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ABSTRACT

A review of research makes it increasingly clear that findings from the areas of brain development and hemispheric specialization, student and teacher learning styles, and holistic and meaning-centered approaches to reading and writing are related, as they all contribute to a richer view of how learners learn. In brain research, the popular focus is on hemispheric specialization, but the systems regulating emotions and attentiveness cannot be neglected. Brain research is also providing indications of the different brain organization of males and females, proficient learners, and the learning disabled. Research into learning style is indicating that when teachers adapt the learning environment to accommodate learners' preferences, there is an increase in academic achievement. Correlating learning style research and hemispheric processing models has received a great deal of research attention. Inquiry into the major areas covered in this review clearly indicates that large numbers of children may have unique modes of learning that are not tapped by the conventional instructional strategies in many schools. It must be recognized that learning style is best defined as a variety of behaviors, rather than an individual trait. One figure and an 128-item list of references are included. (SLD)

National Association of Secondary School Principals

LEARNING STYLES TASK FORCE

Interrelations of Brain and Learning Style Research

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How Brain and Learning Style Research

Contribute to a Process View of Learning

We are experiencing an exciting era in education. Exciting in that we see three fresh perspectives illuminating the educational scene based on how learners really learn. Educators no longer have to blindly experiment with adult-biased methodology, deliver curriculum content through strictly verbal modes, or keep classroom learning environments in traditional row-by-row arrangements in order to achieve academic success with learners having perennial difficulty. We see today the rapidly evolving interaction of three major areas of theoretical and empirical research regarding the human learner - from tiny tot to information-consuming adult. The three areas of brain development and hemispheric specialization, of student and teacher learning styles, and of holistic meaning-centered approaches to reading and writing each singularly hold a powerful message for educators. While each is also pursued by professionals in different disciplines, the implication is becoming more and more clear that findings from one area necessarily impinge on another.

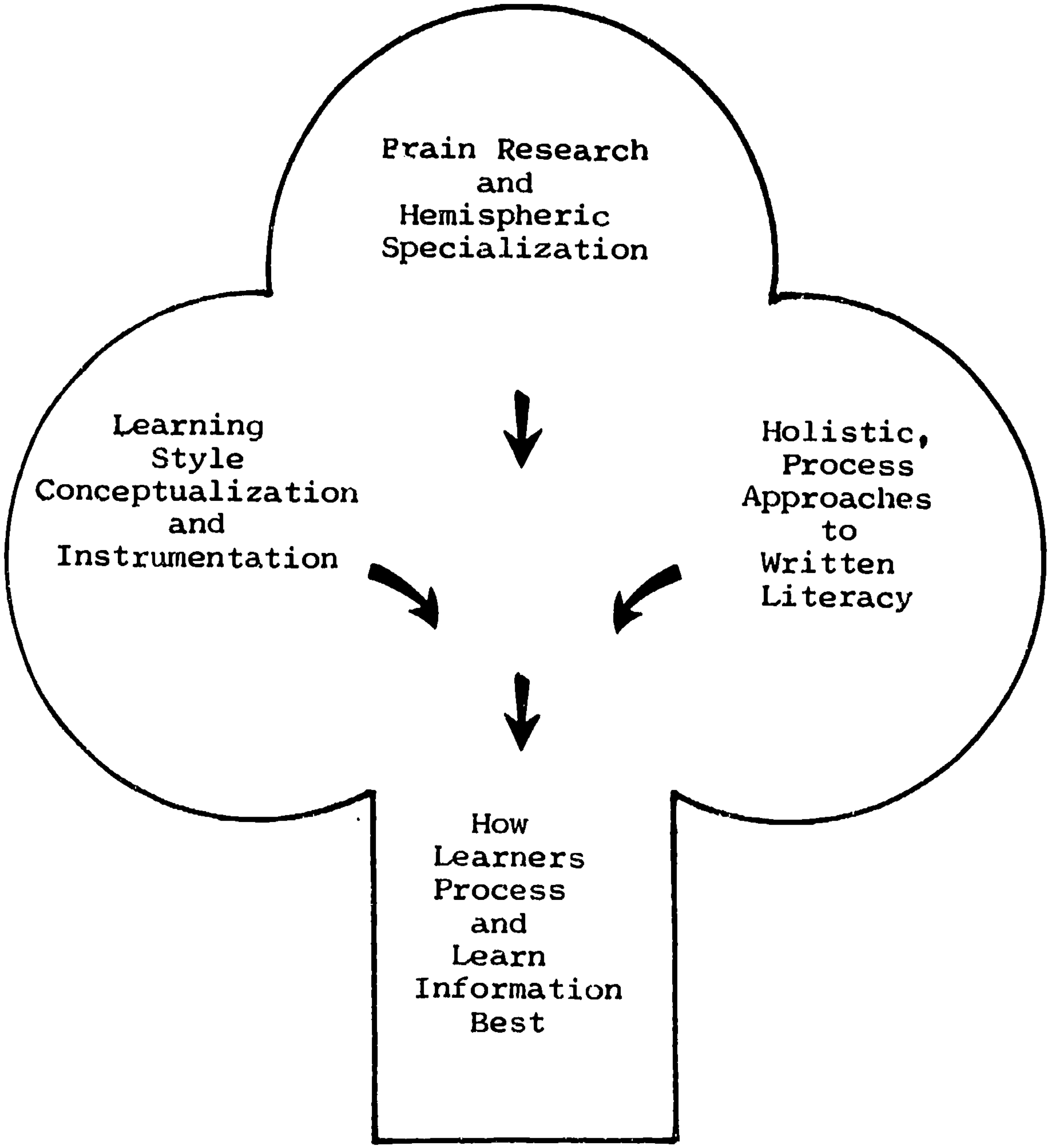
Let's see how this happens. Brain researchers are investigating how brain development and brain hemispheres contribute distinct processing styles for life development and for the learning of specific contents. They are trying to determine how and under what conditions a learner at any age level learns best. Reading and writing theorists are telling us that holistic, process approaches in the learning of written literacy are more powerful and meaningful than piecemeal,skills-oriented methods. All three are concerned with how and in what way information is processed, not in what is being processed. The latter has been the preoccupation of the schools. How the three areas contribute to a richer view of how learners learn is graphically illustrated in Figure 1.

Insert Figure 1 Here

Learning style researchers observing such behavioral dimensions as global/analytic, reflective/implulsive, or any of the abilities in the experiential style model of Kolb (1981) see similarities in learning style dimensions and behaviors associated with left and right brain processing modes. Educators pursuing holistic, meaning-centered approaches in the teaching of reading and writing, generally find that holistic notions incorporate the nonverbal sphere of information which is generally rooted in the right hemisphere of learners. In fact, in another place, I explore how many popular conceptual models of the language arts show nonverbal experience as the core or foundation of the listening, speaking, reading, and writing experiences (Sinatra, 1982). Non-verbal, sensorimotor experience is the real basic in literacy learning. Youngsters deficient in reading and writing may be so because of lack of nonverbal conceptualization, a right brain mode of functioning.

Moreover, according to many brain researchers, the so-called learning disabled may be somewhat disabled in the acquisition of print but quite able in nonverbal, visuospatial forms of learning. For instance, in three studies by Marcel, Katz and Smith (1974), Marcel and Rajan (1975), and Pirozzolo and Rayner (1979), good readers were found to be superior in left hemisphere

Figure 1. Three Major Areas of Theoretical and Empirical Research Regarding How Learners Process and Learn Information



processing for the task of word recognition but poor readers were consistently as good as or superior to the good readers in right hemisphere processing tasks. Witelson (1976 & 1977a), finding that dyslexic children have atypical hemispheric specialization for languge and abnormal right hemisphere specialization for spatial processing, hypothesized that two neural correlates operate for the learning disabled: one a deficiency in the linguistic, sequential mode of information processing and two, an intact or over-developed use of the spatial, parallel, holistic mode.

When curriculum leaders wish to initiate class, school, or district-wide curriculum or institutional changes for able or disabled learners, learning style researchers caution that it is far wiser to determine first how learners learn and in what types of institutional settings before adult notions of "what should be" are implemented.

This manuscript will examine separately the unique contributions of brain and learning style research on modes of learning, the results reported of the interaction of brain and learning style research, and then consider some ways that educators can alter curriculum and classroom climate situations (particularly for the learning of the language arts) in light of these findings.

HOW DO WE KNOW WHAT THE BRAIN DOES

Brain research attempts to take a hard look at what each hemisphere of the brain does during specific learning tasks,how the brain develops in growth spurts (Epstein, 1978), and how it is organized to handle life-regulatory, emotional, and conscious, thinking modes (McLean, 1978). This focus presents a new dimension to educators. Rather than indiscriminately subjecting students to various types of learning tasks that appear to have an inherent logic (carefully worked-out by adults), brain researchers are showing us that different cognitive, social, and aesthetic tasks demand different inputs from the brain. That some learners do not do well with specific tasks may be contingent upon levels and degrees of brain organization in handling the processing demands dictated by those tasks. If a task were delivered in another way, in another emotional or configurational manner, it might be learned. This perspective has appeared only recently in our study of how learners learn.

Split-Brain Research

The modern era of brain research investigation began shortly after the mid 1960's when Roger Sperry and his associates at the California Institute of Technology published their findings about patients who were operated on to control life-threatening epileptic seizures (see Gazzaniga, 1967 for an historical review). Scientists had known for more than one hundred years that two specific regions in the left hemisphere (mainly Broca's and Wernicke's areas) were primarily responsible for the expression and comprehension of language (Geshwind 1972a and 1979). The behavior after surgery of Sperry's epileptic patients changed the view of brain functioning forever.

Sperry, teaming with a neurosurgeon, Joseph Bogen, had known that epileptic seizures began in one brain hemisphere and traveled across the corpus callosum to the other hemisphere, resulting in uncontrolled generalized convulsions. The corpus callosum is the largest of the neural tracts that connect the left and right hemispheres of the brain, allowing the hemispheres to communicate and insuring that the perceptions arising from the differing processing modes of each hemisphere can integrate into a unified whole. When Bogen severed the corpus collosum of these epileptic patients, the epileptic seizures were confined to one hemisphere. Sperry and his research associates then began to test the individual processing capabilities of each hemisphere.

Results from a group of studies on nine commissurotomy (split-brain) patients showed that the surgically separated left hemisphere had its own mode of thinking that was distinctly different from the thinking mode of the right hemisphere (Sperry, 1973). In fact, elsewhere Sperry (1968) described the split-brain syndrome as two separate spheres of conscious awareness, each with its own sensations, perceptions, cognitive processes, and learning experiences. Post-operative testing of the nine right-handed subjects made clear that the disconnected left hemisphere processed information from the right hand and the right-half visual field. The left hemisphere essentially did all the talking, reading, writing, and mathematical calculation (Gazzaniga, Bogen and Sperry 1967). Conversely, the disconnected right hemisphere was essentially speechless, unable to write, and unable to carry out mathematical calculation beyond simple addition problems with sums under twenty. Yet, the right brain was superior and dominant for perceptual recognition of whole figures and patterns, for dealing with visuospatial relationships, for nonverbal thinking, and for making direct perceptual transformations when verbal language was not required to describe the task.

An interesting phenomenon in the post-operative behaviors of the split-brain subjects was their left hemispheres continued to dominate. Sperry attributed this behavior to the highly developed cognitive and expressive capabilities of the left hemisphere and its tendency to take control of the motor system (1973). The left hemisphere, in other words, because it could verbally express itself, gave reasons for right hemisphere behaviors, even though the reasons were not based on total reality. Gazzaniga, Ledoux, and Wilson (1977) felt that their split-brain subject's verbal system attributed causality to the behaviors produced by right hemisphere activity. In exercises requiring the right hemisphere to initiate motor acts, the left brain was forced to analyze responses of unknown origin. Yet, in trial after trial, the left hemisphere was quite adept at providing a reasonable explanation for the response.

This phenomenom of dominantleft hemispheric expressive ability may provide a rationale for how intact humans go about constructing a rationale sense of conscious reality. The verbal system may not always be aware of the origins of everyday actions, yet it attributes cause to behavior as if it knew for a certainty. One's belief or value system forms as a consequence of attributing cause to behavior. In fact, it is probably a very common tendency for the left brain to rationalize and/or take credit for right-brain perceptions of the world. Since most learning style instrumentation asks people to note perceptions about their own preferences in behavior, we must acknowledge the influence of verbal, rational (left brain) processing in how people describe their behavior. In other words, learning style as measured may be influenced by the learner's own ability to think through and verbally express a view of personal behavior.

Furthermore, females appear to be better at rationalizing nonverbal, right-brain modes of behavior than males. Kimura (1969) has shown that when a task can be accomplished by activation of either hemisphere, males tend to favor the right hemisphere more than the females. Garai and Scheinfeld (1968) have noted that females generally have more developed language skills early in life and tend to use left hemisphere verbal mediation to explain behavior to a greater extent than males. Even for tasks which are nonverbal and spatial in nature, verbal processes play a more significant mediational role for females (McGlone and Kertesz, 1973).

Thus far, in the discussion of the two distinct modes of brain processing, the focus has been on split-brain findings. What about the majority of persons whose corpus callosum is intact? How do neuroscientists and clinical researchers go about discovering which hemisphere dominates in normals during specific tasks or moods?

Both Zaidel (1979) and more recently Restak (1982) have cautioned us about the danger of overgeneralizing the split-brain model to normal functioning humans with intact brains. Zaidel writes (p. 65):

> The theoretical importance of the split-brain model of hemispheric specialization lies in its unique combination of neurological circumstances, not in its approximation of normal function. It provides an idealized or limited case study of positive language competence in each disconnected hemisphere in the relative absence of extra-callosal damage.

Restak (1982) adds that commissurotomy has been done with relatively few people, all of whom have suffered unusual, chronic brain disease of disabling seizure disorders. He therefore urges that (p. 93):

> ... it is risky to leap from pathological cases to speculation about how the two hemispheres operate in presumably "normal" people. Cooperation rather than competition between the hemispheres seems to be situation prevailing under most conditions. Both hemispheres, relying on different modes of information processing, operate in tandem to construct a continuous model of reality. Contradictions are resolved via inter-hemispheric connections - principally but not exclusively the corpus callosum.

Procedures to Diagnose Brain Functioning with Intact Corpus Callosum

For subjects having the corpus callosum intact, researchers use six major procedures and approaches to determine which hemisphere processes information during specific tasks:

1. Examining the damaged or diseased brain, either a complete hemisphere or sections of a particular hemisphere. This could result in hemispherectomy meaning a complete removal of either hemisphere which deprives the remaining intact hemisphere of both commissural or brain stem communication with the one removed or in lobotomy which amounts to removal of either frontal, temporal,occipital, or parietal lobes of either hemisphere.

2. Studying brain waves, particularly alpha rhythms from surface electrodes placed on the left and right sides of the scalp. The two major techniques here are the EEG (Electroencephalogram) and the ERP (Event Related Potential) which is a more exact procedure than the EEG. EEG waves are considered background "noise" in the ERP methodology since it is necessary to extract the ERPs from ongoing EEGs by a computer-averaging technique. While the ERP can be quite useful because it is specifically time-locked to a discrete event such as the reading of isolated words flashed by a tachistoscope, Galin (1979) believes that the EEG procedure allows for measurement of the actual engagement of the two hemispheres during a wide variety of naturalistic cognitive tasks such as normal silent reading and composition writing. Furthermore, the EEG provides a more direct and sensitive means of investigating brain laterality than measures based only on hand, eye, or ear dominance as in dichotic listening or tachistoscopic split-field testing.

3. Studying the sex hormones -- the male endrogens and female estrogens and progesternones produced by the sex glands. Scientists now believe that sex hormones are responsible for the physical differences in male and female brains (Weintraub, 1981). They feel that development of the brain parallels that of the genitals. The testosterone that produces the penis of the male fetus masculinizes tissue in the hypothalamus (a brain organ within the emotional brain system) and other nearby cells deep within the brain. Conversely, estrogen passing from the ovaries of the female, feminizes brain tissue in areas of the cortex.

4. Measuring the changes and intensity of blood flow to various areas of the cortex activated by subjects' performance on specific sensory, motor, and mental tasks. In their laboratories in Sweden, Lassen, Ingvar, and Skinoj (1978) measured the blood flow in the normal brains of 80 patients. The cerebral blood flow of these 80 patients compared to over 400 patients with diseased brains allowed the three investigators to draw some conclusions about the localization of functions in the normal cerebral cortex. Because the volume of blood flow in any particular area of the cortex was propositional to the activity of nerve cells in that area, the functions of the cortex were able to be localized by the injection of a radioactive isotope into a brain artery while the regional flow of blood in that area was measured, processed by a computer, and displayed on a color-television screen.

5. Determining which hemisphere is dominant for speech by administering the Wada Test. Ninety five percent of right-handers and 70 percent of left-handers have their speech center in the left hemisphere, and the nonverbal memories of the right hemisphere are not available to the verbal awareness of the left hemisphere after temporary paralysis (Milner, 1975; Rassmussen and Milner, 1977).

6. Activating the sensory/motor system contralateral to the brain hemisphere being studied. Many experimental psychologists use the noninvasive techniques of dichotic listening, visual half-field tachistoscopic testing, eye movements, and dichotomous tactual stimulation for letters and shapes to determine which hemisphere processes information best following a particular type of stimulation.

Zaidel (1979) points out a number of limitations of the indirect and nonsurgical procedures. A shortcoming of the Wada test is that it indicates the limits of hemispheric competence to perform a certain function rather than the actual contribution of that hemisphere to normal performance. Furthermore, the noninvasive psychological procedures such as the dichotic listening and split-visual field studies for testing lateral asymmetries in normal subjects have very poor validity and reliability. Citing Satz (1977), who demonstrated the possible errors of interpretation in inferring specialization from perceptual asymmetries, Zaidel concludes that inferences from left visual half-field superiority or left ear advantage are very likely to be incorrect. Earlier, Satz (1976) had reviewed 19 studies dealing with either the dichotic verbal procedure or with visual half-field verbal tasks and found a host of inconsistencies and controversies. Galin (1979) adds that tachistoscopic tests correlate poorly with dichotic tests because the one involves reading and the other, listening. They represent different brain systems and different tasks.

Brain Specialization and The Learning Climate

Notwithstanding some of the methodological problems in brain lateralization procedures, one emergent conclusion seems clear - that the left hemisphere is the general specialist for language and sequential processing and the right hemisphere excels at visual/spatial/holistic processing. Indeed, according to Levy (1977), separate processing modes is what nature had in mind for the human race. The evolution of cerebral lateralization meant the evolution of two separate genetic blueprints for the neural organizations of logical, analytic processing on the one hand and analogical, holistic processing on the other. Nebes (1974) believes that the advantage of a right hemisphere closure-type perceptual ability is that it allows persons to form a concept of the structure and organization of the environment without subjecting the entire sensory input to a detailed analysis. To gather a more thorough understanding of all the brain lateralization techniques and the findings of each, to see how the brain and eye have organized themselves to perceive in rapid gestalts, and to discover how nonverbal, visuospatial strategies can form the very basis of language arts activities, the reader may refer to a recent book, Using the Right Brain in the Language Arts (Sinatra and Stahl-Gemake, 1983).

However, a major caution needs to be raised. The left hemisphere does not accomplish all language arts processing and the right hemisphere does not do all the picture viewing, puzzle construction, etc. as many would have us believe. The processing demands of the task dictate which hemisphere will tend to dominate. If the processing demands of the task are time-oriented or sequential in nature, the left hemisphere will usually dominate; if information needs to be processed holistically and simulatenously, the right hemisphere will undoubtedly prevail. But a person's "mind set" or preference for solving particular life problems can override hemispheric organization. This preference might well be one's learning style.

Looking for preference through learning style assessment may be an even more powerful way to determine how a learner really learns rather than concentrating on what the brain can or cannot do during specific tasks. Regarding split-brain subjects, Levy and Trevarthan (1976) found that these subjects did not consistently use the hemisphere that was better specialized to perform a task. They suggest that a bias to act develops according to one's established values, expectations, and contentions. They maintain it is dispositional or attitudinal lateralization and not aptitudinal lateralization that determines cerebral dominance for a task. Zaidel (1979) adds that the Levy and Trevarthan data show that unilateral superiority need not signal hemispheric specialization. At the 1981 Learning Styles Network Conference on Student Learning Styles and Brain Behavior, Jerre Levy told educators to observe directly the behaviors of youngsters to ascertain how they think rather than worry about what the brain of each youngster can or cannot do (1981). Hence, in learning style assessment, the youngster may be saying that he or she prefers a left-oriented verbal or a right-oriented nonverbal approach to the learning of specific contents.

Apart from a strong preference to solve a problem in any particular way, the key distinction between the hemispheric modes is the extent to which a linear concept of time informs the ordering of thought. The more a curriculum focuses on the auditory-motor modes of the speech system, the more it will tend to activate the left hemisphere. Beginning reading if the emphasis is on a phonetic decoding process, beginning writing if the emphasis is on correct linear spelling and organization, and beginning arithmetic with step-by-step calculation are examples of strong left-hemispheric oriented activities.

At more global, meaningful levels, however, both hemispheres cooperate in language learning. EEG studies in reading with young children from 6 to 8 years of age (Kraft et al., 1980) and in writing with college undergraduates (Glassner, 1980) show that learners use the right hemisphere during recall and composing processes. Using the EEG technology during two modes of writing - one focusing on the writer's ability to convey a message to another and the second focusing on the writer's ability to express his/her thoughts about a personal experience - Glassner found that while writing presents itself as a product in a linear form, its processes incorporate nonlinear, nonverbal modes of thought. Zaidel (1979) adds that while the right hemisphere has been characterized as synthetic, gestalt, visuospatial, and nonverbal, the labels are merely descriptive and often erroneously applied. The spatial ability to do embedded figures lies in the left hemisphere, and receptive vocabulary, auditory comprehension and reading require the cooperation of both hemispheres. Blood flow mapping in each of the hemispheres has shown that reading aloud activates seven discrete cortical regions on the surface of each hemisphere and silent reading activates four areas (Lassen et al., 1978). When teachers couple holistic, nonverbal, visuospatial strategies with reading and writing experiences, synthesis and integration of processing modes will occur.

The popular focus today is on hemispheric specialization. This focus emphasizes the third brain layer - the cerebral cortex - the layer of the brain quite unique to humans since it influences higher consciousness. However, MacLean (1978), Frostig and Maslow (1979), and Restak (1979) exhort us not to forget the impact of our first and second brains - the reticular formation and the limbic system which govern our alerting and emotional systems respectively. Since the neural pathways between the cortex and the reticular and limbic systems function continuously without our conscious awareness, the development of curriculum content cannot be approached solely by intellectual reasoning. The systems regulating feelings, emotions, and attentiveness are tied to the learning of information. Thus, the classroom learning climate should be built upon a meaningful need to know in which eagerness to know forms the emotional basis of the classroom experience.

Brain research is providing us clear indication of the differing brain organization of two very large groups of learners: males and females, proficient learners and the learning disabled.

LEARNING STYLE RESEARCH

We will treat learning style from a dual perspective - conceptualization and implementation. As a concept. learning style has extensive merit. Style seeks to determine how a learner processes information. Strengths determined in this assessment (the how) help the learner learn any curriculum content - the what. For example, if a learning style assessment of a group of learners shows that some prefer to learn cognitive skills in a certain way, that others like to gather information in different ways or that some like the educational environment arranged in a certain way, educators can present the content - the what of the curriculum - in that frame of reference. Thus rather than be concerned about adult-notions of what reading approach is best for youngsters, what perceptual modalities youngsters should use in learning to read, or how the room environment should be arranged for reading, learning style practitioners can inventory the youngsters directly to determine their learning style preferences and present reading instruction to complement those preferences.

In recognizing style, educators acknowledge the concept of individualization. Keefe (1979) noted that learning style rekindles the real meaning of individualization in education since it starts by considering the learner and then proceeds logically to an investigation of the teaching and learning environments. Keefe adds that learning style diagnosis provides "the most powerful leverage yet available to educators to analyze, motivate, and assist students in school. As such, it is the foundation of a truly modern approach to education" (p. 132).

The Many Tailorings of Style

Style as implementation does suffer from some shortcomings. While style presents a fresh perspective, many theorists and practitioners have presented us with models and testing instruments that do not address all the parameters of style but focus instead on one dimension, slanting the approach the classroom teacher would pursue with learners. Furthermore some of the model conceptualizations are not clearly defined and the testing instruments, based on a hazy premise, are weakened by poor validity, sampling, and reliability procedures. Thus, while the concept is laudable and the enquiry exciting, the educational consumer of style needs to spend some time in review of the many models and instruments that are beginning to flood the educational market place.

Kirby (1979) noted that the term "learning style" has emerged rather recently on the American educational scene (the early 1970's) and serves as an umbrella term for the concept of style. Prior to the 70's, the major focus was on the cognitive view of style, prompting a great deal of research into the singular dimension of cognitive, mental set. The most renowned view of cognitive style assessment, the field dependent and field independent construct of Witkin and his associates, probably has been the most extensively studied and has had the widest application in the field of education (see review by Witkin, Moore, Goodenough, and Cox, 1977). Kirby (1979) describes 18 more cognitive style models, almost all of which were operational prior to consideration of the more expansive views of learning style begun in the early 1970's. Claxton and Ralston (1978) discuss 11 models of cognitive style and analyze in-depth three models relevant at the college level. Messick (1976) presents some 20 dimensions of cognitive style in his review.

What makes the focus of learning style more expansive than the singular dimension of cognitive style? Kirby (1979) feels that cognitive style constructs generally focus on one element of style with two polar extremes; i.e., one is either more field dependent or field independent. Cognitive style constructs are generally expressed in "either-or" extremes while learning style models are composed of a number of elements which are not necessarily bi-polar in nature. The learner may or may not have one or another element of style, and the absence of one element does not necessarily mean that other elements will take its place. In learning style assessment there are varying strengths and weaknesses. Thus, if a practitioner assesses learners' perceptual modality preferences, he would find that some youngsters will show a marked preference for visual learning, a moderate preference for auditory learning, and a negative preference for tactual learning. In Kolb's four-stage experiential learning model (1981), one can be more adept at bringing one set of learning abilities, such as active experimentation, to bear on a learning task but the learner will have some degrees of proficiency in the three other elements of concrete experience, reflective observation, and abstract conceptualizaton.

Secondly, learning style enthusiasts tend to regard cognitive style as just one dimension of the overall learning process. They look beyond cognitive concerns in attempting to meet students' individual physical and social needs of a more practical nature (Kirby, 1979). According to Dunn, Dunn, and Price (1979, p. 53) "learning style is the way in which responses are made because of individual psychological differences." Keefe, research director of The National Association of Secondary School Principals (NASSP), also views learning style in its larger context, as "characteristic, cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (1979, p. 4). Keefe, reviewing some 32 cognitive, affective, and physiological styles, feels that cognitive styles are information-processing habits, affective styles (motivational processes), and physiological styles (biologically-based response modes).

We have to be impressed with the comprehensive efforts of such learning style researchers as Charles Letteri, Ken and Rita Dunn, and David Kolb. Letteri felt that the examination of one single dimension of cognitive style with its bi-polar means of articulation does not provide educators with a realistic picture of how learners use their total cognitive powers in intellectual tasks. In contrast, Letteri is concerned with examining each individual's cognitive profile by studying the inter-relationship of seven dimensions of cognitive functioning and plotting each dimension in given tasks (Letteri, 1976). The seven cognitive style dimensions are category width (based on Pettigrew, 1958), cognitive complexity-simplicity (based on Bieri, 1961 and Bieri et al., 1966), focusing-nonfocusing (Holzman, 1966), leveling-sharpening (Holzman, 1954), tolerance for incongruity (Klein et al., 1962), reflectivity-impulsivity (Kagan, 1965), and field-dependence/field independence (Witkin et al., 1962 and 1971). The Cognitive Profile of Letteri can predict rather accurate levels of school success. Research over a five-year period with more than one thousand subjects, shows profiles which correlate with high academic performance and those that relate to low academic performance. The Cognitive Profiles that emerge reflect three separate types of cognitive behavior and predict three related levels of academic achievement (Letteri and Kuntz, 1980). It is possible to determine if a particular cognitive profile is the appropriate one for an individual to be successful in a specific learning task. Indeed, educators can analyze specific learning tasks and determine beforehand the appropriate cognitive profiles to achieve success in those tasks. Learners who do not have some of the thinking strategies needed to achieve success in a specific task can receive training to improve their inappropriate cognitive profiles. Letteri calls this training "augmentation" and transfer.

Kolb (1981) was impressed with college students who subsequently failed in their career choices because the disciplines they chose to study were incongruent with their personal styles. As a freshman advisor at a leading university, Kolb frequently encountered learners pursuing disciplines which they did not have the cognitive set to enjoy and understand. He undertook the task of inquiring further into the nature of learning styles and how specific university disciplines demand specific cognitive functioning. Kolb's four stage experiential model enables a college student to know his/her process of cognition, the type(s) of learning style most preferred, and the academic disciplines or careers most concomitant with the student's thinking processes and style.

Kenneth and Rita Dunn's conceptual framework grew out of their direct observations of youngsters in varieties of learning tasks. The Dunns noted that some youngsters when faced with a problem, did not go to the teacher but preferred to work with a peer. Some preferred not to sit in their chairs during problem solving while others liked to nibble on food while they independently worked a problem to its conclusion. Because their model is observational, they have tended to expand their elements of style based on what learners have demonstrated about their learning preferences. In 1972, the Dunns' model was composed of 12 elements of style; in 1975, they expanded to 18 elements, (Dunn & Dunn, 1975), and by 1979 with Gary Price they were experimenting with the three additional elements of analytic/global, impulsive/reflective, and hemispheric dominance (Dunn, Dunn, & Price, 1979).

Limitations in the Assessment of Style

Even the most sophisticated learning style instrumentation generally elicits voluntary information through paper and pencil procedures. Because this information is thought out, weighed, and rationalized by the learner, the left hemisphere is a heavy contributor to the response mode. Even Joseph Hill, who systematically worked out a cognitive mapping procedure based on three sets of 64 elements, noted that his reporting procedure may be incomplete. As a more thorough back-up procedure, Hill recommended gathering corroborative data through teachers' observations of individuals in different instructional settings (Radike, 1973). This notion of using results from observed behavior will be explored more fully in the section of this paper dealing with the influence of indirect studies as indicators of style.

Research on style has clearly shown one trend. When teachers adapt the learning environment to accommodate learners' preferences, there is a subsequent increase in school achievement in various disciplines (Douglas 1979; Trautman 1979; Dunn, Carbo, and Burton, 1981) and in school attendance behavior (Lynch, 1981). Furthermore, by plotting a cognitive profile of youngsters (Letteri and Kuntz, 1980), academic behavior can be predicted and provision made for skills' analysis, learning prescription, augmentation, and transfer.

Since most learning style assessment uses paper and pencil instrumentation in a school or clinical setting, it is a bit easier to assess for style than it is for brain lateralization. Furthermore the verbal left brain can explain and rationalize the nonverbal behavior of the right brain. It is important therefore <u>not</u> to overgeneralize between hemispheric modes and learning styles. Brain researchers gain entry to brain functioning by examining, measuring, and recording the workings of the brain directly or assessing what the brain does when information is channeled to a particular hemisphere. When we test youngsters for learning style with paper and pencil instruments, we generally use the verbal modes of reading and writing. How much more guarded must we be in associating learning style results with hemispheric processing?

Nevertheless, the interaction of brain research and learning/cognitive style assessment has begun. In the next section of this paper, we will examine the scope of this dual enquiry and note other ways, apart from a direct brain or learning style research, that learning styles of diverse groups have been ascertained.

CORRELATING STYLE WITH HEMISPHERIC PROCESSING MODES

In this section we can look at those research investigations which show that differing populations of subjects have unique styles and that these styles may affect the way that various information is learned. This enquiry, in turn, can be examined from two perspectives: 1) those studies which have attempted to correlate directly a construct of style with a brain lateralization procedures; and 2) those studies which have shown indirectly that differing populations may indeed have behavior and learning modes that differ from the mainstream and that these differences may reflect unique learning characteristics and circumstances. Although the latter groups of studies may not have used a particular learning or cognitive style instrument or a particular brain lateralization technique, the findings do suggest that particular learning and thinking strategies are employed by some learners who are often considered "failures" by mainstream standards. Lesser (1976), for example, clearly asserts that people who share a common cultural background also share in varying degrees, common patterns of intellectual abilities, thinking styles, and interests. He cites studies that show strong correlations between learners' cultural group background and the type of intellectural strengths and weaknesses they display, and that these regularities of behavior seem to persist as students advance educationally. Perrone and Pulvino (1977) point out that different cultures do educate their youth in different ways, some focusing on one hemispheric processing style more than the other. These researchers concluded that it is highly important to discover the representational systems and consequent learning preferences of diverse individuals to design appropriate educational offerings. Ramirez and Castaneda (1974) found that the processing style of Mexican American children was field-sensitive as compared to a field-independent mode for dominant culture children. They believe that this conflict in style of information processing poses a major dilemma for Mexican American children in mainstream schools. Cureton (1978) maintains that there exists a Black, inner-city learning style in which motivation is the key factor that separates inner-city from the middle-class child.

Direct Focus on Intersecting Style with a Brain Lateralization Technique

By correlating certain elements of style with known findings from brain research techniques, learning style researchers hope to obtain greater evidence that particular constructs or elements of style involve the activation of one brain hemisphere more than the other. Generally, Witkin's model of field-dependence/field-independence is the one dimension of cognitive style most researched while the EEG and the lateral eye movement procedures are the brain research techniques most utilized. A connective link between cognitive style research and lateral eye movements would tend to bolster both constructs, since they both attempt to account for individual differences in preferential modes of cognitive-perceptual functioning and both suggest neuro-physiological involvement (Goodenough & Witken, 1977). While Hoffman and Kagan (1977) suggest that future studies should link other measures of brain lateralization (such as dichotic listening and split-field tachistoscopic tasks) with both eye-movement behavior and cognitive ability, existing investigations looking at the cross-section of both fields have produced rather ambiguous results (Otteson, 1980). As noted earlier, this ambiguity undoubtedly results from problems with brain research methodology, testing procedures and subject selection, and the methodological constraints of each cognitive style construct. No studies reported to date have compared the results of a more comprehensive learning style instrument such as Hill's Cognitive Mapping Procedure (1971) or Dunn, Dunn, and Price's Learning Style Inventory (1978) with a brain lateralization technique.

The EEG and Cognitive Style During Task Processing

A few investigators have sought to determine if cortical activity as measured by the electroencephalogram (EEG) would show changes in alpha rhythm when thinking style was being measured. Most researchers base their work on Galin (1979) who is a strong advocate of the EEG technique as a natural way of measuring hemispheric engagement of normal and disabled subjects during every-day learning tasks. Both Metcalf (1975) and Doktor and Bloom (1979) note that the EEG technique has been used successfully to determine which hemisphere is more involved during verbal-analytic or spatial-intuitive tasks. However, the technique requires meticulous attention to electrode placement.

In a pioneer study, Galin and Ornstein (1972) studied the EEG assymetry of 10 normal subjects recorded at the left and right temporal and parietal areas of the scalp during two verbal and two spatial tasks. They found characteristic EEG patterns of activity and nonactivity during the differential task processing. The verbal tasks were writing and mentally composing a letter; the spatial tasks included a block design much like the Block Design subtest of the Wechsler Scales and one requiring the subject to decide which of five figures was represented by a number of sectioned parts.

Doktor and Bloom (1977) pursued earlier EEG and eye movement findings with high ranking personnel in the management field to determine if there were cognitive style differences between occupational groups. Using the verbal-analytic and spatial-intuitive tasks proposed by Galin and Ornstein (1974), they made EEG recordings on eight high-ranking executives, either Presidents or Chief Operating Officers of large corporations, and six Operations Researchers. The operational assumptions were that Operations Researchers were analytically trained individuals who would construct mathematical models to help solve complex problems while the executives would be more intuitive and "right brained" in problem solving styles.

The results supported the predicted hemispheric dominance of the Operations Researchers. This group showed a consistent alpha ratio shift on the EEG tracings for verbal-analytic and spatial-intuitive tasks while the executive sample showed an opposite mental shift. Although only half of the Executives showed a right-brained style of problem solving for both type tasks, the authors concluded that selective lateralization of cognitive style might fruitfully be related to occupational group.

O'Connor and Shaw (1978) used the EEG to investigate the relationship among psychological differentiation as proposed by Witkin, laterality as determined by left or right sidedness, and EEG coherence defined as the organization of synchronized neuronal activity over an area of the cortex. Specifically, they used the Rod-and-Frame Test to explore the connection between the field-dependent/field independent dimension of cognitive style with 12 left and 12 right-handed subjects during EEG recordings. The findings confirmed expectations. Strong right sidedness and weak left sidedness tended to be associated with field independence while weak right sidedness and strong left sidedness were associated with field-dependence.

Metcalf (1975) also focused on the field articulation construct and hypothesized that use of a certain cognitive style correlates with the brain hemisphere activated to solve a task. Using the field-dependent/independent dimension for the organization of perceptual experiences, Metcalf proposed the following:

1. that there are lateralized cerebral EEG responses that occur during the performance of selected cognitive tasks;
2. that these lateralized EEG responses would be influenced or would interact with the individual's cognitive style;
3. that there are individual differences in cerebral lateral responses during cognitive activity; and
4. that individual differences would relate to cognitive style, age, and sex.

In a very ambitious project involving 22 batteries administered to normal functioning adults and adolescents, Metcalf measured brain wave activity occurring during tasks of cognition and laterality. Each subtest was administered simultaneously during EEG recording while attempting to hold to a minimum the production of excessive eye movements, muscle activity, or other distractors that might interfere with the EEG analysis. Some of the subjects found it impossible to eliminate movement but Metcalf continued to refine the EEG methodology. The cognitive style battery included ten subtests, three of which had been successfully used in previous research on cognitive style: The Schematizing Test of Leveling - Sharpening (Gardner et al., 1959), the Rod-and-Frame Test (Oltman, 1968) and the Embedded Figures Test (Witkin et al., 1971). The laterality battery contained twelve subtests designed to elicit either left or right cerebral activation.

Contrary to the findings of Galin and Ornstein (1972), Metcalf found that his normal subjects did not show consistent use of one hemisphere or the other for any task. Metcalf suggested that this variation may have resulted from the way he analyzed his data (in four second intervals as compared to Galin and Ornstein who analyzed in larger units with a more global averaging of data). He did find that arithmetic tasks almost always resulted in left hemisphere activation, and that the most powerful stimulator of right hemisphere activity was a "mental trip" task. During this task the subject was asked to take a journey with eyes closed and to visualize that journey. The test findings of one 13 year-old girl who had apparently overcome a learning disorder which he termed a "mild dyslexia" were uniquely different. She failed to show a shift of hemispheric dominance in relation to task and even the more normal shift of dominance activity during task performance. This variation in EEG performance for a youngster with a learning disorder may hold some key for diagnosis in the future although the EEG coherence tracings show a strong tendency to field dependence and left-sidedness for both dyslexic and minimal brain damage subjects (O'Connor and Shaw, 1978).

Eye Movement and Style: Most of the investigations comparing differential hemispheric functioning and parameters of style have focused on the lateral eye movement procedure. Of all the brain lateralization techniques noted earlier, the eye movement procedure demands little in terms of special equipment and training. Although eye movements can be measured by a monitor and recorded by oscillograph, most researchers in clinical settings use an observational technique -- observing the first eye movement shift a subject makes in solving either a visual/spatial or verbal/sequential problem. An example of a verbal-sequential problem is, "Susie is taller than Mary and Mary is taller than Jane. Who is the tallest? An example of a problem that requires parallel, visual processing is, "In which direction does George Washington face on the quarter?" The direction of eye shift during questioning is contralateral to the brain hemisphere involved in the solution of the problem.

Research generally indicates that the direction of leftward or rightward eye movements is a function of both problem or question type (Kinsbourne, 1972) and of individual differences in cognitive style (Bakan, 1969). Gur (1975) and Gur, Gur, & Harris (1975) have shown, however, that when an examiner faces the subject during question delivery, individual differences in cognitive style preferences seem to prevail over question type. Hence, subjects tend to shift their eye movements according to their preferred way of solving mental problems. In the face-to-face situation, subjects can be classified as either "right movers," who habitually activate the left hemisphere, or "left movers," who prefer to use the right hemisphere. The face-to-face tecnhique is thought to be more anxiety producing for the subject, predisposing him/her to activate the hemisphere habitually used rather than the one best suited for the processing demands of a given task. This motion is entirely consistent with the metacontrol system concept discussed earlier. A bias to behave in a certain way under anxiety is conditioned by one's attitude or predisposition to act rather than by the type of problem.

Since most subjects move their eyes fairly consistently to either the left or the right in the examiner-facing-subject situation, Hoffman and Kagan (1977) support the view that these subjects are using their preferred cognitive mode in so doing. In fact, they propose that hemispheric dominance, as measured by the lateral eye-movement procedure, is primarily a matter of individual differences in preference, style, and personality.

All that is required in the examiner-facing-subject condition is a trained examiner and an equal number of verbal/sequential and visual/spatial questions. It is easy to see why this procedure has been the most widely used in the clinical setting. The most widely used instruments to measure style have been the Embedded Figures Test and the Rod-and-Frame Test which assess the field-dependence/field-independence construct (Witkin). A number of similarities have been noted between the field-indpendent (analytic) individual and the right mover, and between the field-dependent (global) person and the left-mover (Hoffman & Kagan, 1977). Using the face-to-face questioning technique, and the Embedded Figures Test with 48 female, right-handed, undergraduate subjects, DeWitt and Averill (1976) found that left moving was positively related to field dependence.

Some studies have used the Breadth of Category dimension by Pettigrew (1958) to assess narrow and broad categorizing. Richardson (1977) showed in a series of studies with high school and college students, how a verbalizer-visualizer dimension successfully correlated with eye movement behavior. Richardson concluded that his 15 item Verbalizer-Visualizer Questionnaire provides a stable index of an individual's cognitive style and can be used with reasonable confidence in the study of the sequential and parallel processing of cognitive events.

Huang and Byrne (1978) also studied the relationship of broad and narrow categorizing to lateral eye movement. They wanted to determine if narrow and broad categorizers could be classified as right-and-left-movers respectively and hence likely to make characteristic use of the left and right hemisphere. Huang and Byrne screened 150 undergraduate college students and found 27 females, 16 of whom were narrow categorizers and 11 of whom were broad categorize The narrow categorizers turned out to be rather consistent right-movers. However, the broad categorizers were less straight forward; about 50% of their eye movements tended to shift in either direction. The results suggested that narrow categorizers make more characteristic use of the left hemisphere because they are more analytic in their style of information processing.

Two teams of researchers (Hoffman & Kagan, 1977; Otteson, 1980) have pursued the style-hemispheric relationship using more than one instrument to assess style. Otteson (1980) in particular, pointed out the limitations of studies that explored the stylistic correlates of eye movements relying on single measures such as the Embedded-Figures Test and one consideration of style - the field articulation construct. Otteson systematically explored the relationship between lateral eye movements and several stylistic and personality dimensions.

On the basis of Day's (1967) work about anxiety and the differential way it is displayed by left and right movers, Otteson hypothesized that left-movers would behave in ways more field dependent, less dogmatic, broader in categorizing, more anxious, more introverted and with a more internal locus of control than right movers. He measured the personality and cognitive styles of 136 undergraduates, on such measures as the portable Rod-and-Frame Test, the Category Width Scale (Pettigrew, 1958), and the Locus-of-Control Scale (Rotter, 1966).

Of the 13 factors which emerged for men and women, only two were unpredicted; the remaining ones were generally interpretable, coherent, and consistent across the sexes. The most notable sex differences occurred on the factor of field articulation, with women showing greater field dependence on tests of Picture Completion, Block Design, and Spatial Orientation Memory. Women who made rightward eye movements also showed greater dogmatism than left-movers. Sex differences were found in the Category Width Scale with males showing broader categorization than females. In agreement with Day's claims, factor scores on the dogmatism and externality dimensions showed right-movers to be externally focused and dogmatic while left-movers were more internally oriented and non-dogmatic.

Otteson concluded that such factorial clarity supports the view that cognitive style is far from based on a singular dimension of functioning, but is rather, a heterogeneous clustering of relatively independent dimensions. This would add support to Letteri's view of a multi-dimensional cognitive profile. However, Otteson does show that it is possible to broaden the scope of assessment to include affective and physiological styles with those of the cognitive domain.

Otteson (1980) based his assessment of the field articulation domain on the previous work of Hoffman and Kagan (1977). The latter had tested 41 male and 39 female right-handed undergraduates to determine the relationship between between field-dependence/field-independence and eye movements using the Portable Rod-and-Frame Test, the Embedded Figures Test, and the Block Design, Object Assembly and Picture Completion scales of the Wechsler Adult Intelligence Sacle (WAIS). A composite score called the Analytic Index was constructed from the five individual test scores to obtain a simple measure of field-dependence/field-independence. Male and female subjects were classified into three groups based on their eye movement responses to 60 questions - right movers, left movers, and inconsistent movers. Contrary to predictions for both men and women, right movers did not show more analytic behavior than left movers on the composite Analytic Index. For male subjects, however, both consistent right and left movers performed significantly better in analytic ability than inconsistent movers.

Two critical reviewers (Ehrlichman and Weinberger, 1978) have suggested that the evidence linking lateral eye movements and hemispheric asymmetry is equivocal. The designated left-and-right hemisphere questions registered results favorable to the model in only half of the studies reviewed. These reviewers conclude that further research on the relationship between the direction and extend of eye movements and cognitive-affective processes is necessary before reliable inferences about hemispheric function can be drawn from studies of lateral eye movements.

Findings and Implications from Group Studies

The literature yields a few studies which seem to show that various groups of learners have distinct learning style characteristics. For example, on the basis of performance during verbal and nonverbal/visuospatial tasks (those clinically believed to depend on the processing of one hemisphere more than the other), various learning disabled groups have been shown to favor a right-hemisphere mode.

Zelnicker and Jeffrey (1976) related the reflective-impulsive construct of cognitive style to brain processing modes. Modifying the procedure of the Matching Familiar Figures Test (MFFT), Kagan, 1965), they developed a secondary set of visual problems demanding global analysis of contour differences rather than the detailed analysis of internal features required in the MFFT. Kagan had termed youngsters who were slow but accurate in matching drawings "reflective" while those who were fast but inaccurate were "impulsive."

When Zelnicker and Jeffrey (1976) administered their own visual problems to a previously determined group of impulsive and reflective middle-class children at the third, fourth and fifth-grade levels, they found that the errors of the reflectives increased and the errors of the impulsives decreased. This is a result opposite to that of the detailed stimulus analysis on the MFFT. The reflective children were more accurate than the impulsive children on problems involving matching figures by their details, but no differences were found between the two groups on comparable global problems.

Wittrock (1978) suggests that an important educational implication of Zelnicker and Jeffrey's findings is that impulsive children need not be inferior to reflective children in problem-solving ability when global strategies are used appropriate to the solution of the problem. These findings also imply that learning can be difficult when a mismatch exists between students with global cognitive sytles and curriculum and instructional tasks that emphasize analytic scrutiny. Coleman and Zenhausern (1979) add that the Zelnicker and Jeffrey results are consistent with the belief that implusives process in the holistic style of right-brain preferents while reflectives process in the sequential, left-brain style.

Cohen, Berent, and Silverman (1973) used the rod-and-frame test in a unique way with 36 adult women being treated for depression. The theoretical construct of the investigation was particularly interesting. Earlier, Berent and Silverman had expected extreme field-dependent college women (as measured by the rod-and-frame test) would show inferior performance on a visual forms task. Since the rod-and-frame test measured nonverbal, visuospatial functioning, the women who exhibited extreme field dependence would have a right hemispheric deficit. Their results showed, however, that the extreme field-dependent group was significantly inferior on a word task but <u>not</u> on the visual forms task. An apparent contradiction was posed.

Later Cohen, Berent and Silverman (1973) administered the rod-and-frame test before and after a single electroconvulsive shock (ECT) was delivered to either the right or left hemisphere of 24 of the depressed women patients. (The shock was judged to produce a grand mal eipleptic seizure in each patient.) The remaining 12 patients were administered pre and post rod-and-frame sequences but received no intervening electro-convulsive shock. As in the earlier study, the authors sought a relation between lateralized cerebral dysfunction and field-dependent performance on the rod-and-frame test. If left hemispheric dysfunctioning was implicated in extreme field-dependence, shock to the left hemisphere should result in increased rod-and-frame error scores.

Investigation showed that the women who received shock to the left hemisphere increased their error scores on the second administration of the rod-and-frame test, in essence becoming more field-sensitive.

Conversely, those who received right hemisphere shock increased their error scores and became more field-independent. The findings indicate that although the rod-and-frame test is a perceptual, spatial task, the the key to successful performance appears to be the meaningful sorting-out of elements in the field. The sorting-out seems to be mediated by the analytic processing of the left hemisphere. Zaidel (1979) verified this finding by noting that the ability to do embedded figures was specialized in the left hemisphere.

In a number of studies, Rosalie Cohen (1969) examined the conceptual styles of middle-class and educationally disadvantaged, low-income group youngsters. She showed how conceptual style is, in part, conditioned by the environment. Style, in turn, becomes a rule-set or mind-set for the selection and organization of sense data. She identified two mutually incompatible styles of reality organization, termed analytical and relational, and examined how the relational learner suffers in the analytically oriented learning environment of the school.

The analytic cognitive style was characterized by a formal or analytic mode of abstracting information from a stimulus or situation, by a stimulus-centered orientation to reality, and by a parts-specific search for meaning. The majority of middle-class children use the analytic style, possibly because an analytical approach reflects the view of reality which is modeled by their family structure. The primary structure of the middle-class family is typically formally organized with role assignments that are fairly stable and with a regular behavioral pattern. Father goes to work, mother cooks and takes care of the young.

The nonanalytic cognitive style, more commonly known in the literature as self-centered, was called "relational" by Cohen. The relational cognitive style is characterized by a descriptive mode of abstraction, is self-centered in its orientation to reality and focuses attention on the global characteristics of a stimulus. The global features hold more meaning to the relational thinker, and includes features viewed in some total context.

Cohen found the greatest number of relational thinkiers among poor urban children in whose primary family constellation, roles frequently change and group organization is informal. One of the children may shop or care for the young, the mother may go off to work, and roles change at different times of the day. Since the self is the focal point to which other aspects of reality are related, the child may attend to the global characteristics of the role rather than to a detailed analysis of who "should" do it.

Cohen studied shared-function and formally organized families and friendship groups, relational and analytic conceptual styles, and their relationship to school achievement. She wished to determine the extent to which a given mode of reality organization - either analytic or relational - would relate to adaptations of two well-known tests of cognitive style, Sigel's Conceptional Style Test and Witkin's Embedded Figures Test, to tests of language meaning and organization and to measures of attitude about one's self and one's environment. Dominant patterns of conceptual organization were compared to dominant styles of family and friendship group participation and to eighteen subtests of school achievement.

Cohen was able to identify four clear behavioral, social types with two polar response patterns - polar analytical and polar relational - at the extremes. Pupils with polar response behavior were able to synthesize the expectations for either the alternative kind of group participation or the alternate kind of stimulus analysis.

The dichotomy between the highly relational and the highly analytic styles can best be seen in the schools. Indeed, Cohen believes that the explicit intent of school tests, curricula, and methods is to teach the analytic rule-set. Intelligence and achievement are measured by the school, in part, by how well pupils have learned how to analyze. What is less obvious is that the same analytic rule-set is also embedded in formal school organization and in the social settings where teaching and learning take place. For analytic children, the school's formal organization acts as an additional reinforcer of analytic thinking. For relational youngsters, however, the school's impact on conceptual development is disorganizing and contrary to their shared-function orientation to roles and responsibilities. The school's requirements for social participation and even its climate lack the cues necessary for relational types since the cues are generally delivered in a parts-specific way. Since tests of intelligence and achievement measure analytical skills, children with a relational cognitive style may score below norm or fail on school tests.

What Cohen describes as analytical style parallels quite closely the processing mode of the left hemisphere and the relational style, that of the right hemisphere. This would appear to be an especially fruitful area of resarch.

Cohen concludes that the issues raised in her research reflect basic concerns of science. If cognitive style dimensions mediate between social-system and individual-response characteristics, they can act as important key to the social and psychological research of the future.

Verbal/Nonverbal Indicators of Style Differences: Anther highly fruitful area of inquiry is the processing style of the learning disabled. The term learning disabled may be a misnomer in our culture. Disabled learners very often are neither deficient in use of the oral language nor in the whole realm of nonverbal processing. In fact, they may be more able in visuospatial creation than their linguistically able peers (Sinatra 1980: Sinatra and Stahl-Gemake, 1983).

Traditionally, learning disabled youngsters have been categorized based on a written language deficit model. This model acknowledges that reading and writing are the prized academic pursuits of our culture. Those of average intelligence without evidence of mental retardation, physical abnormality, or emotional difficulty who do not achieve grade level standards must be, in fact, disabled. Geschwind highlights the plight of learning disabled youngsters in our culture (1972b):

> We happen to live in a society in which the child who has trouble learning to read is in difficulty. Yet, we have all seen some dyslexic children who draw much better than controls; i.e., who have either superior visual-perception or visual-motor skills. My suspicions would be that in an illiterate society such a child would be in little difficulty and might do better because of his superior visual-perception

talents, while many of us who function well here might do poorly in a society in which a quite different array of talents was needed to be successful...As the demands of society change, will we acquire a new group of "minimally brain-damaged?"

Vellutino's (1977) exhaustive review of the literature indicated that dyslexics are deficient in both the storage and retrieval of printed and spoken symbols. He found that poor readers neither code (label) nor synthesize (chunk) information for effective storage and retrieval as well as average readers. Zaidel (1979) felt that there was enough accumulating evidence to suggest hemispheric factors in dyslexia. He presented findings to show that deficits in grapheme phoneme integration correspond to left-hemisphere dysfunctioning and deficits in the perception of letters and words as visual configurations represent either a right hemisphere or bilateral dificit.

Vellutino and his colleagues (1975a; 1975b) did find that while significant differences existed between dyslexics and normals on verbal tasks, they did not exist on nonverbal processing tasks. Witelson's investigations of the perceptual modalities of hearing, vision, and touch indicated that spatial functions are found in both hemispheres of dyslexic children in contrast with normal children's spatial specialization in the right hemisphere. Witelson proposed that the dyslexic population, mainly male, shows a deficiency in the phonetic, sequential, and analytical mode of information processing because of an over-developed use of the spatial, holistic mode (1977b). In this regard, Bannatyne (1971) had suggested that many learning disabled males have a visuospatial organized brain with an "executive control" center in the spatially oriented right hemisphere that dominates the whole brain including language functioning. Fadley and Hosler (1979) hypothesized that dyslexic children may look at a word in the same way they look at a picture with eye movements designed to catch the most important aspect of the word to translate it wholly into imagery as quickly as possible. Imagery is a specialty of right hemispheric functioning.

A rather remarkable study showing the right-brained processing proclivities of linguistically deficient students was conducted by Symmes and Rapoport (1972). Fifty four disabled readers, only one of whom was a girl, were considered a group of "unexpected reading failures" since they showed good verbal skills (as reported by their parents). The group had a mean Wechsler (WISC) intelligence score of 110 and performed at a superior level on six tests of spatial visualization. The group's poorest WISC scores were in Digit Span, Coding, and Arithmetic, all tasks of linear sequencing, the processing mode of the left hemisphere. On the other hand, its highest verbal scores were in more "global" functions; i.e., where meaningful discourse is involved in tasks of abstract use of language and in verbal comprehension. As suspected, their average Performance IQ was even higher than the verbal at 116.

There is also some evidence that learning disabled males tend to be field-dependent or "field sensitive" (Keough and Donlon, 1972; Guyer and Friedman, 1975; O'Connor and Shaw, 1978; Ramirez and Castaneda, 1974).

Guyer and Friedman (1975), in particular, explored the relationships between the field articulation style proposed by Witkin and his associates and differential hemispheric processing in normal and learning disabled males. These researchers employed a number of tests chosen for their association with particular brain hemispheric specializations. Right hemisphere-related tasks were visual sequential memory for nonsense forms, visual recognition, and visual closure (the latter the ability to perceive a Gestalt upon presentation of random bits of a picture). Left hemisphere-related tests were a Portable Rod-and-Frame Test devised by Nickel (1971), an auditory sequential memory tests, a verbal recognition test, and a verbal closure test.

The investigators found on the Portable Rod-and-Frame Test that 63% of the learning disabled boys were field sensitive as compared to the 37% of the normal functioning boys. Another interesting finding was that the Visual Closure results were positively related to reading vocabulary and mathematics calculation for the learning disabled group but not for the normal boys. If the Visual Closure test is truly a task measuring right hemispheric processing, the results suggest that learning disabled boys tend to use the right hemisphere, or a nonverbal processing mode, in trying to solve academic tasks.

Many researchers have used various pairings of WISC-R and WAIS profiles of learning disabled and academically proficient students to form hypotheses about their cognitive styles (Galvin, 1981). Levy (1974) indicated that as early as 1955 and 1964 Reitan and Arrigone, and De Renzi respectively, used the verbal and performance scales of the Wechsler Adult Intelligence Scales (WAIS) to measure what was considered left and right hemisphere functions. Learning disabled youngsters have been assessed as equal or superior to normal functioning youngsters in visuospatial tasks (primarily the Performance Scales) but decidely inferior in tasks requiring linear sequencing (Rugel, 1974; Vance and Singer, 1979).

CONCLUDING NOTES

Fagan (1979) maintains that effective teachers have traditionally used holistic methods such as word games, creative writing assignments, and graphic representations, long before the current focus on brain hemispheric specialization confirmed the efficacy of such methods for many students. Inquiry in the major areas covered by this paper is clearly telling us that large numbers of youngsters may indeed have unique modes of learning that are not tapped by the conventional instructional strategies used in many schools.

A summative section will be offered to provide focus for the findings and implications cited in this paper. An attempt will be made to synthesize findings from studies across a variety of fields.

These concluding notes reflect no special hierarchical order but each entry surely resonates on subsequent notes:

1. Differing brain organization exists for verbal and nonverbal modes of learning. Sperry (1973) notes that the differential strengths of left and right hemispheric processing modes allow for a spectrum of individual variations in human intellect -- from the mechanical or artistic geniuses who exhibit difficulty

expressing themselves in verbal modes to the highly articulate who must think almost entirely in verbal terms.

2. Verbal and nonverbal literacies have distinctive features inherent in their very modes of communication and these distinctive features are processed differently by the two brain hemispheres (Sinatra, in press). Inherent in the communication forms of nonverbal modes (visual, artistic, media, and aesthetic literacies) are distinctive features different from those that exist for the verbal literacies. The processing style of the individual in verbal or nonverbal tasks depends to a large extent on the processing demands dictated by the task (Bogen, 1977). It is erroneous to think that everything nonverbal, in pictorial form, or in visual/spatial arrays such as the Group Embedded Figures Test will be processed by the right hemisphere (Cohen, Berent, and Silverman, 1973 and Zaidel, 1979). The ability to perform such tasks rests on the ability to analytically dismember the parts from the whole, a task specialized for left hemisphere processing.

3. Cooperation rather than competition between the two brain hemispheres is the prevailing mode in most learning (Restak, 1982). If 99 out of 100 people initially activate the right hemisphere when presented with a nonverbal task, the hundredth person may take a verbal orientation to the solution. Although possibly a bit more slowly he or she would arrive at the same conclusion but through a different processing style. Hellige (1980) suggests that it is more accurate at the present time in discussion of such global functions as "language processing", "verbal processing", and "visuospatial processing" to think of partial rather than absolute hemispheric specializations. Indeed the dual processing

modes of the hemispheres are beneficial to the full range of human thinking (Sperry, 1973; Nebes, 1974; and Levy, 1977). (Continue on p. 44-A)

4. Educators need to continue the study of the operations of the brain during all stages and levels of learning. Study should occur in natural learning contexts with meaningful content (cf. Glassner, 1980; and Kraft et al., 1980). Galin (1979) and Zaidel (1979) have pointed out the limitations of the noninvasive brain techniques that are easier to perform in clinical settings with bits and pieces of learning. Moreover, while Ehrlichman and Weinberger (1978) agree that recording eye movements after questioning appears to be an attractive way to measure hemispheric functions, direct empirical support for the hypothesis of contralateral activation is quite weak. Educators need applied research to determine whether what is noted in the laboratory can increase learning productivity in the classroom. Studies are needed to examine the variable facilitation of learning that may occur when analytic or holistic strategies are intentionally presented to students learning school subjects (Wittrock, 1978).
5. Educators need to alter the reinforcement procedures of those learners who have not achieved with conventional learning techniques, programs, or room arrangements. We know the value of altering instruction when a point is unclear (Fagan, 1979). We have long cherished the value of repetition in learning. "If at once you don't succeed, try, try again," is a practice we encourage as soon as tiny tots begin to rise up on wavering legs. But learning style and brain researchers are urging us to present the repetition in another way. Witness the procedures in most federal Title, state compensatory, and handicapped programs. Youngsters are diagnosed and found to be deficient in one or more of three skills -- reading, writing or arithmetic. We then pull them

Another model of information processing which can account for the occurrence of a differing processing style than that believed to be inherent in task processing is proposed by Das, Kirby, and Jarman (1975, 1979). These authors propose that the modes of information processing generally associated with left-brain (sequential) and right brain (parallel) are available to the learner at all times. They base their simultaneous and successive information processing model on the work of the Russian neuroscientist Alexander Luria who proposed a hierarchical but interrelated system among three functional units of brain (1966). An input in the form of a stimulus may be presented to any one of the receptors in a parallel (simultaneous) or a serial (successive) fashion. At a higher processing level, a central processing unit (identified with specific brain areas in Luria's work) may process discrete information into simultaneous groups or into a time-ordered, successive series, and can make decisions and plan behavior based on the information integrated during both modes of processing. Irrespective of how the information was processed during input, both simultaneous and successive processes can be involved in all forms of responding.

According to Das, Kirby, and Jarman, the employment of either or both processing modes is dependent on two conditions: "(a) the individual's habitual mode of processing information as determined by socio-cultural and genetic factors, and (b) the demands of the task" (1975, p. 91). Later in their book (1979), the authors speculate that the third unit of brain which plans and wills behavior and has the ability to implement a plan of action is as much concerned with verbal efficiency as simultaneous and successive coding. Testing, then, such as intelligence testing, which does not tap this third functional unit (the frontal lobes comprising one third of the brain area) will not measure the full intellucatual potential of the brain.

Finally, one aspect of the simultaneous/successive model may further illuminate learning style constructs concerned with the sensory modality channels of learning. The activation of either or both parallel and serial processes id dependent neither on the forms of the stimuli nor the modality chaneling.

from their classrooms for corrective work, but deliver the remedial instruction in the same way or under the same rationale as when they failed. If the youngster has a weakness in decoding skills which may be a reason for a limited sight vocabulary, he or she gets more decoding skills and sight vocabularly. Brain and learning style researchers look at the processing strengths of the learner and build the sight vocabulary another way. The studies by Cohen (1969), Guyer and Friedman (1975), Symmes and Rapoport (1972), and Witelson (1976, 1977) clearly show that particular groups of learners, particularly learning disabled males, have distinct learning characteristics that appear to favor a right-brain processing style. Thus, we need to use analogic, metaphoric, and imagistic strategies to encourage verbal literacy in the learning disabled (Sinatra and Stahl-Gemake, 1983). At minimum, we must train right-brain preferent learners in the specific type of thinking needed for success in sequential, analytical tasks (advocated by Letteri in augmentation and transfer training).

6. Educators need to acknowledge the powerful influence of the subcortical systems on cognition by making learning, particularly literacy learning, more meaningful and enjoyable. Since the neural pathways between the cortex and reticular and limbic systems function all the time (without our conscious awareness), subtleties of feelings, attitudes, and concerns pervade the learning climate. Teachers' attitudes toward the disciplines and toward learners themselves may have more impact than the content itself on how well something is learned.

Teachers must learn to adopt instructional procedures aligned to the learner's affective state. Then motivation will act as the compelling force to learn the particular content.

Moreover, Zaidel (1979) indicates that there now appears to be enough evidence to implicate hemispheric factors and sub-cortical integration as the causes of specific developmental language disability.

7. Educators need to realize that learning style assessment, particularly at the upper grade levels, puts us directly "in touch" with the preferred processing mode of the learner, allowing us to capitalize on motivational and emotional mobilizers. When learners say that they prefer to do something in a certain way, they are, in part, telling us how they are motivationally organized to learn. Research such as Cohen's (1969) will be important to replicate with learning style. Her research verified what Lesser (1976) and Perrone and Pulvino (1977) hypothesized about cultural groups. Inner-city, relational learners have a different "mind set" that they bring to academic and intellectual tasks. Hill (1971), Schmeck, Ribich, and Ramanaiah (1977) and Kolb (1981) demonstrate that many learners are more adept at some information processing strategies than others.

8. Be wary of jumping to conclusions in the learning style assessment of young children. Research has been quite consistent in showing that learning disabled youngsters respond differently than normals on cognitive tasks (see review by Kaufman, 1978). Learning disabled youngsters, on the basis of categorizations of intellectual profiles, are equal or superior to normal functioning youngsters in visuospatial tasks but decidedly inferior to normals in tasks requiring linear sequencing (Rugel, 1974; Vance and Singer, 1979). Cordoni et al. (1981) verified that the most marked deficiency in young LD adults was the sequential factor. The type of research reported earlier by Hoffman and Kagan (1977) and Otteson (1980) in which they attempted to correlate a number of

dimensions of cognitive style with specific Wechsler Intelligence Scale tasks needs to be expanded to include recent learning style instruments and brain asymmetry techniques.

9. Note that the style is far more comprehensive than one model or testing procedure and is best defined as a variety of behaviors rather than one individual trait. Even the most comprehensive efforts to measure style will fall short of the mark. All of the elements or factors of style from the various models and assessment procedures suggest the following six areas that broadly define the parameters of style:

   a. genetic, neural factors related to brain organization;
   b. cognitive, intellectual factors;
   c. sensory modality factors related to a marked preference for visual, auditory, tactile, or kinesthetic channels for gaining information;
   d. affective, emotional, motivational factors;
   e. cultural and environmental factors related to child rearing, ethnic, and socioeconomic factors;
   f. educational climate factors including provision for the setting(s) in which the learner prefers to learn.

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