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Chapter II

Theoretical Constructs on Brain Based Education; Hemispheric Preferences in Neurological Teaching and Neurological Learning Styles

This chapter deals with the theoretical constructs on Brain based learning and Neurological teaching and learning styles and on human hemisphere specialization of mental functioning.

2.1 Brain Based Education

According to popular theories, the brain it is divided into two halves: the Right Brain and the Left Brain. Each is responsible for different aspects of mental functioning of a person. Clinical and empirical evidences support the notion that the lateralization of the hemispheres lead to specialized functions of mental labour. That is one’s thinking as well as learning process depends upon the hemispheric dominance of the brain. Mental activities represent varying thinking style approaches to perceiving and assimilating data (Sperry, 1982).

Ornstein (1976), had published clinical evidences on differential thought processes based on hemispheric dominance. The educational significance of this neurological distinction of mental labour is that a person may develop competency in using any hemispheric dominant style, but the naturally preferred styles will be automatic and is the most comfortable stage. Although the predominant hemisphere changes slowly, brain dominance is a flexible and changeable asset.

Each one of the individual possesses right/left brain preferences which influences one’s own neurological styles. According to Connell (2004), individuals with right-brain preferences tend to embrace Howard Gardner’s theory of Multiple
Intelligences. People differ in the strengths of linguistic, logical, spatial, kinesthetic, rhythmic, inter-personal, intra-personal, naturalistic, existential and spiritual intelligences. It would be better served, if disciplines could be presented in a number of ways based on their neurological preference styles.

Brain based education insights into what neuroscience says about teaching and learning and the brain, and educational techniques that are actually keyed to help the brain learn and remember (Wilson, 1997).

The left brain right brain theory states that people can be categorized according to which side of the brain they use most, left or right. People who use both sides of the brain equally are classified as sombreros. Every person has a preference towards one of these ways of thinking. Left brained thinkers are characterized as rational, active, realistic, and directed. It is also proposed that they are inclined to prefer mathematics, classical music, dogs, non-fiction, and details (Pearsons, 2001).

Right-brained thinkers are characterized as metaphoric, receptive, impulsive, free, and intuitive. They are more inclined to prefer arts, rock music, sports, cats, fiction and the acceptance of concepts (Hansen, 2006).

By understanding the process at work in the brain, teachers can better help their students to explore the individual preferences.

2.2 Human Brain

The adult human brain weighs about 1300-1400 gms. Humans have large brain relative to body weight. It consists of 78% water, 10% fat and 8% protein. It is a soft structure and from the outside, the brain’s most distinguishing features are its convolutions. These convolutions effect in maximizing the surface area of cerebral
cortex. The human brain has the largest area of uncommitted cortex of any species on earth (Howard, 1994), that is why, the supremacy of humans extraordinary flexibility for learning.

![Human Brain Diagram](image)

**Figure 2.1**

**Human Brain**

Scientists divide the key functional areas of brain, into four different lobes, as occipital lobe, frontal lobe, parietal lobe, temporal lobe as illustrated in the Figure 2.2. The occipital lobe is the middle back of the brain and is primarily responsible for vision. The area around the forehead is the frontal lobe involved with purposeful acts like judgement, creativity, problem solving and planning. The parietal lobe is on the top back area. Its duties include processing of higher sensory and language functions. The temporal lobes are above and around the ears. This area is primarily responsible for hearing, memory, meaning and language. There is some overlap in the functions of the lobes.
The territory in the middle of the brain includes the hippocampus, thalamus, hypothalamus and amygdala. This mid brain area/limbic system represent 20% of the brain by volume, and is responsible for emotions, sleep, attention, body regulation, hormones, sexuality, smell and production of most of the brain’s chemicals (Paul, 1990).

The sensory cortex and motor cortex are narrow bands across the top middle of the brain. In the back lower area of the brain is the cerebellum which is primarily responsible for balance, posture, motor movement and some areas of cognition. Recent experiments strongly support the conclusion that essential long term memory traced for motor learning, are located in the cerebellum.

Cerebrum makes 75% of the total volume of brain, has not yet identified for single purpose and is often referred to as the ‘association cortex’. Grey neurons or cell bodies form the cerebral cortex and other nuclei.

2.2.1 The Cerebrum

Cerebrum, the largest part of the brain situated in the anterior and middle cranial fossae of the skull occupying the whole concavity of the vault of the skull. The general morphology of the cerebral hemispheres is illustrated in the Figure 2.2.
The longitudinal fissure separating the two hemispheres is largely occupied by a field of dura matter, the falx cerebri. The convolutions are called as gyri, the fissures between them as sulci, and many of the both are named in the Figure 2.3. The frontal lobe lies anterior to the central or Rolandic sulcus, the temporal lobe, below the lateral sulcus. (fissure of sylvius) in the depth of which is the insula. The parietal lobe lies behind the central sulcus, but the division between it and the posterior part of the temporal lobe is not well defined, the transition between both these lobes and the occipital lobe is also some what arbitrary, not being defined by any single sulcus. The frontal parietal gyrus of the parietal lobe with somatic sensation, the middle part of the superior temporal gyrus with learning, and the striate cortex of the occipital pole with vision. The prefrontal cortex plays a part in controlling intellect and personality, the orbital cortex (and especially its angulate gyrus) in visual and emotional activity, and the medial temporal cortex (especially hippocampal gyrus and related structures) in controlling the sense of smell and memory. In man, specialized functions relating to the production and perception of speech and to various executive and cognitive skills (praxis and gnosis) reside in one
cerebral hemisphere; this is called the dominant hemisphere. Deep in the cerebral cortex are many myelinated fibre tracts forming the central white matter of the hemispheres and joining the various cortical area ending tracts connecting with the central grey matter of the basal ganglia and other nuclei and with the brainstem and spinal cord, yet others cross to the opposite hemispheres in various midline commissures, of which the corpus callosum is the most important. The principal grey nuclei in the depths of each hemisphere are the thalamus and hypothalamus, the caudate and lenticular nuclei which together form the corpus striatum, the globus pallidus, and the putamen. The internal capsule is an important collection of myelinated fibre tracts, connecting the central white matter above with the cerebral peduncle below.

2.2.2. Sub Divisions of the Cerebrum

Cerebrum may be divided into two parts.

(i) The diencephalon, which form the central core &

(ii) The telencephalon : which forms the cerebral hemispheres.

Diencephalon

The diencephalon consists of the third ventricle and the structures that form its boundaries. It extends posteriorly to the point where the third ventricle become continuous with the cerebral aqueduct and anteriorly as far as the interventricular foramina. The diencephalons is thus a middle structure with symmetrical right and left halves. The diencephalons consists of four major parts.

(i) thalamus

(ii) Sub thalamus
(iii) Epithalamus

(iv) Hypothalamus

2.2.3 Cerebral Hemispheres

The cerebral hemispheres are the largest part of the brain and are separated by a deep midline sagittal fissure, the longitudinal cerebral fissure. The fissure contains the sickle-shaped fold of dura matter, the falx cerebri, and the anterior cerebral arteries. In the depths of the fissure, the great commissure, the corpus callosum, connects the hemispheres across the midline. A second horizontal fold of dura mater separates the cerebral hemispheres from the cerebellum and is called the tentorium cerebelli.

To increase the surface area of the cerebral cortex maximally, the surface of each cerebral hemisphere is thrown into folds or gyri, which are separated from each other by sulci or fissures. For ease of description, it is customary to divide each hemisphere into lobes. Which are named according to the cranial bones under which they lie. The central and parieto-occipital sulci and the lateral and calcarine sulci are boundaries used for the division of the cerebral hemisphere into frontal, parietal temporal and occipital lobes. The major gyri and sulci have been shown in Figure 2.3.
2.2.4 Main Sulci

The central sulcus is of great importance because the gyrus that lies anterior to it contains the motor cells that initiate the movements of the opposite side of the body, posterior to it lies the general sensory cortex that receives sensory information from the opposite side of the body. The central sulcus indents the superior medial border of the hemisphere about 0.4 inch (1cm) behind the midpoint. It runs downward and forward across the lateral aspect of the hemisphere, and its lower end is separated from the posterior ramus of the lateral sulcus by a narrow bridge of cortex. The central sulcus is the only sulcus of any length on this surface of the hemisphere that indents the superomedial border and lies between two parallel gyri.

The lateral sulcus is a deep cleft found mainly on the inferior and lateral surfaces of the cerebral hemisphere. It consists of anterior horizontal ramus and the anterior ascending ramus, and continues as the posterior ramous. An area of cortex called the insula lies at the bottom of the deep lateral sulcus.
The Parieto–occipital sulcus begin on the superior medial margin of the hemisphere about 2 inches (5 cm) anterior to the occipital pole. It passes downward and anteriorly on the medial surface to meet the calcarine sulcus.

The calcarine sulcus is found on the medial surface of the hemisphere. It commences under the posterior end of the corpus callosum and arches upward and backward to reach the occipital pole, where it stops.

2.3 Developmental Background of Cerebral Cortex

The cortex develops more slowly than other parts of the brain, and parts of the cortex mature at different rates. The part of the cortex that controls physical-motor movement matures first, then the areas that controls higher order thinking processes. The temporal lobes of the cortex that play major roles in emotions and language do not develop fully until the high school years and may be later.

Neuroscientists are just beginning to understand how brain development is related to aspects of adolescents such as risk-taking, decision making, and managing impulsive behaviours. Prefrontal cortex control the emotional impulses inhibiting capacities of the brain are not present at birth.

Research now indicates that it takes at least two decades of the biological processes of brain development to produce fully functional prefrontal cortex (Weinberger, 2001)

2.4 Hemispheric Specialization and Processing of Information.

Continued testing of split-brain patients and brain scans of normal (whole-brained) individuals have revealed considerable consistency in the different ways the two halves of the brain store and process information. This cerebral specialization is
also called Hemisphericity. The right and left hemispheres of the cerebrum specialize in different functions. For e.g., the left hemisphere specializes in language functions – it does the talking, so to speak. The left hemisphere also appears to dominate the control of certain kinds of hand movements, notably skilled and gesturing movements. Most people use their right hands for performing skilled movement and the left side of the cerebrum controls the muscles on the right side that execute these movements. People who are talking will gesture mostly with their right hands indicative of left cerebral control.

The right hemisphere of the cerebrum specializes certain functions has also been reported. It seems that one of the right hemisphere’s specialties is the perception of certain kinds of auditory stimuli for instance, some studies show that the right hemisphere perceives, non-speech sounds such as melodies, coughing, crying and laughing better than the left hemisphere. The right hemisphere may also function better at tactual perception and for perceiving and visualizing spatial relationships.

Despite the specializations of each cerebral hemisphere, both sides of the normal person’s brain communicate with each other via, the corpus callosum to accomplish the many complex functions of the brain.

2.4.1. Left Hemisphere

Left brain is the logical hemisphere. It monitors the areas for speech. It analyses and evaluates factual material in a rational way. It understands the literal interpretation of words and detects time and sequence. It also recognizes words, letters, and numbers written as words.
2.4.2. Right hemisphere

The right brain is the intuitive hemisphere. It gathers information more from images than from words and looks for patterns. It interprets language through context-body language, emotional content, and tone of voice rather than through literal meanings. It specializes in spatial perception and is capable of creativity. It also recognizes places, faces and objects.

Table 2.1 describes the functional differences of the cerebral hemispheres proposed by Carter and Gazzaniga (1988)

Table 2.1
Functions of Left and Right Cerebral Hemispheres

<table>
<thead>
<tr>
<th>Left Hemisphere Functions</th>
<th>Right Hemisphere Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected to right side of the body</td>
<td>Connected to the left side of the body</td>
</tr>
<tr>
<td>Process input in a sequential and analytical manner</td>
<td>Processes input more holistically and abstractly</td>
</tr>
<tr>
<td>Time sensitive</td>
<td>Space sensitive</td>
</tr>
<tr>
<td>Generates spoken language</td>
<td>Interprets language through gestures, facial expressions, emotions, and body language</td>
</tr>
<tr>
<td>Specializes in recognizing words and numbers (as words)</td>
<td>Specializes in recognizing faces, places, objects and music</td>
</tr>
<tr>
<td>Active in constructing false memories</td>
<td>More truthful in recall</td>
</tr>
<tr>
<td>Seeks explanations why events occur</td>
<td>Put events in special patterns</td>
</tr>
<tr>
<td>Better at arousing attention to deal with outside stimuli</td>
<td>Better at internal processing</td>
</tr>
<tr>
<td>Does invariable and arithmetic operations</td>
<td>Does relational and mathematical operations</td>
</tr>
</tbody>
</table>

Sources: Carter (1998); Gazzaniga (1998a, 1998b)
2.5 Hemisphericity and Intelligence

There is no research to support the notion that those with one hemispheric preference are more or less intelligent than those with the opposite preference. Individuals who are strongly and oppositely preferred will exhibit vastly different personalities and learning styles, but this has no connection to intelligence.

2.6 Hemisphericity and Inheritance

There is no evidence that hemispheric preference is inherited. Studies of several generations of many families show mixed, unpredictable preference patterns.

2.7 Hemisphericity and Gender.

Studies began in the early 1970s by Jerre Levy at the University of Chicago, and subsequent studies by other researchers have shown some gender differences in brain characteristics and capabilities. PET scans and MRIs for instance, indicate that males and females use different areas of their brains when accomplishing similar tasks. There exists structural and performance differences among males and females and some of them are classified in the Table 2.2 and Table 2.3

| Table 2.2 |
| Structural Differences |
| Males | Females |
| Higher percentage of gray matter in the left hemisphere than females | Percentage of gray matter is same in both hemispheres. |
| Have more neurons in the cerebral cortex | Have more connections between neurons. |
| Language areas are in the left hemisphere | language areas are in the left hemisphere but also have an active language processor in the right hemisphere |
Table 2.3
Performance Differences in Males and Females

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males perform better on spatial tasks, such as mentally rotating three dimensional objects; at target-directed motor skills; at spotting shapes embedded in complex diagrams; and in mathematical reasoning. When recalling emotions, males use a smaller portion of their limbic system and are poor in recognizing different types of emotions in others. Boys scored better on mathematics, science, and social studies questions.</td>
<td>Females perform better on tests of perceptual speed, verbal fluency, determining the placement of objects (sequence), identifying specific attributes of objects, precision manual tasks, and arithmetic calculations. When recalling emotions, females use a larger portion of their limbic system and are also better at recognizing different types of emotions in others. Girls scored better on reading comprehension, perceptual speed, writing and in remembering associated facts, writing and concepts.</td>
</tr>
</tbody>
</table>

2.8. **Neurological Causes of Hemispheric Specialization.**

The left and right hemispheres are physically different and is made up of cortex, called gray matter and the supportive tissue below it, called white matter. The left has more gray matter. The right has more white matter with tightly packed neurons and are better able to handle intense, detailed work. The right hemisphere’s white matter contains neurons with longer axons that can connect with modules further away. These long-range connections help the right hemispheres to come up with broad but rather vague concepts.

2.9 **Hemisphericity and Integration of Information Processing**

The Researches on hemispheric specification support the notion that each hemisphere has its own set of functions in information processing and thinking. However, these functions are not always exclusive to only one hemisphere, and in even some simple tasks, it is possible for both hemispheres to be involved. In a
normal individual, the results of the separate processing are exchanged with the opposite hemisphere through the corpus callosum. There is harmony in the goals of each, and they complement one another in almost all activities. Thus, the individual benefits from the integration of the processing done by both hemispheres and is afforded greater comprehension of whatever situation initiated the processing.

Sousa’s (2001) views on hemispheric specialization conveys the idea that the individual benefits from the integration of the processing done by both hemispheres and is afforded greater comprehension of whatever situation initiated the processing. His views regarding this concept can be summarized as follows

(i) Logic is not confined to the left hemisphere. Some patients with right-brain damage fail to see the lack of logic in their thinking when they propose to take a walk even though they are completely paralyzed.

(ii) Creativity or intuition is not solely in the right hemisphere. Creativity can remain, though diminished, even after extensive right-hemisphere damage.

(iii) Because the two hemispheres do not function independently in a normal brain, it is impossible to educate only one hemisphere.

(iv) Specialization does not mean exclusivity. People are not purely left or right brained. One hemisphere may be more active in most people, but only in varying degrees.

(v) Both hemispheres are capable of synthesis, that is, putting pieces of information together into a meaningful whole.
2.10 Possible Theories behind Cerebral Hemisphericity.

There are various theories regarding the origin of hemisphericity. Of which the main theories are Hormone Theory, Natural Selection Theory and Environmental theory. They are been explained below.

2.10.1. Hormone Theory of Hemisphericity

Hormones, such as testosterone and androgen influence brain development differently in the sexes. Testosterone seems to delay the development of the left hemisphere in boys. Thus, girls get a head start in using the left hemisphere, but boys are forced to rely more on their right hemisphere. The early exposure to these hormones seems to alter other brain functions (such as language acquisition and spatial perception) permanently for the individual. The resurgence of hormones with the onset of puberty may further reconfigure the mental organization of teens, especially as new social pressures emerge with their accompanying emotional shifts (Kimura, 1992).

2.10.2. Natural Selection Theory of Hemisphericity

Natural selection theory suggests that natural selection affected our brain characteristics as we evolved. For thousands of years, the division of labour between the sexes was distinct. In prehistoric times, men were responsible for hunting large game over long distances, making weapons, and defending the group from predators, animals and otherwise. Women took care of the home and the children, prepared food, and made clothing. Such specialization required different cerebral operations from men and woman. Men needed more route-finding and spatial abilities and better targeting skills; women needed more fine-motor and timing skills to maintain the household. The individual males and females who could perform
their respective tasks well survived to pass their genes onto their children. Moreover, any new genetic combinations eventually led to structural changes in the brain—and other parts of the body—that were gender specific.

2.10.3. Environmental Theory of Hemisphericity

The Environment Theory which was popular in the 1980s, looks to a combination of the different ways the sexes develop and interact with their environment. Studies of infant boys and girls demonstrate that the acuity of senses does not develop identically in both genders. That is, hearing and touching, which are left brain controlled characteristics develop more quickly in girls. Spatial vision (right hemisphere controlled), however, develops more rapidly in boys.

More often parents tend to treat baby boys differently from baby girls and boys and girls between the ages of 6 and 12 typically spend their out-of-school time quite differently as they are growing up. In the structured environment of home, girls are exposed to more language through radio and television, and they are more conscious of time because of clocks, media, and other family members who may be coming home. This environment, psychologists argue, organize differently from very early, enhances left hemispheric processing of information. On the other hand, more boys spend their free time in unstructured environment, and thus, boys rely more on space (location) than time, design their own games, use more visual than verbal skills during play, and use little language and only in context to accomplish a task. This behavior enhances right-hemisphere processes. Thus, a combination of natural and nurtural factors causes the brains of males and females to organize differently from very early in their development through their formative years, leading, to different preferences in learning.
2.11 Hemisphericity & Differences in Thinking Process.

Right brain or creative thinkers gather information by feelings and intuition. This information is retained by using images and patterns and also able to visualize the whole idea as we gather our research. The thought processes appear illogical and meandering because they are emotional, abstract and laterally connected. Analysis of this information or problem-solving often involves free association and, while the solutions may be quite innovative, the route traveled to reach this conclusion would be impossible for a more rational left brain thinker to follow. Visual thinkers do not use a step-by-step process to gather information rather it is visually gathered all at once which makes organization of this information, and verbalizing the accumulated data, either in written or verbal form, difficult. Right brain thinkers are best to express themselves using art, music or dance.

Left Brain or Critical Thinkers collect information using logic and sense. This information is retained using words, numbers and symbols. Unlike right brain thinkers who see the whole concept, left brain thinkers see only parts of the whole idea which guides them in their logical, step gathering of information. Their brain processes are deductive, rational, concrete and analytically connected. Left brain thinkers express themselves with concise words, numerical concrete and analytically connected. Right brain thinkers express themselves with concise words, numerical and written formulas and technological systems. Modern scientists know that our left brain is our verbal and rational brain while our right brain is nonverbal and intuitive brain. We require special functions from both sides of our brains to accomplish most tasks in our daily lives. There are more non verbal tasks-such as drawing, painting, dancing and music, in which our right brain excels.
2.12 Brain based Theories and Hemispheric specialization

The important theories reviewed based on the functional analysis of the brain from neuroscience and education are discussed in the coming sections. There are various arguments interpreted with evidence that these functional variations are not alike. Various theories postulated in such a way to evidence their conclusions accordingly.

2.12.1 Triune Theory

The Triune theory developed by MacLean (1913) revealed the existence of the three evolutionary evolved brain parts, namely, limbic system or R-complex which is located in the brain stem which is mostly concerned with the survival. Limbic system or the second evolved system including hippocampus (to deal with memory locations) and amygdala (primary centers of emotions and connects it with events). Limbic system is able to combine inner and exterior experiences. Thirdly the most evolved neo cortex or mammalian brain (a network site of vastly interconnected neurons responsible for multitask oriented mental functions). Caine (1991) also opined that neo cortex as the seat of creativity, language development, musical composition and formal operations.

2.12.2 Hemispheric Theory by Edward

In his theory Edwards (1979), compares the left mode and right mode characteristics as summarized below.
Two of the theories which are most important and of recent origin are those of Robert Sternberg of Yale and Howard Gardner of Harvard.

### 2.12.3 Theory of Multiple Intelligences

A related theory is Howard Gardner’s 1983 theory of Multiple Intelligences. He identified seven types of intelligence and these are Verbal-linguistic, Logical-mathematical, Visual-spatial, Bodily-kinesthetic, Auditory-musical, Inter-personal communication, Intra-personal communication. Later he added naturalistic intelligence and Existentialist intelligence into it. The pursuit for the existence of spiritual intelligence is still going on.

Multiple intelligence theory initially identified and rated seven types of intelligence and is explained below based on the mental abilities.

<table>
<thead>
<tr>
<th>Left mode characteristics</th>
<th>Right mode characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>Non- verbal</td>
</tr>
<tr>
<td>Analytic</td>
<td>Synthetic</td>
</tr>
<tr>
<td>Symbolic</td>
<td>Concrete</td>
</tr>
<tr>
<td>Abstract thinking</td>
<td>Analogical</td>
</tr>
<tr>
<td>Temporal</td>
<td>Non temporal</td>
</tr>
<tr>
<td>Rational</td>
<td>Non rational</td>
</tr>
<tr>
<td>Digital</td>
<td>Spatial</td>
</tr>
<tr>
<td>Logical</td>
<td>Intuitive</td>
</tr>
<tr>
<td>Linear</td>
<td>Holistic</td>
</tr>
</tbody>
</table>
### Table 2.5

**Intelligence and corresponding mental abilities proposed by Howard Gardner**

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>Mental abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistic</td>
<td>use language</td>
</tr>
<tr>
<td>Mathematical-Logical</td>
<td>use logic, numerical concepts and scientific thinking</td>
</tr>
<tr>
<td>Bodily–kinesthetic</td>
<td>use movement and touch</td>
</tr>
<tr>
<td>Visual-Spatial</td>
<td>use visuals to manipulate images</td>
</tr>
<tr>
<td>Musical</td>
<td>use the rhythm, tone quality, volume and pitch</td>
</tr>
<tr>
<td>Interpersonal</td>
<td>use of interactions between self and others</td>
</tr>
<tr>
<td>Intra personal</td>
<td>use body states, emotions, intuitions and spiritual awareness</td>
</tr>
</tbody>
</table>

Later Gardner speculated for the possibilities of intelligence behind smell and taste, naturalistic, spiritual and ethical or moral independently and attached spiritual intelligence and emotional intelligence independently to the above list. Of these the visual-spatial, linguistic, kinesthetic and interpersonal seems to have some aspect of right brain styles. The interpersonal, musical and logical-mathematical can be grouped under the mental abilities of left.

### 2.12.4 Theory of Triarchic Mind

In the Triarchic Mind (1988), Sternberg proposed that there exists three types of intelligence, as Componential, Contextual and Experiential intelligence. Conventional school activities must orient upon componential intelligence, while Contextual and Experiential intelligence are what we tend to use in everyday world. According to him, this causes a problem for many children.
2.12.5 Somatic Marker Theory

Somatic marker theory by Domassio (1994) postulated that emotion is an integral part of thinking process. He said cognition possess no entity without emotions. The new information reached in cerebral cortex is transformed into appropriate body response. Neuropeptides transforms it into pleasure, pain and anxiety followed by the internalized mapping of this body state into memory. This memory get associated with the emotions and result in an inner intuition of the acceptance or rejection for a particular repeated situations later. Thus somato marker decreases the range of certain choices for the process of decision making.

The important finding of this theory to the present study was much of this process are taking place in the left cortex of the body and this was antagonistic to the dimensions set by the study that emotions comes under right hemispheric preference.

2.13. Various Models of Brain Functioning

There are various models describing the cognitive functioning of human brain and the main models discussed here are Sperry’s Model of Brain Functioning, Hermann’s model of brain functioning & Katherine Benziger’s Model of Brain Functioning and model of system thinking by Russel.

2.13.1. Sperry’s Model of Brain Functioning

In 1976 Sperry, in collaboration with Ornstein published a model regarding the functioning of human brain. He explained various thought process originated in either the right or left hemisphere of the brain. A summary of the model is given below.
### Theoretical Overview

<table>
<thead>
<tr>
<th>LEFT HEMISPHERE</th>
<th>RIGHT HEMISPHERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech Verbal</td>
<td>Special Musical</td>
</tr>
<tr>
<td>Logical Mathematical</td>
<td>Holistic</td>
</tr>
<tr>
<td>Linear, Detailed</td>
<td>Artistic, Symbolic</td>
</tr>
<tr>
<td>Sequential</td>
<td>Simultaneous</td>
</tr>
<tr>
<td>Controlled</td>
<td>Emotional</td>
</tr>
<tr>
<td>Intellectual</td>
<td>Intuitive and Creative</td>
</tr>
<tr>
<td>Dominant</td>
<td>Minor</td>
</tr>
<tr>
<td>Worldly</td>
<td>Spiritual</td>
</tr>
<tr>
<td>Active</td>
<td>Receptive</td>
</tr>
<tr>
<td>Analytic</td>
<td>Synthetic, Gestalt</td>
</tr>
<tr>
<td>Reading, writing, naming</td>
<td>Facial Recognition</td>
</tr>
<tr>
<td>Sequential ordering</td>
<td>Simultaneous Comprehension</td>
</tr>
<tr>
<td>Perception of significant order sequences</td>
<td>Perception of Abstract Patterns Comply motor recognition of complex figures</td>
</tr>
</tbody>
</table>

**2.13.2. Herrman’s Model of Brain functioning**

Ned Herrman (1997), developed four quadrant model of cognitive preferences and a questionnaire called Herrman Brain Dominance Instrument (HDBI). He divided the functional brain area into upper /cerebral and lower/limbic hemisphere. Where the former for logical, analytical, synthetic and holistic thought process and the latter for organizational need for control, emotional and interpersonal interactions.

The four hypothetical regions and defined specific functions corresponding to these areas in Herrman’s model of brain functioning can be summarized as
follows which definitely a metaphorical model of the relationship between cerebral and limbic thought process.

Figure 2.4
Herrman’s Model of Brain Functioning

It is worth examining these four styles in more detail:

A Quadrant: Analytical thinking.
- Sub components: logical, factual, critical, technical and quantitative.
- Preferred activities: collecting data, listening to informational lectures, reading textbooks. Judging ideas based on facts, criteria and logical reasoning.

B Quadrant: Sequential thinking.
- Sub Components: conservative, structured, organized, detailed, and planned.
- Preferred activities: Following directions, repetitive detailed homework problems, time management and schedules.
C Quadrant: Interpersonal thinking.
- Sub components: Kinesthetic, emotional spiritual, sensory, feeling.
- Preferred activities: listening to and sharing ideas, looking for personal meaning, sensory input, and group study.

D Quadrant: Imaginative thinking.
- Sub component: Visual, holistic, intuitive, innovative, and conceptual.

2.13.3. Katherine Benziger’s Model of Brain Functioning

According to Katherine Benziger’s Model brain has four brains specialized areas responsible for different functions. These specialized areas are mentioned by him as “mode”. He says that the different modes are particularly specified for performing different functions. It is given in the figure below.

![Figure 2.5](image)

Figure 2.5
Katherine Benziger’s Model of Brain Functioning
Theoretical Overview

Details of specialized areas in various modes and corresponding brain functions in this model are given in the table 2.4

Table 2.6

Brain Functions in Katherine Benziger’s Model

<table>
<thead>
<tr>
<th>Mode</th>
<th>Specialised area</th>
<th>Brain functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basal left</td>
<td>Order and habit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ordered procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sequential routines</td>
</tr>
<tr>
<td>2</td>
<td>Basal right</td>
<td>Spiritual experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rhythm and feeling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Harmony</td>
</tr>
<tr>
<td>3</td>
<td>Frontal right</td>
<td>Internal imaging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metaphor and imagination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expressiveness</td>
</tr>
<tr>
<td>4</td>
<td>Frontal left</td>
<td>Structural analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prioritising and logic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mathematics</td>
</tr>
</tbody>
</table>

2.13.4 System Thinking Model of Thought Process

Russel (1993), in his thinking model based on the fusion of analysis, synthesis and holism reveals both understanding and knowledge. It is based on the notion that knowledge he is derived from analytical thought process and understanding from synthesis and holistic thought process. If one is analytical and synthetic in thought process he represents the upper level of hemispheric preference and one is synthetic and holistic but not analytic in thought process represent lower level of hemispheric preference.

2.13.5 Learning Style and Strategies

The theories of learning styles connect neuroscience with education. The complexity of individual and differential complexities of the brain brings
heterogeneity among individuals. Learning style is the combination of a variety of natural styles exhibited by an individual to process new and challenging information. Any individual can adopt different styles provided the stronger tendency to choose the learning style which is highly developed when one is confronted with the learning of a highly complex task. The important background knowledge about various learning styles were collected and reviewed and studies relevant to the topic are presented on this section.

Learning or instructional strategies determine the approach for achieving the learning objective and are included in the pre-instructional activities, information presentation, learner activities, testing, and follow-through. The strategies are usually tied to the needs and interests of students to enhance learning and are based on many types of learning styles (Ekwensi, Moranski, & Townsend-Sweet, 2006).

Dunn and Dunn (1972) is one important old theory in which learning style is divided into five categories, namely environmental, emotional, sociological, physical and psychological. It can be summarized as follows based on the tendencies they attached themselves with.

**Environmental**  - respond to a stimulus like sound, light, temperature and formal or informal design.

**Emotional**  - respond to a stimulus like motivation, persistence, responsibility and structure.

**Sociological**  - favours colleagues, self, pair, team, authority figures, and varied or mixed group.
Physical - includes perceptual modalities, intake of food or drink and time specific

Psychological - consisted of analytical or global, hemispheric preference and reflective or impulsive tendencies

Based on this classification it was assumed that hemispherical learning comes under the psychological aspect of learning.

Learning style is a consistent pattern of behaviour and performance by which an individual approaches educational experiences. It is the composite of characteristic cognitive, affective, and physiological behaviours that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environments (Bennett, 1990).

Two other theories worthy of note are the 4 MAT system of learning styles developed by Nenrice Mc. Carthy. Through this he identifies four main types namely Divergens, Assimilators, convergers and Accommodators. The VARK (Visual Auditory Reading Kinesthetic) is another model explaining various brain based learning styles. VARK model shows some characteristics of a left-right distinction, such as the presence of visual and kinesthetic components associated with the right hemisphere, it is a model of perceptual style rather than cognitive style.

Learning strategies are methods or techniques individuals use to improve their comprehension, learning, retention and retrieval of information. Strategies are mental procedures that assist learning and may also include over activities (Husen & Postlethwaite, 1985).
In conclusion, each and every learner in any learning situation is clearly and absolutely influenced by their own preferences in the process of learning. A wide range of learner difference was noticed in case of learning style or learning preferences. Each learner’s style of learning or preferences in the learning situation is characterized mainly by their personality configuration and how far they are successful in the learning task at hand. Once the learner has clearest understanding and realization about their own preferences in learning, especially which yielded advantage or mastery in learning task as reward.

2.14 Cognitive Styles of Teaching and Learning

The cognitive styles are concerned with the form rather than the content of activity. They refer to individual differences, how we perceive, think, solve problems, learn etc. (Witkins et.al,1962)

In cognitive style processing one is dealt with broad dimensions of individual differences that extend across both intellectual and perceptual activities. In such case the characteristic approach of the individual that he employed into wide range of situations must considered for the individual cognitive style (Paul, 1993)

The cognitive styles are concerned with the form rather than the contents of activity. They are unique with individual differences. How we perceive, think, solve problems learn etc contribute to our cognitive style of learning. (Witkin et.al, 1962)

2.15 Neurological Teaching Style and Learning Style based on Hemispheric Specification

Understanding of one’s own neurological strengths and weaknesses, teachers should adapt the lessons to reach appropriately to all the students. The neurological teaching style preference adapts our teaching to reach and engage many of the
students as possible. Again, teachers by understanding of their own ‘neurological’ style can alternate their teaching pattern based on hemispheric preferences of their students. Thus knowing the neurological preference style, teachers can explore the individual differences among students, Connell (2006). The left brain teachers tend to teach in a left brain style and right brain teachers in a right brain style and middle brain teachers tend to vary their teaching between the two approaches. Teachers tend to better reach students were those who share their same neurological preferences. Thus she argued a strong left-brain teacher, make a conscious effort to reach the strong right brain students in the class room.

2.15.1. Hemispheric preference and Teaching Style

Teacher with left brain strengths generally prefer to teaching by lecture method based upon research and discussion. To incorporate sequence, they put outlines on the board and like to adhere to prepared time schedules. They give problems to the students to solve undependably. Teachers with left brain preferences assign more research writing than their right brain peers. They prefer quiet, structured classroom which are clean and organized.

Teachers with right brain strengths generally prefer to use hands on activities to lecture format. In concern with the right brain preference of seeing the whole art these teachers incorporates more art, manipulative, visuals and music into their lessons. They tend to embrace Howard Gardner’s multiple intelligences. They assign more group projects and activities and prefer a noisy, active and busy class environment. They prefer unorganized class room atmosphere (Connel, 2006).
2.15.2. Hemisphere preference and Learning Style

Left-brain students prefer to work alone. They like to read independently and incorporate research into their papers. They prefer a quiet classroom without a lot of distraction. They face difficulty in understanding lessons with a visual-spatial orientation. They are perfectionist also. Students with left brain preference style are strengthen in appropriate sequencing, listening to expert talks, accumulation of vocabulary, research activities oriented concept formation & conceptual analysis. They prefer to work alone (Connell, 2006).

Students with Right brain preferring learning style prefer to work in groups. They face difficulty in information processing, when it is presented verbally. Right brain students are efficient in painting & drawing. They are more often visual learners and bodily kinesthetic learners. They shows an excellent bye-hand coordination. They are efficient in comprehending the points which are presented in a nonverbal manner. They are intuitive and strength enough to follow the Visio-spatial patterns. (Connell, 2006).

They are efficient in map reading and plays. They are overwhelmed from all the auditory inputs. The educational significance of hemisphericity based teaching and learning style is that even though students and teachers can learn and perform different methods, they get excited and involved when they can learn and do assignments in the area of their neurological preference strengthened style.

Incorporating neurological teaching method into our classrooms will make the classroom atmosphere more efficient. A right brain oriented teaching/learning style can be brought into the classroom by bringing over overheads, videos, music, role playing, dance and other group activities. Again the right brain teacher by
adding more direct teaching and lecturing and by assigning individual and/or research oriented projects can make his/her classroom teaching – learning process into the maximum.

Neurological teaching method prefer to present a variety of assignments in front of the learners because students gravitate towards their neurological strengths when given a choice of assignments. Hence by better understanding their own neurological preferences – strengths and weaknesses – teacher can make their classroom more interesting & effective.

If one is a middle brain/whole brain teacher or learner, select and incorporate something from either area based on one’s mode of preference.

2.15.3. Brain Based (Compatible) Learning

Brain based learning definitely offers a constructivist, active model which encourages student involvement in learning. The twelve implications for teaching listed by the Southwest Educational Development Laboratory (2000) are typical of those offered by proponents of brain-based learning. Many of these principles are consistent with ideas from other theories of learning:

(i) The brain is simultaneous processing system; therefore, learning is enhanced by a rich, stimulating environment and the use of a variety of teaching strategies.

(ii) Learning engages the entire physiology, suggesting that factors such as stress, exercise, and nutrition affect learning.

(iii) The search for meaning is innate. Lesson, such as those using discovery-based strategies that stimulate this tendency, are particularly effective.
(iv) The brain perceives and generates patterns; therefore, lessons presented in context, such as through thematic teaching, help students identify patterns and connect new content with previous experiences.

(v) Emotions and learning are connected. Students learn and form patterns best in classrooms with a favourable emotional climate.

(vi) The brain processes parts and whole simultaneously. Presenting bits and pieces of information outside of their context is ineffective.

(vii) Learning involves focused and peripheral attention. Therefore, the entire classroom environment affects student learning.

(viii) Because learning involves both conscious and unconscious processes. Encouraging active, intentional processing through reflection and metacognition enhance learning.

(ix) There are at least two types of memory: rote and spatial. An overemphasis on rote learning may actually interfere with the development of understanding.

(x) The best learning occurs through natural spatial memory. Multi-sensory techniques and those that simulate real-world experiences are most effective.

(xi) Learning is most effective in a challenging but low threat environment.

(xii) All brains are unique, and their structure is affected by learning. Using multiple approaches and teaching through multiple modalities will appeal to students’ individual interests and learning preferences.
Sousa (2000), explained motivation, analytical thinking, and hemispheric preferences account for eighty percentage of the influential factors of learning style.

Brain based learning has been called a combination of brain science and common sense. Hart (1983) called the brain as “the organ of learning.” Cane and Cane (1991) developed twelve principles that apply what one should know about the function of the brain to teaching and learning. This principles were derived from an exploration of many disciplines and are viewed as a framework for thinking about teaching methodology. The 12 brain learning principles by him can be summarized as follows:

(i) The brain is a complex adaptive system.

(ii) The brain is a social brain.

(iii) The search for meaning is innate.

(iv) The search for meaning occurs through patterning.

(v) Emotions are critical to patterning.

(vi) Every brain simultaneously perceives and creates parts and wholes.

(vii) Learning involves both focused attention and peripheral attention.

(viii) Learning always involves conscious and unconscious processes.

(ix) We have at least two ways of organizing memory.

(x) Learning is developmental.

(xi) Complex learning is enhanced by challenge and inhibited by threat.

(xii) Every brain is uniquely organized.
Theoretical Overview

Teaching style and teaching strategies

Teaching style refers to the teacher’s pervasive personal behavior and media used during interaction with learners. It is the teacher’s characteristic approach whatever the method used (Bennett, 1990).

Modern neuroscience postulated that both hemispheres are involved in higher order cognitive functions and each half of the brain is specialized for differential modes of thought processing—both complex and simple—in a complementary manner.

Learning Strategy

A learning strategy is a mnemonic device that assists a student in understanding and completing an academic task, usually by specifying a series of steps to be completed in sequential order (Marks et al. 1996).

More specifically, a learning strategy is a method of cognitively planning the performance of a learning task, completing the task, and monitoring the completion of the task (Ellis, 1994).