972) who may have read this specific quote in Bruner's (1962) work: "the elegant rationality of science and the metaphoric nonrationality of art operate with deeply different grammars; perhaps they even represent a profound complementarity." Bruner (1962)

m. origins uncertain, but from a faulty premise that the visual hemisphere is the right; both hemispheres have visual cortices in the occipital lobes

n. see [m]

o. originated from Ornstein (1972) or Samples (1975)

p. both hemispheres are active; one may be more active than another depending on the task and the individual's strategies of negotiating with the environment

q. Although the R.H. is said to be dominant for most aspects of music, sequence, tones and pitch are probably left hemisphere based (Milner(1962) and Gordon (1974))

r. this may be initiated from Ornstein "... the word most employed is mysticism. It is the taboo area of inquiry which is symbolized by the dark, left side of ourselves, the night (p.113) [and thus the right hemisphere p.83]

TABLE 5 - The Extreme Limits of Hemispheric Specialization

Left	Right
western logic	eastern paradoxes
functional	inventive
measurable	creative
product-orientated	process-orientated
indep/separate/atomistic	interdep/continuous/conflict
precise/explicit/digit	approximate/implicit/tacit
	intuitive/configuration
objective	subjective
either/or/different	interactive/ multiple
	holistic
black/white	grey areas
deductive	inductive
hierarchical	hetrodoxical
structure/order/conforming	unity-in-diversity
closure	open-ended
direction	non-directive
vertical/longitudinal	horizontal/latitudinal

Conclusion

a. As shown in Table 3 two sets of dichotomies were not usually cited by educators - focal/diffuse and serial/parallel. There may be two reasons for this. First, focal/diffuse (Semmes, 1968) was suggested as a means of differentiating the neuronal organization of the hemispheres rather than as a description of cognitive processing strategies. Second, both sets of nomenclature appeared in somewhat esoteric journals, Neuropsychologia and The Journal of Experimental Psychology (respectively). This latter point, though seemingly small, may be indicative of a greater issue, i.e., most educators who published articles concerning the educational use of hemispheric specialization appeared to use only those relatively easily accessible sources which were, in many cases, based on a secondary source. In effect, when the same information moves in many circles a hazard presents itself; "... a signal that spreads to infinity loses its integrity since it picks up noise from the environment as it spreads itself through the environment." (Thompson, note 3) Thus, at least two levels of distortion occur. The first comes from the interpretation of the initial source by an author or popularizer and the second, from the fact that as the information continues to meander through the culture a further distortion or bias occurs.

b. As previously mentioned, the educational articles could be characterized by the chosen seven articles cited in table 4(a). The characteristics of both hemispheres appears to reflect the spirit of the original research. In fact many of the same terms are used. The majority of attributes that could be described as "suppositional" or inferential (Table 4(b)) from the same articles appear to have their origins primarily in Ornstein's (1972) work. Ornstein's role in extending the known characteristics of the right hemisphere to the more speculative and inferential should not be underestimated. Specifically he stated the right hemisphere's role in the arts, intuition and the "spiritual," the first two of which were derived probably from Bruner's work (1962). (It is interesting to note the effect a mass-market hard cover and paper-back book could impact upon a large and uncritical audience.)

Haglund's (1981) dichotomies could be characterized as "metaphoric", yet, the clarity and crispness of the original is lost in these popularized descriptions. Thus while they are colourful they obscure a competent and precise model of what is presently known.

c. The comparison being drawn between the two sets of literature has shown that the goodness of fit is generally satisfactory within the framework of a certain group of articles which is in the majority. However a group (a minority) of articles has been discarded. These were written

by some educators and journalists that were far more speculative and imaginative than based on neurological research. Because of the highly speculative characteristics of these articles they would not likely lend themselves to empirical research due to the difficulty in assuming any consensus for an operational definition or construct. It is important to be most cautious about seeing the usual hemispheric dichotomy charts with strands of characteristics for each hemisphere as in Table 5. It is also important to question the discrimination of an author who cites the more elusive characteristics as "known attributes" rather than noting them as speculative,and based on imagination and conjecture rather than on the data. There seems to be a common predicament - how to speculate audibly without having lay people seize upon the ideas as "facts" or "truths". In such a crystallization the fluidity of ideas in the culture gets stifled and ultimately passes as "another fad". Thus even seed ideas get buried.

The Theory/ Practice Gap

As mentioned in Chapter 3, there have been two levels of educational literature.First, there were those articles which offered "interesting techniques" applicable to classroom practitioners. This could be called "reportage". Second, there were other articles which carried an implicit or explicit

message about education and the limited role it played in human development. The message in these cases was classified as "teaching half a hemisphere is teaching half a person". These latter articles were more theoretical and usually did not contain strategies of implementation for the practitioner.It is the former set that will be examined here.

It is important here to mention and elaborate upon the theory/ practice gap that has subsequently arisen in this body of educational literature. I am specifically referring to the lack of scientific substantiation for the claims of particular practices or techniques being linked to specific hemispheric functions. In the following pages, a sample of techniques advanced by a number of educators which evidence this inconsistency will be presented. The practice of these techniques often has been shown to positively affect classroom performance. This success has then been inferred to indicate that these techniques increased particular hemispheric functioning. What has been absent is the application of physiological criteria such as had been used in the neuropsychological experiments(such as cerebral blood flow, E.E.G. etc.) to the technique to substantiate claims that a specific hemisphere was particularly activated during the application of that technique. In addition discriminations between those techniques which seem closer to the original claims and attributes than the more "extended" or hypothetical ones will be made.

The following are various educators' viewpoints. Vitale (1983), in her recent book on right-brain strategies, has written:

> The learning strategies presented are all right brain in their approach... that is they use one of the characteristics or skills attributed to the right brain to introduce the concept. This does not indicate that I do not believe in left hemispheric approaches. It does indicate that I believe there already are enough left hemisphere approaches in today's curriculum.

She goes on to say that exercises involving tracing numbers in the air or moving the body to form shapes are right hemisphere activities. In general, Vitale believes the use of colour, movement and imagery all involve the right hemisphere.

Williams(1983) has suggested among other techniques the use of metaphor to teach academic subjects."It focuses on the process of recognizing and understanding patterns and general principles which give meaning to specific facts... an opportunity to make new connections to gain insight into both the new subject and that which is already known"(p.59). For example, on a history exam, a possibility of two kinds of questions, with and without metaphor would be:

a. List the major events leading up to the French Revolution and explain their importance.

b. How was the period up to the French Revolution like the building up of a thunderstorm. Be sure to include in your analogy the major events leading up to the revolution.

Another activity that Williams considers to activate the right hemisphere is visual thinking."Mapping allows one to see

and represent connections more easily than does a linear outline... making visual thinking an explicit part of the classroom learning also enables students to develop their capacities in that area so that they may become more efficient learners"(p. 113).

As stated in Chapter 3, there were other suggestions for engaging the right hemisphere. Guckes and Elkins(1981) were of the opinion that language experience and affective education were educational strategies that would activate the right hemisphere; Ogletree's(1978) suggestion was for basketweaving, woodwork, colouring and crocheting while Hudgens (1980) felt that engaging students in more concrete experiences to increase their understanding of the abstract material would be beneficial. Most of the educators believed in the value of utilizing some form of imagery or fantasy strategy. For example, in using fantasy tc help students assimilate the concept of combustion the following exercise was suggested:

> You are the piston of an internal combustion engine. You do all the wcrk. You suck in the air and gasoline mixture. You compress it so it will burn with more power. You're the one that's exploded down when the mixture ignites. You turn the crankshaft and you do the cleaning up. You force out the burnt gases so that everything is ready for the next cycle. Describe what your"piston body" experiences as you go through the four cycles of internal combustion.(Gordon and Poze, 1972 as cited by William 1983)

In her best-selling book ,Drawing on the Right of the Brain, Edwards(1979) suggested specific techniques to help the reluctant drawer regain some confidence by utilizing some right-hemispheric strategies. For example, when wishing to draw

the vase/face paradox, she suggested noting the space (a so-called right hemisphere activity)instead of naming the parts of the face("eyes, mouth,nostril" etc.- a so-called left-hemispheric activity).In doing so she remarked that a shift would occur from the left to the right hemisphere. She stated "if you use words to think, ask yourself only such things as: 'Where does the curve start? How deep is that curve? What is that angle relative to the edge of the paper?'These are R-mode questions; spatial relational and comparative. Notice that no parts are named" (P.48). Another exercise she uses is to turn the proposed drawing the student will attempt to copy upside down. She hypothesized that by reversing the drawing, a gap is created in the logical abilities of the left hemisphere freeing the right to take over for a while.

Finally, Buzan(1983) in his recent book has stated that the two sides of the brain should be considered in any scheme of self-development or self-management. This would include programs of memory and vocabulary improvement as well as work with self-image improvement. For example he stated that the image of oneself is a vital ingredient for self-improvement and is under our control "....(it is) the function of the image to trigger the imaginative right side of your brain and to give you a mental set that allows your self-correcting brain to aim constantly at an ideal"(P.66).

Some conclusions can be made concerning the description of right hemisphere classroom activities as detailed above.

1. First, some of the activities seem closer to the original hemispheric attributes than others. For example,to the extent that there are experimental data about emotion, one could hypothesize that affective education and language experience programs would be more likely to involve both hemispheres than would a "regular" language arts program. The research on the right hemisphere's involvement with imagery also seems quite stable.Concerning this latter point however one should keep in mind the recent research concerning the left hemisphere's role in "cooked" or manipulatable images (Bakan 1980).
2. Second, there are hazy or grey areas where an activity could be argued as being either left or right orientated dependent upon the strategy used by the student. For example, crocheting, woodworking, colouring, metaphor, tracing the alphabet in the air or concrete experiences are not necessarily right hemisphere activities. Another example would be a spatial task such as map reading which could be handled by using mneumonics or verbally labelling the specific areas and committing the label to memory.Thus,as Levy(1983 a) pointed out, tasks in the normal intact brain are rarely the unique property of one hemisphere .

As mentioned previously, the acid test for determining the hemispheric locus of activity for a task such as described above would be to actually test the children with the physiological measures used in the original research. This has already been

shown to be possible by the results of EEG and cerebral blood flow work,which measures were able to differentiate between verbal and visuospatial tasks. (as described in Chapter 2).It is unlikely that any classroom activity would be shown to be a "pure" right hemisphere task.

CHAPTER 5

ACCEPTANCE OF THE MODEL: A SOCIAL AND HISTORICAL CONTEXT

This chapter will chronicle and describe the acceptance of hemispheric specialization (H.S.)in the culture. It will attempt to clarify its popularity and its translocation from the neurosciences to popular psychology and education. The chapter will include a comparison between H.S.'s acceptance in the latter half of the twentieth century and phrenology's popularity in the nineteenth century.

An Historical Parallel for the Acceptance of Hemispheric Specialization Research

Information concerning the brain and its function has not only drawn attention in the 1970's and 80's, but a similar phenomenon was observed in the 1800's with Phrenology, the pseudo-science correlating protuberances on the skull with inherited character traits. Although there is no basis for a scientific comparison between the discovery of phrenology and the research leading to hemispheric specialization, the parallel in public acceptance of the two ideas is striking. The public climate in Britain and America which was most receptive for phrenology will be described. Second, a description of the 20th century Western culture which eagerly greeted hemispheric specialization will also be discussed and parallels between the

two periods will be explored.

An Accepting Climate - Britain and America in the 19th Century

The 19th century Viennese physician, Franz Gall, and his pupil Dr. J.Spurzheim were responsible for the discovery and proliferation of information regarding "bumps on one's head" as an indication of inherited character traits. While this idea was ultimately abandoned it nonetheless lasted a century in Britain and America. There were some key cultural elements at that time which may have been responsible for phrenology's success. First, the prevalent philosophy of the time , based on the idea of John Locke, was that the intellect and the soul were located in different organs of the body, particularly in the heart and stomach - a theory considered by some to be metaphysical. In other words it was based on faith and was not subject to personal verification. As well, Locke espoused the philosophy that the mind at birth was a tabula rasa (a blank slate) with the environment and culture continually edifying it. Locke had also developed a system of psychology concerned with "the limits of understanding the source, the source of ideas and relations between mind and objects in the process of learning and knowing" (as cited in Young 1970). Twelve years before Gall received his medical degree, Prochaska in 1784, had pointed out the valid notion of cerebral localization while recognizing that no scientific proof was then available to support the concept. The

culture of the time was retracting from the unsubstantial notion of the soul to a physically based understanding of behavior and functionality.

What in essence did Phrenology offer to the British people? First it was a comprehensive package combining science with a philosophy of man that avoided the prevalent unprovable metaphysics. As one of its proponents, George Combe stated,"Phrenology was the clearest, the most complete and best supported system of human nature" (as cited by de Guistino, 1975). Gall argued for the dependence of the mind on the brain and demonstrated distinct parallels between variations in the brain and variations in mental and behavioral phenomena. Thus was presented a tctal package of mind and body to which ultimately the reader or interested populace was invited "to look for yourself." According to Gall the proof was in the calipers. In fact the philosopher Thomas Brown remarked that the theory would never gain acceptance because anyone could test it simply by looking at heads. Spurzheim suggested that it was for this very reason that it gained acceptance, because anyone could test it simply by looking at a head. It thus superceded the nebulous metaphysical or philosophical debates, which were largely in the domaine of intellectuals of the time.

Gall's objective was the development of a doctrine which would give a complete view of the"perfect knowledge of human nature". "It was attempting to uncover the greatest puzzle which everyman faces--himself and secondly other persons"(Boring

1950,P.56).The process of studying this phenomena,Gall thought, would need to be initiated by a physician not a philosopher. Phrenology,as described and practiced by Gall and his followers, was able to amass large amounts of information in the natural and behavioral sciences and present it in a comprehensive and cohesive manner for the populace without the encumbering language and logic of metaphysics. The public were becoming weary of "the barbarous jargon and logic...of the intricacies of metaphysics"(de Guistino 1975,P.34). The culture seemed to lack a comprehensive popular science. Phrenology attempted to interject the precision of math and physics into the foggy realm of "human nature" and to provide great predictive value. It should be noted, of course, that by 1800 science had challenged the authority of religion in many areas, and, via its application in technology, was starting to usher in the industrial revolution. The culture was prepared to entertain "scientific" explanations of human behavior based on " precise" empirical physical evidence. The phrenologists appeared to be able to meet the need for scientific explanations,but at the same time,they provided a philosophy of mankind consistent with traditional morality. Critics considered books like the Constitution of Man by Combes(1853), a popular phrenologist, to be "the new gospel of practical ethics",providing a philosophical, psychological and scientific understanding of man and his predicaments.It dealt, for example, with common subjects like "how to be happy", "how to choose a wife","how to raise

children", proper exercise, proper clothes and correct diet. For the man who did not understand philosophy, psychology or physiology , it appeared to give a scientific rationale for diverse areas of decision-making. Phrenology was more appreciated by the common human than by the scientific community and attracted only a few people from the scientific and medical establishments. Indeed," for a scientist to have taken phrenology seriously would have placed him in the camp of palmists, astrologers and crackpots" (Krech 1968). There were many money-minded amateurs who"read head for hay". As de Guistino (1975) has noted, it provided a "short-cut to knowledge for the masses". The popularity of phrenology was clearly displayed by the acceptance of Combe"s book Constitution of Man which sold 2000 copies in days and 17,000 in one year. As well, Britain in the mid-1800s was the home of 29 phrenological societies and several journals on the subject.

Essentially Phrenology was a hopeful philosophy dealing with the morality and habits of a nation and included such topics as education, good government, prison reform and health and living conditions. In fact it was concerned with the well-being of the total person, not just merely his mental activity. Phrenology outweighed fatalism, because although cranial bumps were fixed, one could do mental exercises to improve specific weak inherent characteristics. For example, members of the working class, in whom the phrenologists were particularly interested, were told that they could continue their education after having left the

education system. The rigidity of religion was also challenged with the phrenologists forming small groups of men who denounced the habits of organized religion. As one phrenologist said,"obviously Providence has intended Sunday for field trips and exercise".

Phrenology and Public School Education

> The moral and social evils existing in society were dependent upon a wrong system of education....wrong because it was not in harmony with nature and did not develop the physical ,intellectual and moral nature of man;a correct system of education would do this and consequently reform and renovate the world.
> Dr.W. Elder in the American Phrenology Journal (1850 as cited by Davies, 1955)

It was the view of the phrenologist that education was the most important endeavour because it was a process that helped form "mental organs that had not developed properly". Most phrenologists had something specific to write about in the phrenology journals concerning education's leading role. The American Annals of Education consistently published articles by Combes and Spurzheim while converts to phrenology included Horace Mann, one of the founders of the American public school system. Thus it could be said, phrenology "hit the American educational circuit." The individuality of students was a major tenet of phrenological education. In fact, as each child had a different constellation of cranial bumps, it was felt that each child was endowed with a specific character. Thus a teacher's

judgment and treatment of a child should be in accordance with this individuality. Successful teachers were those who challenged the right mental faculties in the proper manner. This had specific repercussions for teacher training. As de Guistino has remarked;

"even if a head master knew phrenology,the school itself would fail when the staff were not in possession of any scientific knowledge of human nature.."

Phrenology in America

When Spurzheim arrived in America to preach the gospel of phrenology in 1832, he met with receptive audiences, open to reform for the many ills plaguing America during this period: slavery, oppression of labour, currency irregularities, improper soil cultivation ,alcoholism, rigid marriage laws, and even impaired digestion(Stern 1971). A swift panacea was offered to a new world which was sympathetic with the novel and the unexplored. As one writer stated during this period,"the shape of things was a sure sign of their nature...a more correct index to..character than the pen of a ready writer"(cited in Stern 1971 p.x111).For a nation that loved facts, Spurzheim, and later promulgaters like the Fowler Brothers, supplied a beautifully neat, "scientific" system by which humans could know themselves. As Stern(1971) remarked," it seemed in keeping with the philosophy of this new land that a man's character could be read

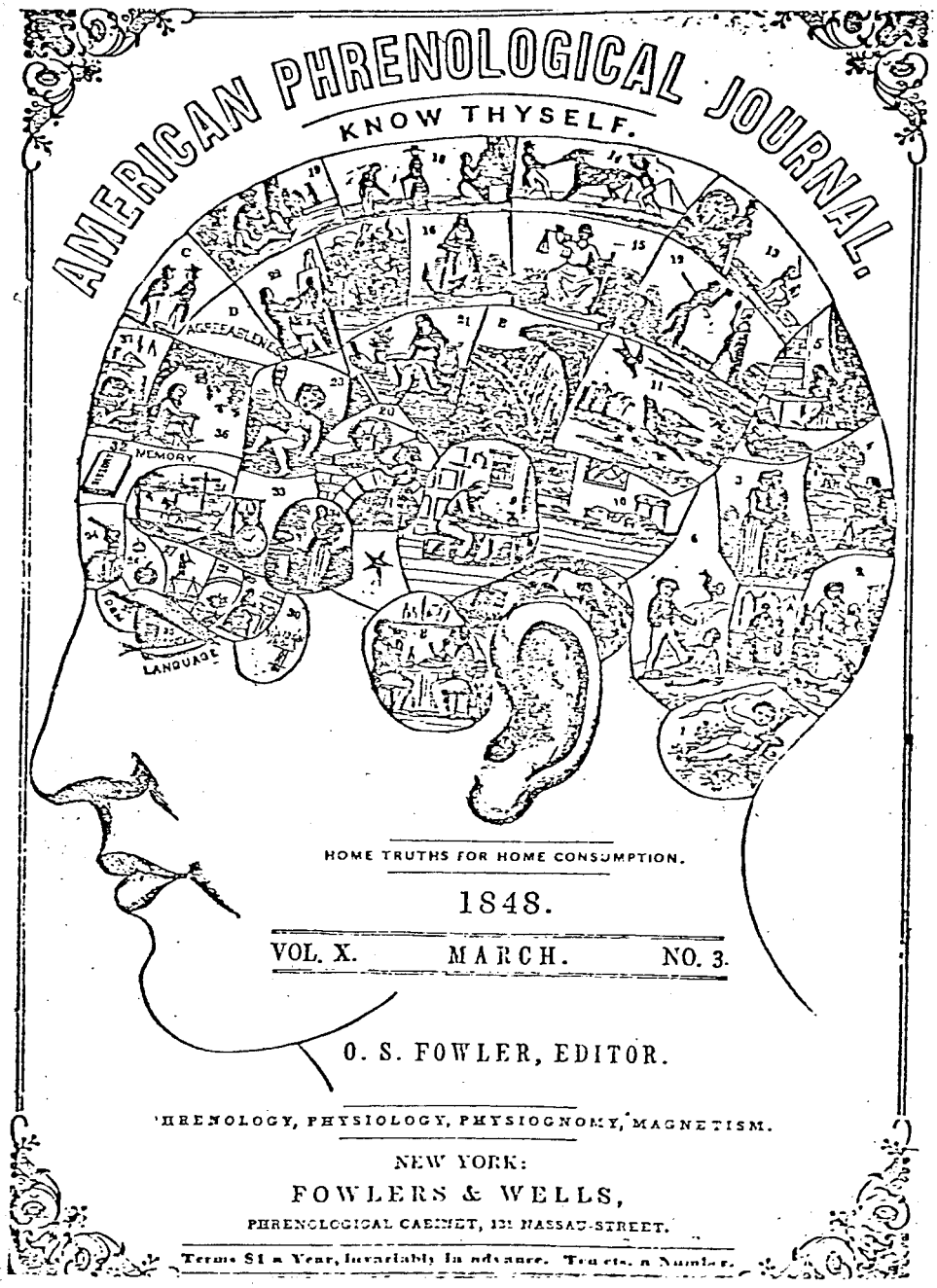
from the shape of his skull and improved by various mental exercises."

Summarizing the characteristics of phrenology and the circumstances to which it applied, de Guistino(1975) stated,

> Avoiding metaphysics and the unfamiliar language , phrenology was a tidy mental science for the gentleman.....In view of phrenology's evidence(or lack of it)..a philosophy was available with scientific pretensions speaking the layman's English and connected to the most digestible ideas of recent times;that in itself was alluring to those who read more than newspapers and novels. But a system of knowledge based on hundreds of visible case studies and honest enough to admit of further development, that was almost compelling. Men of all professions found these features to their liking;lawyers, educators , chemists and writers..... phrenology was logical and slightly mysterious, precise but flexible, awesome in judgement,but humanely hopeful"(p.74).

The cartoon on the following page seems to capture the appealing message of phrenology- "Know Thyself" & "Home truths for Home Consumption." This system offered humans the chance to know themselves. This knowledge could not be gained in a doctor's office or in the Reading Room of the British Museum, but in a home atmosphere amongst close friends and family members. It enabled the individual to make improvements,not in a piecemeal fashion, but to his/her whole persona - in short a swift panacea . Even though the actual neurological information was grossly incorrect it was one of the earliest theories concerning the cerebral localization of function. The decline of phrenology in the 1800's was not due to its critics, but rather to the development of new research on brain physiology published by scientists such as Broca and Fritch(Dallenbach,1955).

Figure 1: The Parallel Comment 1850/1970



Source: adapted from Stern, 1971; the original from The American Journal of Phrenology, 1850

The Cultural Acceptance of Cerebral Specialization and Phrenology - a 19th and 20th Century Comparison

As previously mentioned , cerebral localization had been suggested by Prochaska even before Gall had received his medical degree. The antecedents to hemispheric specialization of the 20th century were the discoveries pertaining to aphasia (due to stroke and war injury). At a non-technical sociological level, the coined phrases from the 1848 cartoon -" Know Thyself" and "Home Truths for Home Consumption" -would be most applicable for this period. As was the case in the previous century, the general cultural mythos seemed to be one of empowerment of the individual. The straight-jacket effect that Locke's notions of metaphysics and intellectual psychology had had on some sectors of the population appears similar to the rigid behavioristic and Freudian models of human behavior and interaction held in the 20th century. In the lapsing of the prevailing mythos of the 19th century, the external forces that could have an effect on man-- soul, God and the impinging philosophy of psychology- was replaced with a mythos that was now under his control and by its nature was adaptable.

This shift to a more introspective "Know Thyself" stage could also be seen by looking at the progression during the decades of the 20th Century. In the 1930's people were preoccuppied with the economics of the Great Depression and the

growing threat of war. In the 1940's the world was at war or recovering and rebuilding from it. The 1950's was a period of relative peace (except for the Korean War) and prosperity. By the mid 1960's, however, people appeared to question the growing ecological destruction and to challenge the power of governments to commit nations to wars (eg.Vietnam). At the same time, the changing status of the family, linkedto the changing sex roles for men and women, led to a strong interest in self-analysis and development.One could say that the cultural context was ripe for a system of self-knowledge such as hemispheric specialization.

The strict behaviourist and Freudian psychology of the 20th century which was dependent on learned men and outside specialists was beginning to succumb to a psychology of personal power, assertiveness, awareness, clarity of thought/desire/feeling and ultimately the care and respect for the individual and his inherent wisdom - simple and unencumbered ideas for a complex world. This new alternative for the 20th century, which some have called "third force" or "humanistic psychology", had its roots in the writings of Maslow(1962) and Rogers(1961) among others.

Maslow's work investigated the components of the healthy individual, rather then the preceding Freudian emphasis on aberant or neurotic behavior. It also paralleled a shift of emphasis from disease mediation, to disease prevention, to health maintenance, and finally to health improvement. In effect, therefore, psychology and certain elements of medicine

are being"deprofessionalized" by being made accessible to lay people who now are seen as taking an active role in their psychological and physical well being. It should also be noted that in the 70's there has been a general increase in "translating" science to the general public via media of all types, as can be witnessed in the number of new publications which interpret science (i.e. Science Digest and Omni) and in the mass of self-help and self-improvement books and articles. In short, the context of the 60's and 70's is one in which people are interested in science and in themselves, in which "scientific" approaches to self are offered on a wide front. Humans are seen as capable of improvement, of change, of life-long physical and psychological development. In such a context, a concept of educational practice which proposes to develop human potential more fully, but which offers a scientifically based brain physiology and structural basis for its methods, was likely to be accepted by many teachers, parents and students. The concept of two distinct processing modes residing in the left and right hemispheres was simple enough.However when this notion was offered with a clear and simple program of techniques by which people could address the two modes selectively, then its appeal became quite compelling. Just as Phrenology, 100 years before, had offered people simple techniques for self-improvement, so "brain research"now rationalized methods for improved writing,drawing and general problem-solving and even avenues to greater" creativity." Titles

such as as,Drawing on the Right Side of the Br Edwards(1979) or Using Both Sides of Your Brain Buzan(1974:1983) illustrate the self-help genre of "brain-research" books.The popularity of these books is evident in the fact that Edwards' "Drawing" has now sold over half a million copies. Other popular titles include: The Brain Book by Russell(1979),Writing the Natural Way by Rico(1983), Teaching for the Two-Sided Mind by Williams(1983) and The Brain Users Guide by Buzan(1983). The accessability of information on phrenology was notable. Many pamphlets and books were available to the lay public on self-improvement.What Davies(1975) said of phrenology could equally apply to the exposure hemispheric specialization received:

> Thus a large volume of literature was produced upon many topics and through lectures, societies,magazines, books and periodical articles, phrenological tenets were dinned into American ears while the appropriation of their peculiar vocabulary by fiction and popular speech made them familiar to everyone (P.XI).

Both phrenology and hemispheric specialization have seemed to offer a shortcut to knowledge, bypassing the need for extensive training to become an "expert".

In both cases the"mysteriousness" of the brain has been an important factor which has maintained the public's appeal for the concepts and ensured their success. The fact that the concepts have not been fully understood has not lessened their appeal. Also their popularity has been enhanced by such circumstances as the recent commissurotomy experiments being simple enough in technique to be easily understood by the lay

public.Just as the phrenology vocabulary came to be used in common expressions eg."look for yourself and don't rely on anything but the calipers", in the same way, this right/left fascination has had repercussions in advertising, mass media and even in our common language.One knows too well what the statement "you're too left-brained" means in common contemporary parlance. Another good example is the recent advertisement for the Saab:"a car for both sides of your brain".

Hemispheric specialization appeared to offer a complete package for understanding human behavior and rationalizing it. In attempting to offer a gestalt,wholistic view of humanity, hemispheric specialization, like phrenology before it, has been applied to areas of life as different as education, mental health, and advertising. There is the implicit notion that this system may be the answer for many of our ills - a western panacea based on the neuronal organization of the brain and within our own control and free will.

Education in the 1960s and 70s

A brief educational historical perspective from the early 1960s will provide a background for an appreciation of the cultural context in which the hemispheric specialization research flourished. The emergence of the human potential movement as described by Rogers and Maslow had specific repercussions in education. Rogers wrote Freedom to Learn(1969)

which was based on his client-centered therapy approach. Based on the research of Raths, Harmin and Simon (1966), the "values work" began in schools. In 1962, Combs edited a classic book on educational reform based on so-called "third force psychology", Perceiving, Behaving and Becoming: A New Focus for Education. Other notable educators writing and attempting to affect change during this period were Ashton-Warner(1963), Kohl (1969) and Leonard(1968), to name but a few.

The late 60's saw the birth of the humanistic education movement, initiated by educators who felt that public school education was not meeting the needs of the whole person.It was their concern that a fractured view of life was being presented in schools which would be deleterious for the child becoming adult. This is most poignantly described in Kozol's (1967) indictment of the school system and in the concerns maintained by Silberman (1970) and Holt(1969).

Concurrently using gestalt therapy as a guiding theory, Brown(1971) established"confluent education"-the amalgamation of the seemingly disjcinted affective and cognitive domains of the psyche. Summarizing the period, there is a parallel developmentbetween of the human potential movement and humanistic education. Like the human potential movement, the antecedant of the humanistic approach to education was a behavioristic model of dealing with children and instructional practices.

A recent publication by Robinson(1982) has summarized some basic tenets of humanistic education which are generally accepted by its practitioners:

1. it teaches a wide variety of basic skills including problem solving, communicating and self-understanding;
2. it helps students believe in themselves and their potential, while encouraging compassion and understanding-- this would foster self-respect and respect for others; as well it promotes skills in conflict resolution;
3. it deals with basic human concerns,with issues throughout history and today that are of concern to human beings trying to improve the quality of life - to pursue knowledge, to grow, to love, to find meaning for one's existence.

Humanistic education as described above has a strong proclivity for working with values and with the emotions of an individual. According to Robinson, terms such as affective, wholistic or psychological education are sometimes used interchangably.

It must be remembered that the sentiments expressed during this period were essentially hopeful statements of belief about humans,their condition and potential. Little empirical research was done or existed to support any of the major humanistic tenets. The arguments presented for educational change based on humanistic psychology were based on moral,religious, philosophical or metaphysical grounds,or on anecdotal reports of therapy and clinical practice (Rogers 1961; Maslow 1968;)

Thus the "discovery" by humanistic educators in the mid-70's (Samples, 1975a + b) of neurological research on hemispheric specialization appeared to offer for the first time, a "hard-evidence" base for their claims and approaches. How opportune this was for educators who faced both institutional resistance and their own insecurities about changing instructional practice based on theories of human potential. Now there was "scientific evidence." The findings about the split-brain patients as described from 1964 onwards provided needed and legitimate, sound arguments as to why schools should become more "creative" or "holistic" in their approach. Moreover, if the research was ignored, the inference was that the practitioner was ignoring the inherent neurological organization of the human cortex. The seemingly legitimate arguments based on the split brain research gave many authors more authority in their writings in educational journals. Using opening paragraphs beginning with "Recent neurological findings tell us ..." these writers developed arguments about the lack of specific emphasis (art, drama, etc.) or indicted "bankrupt"teaching methodologies. As was pointed out in Chapter 3, most educators did not delve into complex or debatable issues that would reduce their strong arguments into luke-warm topics of discussion. As a consequence of ignoring these finer areas of discrimination and learning style such as sex-differences, handedness, field dependent/independent , a disservice was done to the targeted clientele - students in public schools. Paradoxically, the very

advocates of individualization of instruction were ignoring major elements in the spectrum of individual differences. Typical"left/right bilateralization" was claimed to be obtained in fewer than 15% of the population.

For educators, reports of hemispheric specialization were easy to understand and convey to others. Its basic principles could be understood with little prior background in neuropsychology or neurophysiology. An investment of time to access knowledge of the field was not needed. The popularity of the concepts led to their inclusion in metaphorical expressions about life and its personal predicaments, For example, "Their marriage didn't work because he was too right-brained and she, too left." As one researcher mentioned in an interview , "it's pretty research" (Segalowitz, note 5)

The educators' interpretations of research did not have to be flawless. They were not scientific treatises, but basically a means of supporting and edifying the larger issue of treating the individual and his/her uniqueness as important elements of schooling. As a major force in the modern world, "hard", empirical, medical science was being called upon to support an ideology of schooling, a value position which saw the individual as important and human potential as greater than that which is now addressed (and evaluated) by modern schools.

In essence we may be experiencing what Toffler(1982) called the emergence into the "Third Wave", a post-industrial period characterized by a civilization "developing its own

superideology to explain reality and to justify its own experience"(P.5). The conflict Toffler sees is between the partisans of the industrial past (second wave) and "those millions who recognize that the most urgent problems of the world - food, energy, arms control, population, poverty, resource, ecology,climate, the problems of the aged, the breakdown of the urban community, the need for productive,rewarding work can no longer be resolved within the framework of the industrial order"(P.17). A similar metaphor is used in Ferguson's (1979) recent book. She has written of a new paradigm called the Aquarian Conspiracy and has characterized it as,

> promoting the autonomous individual in a decentralized society.. heirs to evolutionary riches, we are capable of imagination, invention and experiences we have only glimpsed.... the new perspective reflects the ecology of everything:birth, death, learning, health, family, work, science, spirituality, the arts, the community, relationships, politics (P.29).

Thus , the educators who employed neurological research as a support for reforms in schooling should be seen as advocates of this "paradigm shift."In fact, the first articles on the educational significance of hemispheric specialization were written by Samples (1975 a & b) and the continued work of the same author represents an argument that this paradigm shift in our view of reality and of human beings is in fact underway (Samples 1981).Recent work by Goodlad(1983) reflects this desire to redefine schools even further.Goodlad notes that in his observations of over a thousand classrooms, what actually is of

significance comes from children's social and personal lives, not academics. Goodlad has stated : "If we can only understand schools clearly in our minds, we might be more successful in improving them. We might understand why changing the method of teaching reading, for example accounts for so little in the variance of reading scores"(P.9).

On this same theme he remarked,"It is not acknowledged or practiced that subject matter (is) merely turf on which to experience the struggles and satisfaction of personal development"(P.15).

Second, although the philosophy of schools in general bespeaks an array of democratic processes,truth and values, self-confidence, creativity etc.(i.e.goals directed to the growth of the individual), it is not the case in practice. Goodlad, in discussing the dichotomy between educational goals and existing classrooms practices, makes the wry remark,"I wonder how serious we are in stating such expectations in the first place" (P.10).

His remarks continue :

> I think that school programs.. were far more orientated to the topics and skills of the courses than to the role of organized knowledge and processes of disciplined inquiry in the development of human beings.. I see little in the curriculum explicit or implicit likely to promote a keen awareness of humanity (P.18).

These comments may serve to summarize the concerns of humanistic educators-- concerns which continue to the present day. The use of neuropsychological research is suggested as a credible and powerful method of supporting them.

What are the driving forces for such educators who have seemingly used the hemispheric specialization material in a quasi-political manner? Salk(1983) has suggested;

> ..that either because of genetic determination or through intellectual/intuitional development, a sufficient number of human beings now exist who, as individuals are impelled to counter the self-destructive and devolutionary influences in our society and in the world (P.3).

It might be, as Jung(1965) has suggested, that such a change is occurring at the level of the "collective unconscious"(p.138).As Sperry (1983) has stated, "the collective consequences clearly promise to profoundly affect our values and touch our lives in many ways"(P.3).

Thus our present state of affairs seems to be one of shifting from a science predicated on an impersonal, remote body of knowledge to one in which concerned persons are demanding an interplay with human values, resulting in the possible enhancement of man's life. Salk makes this suggestion:

> We have gone beyond the use of science and technology to control nature; we are now in a position to influence the healthy development of the human mind through the use of the concepts of science and scientific knowledge, applying such concepts to the study of the human mind and using the knowledge so gained for improving the quality of the minds of humankind.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

This chapter has a number of purposes. First, it attempts to summarize the neuropsychological and educational literature. Second the chapter will outline the incomplete nature of the educators' survey of the literature and suggest reasons for what appears to be a possible" hidden agenda."

An Assessment of Neuropsychology as it Relates to Hemispheric Specialization

From a researcher's perspective the problem of hemispheric specialization is not as clean and crisp as the popular literature suggests. The experimental psychologist, Hellige (note 4) describes for example, the variabilities involved in dealing with the common notion that "creativity is in the right hemisphere".

> If you were going to do a scientific study to see if the hemispheres are differentially involved in creativity, the important thing would be to come up with an acceptable definition of creativity which could be studied in an experimental way; I'm not sure you could get more than a handful of people to agree on an acceptable definition. That's only part of the problem. Then if you want to demonstrate that one hemisphere is more responsible for creativity, or more involved, or one is more creative then the other, there's a whole host of other things about how you would administer the task so you could see one hemisphere in operation as opposed to the other. My own suspicion and partly my bias, which is a fairly strong one at this point... is that there's a lot of speculation about higher order

> cognitive processes like creativity, analytical thinking, artistic appreciation and production and so forth, tasks which are so complex that it's inconceivable to me that they would be the exclusive province of one hemisphere or the other. To claim that, for example the left hemisphere is responsible for analytic thinking and the right hemisphere for intuition and creativity is to imply that creativity doesn't involve analytic thinking... I would suspect that it would be very difficult to find a creative individual who didn't , while he was creating, involve himself in an analytic activity.

When Hellige's remarks are coupled with the published comments of four reputable researchers, one senses the "delicate" state of the field as well as the "slippery nature" of the research itself. The cautionary remarks are aimed at the popularizers since it is through their distortion that the field has the appearance of being solidified, thoroughly researched and applicable to most disciplines or situations. As Cohen (1977) has remarked;

> It is unfortunate that the serious study of hemispheric differences has succeeded in attracting a lunatic fringe of adherents who have been engaged in parcelling out attributes and functions between the hemispheres on the grounds that are more mystical than scientific. In the popular literature on this subject, the right hemisphere is sometimes characterized as sensual, artistic, intuitive and as the predominant influence in oriental cultures; while the left is considered as rational, logical, intellectual and predominant in Western cultures.... It is hard to see how research on hemisphere differences, however perfect it may be, could have generated this kind of nonsense. In spite of the methodological criticisms that can justifiably be made of experimental techniques, and in spite of the lack of a theoretical explanation that can satisfactorily account for all of the findings, the convergence of results from a wide variety of sources has provided a solid empirical basis of evidence for functional specialization of the hemispheres, and it would be a pity if this should be tainted by the wilder speculations that have been advanced (P.209).

The eminent British psychologist Zangwill(1976) responds as well

to this popularization:

> One recent author, Robert Ornstein (1972), has made large claims on behalf of the right hemisphere as the seat of intuition as opposed to analytical thought.He claims that Western culture, with its stress on logic and literacy, has done much to damp down a whole world of intuitive and mystical experience... Let us, therefore be wary of an updated phrenology that seeks to provide a scientific justification for some, to me at least, irrational and disturbing trends in modern thought (p. 309).

Sperry comments on this same aspect in his Nobel Prize Speech (1982):

> The left/right dichotomy in cognitive mode is an idea with which it is very easy to run wild. Qualitative shifts in mental control may involve up-down, front-back or various other organizational changes as well as left-right. Furthermore in normal states, the two hemispheres appear to work closely together as a unit rather than one being turned on while the other idles (P. 1225).

Zaidel's recent comments concerning the state of the field are a most poignant indication of the unclarity and tenuous nature of research. Commenting on Bradshaw & Nettleton's (1981) article in which they suggest that the natural dichotomy of the two hemisphere's is "analytic/holistic," Zaidel(1983 a) replies:

> ... yet it (the paper) is also misleading in giving the impression of an orderly, logically processing evolution of research on hemispheric specialization, allegedly leading to unambiguous advances and to definite conclusions. On the other hand, these authors fail to convey the methodological anarchy in the field; the conflicting data, the lack of convergence among different experimental paradigms... and generally too uncritical in reviewing experimental evidence. This is partly attributable to the plethora of publications in the field... Laterality research in normal subjects (is at) a point of diminishing scientific returns attributable to many poorly trained, uncommitted or overzealous experimenters. The result is that the field is now replete with unreliable, unreplicated findings,conflicting results and one-time dramatic,

superficial demonstrations of hemispheric specialization on this task or that (P.524).

In reflecting upon the preceding comments of these and other researchers a continuum seems to exist between two poles. At one extreme is the view held by a minority of researchers which gives the impression of data being clear,precise and with few contradictions or uncertainties. Juxtaposed is the other extreme in which the varied research is considered too tenuous to suggest any specific conclusions in the field itself,including planning programs based on this information in disciplines like education. In fact, due to the inconclusive data and continually evolving theory, some educators suggest a most cautious attitude bordering on paralysis of future work.(Straus-Garner & Garner 1977; Chall & Mirsky 1978)

In this writer's view, a middle way seems advisable-- that is, a cautious attitude toward the application of the claims of hemispheric specialization while adopting an experimental attitude and investigating its applications across disciplines. A further question also presents itself which only continued research can answer: that is,to what extent do groups of people act in a certain manner due to inherent neuronal patterns or environmental-cultural pressures or both? The difficulty is attempting to label and crystallize characteristics in normal, intact human beings who by their nature are fluid, dynamic entities. As Eisner(1981) has remarked: "A mean cannot be found when dealing with human beings".

The liklihood is great that investigative tools for brain functioning will continue to improve in sophistication and will provide us with evidence on the wide variance in human neuronal structure. Thus it is likely that this element termed "cognitive style" will become evident.

An Assessment of the Educational Literature as it Relates to Hemispheric Specialization

A review of the educational literature reveals that there appear to be two kinds of articles which educators used to inform themselves about neuropsychological research. First, there are articles that are informational in nature, aimed at informing the classroom practitioner of "interesting developments from the world of the neurosciences." This type of article could be called "reportage" and usually suggested interesting teaching techniques based on the presented research. Second, there are educational articles which utilized the neuropsychological information as a leverage in bringing broader issues to the fore. These have been summarized in tabular form (see table 6). The titles are to be noted for they themselves provide a good example of the range of topics to which the neuropsychological literature was extended. The motivation and rationale of the authors of these articles will be dealt with in the next section.

Table 6 - The Two Kinds of Educational Articles

Information Articles	Articles with Other Motivations Beyond Informational
Hildebrand(1980): Right-brained activities for the chemistry classroom	Beals(1981): The Right brain: an emerging frontier in education
Hudgens(1980): Implications of hemisphere for remedial programs	Elliot(1980): Going back to basics in mathematics won't prove who's 'right' but who's 'left' (brain duality mathematics learning).
Iannazzi(1975): Brain asymmetry	Garret(1976): Putting our whole brain to use: a fresh look at the creative process
Wheatley(1977):The right hemisphere's role in problem solving	Hunter(1978): Right-brained kids in left-brained schools
Blau & Sinatra(1981):Word learning: using the right brain	Konicek(1975):Seeking synergism for man's 2 hemisphere brain.
Fox(1979):Reading as a whole brain function	Nelson(1977):Toward a new english teacher

Rico(1983):Writing the natural way

Ogletree(1983):A curriculum for two modes of consciousness

Vitale(1983):Unicorns are real

Wolfe and Reising(1978):Politics and english teaching or (can, should, will) we teach the whole brain

Scotthorne(1981):Children need the arts

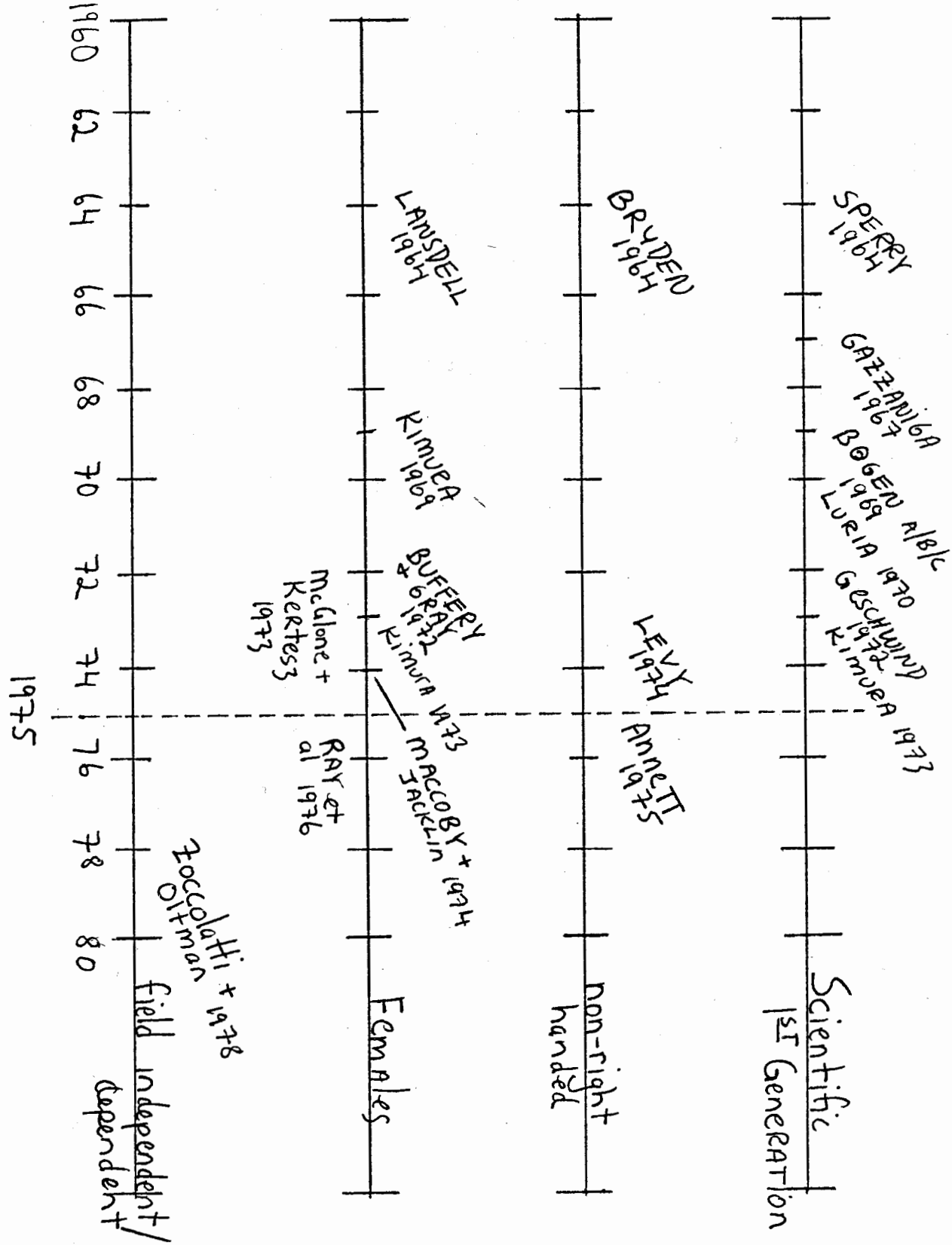
The Incomplete Education Assessment

In an attempt to translate the neuroscientific information rapidly to education, the data had to be clean and unencumbered by variables--variables which could dilute the power of the argument. In haste, the educator's assessment of the field was incomplete. There is a definite element missing in the educational literature beginning with the Samples 1975 work and the articles which followed. (As previously mentioned this is the point where educators attempted to transfer the neuroanatomical and neuropsychological data to a regular school-age population). Most of the educational authors discuss the initial right/left dichotomy from the perspective of the early sixties data onward, relying on certain foundational articles: (e.g. Sperry 1964; Gazzaniga 1967; Bogen 1969 b; Bogen and Bogen, 1969; Kimura 1973

etc.). One could describe these articles as "first generation." Yet as the normal and lesion subject literature suggested, there were other factors that clouded the clear and precise scenario of hemispheric specialization painted by first generation articles. For example, differences in cerebral functional organization exist for non-right handers (Annett 1975; Bryden 1965; Levy 1974) for females (Buffery and Gray 1972; Lansdell 1964; McGlone and Keretsz 1973; Kimura 1969; Ray et al 1976) as compared to right handers and males. In a foundational article, Kimura (1973) discusses the female/male functional differences, yet, this point was not reflected in the educational literature. As well Zoccolotti and Oltman (1978) have shown field dependence-independence (the tendency when judging a perceptual event, to be/not be prejudiced to surrounding information) to be another variable which is associated with the degree of cerebral lateralization. These three important variables of handedness, sex and field dependency were seldom mentioned by educators. Thus curricula claiming to be "brain-based" were not taking into account the many variables which influencee "typical"left/right hemispheric differences. Children were still treated as being "uniform", although their uniformity or "nature" now included dichotomous cerebra.

Most of the educational articles were written between 1977-1980. Was there a lack of specific information relating to individual differences in hemispheric specialization during this period? Figure 2 on the next page shows the flow of events. The

Figure 2: Some Factors Missing from Educational Literature



most salient features could be described as follows. First generation material as described earlier was teacher/lay-person accessible (Scientific American, New York Times, Saturday Review and teacher journals etc.). However the articles(on individual differences) approved the more " professional","scientific" journals and consequently were not secured in spite of their appearance and availability before the educators' prolific period. An educational program planned according to the incomplete concept of "typical" hemispheric dichotomy, which disregarded the variables described above, would be a disservice to children and would poorly reflect the multifaceted heterogeneous nature of the theory. The educational literature in general has been slow to popularize new,confounding items of data. It is only recently that popular articles by non-education writers, for example Restak(1979) and McGuiness (1979), specifically delineate differences between female/male cerebral functional organisms.

Levy(1983 a) has made two important points worth noting which appeared in a recent article in an educational journal, Educational Leadership . First,she dealt with the popular misconception concerning perceptual and cognitive processing, challenging the long-held notion (on the part of foundational researchers and popularizers alike) that the 3R's are the property of the left hemisphere. Levy (1983 a) has remarked:

> The realization that the whole brain is actively participating in perception, encoding of information, organization of representations, memory, arousal , planning, thinking, understanding, and all other mental

> operations whether it be a social interaction, painting a picture, playing the piano, doing mathematics, writing a story, attending a lecture, or seeing a movie, seems to have escaped many, if not most, popular writers.

In this statement,Levy has attempted to persuade educators that traditional academic subjects do require both hemispheres in the learning process. The comprehension of written material, the spoken word, as well as expressive speech and writing all require both hemispheres functioning together. This contradicts initial statements by researchers that only the left hemisphere is utilized in schools. Levy also took issue with the idea of creativity, art and music being only right hemisphere activities.

Her second point is noteworthy because she quotes recent research indicative of a hemispheric preference (hemisphericity) in specific tasks for some individuals. Citing the blood flow research of Gur and Reivich (1980),Levy noted that subjects having an asymmetric flow in favour of the right hemisphere did better on a perceptual completion task; those subjects whose blood flow favored the left, did better on a verbal test, (Miller Analogies). This suggests that indiviual differences in hemispheric activation (as indicated by blood flow) may exert significant influence on cognitive performance and task related strategies. Individual differences do exist and based on a person's preferred mode, a "gateway" can be opened apparently for more effective teaching and learning. Levy means that one hemisphere can be "stronger" or more active than another and strategies thought to be the property of that hemisphere should

be utilized first in the introduction of material to the child.

> I am suggesting only that the gateway into whole-brain learning may differ for different children, not that one hemisphere or the other should be the object of education ... "learning styles" refer to the method of introducing what we ultimately want the child to gain (Levy 1983 (a), p. 70)

This remark, indicates Levy's ultimate concordance with differences inhemispheric functioning of individuals, what Bogen et al(1972) would call "hemisphericity."

It was important that Levy and educational critiques (Chall & Mirsky, 1978; Fagan 1979; Franklin & Franklin, 1979;Hutson 1981; Morrow 1979;Straus-Garner & Garner,1977;Tipps et.al. 1982) stated these facts in order to clarify for educators their incorrect/correct notions. However there was an underlying unstated issue which prompted the educator's interest in the field in the first place. This issue had its roots in the philosophy of education and the educators in their zealousnesss substituted expediency for accuracy. Essentially they were trying to "shift the balance" from a reliance and emphasis on linear, sequential, analytical approaches to to one which utilized a wider range of approaches. As Sperry (1982) said in his Nobel Prize speech

> Regardless of remaining uncertainties concerning laterality, one beneficial outcome that appears to hold up is an enhanced awareness in education and elsewhere of the important role of non-verbal components and forms of intellect (P.1225).

The Educators' Hidden and Not So-Hidden Agendas

An initial question should be addressed at this point. With an abundance of scientific work occuring in many diverse fields which could have educational implications, why did educators seize upon hemispheric specialization? For example there was research in experimental psychology and neurobiology showing the effects of continual aberrant stimuli on the neuronal structure of the visual cortex in cats (Hirsch and Spinelli, 1970; Blakesmore and Cooper, 1970; Blasdel et al 1977;) as well as dendritic branching in young kittens (Spinelli et al 1980). Other studies as diverse as those dealing with the role of the hippocampus in memory (Milner 1971) or the neuronal columnar network of the cortex (Szentagothai, 1978) were some of the highlights in the neurosciences during this period. It should also be remembered that Sperry shared the Nobel Prize in biology with Hubel and Weisel(Hubel, 1982) for their work on the primary visual cortex of the cat. Yet none of this work was popularized or translated. One could easily speculate that the work on the early experiences of young kittens could (if applicability to humans was warranted) be useful to the early preschool/nursery years of education. However , because of its seemingly limited applicability, one could hypothesize its general limitations to the overall educational landscape. One is surprised at the little attention or understanding paid in the educational literature to the neuronal and cortical structures implicated in

memory since it is the major learning strategy used in contemporary education. It appears that the educational/curriculum planners are satisfied with their knowledge of memory through behavioristic or cognitive psychological paradigms.

There are in my opinion some basic reasons why the above mentioned research was not of interest in this case to educators while hemispheric specialization was.. First, the research on hemispheric specialization had been through its initial animal experimentation stage (Myers and Sperry, 1958). Humans were nowthe subjects and there was congruent validity between the findings on varied invasive and non-invasive measures. In other words, in the popular literature, speculation was counterbalanced by the seemingly factual nature of the observations. Second the right/left story of hemispheric specialization was readily applicable to an underlying trend in the culture and thus in education - the acknowledgment of the depth and variation of the human experience. In this way, brain research could be likened to a streetcar: we use it when we need it.

It seems evident from the introductory and/or concluding paragraphs of many educational articles that the authors were attempting to promulgate a message beyond the simple discussion of hemispheric specialization. It might be concluded that they had "an axe to grind" and that brain research was used to support and validate their arguments. Some authors felt that the

brain research would break behaviorism's grip on public school instruction. For example:

> The influence of the behaviorist school of psychology on education during the last twenty years has been substantial.... little attention is given to variations in capacities between individuals, or groups ... it does appear that some moderation of the strict behaviorist tradition may provide us with more tenable answers about the ways in which children learn. This article will address itself specifically to the seat of learning, the human brain and will cite research evidence which suggests that biological information about brain development may contribute greatly to our understanding of children's learning. (Fultz-Telzrow 1981, p.477)

Other authors claimed that behaviorism, by definition, does not have a place in the private inner life of a child. As DeMille (1967) has stated,"behaviorism tells us nothing about imagination or how to use it" (p.X). Ornstein (1972) in his book on hemispheric specialization makes a plea for a broader view of human life. Quoting Maslow he states, "if the only tool you have is a hammer you tend to treat everything as if it were a nail " (p.23). The limits of behaviorism in educational practice and its antecedents in general psychology are being questioned in light of the brain research. Coupled with a strong behaviorist tradition is the emphasis on the precision of science and Aristotelean logic which Nelson (1977) felt belittled the intuitive, imaginative and emotional (R.H.) aspects of an individual-

> we've allowed ourselves to evolve into a mentally handicapped culture and very nearly into self-destruction [by consistently using a left-brained approach] p.132

The results of this emphasis on logic and behaviors in education

is seen as "potentially criminal, because it robs learners of the opportunity to develop their human potential" (Elliot 1980, p.218), which is for some practitioners the basic goal of education. Some education writers are of the opinion that this anti-right-brain movement equals an anti-human potential sentiment having its roots in political circles, notably among right-wing elements (Elliot 1980) while others think that this emphasis on logic and precise behavioural outcomes is just a product of a Western mind.

> "...the thrust of the whole history of western culture has been toward the deification of left-brain perception and the denigration of right-brain perception, and our American society, with the ultimate scientific technology, is the culmination of that historical movement. And a society that now finds itself in deep trouble ..." (Nelson 1977, p.132)

After noting the imbalance in our thinking process and in the public school's instructional practice, different authors suggested specific remedies to equalize supposed lopsided curriculums. For example, chanting, imaging, breathing and movement (Galyean 1981), art, dance and drama (Garret, 1976; Raina, 1979) and guided fantasy (MacKinnon, 1981; Rose, 1979) were considered right hemisphere tasks that could be implemented in the regular classroom. Some authors saw hemispheric specialization research as supporting the earlier research-barren confluent and affective educational movements of the seventies (Galyean 1981, Clark 1979, Andrews 1980). As Wolfe Reising (1978) have stated,

> "As a result of current brain research it offers verification of the notion that sensitivity in teaching

to what we have traditionally called the "affective domain" is immensely important" p.30

It has been suggested that these so-called right hemisphere practices, such as chanting, breathing and "others" that have an Eastern or mystical air about them, are in some sense "getting in under the wire of right hemisphere activities". It legitimizes them, in contradistinction to a more Western recreational or utilitarian approach like Edward's (1979) book Drawing on the Right Side of the Brain which in my estimation, is most acceptable for the Western culture.

It is most relevant that the claim of the right hemisphere as the sole province of creativity was the most overstated and "stretched" concept in the educators' reporting. This may be because of the freedom an educator could have with such a statement. For example, if the right hemisphere is the"creative" one and educational practice as previously suggested by researchers is in the domain of the left hemisphere, schools by design are not supporting a child's creativity.... a most important indictment of the school system. Thus the argument could be seen as a political pivot to reinstate drama/arts (supposedly right hemisphere activities) which may have been cut in budget restraint programs or to catapult a new program into place.

In summary , it may be said that this"hidden and not so hidden agenda" was an attempt to legitimize what may loosely be called "person-centered teaching" stemming from the client-centered psychology of Rogers(1961). This model which

Joyce and Weil(1972) consider to be "entirely nurturant in character" has as its aim:

> an individual's reorganization of himself so that he will (1) be more integrated,more effective (2)have a more realistic view of himself and (3) be less defensive and more adaptive to new situations and information (P.211).

This view of the human being as seen by Rogers is diametrically opposed to the behaviorist paradigm where these educational authors appear to be rejecting. These ideas are discussed in more depth later in the chapter. (For an account of this debate the reader may avail him/herself of the classic Skinner/Rogers debate "Some issues concerning the control of human behavior" Rogers (1956)).

Possible Detrimental Effects

A vital question must be addressed in this section before proceeding. Are the results of the "slippage" that did occur between the two sets of literature benign or can some "damage" accrue to those students enrolled in classes in which the classroom teacher is utilizing such "whole-brain or right brain strategies?" A response can be made that such programs or techniques would not be detrimental to children for the following reasons. First, the cerebral locus of specialization of an attribute or process strategy is of minor importance (even if one does not exist) in comparison to the acknowledgement of the existence of such factors. For example,a student's academic

progress would not be impeded if a classroom teacher or curriculum advisor was informationally incorrect in assessing the left-hemisphere's role as responsible for gestalt or synthesis. It would in fact be advantageous for such processes themselves to be considered a variable in the thinking process. Second, the educational articles reviewed all shared a common theme - the need to blend the known attributes of both hemispheres. It was a rare article that debased the left-hemisphere's known attributes in favour of the right. All articles called for a balanced curriculum. Third, the exercises or strategies suggested by the educators basically enrich the subject matter and bring a broader experience to bear on the learner. Although some critics of such procedures would argue that time is being used to elaborate on strategies that otherwise could be taught with minimal instruction and "fuss", as suggested in Chapter 3, initial indications suggest positive outcomes with these techniques.

Conclusions

1. This paper began with the hypothesis that educators had distorted the neuropsychological data and that because of this, the match between the two sets of literature was a poor one. I have concluded that this was not the case, that educators in fact were quite faithful to the original split-brain research. They did however generally neglect the

later data elaborating upon the variabity of laterality. The minor misinterpretation that did occur was due to the overzealous nature of a few popularizers who suggested that the right hemisphere was the sole seat of creativity and the arts.

2. One of the initial questions posed was whether a restructuring of educational policy was indicated by the hemispheric specialization research? While the field of neuropsychology offers many uncertainties, specific points should not be overlooked.

   a. The educational practices that have been reinforced by the hemispheric laterality research do in fact seem to enhance learning. The fact that the research literature has become burdeoned with elaboration and variations does not lessen the value of the initial paradigm of hemispheric specialization.

   b. An increased knowledge of the various hemispheric processing characteristics can be important information for it will broaden both the philosophy of what learning is as well as the instructional experiences available to the student. While the broad outlines are of importance, the specifics of hemispheric activity,of interest to the specialist, are of secondary concern.

3. In this thesis it was pointed out that for many promulgators of the hemispheric specialization model, a motivating factor had been a prior belief in the importance of acknowledging

human values in the classroom. In effect these educators were reflecting a greater cultural shift towards this human emphasis. Hemispheric specialization in this light has clearly served as an adjunct in support for this point of view. Those who find the brain laterality model helpful, have at the same time however, incurred an obligation to continually update their familiarity with the scientific foundations they wish to exploit.

Implications of this Study

There appear to be 3 major implications:

1. Teachers should have a basic understanding of neuropsychology. College courses in learning theory and cognitive psychology usually do not cover this topic. In this view, school boards should support attempts in training a group of teachers to become "neuroeducators". Their mandate would include keeping abreast of pertinent research and to serve as a resource for the district.At another level, they could also serve as a "rumor control group" on issues of learning theory and the brain.
2. More thorough research is needed to ascertain the effects of specific learning experiences on school aged populations. I would see investigations of multi-modal teaching, the use of imagery and affective techniques as well as other techniques which a teacher believed would motivate the learning process. Specific conditions of the testing would include, reliable pre/post testing instruments, broad teacher training to give an understanding of the greater theory being presented as well as sufficient testing periods that would allow a class to overcome a possible Hawthorne or "glamour" affect. This may result in the isolation of specific teaching/learning techniques that could enhance and promote greater content mastery, leading to competent

thinking skills and ultimately heighten the creativity of the learner.

3. Above all, there is a definite indication of the variability of the human species in the range and style of learning patterns. It would seem incumbent for educators to attampt to increase their understanding and meet the needs of each individual learner. Ignoring such uniqueness will lead to the restraining and suffocating of our neuronal/human heritage.

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3. Thompson,W.I. ¬Personal communication, November 27,1982.

4. Hellige,J.B. Personal communication, June 16,1982.

5. Segalowitz,S. Personal Communication, December 16,1983.

APPENDIX (A)

Interviews Conducted by Mel Kaushansky: June 1982 - February 1983

June 1982-California

Dr.Joseph Bogen - U.S.C.

Dr.Charles Hamilton - CalTech

Dr. Joseph Hellige - U.S.C.

Dr.Paul Satz - U.C.L.A.

Dr. Roger Sperry - CalTech

Dr. Merle Wittrock - U.C.L.A.

Dr. Eran Zaidel U.C.L.A.

November 1982 - Victoria, B.C.

Dr.Lou Costa - University of Victoria

Dr. William Gaddes - University of Victoria

Dr.O Spreen -University of Victoria

November 1982 - British Columbia

Dr. William Irwin Thompson - Lindisfarne Association, Crestone, Colorado.

December 1982 -Ontario

Dr.Phil Bryden - University of Waterloo

Dr. Morris Moscovitch - University of Toronto

Dr. Sid Segalowitz - University of Waterloo

December 1982 - Quebec

Mr. L. Taylor - Montreal Neurological Institute

January 1983 - Britain

Dr. Gillian Cohen - Open University, Milton Keynes

Dr. John Marshall - Radcliffe Infirmary, Oxford

Dr. Colwyn Trevarthan - University of Edinburgh

Dr. Oliver Zangwill - King's College, Cambridge

February 1983 - British Columbia

Dr.Robert Ornstein - Langley-Porter Institute, San Fransisco

APPENDIX (B)

Linguistic abilities of the Right Hemisphere-1969-1974

Initial speculation on the R.H.'s role in language production and comprehension were important for it served as additional weight in questioning the validity of a strict interpretation of hemispheric asymmetry based on the left/verbal, right/visuospatial paradigm. In his argument Zangwill (1967) stated:

> (1) Right cerebral lesions in children give rise to aphasia much more so than in adults;
>
> (2) Articulation problems can result from right hemisphere lesions in children, pointing to the fact that the right hemisphere's role is significant in the acquisition of speech in young children;
>
> (3) As is known, when there is left hemisphere damage or a left hemispherectomy is performed, speech may develop normally.

Drawing on Eisenson's work, Zangwill noted that right cerebral lesions (in right handers) may give rise to subtle defects in linguistic abilities, specifically in abstract meaning and grammatical transformation. As well, when a left hemispherectomy is performed on right handed patients, some minimal speech (usually attributed to sub-cortical mechanisms), comprehension and affect are spared.

Bogen (1969 b) described the R.H.'s capacities for speech and language with a clinicial population. The main points included:

1. Aphasics could often utter words or sentences, use similies

and metaphorical expressions in an appropriate manner. Bogen pointed out:

> When an aphasic cannot employ abstract terms, he often uses descriptive phrases, similies and metaphorical expressions in an appropriate manner.

2. R.H. injuries produce certain defects in language or verbal ability.
3. A gross defect in understanding speech usually resulted not only from a left hemisphere lesion but also required an associated deconnection of the right temporal lobe
4. Vocalization as well as alteration of ongoing speech have been produced by stimulation of the right hemisphere.
5. The right hemisphere of the split brain patient can interpret words as well as understand spoken sentences.

Zaidel (1973) developed an ingenious device, a "Z-lens", for use with commissurotomy patients which allowed continuous visual information to be lateralized to a specific cerebral hemisphere -in contrast to the usual millisecond "flash " of the tachistiscopic approach. In the two patients on which this research was based,the right hemispheres showed evidence of eliciting meaning from pictures, of recognizing semantic association and forming concepts. The right hemisphere recognized the higher order semantics rather than paying heed to just perceptual stimuli. Zaidel also found that the R.H. could comprehend abstract words and syntactic structures, including verbs and sentence transformations. In a discussion of the expressive language capabilities of the R.H. (Levy, Nebes and

Sperry, 1971), it was suggested that the R.H. had more verbal ability than it does, but the L.H.'s grip on language is so strong it also controls the motor mechanism of speech. Coupled with this is the L.H.'s supposed superiority for language - thus the R.H. does not have the opportunity for verbal expression.

From these researchers we may see that the R.H. was now acknowledged to have speech and language capabilities which seemed to be spread across a spectrum from zero capacity to some language ability. The researchers however agreed that in comparison to the left hemisphere, these R.H. abilities were of limited significance.

1974 to the Present

A recent study by Wapner, Hamby and Gardner (1981) with R.H. damaged patients confirmed that cognitive processing problems included (i) integrating specific information, (ii) drawing inferences with regards to moral issues, (iii) assessing the appropriateness of various facts, salutations and characterizations, and (iv) and inferring about content, particularly if emotionally laden. The authors suggested that the observed patterns might not be due to a deficit in the processing of complex linguistic material, but rather to the R.H.'s weakness in assessing complex "ideational" material. As well, patients' inability to understand jokes might be linked to their overall lack of "gestalt" abilities, a so-called right-hemisphere task (Levy-Agresti and Sperry, 1968).

Weaknesses of the Right hemisphere included poor phonetic skills while its strength was whole-word gestalt patterns of recognition (Zaidel, 1977) without the intermediary grapheme to phoneme translation (Zaidel and Peters, 1981). Zaidel (1977) suggested that the left-hemisphere's specialty was analysis by feature extraction in a "precise, sequential algorithmic process" (p.270). Hecaen's (1978) findings were in concordance with Zaidel's on the nature of linguistic abilities of the hemispheres. Using his Z-lens, Zaidel's (1976) research with two split-brain and three hemispherectomy patients (one left and two right) suggested that the auditory vocabulary of the R.H. was somewhere between 8.1 and 16.3 years with a mean of 11.7 years. He noted that with patients in this series and other aphasics the right hemisphere did have intact grammatical and syntactic structures at the word/phrase level, was able to recognize diverse semantic relationships and did have a rich auditory vocabulary. Zaidel (1977) estimated that the phonetic, semantic and syntactic components of the R.H. were at about a five year age level.

This issue of the presence of R.H. language has been further reinforced and advanced by subsequent research, most notably that by Zaidel.This work ostensibly limits the basic dichotomy that verbal/non-verbal differences are the chief factors in cerebral duality. Yet in a recent critique , Gazzaniga (1983 a, b) has argued against Zaidel's position, stating that R.H. language in split-brain patients occurs

infrequently and that the two specific patients tested by Zaidel and Gazzaniga, N.G. and L.B., were not representative of split-brain patients and thus could not be generalized to the greater population. He stated that those patients who have R.H. language have it as a result of pre-operational damage to critical left-hemisphere areas of speech causing bilateral representation of language or a reorganization of these functions. They are thus considered unrepresentative of normal intact brains. Although Gazzaniga does credit the R.H. with a unique capability in processing some visual, tactile and auditory tasks, he has maintained that it lacks language capability. Gazzaniga's arguments were recently challenged in a rebuttal (Myers 1983) article claiming gross misinterpretation of the data on Gazzaniga's part. This author (Myers) maintains the position held by the California team (Sperry, Bogen and Zaidel among others), that in fact L.B. and N.G. are representative of R.H. language patients.

Although the question of R.H. speech is still being debated (it is beyond the scope of this dissertation to resolve the issue) it indicates the problems of using a specialized population (in this case the split-brain patients) as a major source of new information.

Music and Hemispheric Lateralization-1969-1974

Findings regarding the hemispheric specialization of music appreciation and awareness diminished the strict verbal/nonverbal dichotomy between the two hemispheres. Musical perception was suggested by Segalowitz (1983) to consist of several factors: (i) the ability to differentiate and remember values; (ii) time duration; (iii) pitch separation (which note is higher); (iv) loudness (v) timbre and (vi) melody contour. Based on his work and that of Milner, Kimura and Segalowitz, he suggested that all of these factors may not be lateralized to only one hemisphere.

In his review of auditory hemispheric specialization Gordon (1974) showed that although the R.H. was the dominant hemisphere for music, temporal sequencing and rhythm were more likely to show a REA-LH preference, while the right hemisphere(LEA-RH) was more involved for melodies and chords. The predominant view now emerging supported that the hemispheric specialization for music could depend on the task assigned to the subject and on the resultant strategy used.

Sodium amytal studies of singing showed that in those subjects whose R.H. was depressed, singing ability was severly impaired while their speech was only slurred. With a left hemisphere depression both singing and speaking were temporarily non-existent. This study indicated not only the major role of the R.H. in singing but the right and left hemisphere's involvement in music.

1974 to the Present

In a review of the literature, Gates and Bradshaw (1977) in support of Gordon's findings (1980) , music can be divided into two major factors, melodic and rhythmic, yielding a differential hemispheric specialization (right and left respectively). However, because in each melody or rhythmic framework the listening strategies of the individual varied , both hemispheres were alternatively involved. There was no one hemisphere consistently "specializing" in the task.

The extent to which each hemisphere contributes varying aspects of musical expression or reception continues to be a matter for investigating and review. (Brust 1980;Bradshaw and Nettleton, 1981; Damasio and Damasio, 1977;). Thus he concluded that the popular notion of expressive amusia following R.H. damage and receptive amusia following L.H. damage is an overgeneralization. As well he contested the Bever and Chiarello (1974) study which cited the L.H. preeminence for musical abilities in the experienced musician. He regarded any broad generalization about music and hemispheric specialization as an oversimplification and as premature at this stage.

Although it was clear that both hemispheres were involved in the musical process, broad generalizations as to hemispheric involvement in particular aspects of music could not be made. At this time, the mediating factors were judged to be dependant on individual differences.

Dyslexia and Laterality

The initial cause of dyslexia or word-blindness was considered to be incomplete cerebral dominance. This theory originated by Orton (1937) specifically cited the cause as an unstable hand preference and mixed dominance (i.e. a preference for one hand and the contralateral eye). In fact, Orton was the first researcher to link dyslexia with neuronal structures. Subsequent investigations have, in the last decade, used the methodology and paradigm of hemispheric asymmetry to investigate possible correlations between dyslexia and irregular lateralization patterns. Zurif and Carson (1970), for example, in one of the original studies, showed that while normal students displayed a significant REA for digits the dyslexic group showed a weak non-significant LEA. While this and other studies pointed to a correlation between the groups (Marcel et al 1974; Kershner 1977), studies reporting no difference between dyslexic and normal populations using dichotic listening and visual half-field experiments were also prevalent. (Springer and Deutsch 1981, P.162) Witelson proposed that dyslexics had bilateral representation of spatial functions which might constrict linguistic processing in the left hemisphere and cause a deterioration in verbal performance. (Witelson, 1977) In recent research Brumback and Staton(1983) have suggested that learning disabled students and those having childhood depression and attentional deficits may have a dysfunction of the right

hemisphere. Similar findings were found by Gordon (1980) who hypothesized that dyslexics may be "locked into"a right hemisphere cognitive mode of processing which may govern all cognitive activity.

In his review of the dyslexia research, Bryden(1982) proposed that the conflicting findings probably reflected subject-task variations rather then real differences in the cerebral organization of normals and dyslexics; that it might have to do with the initial strategies of information processing rather then a distinctive "hard-wired" neuronal circuitry difference. Problems accrue with the hemispheric lateralization explanation since many people show little asymmetry in dichotic or tachistiscopic research, yet have normal reading ability. The converse is also true,as some people have reading problems with normal hemispheric lateralization. Thus the researchers have suggested that reduced laterality is not a sufficient condition to explain persistent reading problems, although it may be a contributing factor. The right hemisphere though has been implicated in reading "ideographically", i.e. recognizing words as gestalts without the intermediate grapheme to phoneme translation. (Zaidel & Peters 1981). Coltheart(1981) has recently suggested that this may be responsible for the reading disability in what he has called the "deep dyslexic". In their review on laterality and dyslexia, Hiscock and Kinsbourne(1982) also questioned the strength of this relationship. Specifically they cited the poor data base that exists for both dyslexics and

normals in reading and hemispheric asymmetry. They pointed out that as dyslexia changes from being seen as a unitary disorder to a multi-faceted problem encompassing a variety of reading problems and their probable causes, the many models generated from them preclude exhaustive hypothesis testing due to the diversity of variables. The methodological problems in the behavioral techniques used to assess cerebral asymmetry (T-scope, dichotic listening) as indicated elsewhere are prone to subject-task variation. As well, even if such problems could be dealt with, the basis on which these indices demonstrate cerebral laterality is in itself not strong. Hiscock and Kinsbourne are of the opinion that the general thesis linking dyslexia to laterality is a weak one. It would be more probable that specific mechanisms responsible for dyslexia could be investigated by the new non-invasive techniques such as the Positron Emission Tomography Scan(PET) or Nuclear Magnetic Resonance(NMR). One researcher has already been investigating dyslexic children using EEG, high-speed graphics and a computer(Duffy 1981).

Emotions and the Hemispheres

In an comprehensive review of the research, Bryden and Ley (1983) concluded that from 1971 until the present, most visual and dichotic studies with normals that implicated emotionality showed a significant LVF-R.H. and LEA effect. This was also the case with brain lesioned patients (Heilman *et al*, 1975;Tucker

1981). In the Heilman study six patients who had right temporoparietal lesions scored significantly lower on the emotional content of a sentence test than did those having left temporoparietal lesions.

While there had been a suggestion in some research that each of the hemispheres was responsible for either a negative or postive emotion, the majority of the studies claimed a unilateral R.H. superiority for the task. As Bryden and Ley claimed, those studies indicating a different emotional valance in each hemisphere came primarily from the clinical literature and were concerned with expression of affect rather than with its perception.

Their own study, "The Waterloo Research on Hemispheric Specialization for Emotion" used tachistiscopic and dichotic methods to investigate hemispheric specialization for emotion. The results indicated a R.H. superiority among children and adults for the recognition of emotionally laden (i) faces (ii) music and (iii) spoken sentences . Second, priming either visually or orally through affective word lists (both positive and negative) was effective in increasing the receptivity of the right hemisphere to further incoming stimuli. Third, R.H. mechanisms for emotional recognition were active in young children and appeared not to alter with age.

The research in cognitive psychology by Paivio (1971) on dual encoding, coupled with Bryden and Ley's work, combine to form a most interesting view of learning. Verbal material could

be seen to have two aspects, the verbal and the emotional (high imagery) components (left and right hemisphere respectively). One could then postulate that emotionally-laden material would have a better possibility of being stored in long term memory because of its dual nature (content and emotion), this being in part caused by the primary effect the affective material has on the right hemisphere.

Research with psychiatric patients has suggested that arousal systems that regulate cortical activity are lateralized to both hemispheres and have a modulating effect on an individual's information processing strategies. Specific neurotransmitters in this system like norepinephrine and serotonin are suspected of having their regulatory bodies in the R.H..Consequently psychiatric patients may be affected by poor regulatory controls of these neurotransmitters. It was thus suggested that mood swings in an individual would show "alteration in the R.H.'s role and therefore in the relative balance between the hemispheres' cognitive performance" (Tucker 1981, p.39). He suggested that although the research was with psychiatric patients, mood changes in normals might have an effect, though less extreme,on the right hemisphere's contribution to information processing.

This tentative explanation could explain neurophysiologically the intermittant learning that does occur when one is moody or upset. Those in the teaching profession could recognize this dynamic as "upset kids don't learn."

The opinion that the R.H. as the dominant hemisphere for emotions may have been inferred from its supposed integrative and gestalt nature which seems to support the encoding of the multi-dimensional aspects of a set of stimuli. (Bryden and Ley, 1983, p.45) Tucker(1981) has suggested that the concept of the R.H. as the "emotional" hemisphere may lie with MacLean's theory of the Triune Brain (1978). Tucker's theory holds that the right cortex has better vascular and neuronal connections with the subcortical or limbic system (supposedly the "emotional brain") than the left cortex does. However actual data are scarce on this issue. It does appear however that research on the lateralization of emotions is quite widespread and increasing and in the opinion of some conclusive. and thorough, yielding quite conclusive results.

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