CHAPTER - I
INTRODUCTION
The great topmost sheet of the mass, that where hardly a light had twinkled or moved, becomes now a sparkling field of rhythmic flashing points with trains of traveling sparks hurrying hither and thither. The brain is waking and with it the mind is returning. It is as if the Milky Way entered upon some cosmic dance. Swiftly the head mass becomes an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting harmony of sub patterns. Sherrington, 1942, Man on his Nature

Motor learning is a process of acquiring, completing and using motor information, knowledge, experience, and motor programmes (Adams, 1976). It is closely connected with mental abilities, motor abilities, foreknowledge, the cognitive and connative characteristics of an individual as well as his familiarity with the theoretical bases of movement technique. Based on Hay’s biomechanical studies (1985), it may be ascertained that running, as the most elementary manifestation of human motor abilities, involves more than 80 muscle groups and 46 bones of the locomotor system. To facilitate the correct performance of a motor action, optimal coordination of movements is necessary.

Hence, in the present investigation researcher decided to assess motor learning which is also referred as motor educability of Indian adolescents between 12 to 15 years in the light of brain hemisphere dominance and their cognitive ability i.e. intelligence.
To have in depth knowledge of theories and principles associated with variable selected for the investigated, researcher thoroughly studied them and then presented them in the following pages:

1.1 ANATOMY OF BRAIN

The brain is the center of the nervous system in all vertebrate. It is located in the head, usually close to the primary sensory organs for such senses as vision, hearing, balance, taste, and smell. The brain of a vertebrate is the most complex organ in its body. In a typical human the cerebral cortex (the largest part) is estimated to contain 15–33 billion neurons (Pelvig, 2008), each connected by synapses to several thousand other neurons. These neurons communicate with one another by means of long protoplasmic fibers called axons, which carry trains of signal pulses called action potentials to distant parts of the brain or body targeting specific recipient cells.

From an evolutionary-biological point of view, the function of the brain is to exert centralized control over the other organs of the body. The brain acts on the rest of the body either by generating patterns of muscle activity or by driving secretion of chemicals called hormones. This centralized control allows rapid and coordinated responses to changes in the environment. Some basic types of responsiveness such as reflexes can be mediated by the spinal cord or peripheral ganglia, but sophisticated purposeful control of behaviour based on complex sensory input requires the information-integrating capabilities of a centralized brain.

From a philosophical point of view, what makes the brain special in comparison to other organs is that it forms the physical structure that
generates the mind. As Hippocrates put it: "Men ought to know that from nothing else but the brain come joys, delights, laughter and sports, and sorrows, grief’s, despondency, and lamentations Hippocrates (400 BCE)". In the early part of psychology, the mind was thought to be separate from the brain. However, after early scientists conducted experiments it was determined that the mind was a component of a functioning brain that expressed certain behaviours based on the external environment and the development of the organism. (Rosenberger, 2011) The mechanisms by which brain activity gives rise to consciousness and thought have been very challenging to understand: despite rapid scientific progress, much about how the brain works remains a mystery. The operations of individual brain cells are now understood in considerable detail, but the way they cooperate in ensembles of millions has been very difficult to decipher. The most promising approaches treat the brain as a biological computer, very different in mechanism from electronic computers, but similar in the sense that it acquires information from the surrounding world, stores it, and processes it in a variety of ways.

**The most important vertebrate brain components are:**

- The medulla, along with the spinal cord, contains many small nuclei involved in a wide variety of sensory and motor functions.

- The pons lies in the brainstem directly above the medulla. Among other things, it contains nuclei that control sleep, respiration, swallowing, bladder function, equilibrium, eye movement, facial expressions, and posture (Seigel, 2010).
- The hypothalamus is a small region at the base of the forebrain, whose complexity and importance belies its size. It is composed of numerous small nuclei, each with distinct connections and neurochemistry. The hypothalamus regulates sleep and wake cycles, eating and drinking, hormone release, and many other critical biological functions (Swaab, DF, 2003).

- The thalamus is another collection of nuclei with diverse functions. Some are involved in relaying information to and from the cerebral hemispheres. Others are involved in motivation. The subthalamic area seems to contain action-generating systems for several types of "consummatory" behaviors, including eating, drinking, defecation, and copulation (Jones, EG, 1985).

- The cerebellum modulates the outputs of other brain systems to make them precise. Removal of the cerebellum does not prevent an animal from doing anything in particular, but it makes actions hesitant and clumsy. This precision is not built-in, but learned by trial and error.

- The optic tectum allows actions to be directed toward points in space, most commonly in response to visual input. In mammals it is usually referred to as the superior colliculus, and its best-studied function is to direct eye movements. It also directs reaching movements and other object-directed actions (Saitoh, K, 2007).

- The pallium is a layer of gray matter that lies on the surface of the forebrain. In reptiles and mammals, it is called the cerebral cortex. Multiple functions involve the pallium, including olfaction and
spatial memory. In mammals, where it becomes so large as to dominate the brain, it takes over functions from many other brain areas. In many mammals, the cerebral cortex consists of folded bulges called gyri that create deep furrows or fissures called sulci. The folds increase the surface area of the cortex and therefore increase the amount of gray matter and the amount of information that can be processed (Puelles, L., 2001).

- The hippocampus, strictly speaking, is found only in mammals. However, the area it derives from, the medial pallium, has counterparts in all vertebrates (Salas, C., 2003).

The basal ganglia are a group of interconnected structures in the forebrain. The primary function of the basal ganglia appears to be action selection: they send inhibitory signals to all parts of the brain that can generate motor behaviors, and in the right circumstances can release the inhibition, so that the action-generating systems are able to execute their actions. Reward and punishment exert their most important neural effects by altering connections within the basal ganglia (Grillner, S et al., 2005).

**Physiology**

The functions of the brain depend on the ability of neurons to transmit electrochemical signals to other cells, and their ability to respond appropriately to electrochemical signals received from other cells. The electrical properties of neurons are controlled by a wide variety of biochemical and metabolic processes, most notably the interactions between neurotransmitters and receptors that take place at synapses.
Neurotransmitters are chemicals that are released at synapses when an action potential activates them—neurotransmitters attach themselves to receptor molecules on the membrane of the synapse’s target cell, and thereby alter the electrical or chemical properties of the receptor molecules. With few exceptions, each neuron in the brain releases the same chemical neurotransmitter, or combination of neurotransmitters, at all the synaptic connections it makes with other neurons. Thus, a neuron can be characterized by the neurotransmitters that it releases.

1.2 FUNCTIONS OF BRAIN

From an evolutionary-biological perspective, the function of the brain is to provide coherent control over the actions. A centralized brain allows groups of muscles to be co-activated in complex patterns; it also allows stimuli impinging on one part of the body to evoke responses in other parts, and it can prevent different parts of the body from acting at cross-purposes to each other (Carew, T.J., 2000).

To generate purposeful and unified action, the brain first brings information from sense organs together at a central location. It then processes this raw data to extract information about the structure of the environment. Next it combines the processed sensory information with information about the current needs and with memory of past circumstances.

Perception - One of the primary functions of a brain is to extract biologically relevant information from sensory inputs. The human brain is provided with information about light, sound, the chemical
composition of the atmosphere, temperature, head orientation, limb position, the chemical composition of the bloodstream, and more. One way or another, all of these sensory modalities are initially detected by specialized sensors that project signals into the brain.

**Motor control** : Motor systems are areas of the brain that are directly or indirectly involved in producing body movements, that is, in activating muscles. Except for the muscles that control the eye, which are driven by nuclei in the midbrain, all the voluntary muscles in the body are directly innervated by motor neurons in the spinal cord and hindbrain. Spinal motor neurons are controlled both by neural circuits intrinsic to the spinal cord, and by inputs that descend from the brain. The intrinsic spinal circuits implement many reflex responses, and contain pattern generators for rhythmic movements such as walking or swimming. The descending connections from the brain allow for more sophisticated control.

The brain contains several motor areas that project directly to the spinal cord. At the lowest level are motor areas in the medulla and pons, which control stereotyped movements such as walking, breathing, or swallowing. At a higher level are areas in the midbrain, such as the red nucleus, which is responsible for coordinating movements of the arms and legs. At a higher level yet is the primary motor cortex, a strip of tissue located at the posterior edge of the frontal lobe. The primary motor cortex sends projections to the subcortical motor areas, but also sends a massive projection directly to the spinal cord, through the pyramidal tract. This direct corticospinal projection allows for precise voluntary control of the fine details of movements. Other motor-related brain areas
exert secondary effects by projecting to the primary motor areas. Among the most important secondary areas are the premotor cortex, basal ganglia, and cerebellum.

The human brain controls the central nervous system (CNS), by way of the cranial nerves and spinal cord, the peripheral nervous system (PNS) and regulates virtually all human activity. Involuntary, or “lower,” actions, such as heart rate, respiration, and digestion, are unconsciously governed by the brain, specifically through the autonomic nervous system. Complex, or “higher,” mental activity, such as thought, reason, and abstraction, is consciously controlled.

Anatomically, the brain can be divided into three parts: the forebrain, midbrain, and hindbrain; the forebrain includes the several lobes of the cerebral cortex that control higher functions, while the mid and hindbrain are more involved with unconscious, autonomic functions. During encephalization, human brain mass increased beyond that of other species relative to body mass. This process was especially pronounced in the neocortex, a section of the brain involved with language and consciousness. The neocortex accounts for about 76% of the mass of the human brain; with a neocortex much larger than other animals, humans enjoy unique mental capacities despite having a neuroarchitecture similar to that of more primitive species. Basic systems that alert humans to stimuli, sense events in the environment, and maintain homeostasis are similar to those of basic vertebrates. Human consciousness is founded upon the extended capacity of the modern neocortex, as well as the greatly developed structures of the brain stem.
A cerebral hemisphere (hemispherium cerebrale) is defined as one of the two regions of the brain that are delineated by the body’s median plane. The brain can thus be described as being divided into left and right cerebral hemispheres. Each of these hemispheres has an outer layer of grey matter called the cerebral cortex that is supported by an inner layer of white matter. The hemispheres are linked by the corpus callosum, a very large bundle of nerve fibers, and also by other smaller commissures, including the anterior commissure, posterior commissure, and hippocampal commissure. These commissures transfer information between the two hemispheres to coordinate localized functions. The architecture, types of cells, types of neurotransmitters and receptor subtypes are all distributed among the two hemispheres in a markedly asymmetric fashion.

Almost about 20 years ago neuro-scientist suggested that the circuitry of the cerebellum resembles the learning machine known as the “perceptron.” A perceptron learns how to assign an appropriate output to each input by obeying the suggestions of its “teacher”. The teacher provides encouragement when the perceptron is successful, and discouragement otherwise. Marr and Albus proposed that the climbing fibers in the cerebellum play the role of the teacher, and the mossy fibers play the role of the input to which the perceptron is supposed to assign output.

Perceptrons are no longer in vogue. However, the general view of the cerebellum as a learning machine has received a significant amount of experimental support. Vestibulo-ocular reflex — the reflex which keeps the gaze of the eye at a fixed point, regardless of head movement relies on
a highly detailed program, but it is also situation-dependent in certain respects; and it is now clear that the cerebellum can change the gain of the vestibulo-ocular reflex in an adaptive way.

The cerebellum, in itself, is not capable of coordinating complex movements. However, Fabre and Buser (1980) have suggested that similar learning takes place in the motor cortex — the part of the cortex that is directly connected to the cerebellum. In order to learn a complex movement, one must do more than just change a few numerical values in a previous motion i.e. the gain of a reflex arc, the speed of a muscle movement etc.

1.3 LATERISATION OF BRAIN FUNCTION

Laterality refers to the structure and function of paired organs or of two similarly arranged areas of non-paired organs, distributed on the right and left sides (Eysenck, Arnold, Wurzburg, & Meili, 1972). It implies that certain functions are differentially represented in the two sides of the brain. While the ideas of brain lateralization and hemispheric dominance are in vogue since long the picture is still not clear beyond a general statement that there are two hemispheres which vary in specialization and there is hemispheric asymmetry. The nature of evidence, type of technique, range of sense modalities, and the role of various organismic and contextual variables is yet not clear.

Laterality is structural as well as functional. Structurally, the cortex is divided anatomically into two hemispheres, the right and the left. The two hemispheres are roughly symmetrical in appearance, but not in structure and functions. For instance, while the left hemisphere (LH) is
found to have longer sylvian fissure, relatively more gray matter, larger planum temporale, and wider occipital lobe, the right hemisphere (RH) is documented to be heavier, having larger Herschel’s gyrus and a wider frontal lobe (Foundas, Leonard, & Hanna-Pladdy, 2002; Gazzaniga, Ivry, & Mangun, 2002; Kolb & Whishaw, 2003). This structural asymmetry leads to functional asymmetry. While the LH specializes in processing information that is predominantly analytical, linear, serial, and temporal, the RH specializes in processing information that is synthetic, configurational, simultaneous, and holistic in nature (Borod, 1992; Bryden, 1982; Hellige, 2001).

Empirical evidence suggests that in a large majority of the human population, the LH is superior to the RH for language functions, whereas the RH is superior to the LH for visuo-spatial functions (Beaton, 1985). However, in a substantial minority of the population, hemispheric asymmetry does not follow this pattern (Bishop, 1990; Geschwind & Galaburda, 1987; McManus & Bryden, 1991). The minority with anomalous hemispheric asymmetry may show a reversed direction of hemispheric asymmetry or various degrees of bilateralization of language and visuo-spatial functions. Individual variations in hemispheric asymmetry have been ascribed to a multitude of factors, such as heredity (Annett, 1964), cytoplasmic left-right gradient (Morgan & Corballis, 1978), fetal testosterone levels (Geschwind & Galaburda, 1987), loss of colossal axons (Witelson & Nowakowski, 1991), and birth stress (Bakan, 1971).

A longitudinal fissure separates the human brain into two distinct cerebral hemispheres, connected by the corpus callosum. The sides resemble each other and each hemisphere's structure is generally
mirrored by the other side. Yet despite the strong anatomical similarities, the functions of each cortical hemisphere are managed differently. For example, the lateral sulcus generally is longer in the left hemisphere than in the right hemisphere.

Broad generalizations are often made in popular psychology about one side or the other having characteristic labels such as "logical" or "creative". These labels need to be treated carefully; although a lateral dominance is measurable, these characteristics are in fact existent in both sides Westen et al. (2006) and experimental evidence provides little support for correlating the structural differences between the sides with functional differences. (Toga, A.W. et al, 2003)

The extent of any modularity, or specialization of brain function by area, remains under investigation. If a specific region of the brain or even an entire hemisphere is either injured or destroyed, its functions can sometimes be assumed by a neighboring region, even in the opposite hemisphere, depending upon the area damaged and the patient's age. When injury interferes with pathways from one area to another, alternative (indirect) connections may come to exist to communicate information with detached areas, despite the inefficiencies.

While functions are lateralized, these are only a tendency. The trend across many individuals may also vary significantly as to how any specific function is implemented. The areas of exploration of this causal or effectual difference of a particular brain function includes its gross anatomy, dendritic structure, and neurotransmitter distribution. The structural and chemical variance of a particular brain function, between
the two hemispheres of one brain or between the same hemisphere of two different brains, is still being studied.

Brain function lateralization is evident in the phenomena of right- or left-handedness and of right or left ear preference, but a person’s preferred hand is not a clear indication of the location of brain function. Although 95% of right-handed people have left-hemisphere dominance for language, only 18.8% of left-handed people have right-hemisphere dominance for language function. Additionally, 19.8% of the left-handed have bilateral language functions. (Taylor, 1990) Even within various language functions (e.g., semantics, syntax, prosody), degree (and even hemisphere) of dominance may differ.

Handedness is the most obvious type of cognitive and behavioural asymmetry reported in human beings. It refers to the preference to perform several tasks with one hand rather than the other. Also, the brain mechanism underlying handedness is such that handedness is contra laterally related to the two hemispheres, left hand to the RH and right hand to the LH. There is evidence that left- and right-handers differ when compared on a variety of behavioural measures (Annett & Alexander, 1996; Herron, 1980; Peters, 1995). Generally, right-handers are more homogeneous than left-handers on behavioural measures, as they are more likely to prefer the right hand for manual activities, to be more dexterous and powerful with the right-hand, and to have language lateralized to the contra lateral left cerebral hemisphere. Thus, in right-handers the neural systems that contribute to these behaviours are lateralized predominantly to the LH, and the hand used to write is contralateral to the hemisphere mediating language functions. In
contrast, in most lefthanders language is ipsilateral to the preferred hand. About 60% of left-handers have LH dominant for language. In addition, left handers are more likely to be dissociated on measures of hand preference, skill and strength than right-handers (Peters, 1995; Schacter, 1997). In many cultures including the Indian culture, the right hand is the preferred hand and the left hand is avoided and strict sanctions about its use are observed. Past research has indicated that in many non-western cultures the prevalence of right handedness is greater than that found in the Western cultures (Mandal & Dutta, 2001).

Handedness has implications for task performance and raises concerns for making various policy provisions at the work place. This is important because the environment and various gadgets and instruments are often organized in favour of right-handed people. Handedness, however, has been approached from the perspective of preference as well as performance. While performance measures are behavioural and objective, the preference measures involve self reports and are primarily based on memory. In view of these and related differences some researchers (Bryden, Ardila, & Ardila, 1993; Peters, 1995; Provins & Magliaro, 1993) argue that hand preference and asymmetrical task performance involve fundamentally different phenomena. This is because, first, the correlations between hand preference and hand performance asymmetries are of only modest size (Raczkowski et al., 1974).

Second, the scores on preference and performance measures yield distinct population distributions. While the population distribution of hand preference scores is described by a bimodal J-shaped distribution
(Annett, 1970), the distribution of hand performance scores is portrayed by a normal distribution with a mean shift towards superior performance of the right hand and lower performance of the mixed / ambiguous-handers below the middle zone. Annett (1972, 1985), however, has indicated that the J-shaped distribution of preference can be superimposed on the normal distribution of performance asymmetry when the distributions are accurately represented.

Contrary to the above view, some studies have demonstrated that consistent hand preference is associated with efficient motor performance (Kee, Gottfried, & Bathurst, 1991; Tan, 1985). They suggest that more lateralized people would be less variable in hemispheric specialization and, therefore, would display more pronounced functional asymmetries than the inconsistent persons. Consistent lateral preference is expected to lead to coordinated movement patterns indicating fine motor control. The empirical evidence on this issue is diverse. During the early years, right handers are found to differ from mixed-handers but not from lefthanders on foot performance (Gabbard, 1989). Significant right and left hand difference has been reported on tasks like tapping (Carlier, Dumont, Beau & Michel, 1993) and pegboard (Fagard & Dahmen, 2004). Using monozygotic twins, Gurd, Schulz, Cherkas and Ebers (2006) have found that right-handers are more strongly lateralized than their left-hander sisters. Also, the preference-performance score correlations are significantly positive. In young adults, hand preference is significantly related to performance (Corey, Hurley & Foundas, 2001; Nalcaci, Kalavcioglu, Cicek & Gene, 2001). Peters (1995) argued that preference induces asymmetry in a given skill as a result of increased use of the
preferred hand. However, hemispheric specialization has also been implicated. Thus, rapid finger tapping has shown right hand advantage (Todor, Kyprie & Price, 1982; Todor & Smiley, 1985) which is attributed to LH specialization for the organization and control of sequential movement.

Most of the previous studies mentioned above have used right handed persons and a few have used the left-handers, and have generally not considered the mixed-handed persons. Mixed-handed persons have been dubbed as ‘inconsistent’, ‘clumsy handers’, and ‘ambidextrous’ (Gabbard, Hart & Gentry, 1995; Peters, 1990). The documented evidence existing for mixed-handed persons consists mainly of peripheral measures of laterality such as hand preference and motor performance. These studies show that children who exhibit consistent hand preferences are motorically superior to their inconsistent (mixed-handed) peers (Armitage & Larkin, 1993; Gottfried & Bathurst, 1983; Kee, Gottfried, Bathurst, & Brown, 1987; Tan, 1985). The implied underlying premise is that persons who are more strongly lateralized are less variable in hemispheric specialization and exhibit more pronounced functional asymmetries compared to their inconsistent (mixed-handed) counterparts. Some studies do show that mixed-handers have inconsistent or weak brain lateralization (Bishop, 1990; Crow et al., 1989; Spere et al., 2005). This inconsistency in brain lateralization leads to deterioration in motor performance and may lead to accidents (Daniel & Yeo, 1991; Hicks, Inman, Ching, Bautista, Deharo, & Hicks, 1998; Mandal, Suar, & Bhattacharya, 2001; Segalowitz & Brown, 1991). However, a few studies provide contradictory evidence which shows that there is no
significant difference in terms of motor performance between mixed-handers, and left- or right-handers (Gabbard, Hart & Gentry, 1995b; Peters, 1996). These inconsistent findings create scope for reinvestigation.

In general the left and right hemispheres of our brain process information in different ways. We tend to process information using our dominant side. However, the learning and thinking process is enhanced when both side of the brain participate in a balanced manner. This means strengthening our less dominant hemisphere of the brain. These are the information processing styles that are characteristically used by our right or left brain hemisphere:

**Linear Vs. Holistic Processing**

The left side of the brain processes information in a linear manner. It processes from part to whole. It takes pieces, lines them up, and arranges them in a logical order; then it draws conclusions. The right brain however, processes from whole to parts, holistically.

**Sequential Vs. Random Processing**

In addition to thinking in a linear manner, the left brain processes in sequence. The left brained person is a list maker. If someone is left brained, he will enjoy making master schedules and and daily planning. The left brain is also at work in the linear and sequential processing of math and in following directions. By, contrast, the approach of the right-brained people are random.

**Symbolic Vs. Concrete Processing**

The left brain has no trouble processing symbols. Many academic pursuits deal with symbols-such as letters, words, and mathematical notations. The left brained person tends to be comfortable with linguistic
and mathematical endeavors. Left-brained person will probably just memorize vocabulary words or math formulas. The right brain, on the other hand, wants things to be concrete. The right brain person wants to see, feel, or touch the real object.

**Logical Vs. Intuitive Processing**

The left brain processes in a linear, sequential, logical manner. When you process on the left side, you use information piece by piece to solve a math problem or work out a science experiment. When you read and listen, you look for the pieces so that you can draw logical conclusions. If you process primarily on the right side of the brain, you use intuition.

**Verbal Vs. Nonverbal Processing**

Left brain persons have little trouble expressing themselves in words. Right brain persons may know what they mean, but often have trouble finding the right words.

These are just some of the differences that exist between the left and right hemispheres, but one can see a pattern. Because left brain strategies are the ones used most often in the classroom, right brain students sometimes feel inadequate. However, one can be flexible and adapt material to the right side of brain. Likewise, those who are predominantly left brain know that it would be wise to use both sides of the brain and employ some right brain strategies.
1.4 MOTOR LEARNING:

1.4.1 Brief Historical Review

As to motor learning, it is true that reaction time was studied by Dutch scientist Donders in the nineteenth century. His classic paper was reported in 1869. However, her was more interested in the mental processes that composed RT rather than RT in relation to motor learning.

The Bryan and Harter study (1897) is often times given credit as the first one on motor learning, as it dealt with learning to send signals in American Morse code. Perhaps the most serious and in-depth work to influence motor learning in contemporary times fermented in 1940s and 50s. This is when military circumstances influenced governments to find out more about learning and achievement in psychomotor tasks related to military demands. These thrust were specially appealing in the 1960s to those (Adams, 1971) who felt that mechanistic and strongly influential behaviouristic tradition had limited value in the study of motor learning.

The attentional, perceptual, memorial and decision-making capacities as well as control possibilities of human functionary systems were scrutinized under rigid laboratory conditions by the likes of Bernstein (1967), and Broadbent (1958). Thus, the strong experimentalist foundation of motor learning was established.

Scholarly work in motor learning has continued today with efforts in motor control, with occasional overlap in concerns. The nature of peripheral and central control (programmes, schema, coordinative structures) over generated movements, cognitive processes in motor learning, and the influence of alternative practice conditions on
achievement in motor skills are typical concerns. Evidently, physiological, experimental and educational psychology, educational research and engineering greatly influence these scholarly directions, and in turn are influenced by the findings derived from the motor learning research.

As well, psychologists such as Fleishman (1972), have made their impact. His concern for the nature of abilities and their relation to achievement in psychomotor tasks at various stages of learning, has resulted in a more complex picture of the process of motor learning.

Interestingly enough, probably none of the more outstanding and enduring contributors to the study of motor learning would be considered as outstanding contributors to the study of sports psychology. However, resource material from each is especially helpful in providing different and more complete perspectives about the operation of certain phenomena associated with the ability to perform motor skills.

1.4.2 Theories and Principles:

The official definition of learning (UNESCO/ISCED 1993) reads as follows: “Learning is any permanent change in behaviour, acquaintance, knowledge, comprehension, viewpoints, skills or abilities that cannot be ascribed to physical growth or development of inherited behavioural patterns.”

Motor learning is a process of acquiring, completing and using motor information, knowledge, experience, and motor programmes (Adams, 1976). It is closely connected with mental abilities, motor abilities, foreknowledge, the cognitive and connative characteristics of an
individual as well as his familiarity with the theoretical bases of movement technique. Abernethy et al. (1997) distinguished between three phases in the process of motor learning: the verbal-cognitive phase during which a new movement structure is first identified and then understood; the associative phase during which several elements of the movement structure are integrated and adapted to the changing circumstances; and the autonomous phase during which movement becomes automatic and results in few errors. During the first phase, a beginner executes a series of unnecessary movements, activates muscles that are not relevant and is unable to bring them into balance. Consequently, his starting position and movement rhythm are incorrect, while his posture is stiff. This phase of motor learning lasts from 15 to 30 hours. In the second, associative phase, the quality of movement improves substantially. Movements are already smoother and more relaxed, while superfluous movements gradually vanish. In the motor part of the central nervous system a notion appears as a motor stereotype. This phase lasts from 3 to 5 months. The third, autonomous phase is that of movement automation, where the individual kinematic and dynamic parameters of movement are optimally integrated. This lasts for several years and is never quite finished. The motor stereotype collapses only in extremely unpredictable circumstances such as fatigue, enormous pressure or stress.

Barrow and McGee (1964) defined motor ability as the present acquired and innate ability to perform motor skills of a general or fundamental nature, exclusive of highly specialized sports.
Traditionally motor ability has been considered as one’s level of ability in a wide range of activities. It has been thought of consisting of individuals traits as strength, power, speed agility, balance, reaction time and coordination.

Magill’s (1993) definition of motor learning divides muscle activity into seven phases: The selection and innervation of those muscles necessary for the efficient execution of a movement; Sequencing (the correct sequence of muscle activation); Time structuring of the movement (the duration of the activity of an individual muscle during the entire movement); Gradation (varied application of the power of the engaged muscles); Timing (adapting the structure of the movement to external conditions); Alternative movements (selection of the optimal movement structure in view of the current situation); Movement control (movement automation and movement adaptation in non-standard circumstances).

The neurophysiologic research conducted over the past decades has left a visible mark on the study of motor learning processes in various fields. Despite many research efforts in this field, no satisfactory answer has yet been given. We know that certain parts of the brain are responsible for certain functions. In the cerebral cortex there is a motor centre in charge of motor functions. Moreover, the left and the right hemispheres do not function symmetrically, as each of them has its own specialised functions. Learning is most efficient when the two hemispheres function in synchronisation. Communication between them is made possible by the neural bridge – the corpus callosum. The right hemisphere of most people controls movements and sensations of the left half of the body, and vice versa. There is no symmetrical division of
functions and it is a known fact that 90% of all people are right-handed. Research conducted by Sperry (1971) established two ways of thinking, one manifesting itself through speech and the other not. The left hemisphere is “talkative”; the right is “silent”. The educational system and the Western civilisation both give primacy to the functions controlled by the left hemisphere, at the same time neglecting those controlled by the right hemisphere. The functioning of the left hemisphere is connected with analytical thinking, logic, reading, writing, speaking, counting, and calculating. The functioning of the right hemisphere is connected with intuition, spatial processing, overall comprehension, movement, drawing, rhythm, feelings, creativity and dreams. In motor learning, both hemispheres jointly control movement; however, cognitively and rationally mediated functions originate more from the right one. The right hemisphere is responsible for overall spatial cognition, visual presentation of spatial depth, rhythm, recognition of movement patterns, and for concurrent processing of many pieces of incoming information. The left hemisphere is “smart”, while the right one is “adept”. The theory of the hemispheres’ functions has not been altogether confirmed, yet it still offers interesting considerations regarding motor learning.

It is possible to achieve optimal results in motor learning as soon as the right hemisphere is activated in addition to the left one. Spontaneity and intuitiveness make exercising more fun. If one enjoys movement, one progresses much faster. Beginners make a big mistake trying to control their movements by focusing on inner consciousness. This way they activate their left i.e. analytical hemisphere, which triggers a series of commands in the body, generally disrupting the overall
coordination of movement. That is the primary function of the right hemisphere.

The overall comprehension of movement is the function of the right hemisphere of the brain. Learning a movement is easier if it is considered as a whole, not a jigsaw of many pieces.

General motor abilities entails one’s present performance level - the efficiency with which a person executes motor skills. General motor capacity means an individual’s innate potentialities for performance in motor skills, the limit to which an individual may be developed. The capability of an individual to learn new skills is termed as **general motor educability**.

The biological understanding of how two the two hemisphere of our brain function has now reached general consensus. There is still much work to do, particularly on the differences observed between individuals and understanding all the brain processes involved on cognition.

**Phase of Motor Learning:**

**The Phase of Basic Movement Coordination:** In this phase of learning, an individual first learns about basic movements and is able to execute them only under favourable conditions and with sustained conscious concentration. The results are quite modest as the technique is poorly developed and uneconomical. The notion of movement and motor sensations are vague, dull, incomplete, sometimes even wrong and not in harmony with the dynamic and temporal components of then optimal movement. In this phase a beginner often thinks that he is executing the
task correctly, while in fact he is doing it perfunctorily or completely wrong. Why? Because control over his movement is very weak. He is capable of controlling movement only through his visual signal system. The eyes may be the most important optical analyser but they are not enough. The most important function in the coordination of movement is that of the kinesthetic receptors (Schmidt, 1991). These are sensory bodies that are scattered over joints, ligaments and tendons and monitor body part position and movement, joint angles and muscle tension. In the case of beginners, the function of kinesthetic analysers is substantially less prominent, as they depend on experience and the already mastered motor programmes and motor memory. Therefore, the feedback information flow is very weak, the information is incomplete, imprecise and untimely.

The main characteristic of this phase of motor learning is rigidity of movement, manifested in the inability to distinguish between correct and incorrect movements, inadequate movement amplitude, stiffness and tension, inappropriate execution tempo and poor movement coordination.

The Phase of Accurate Movement Coordination: During this phase an individual is capable of executing high-quality movement in regards to optimal technique pattern, provided that the circumstances are normal. Errors still occur but they are less obvious and less frequent. As the player repeats the movement, his results improve. Movement becomes more coordinated, individual motor phases are interconnected, leading to a good and refined movement coordination.
The Phase of Stabilising Movement Coordination under Changeable and Difficult Circumstances: A learner is able to execute the optimal technique in changeable and difficult circumstances with a high level of stability. One of the most important components of learning and executing one's technique in competitive circumstances is concentration. In fact, concentration is a process which may last anywhere from only a few minutes to a few hours. An athlete has to focus on the execution of the movement and concentrate his thoughts in a pre-defined direction. He should repeat the movement scheme in his mind several times (ideomotor training). In this way the movement pattern and motor memory will be consolidated (Singer, 1981).

Learning Methods:

Learning methods are conventional procedures or sequences of procedures used for acquiring knowledge (Marentič Požarnik, 1980). In motor learning methodology various learning methods are used and combined, depending on the exactness and character of the motor task and on the learner's age and stage of motor learning. The most important characteristic of a motor task in terms of choosing the learning method is its integration. The more the individual parts intertwine, the more significant the synthetic and combined methods are. If an individual is completely unfamiliar with the components of movement and considers them very demanding, the method of learning part by part is more appropriate.

The Method of Instruction: Verbal instruction is one of the most elementary forms of human expression and communication. It is
important during the initial phase of motor learning, when an individual is becoming familiarized with the basic movements. It may include descriptions of the basic characteristics of movement, explanations of concepts, rules, inferences, definitions of models and the like.

**The Demonstration Method**: The initial notion of motor learning is primarily based on a sensory signal system which provides optical information (sight). The demonstration method has to be combined with other learning methods, especially the method of instruction. The demonstration must be absolutely correct, clear and suitable to the learner's age and level of maturity.

**The Situational Method (Synthetic Method)**: It is one of the most frequent and most natural methods of motor learning, which is usually used for less demanding movements. The method is more suitable and effective for beginners, as they have a higher ability of understanding movement as a whole rather than its individual parts.

**The Analytical Method**: The essence of this method is to divide the movement technique into individual fractions, teach these fractions one by one, and in the last phase, gradually combine the learned fractions with the basic movement. It is generally used for very complex movements, which cannot be learned as a whole. In this method, difficulties occur due to the long-term learning of certain fractions, and problems arise in the process of combining the learned fractions into a whole. The overly repeated fractions, which sooner or later become automatic, may completely alter the overall movement scheme and
rhythm. Therefore, the order of learning individual fractions is important. The basic movement scheme has to be preserved throughout the process.

**The Complex Method**: This method is a combination of the situational and analytical methods. In motor learning both methods intertwine and complement each other. First, individual elements are practised, then there is a gradual shift to practising the entire technique and, finally, some elements are practised again to perfection.

**The Ideomotor Method**: The basis of successful motor learning is a good notion of movement. When it comes to beginners, the notion of movement is vague, incomplete, sometimes even wrong and not in harmony with the real dynamic and temporal parameters of movement technique. A correct notion is formed on the basis of the instructor's explanation and demonstration. By means of visual and verbal information, a beginner can easily form a basic notion of movement and enhance it by the already existing motor programmes stored in his motor memory. In the ideomotor method, movement is performed inside one's mind, which makes it an example of mental learning. Only the motor cortex is activated and is responsible for the planning of motor structures.

**The Iterative Method**: During the phase of automated and highly adaptable movement, when the athlete is able to execute optimal technique in changeable circumstances, the iterative method (Latin *iteratio* from *iterum* – repetition, doing anew) is one of the most common exercise methods. It involves repetition of a movement in a series over a period of short intervals. Each execution leaves a trace in the motor memory and paves the way for another trace.
Motor learning is a complex and continuous process consisting of several phases. The margins between the phases are usually not clear. The basis of motor learning is a specific motor programme, which is created by the motor cortex based on external and internal information. The essence of efficient motor learning in sport is a correct notion of movement. In the case of beginners, the notion of movement is vague, incomplete, sometimes even wrong and not in harmony with the real dynamic and temporal parameters of movement technique.

**Neural Mechanism of Motor Skill Learning:**

A complex motor skill is often composed of a fixed sequence of movements (Rosenbaum, 1983 and Willingham, 1998). It has been suggested that the supplementary motor area (SMA) plays an important role in sequential movements (Tanji, 1996). Neurons in the pre supplementary motor area (preSMA), a cortical area anterior to the SMA, may be active specifically at certain rank orders in a sequence. On the basis of these results, Tanji proposed that the SMA and the preSMA work together to produce sequential movements correctly (Tanji, 2001).

**Acquisition of Motor Skill in Brain:**

Hikosaka et al. (1993) devised a sequential button press task, called the 2:5 task, in which the subject (either monkey or human) learned to press buttons in the correct order, by trial and error. This task enables the testing of an infinite number of different sequences and the effect of well-learned motor skills simultaneously on the same subject. Using this task, Nakamura et al. showed that the preSMA, rather than the SMA, is crucial for learning new sequences. Many neurons in the preSMA were activated
during learning of new sequences, but not during the performance of learned sequences (Nakamura K. et al., 1998). Furthermore, functional blockade of the preSMA led to selective deficits in learning new sequences. The anterior cingulate cortex, ventral to the preSMA, may also contribute new sequence learning. As well as higher premotor areas, the primary motor cortex (M1) has been implicated in motor learning. Functional and structural changes occur in M1 during simple motor learning (Klintsova AY et al., 1999).

Toni et al. (1998) and Petersen et al. (1998) also reported dynamic changes in human cortical activation during motor learning. Furthermore, a change in motor effector (finger versus arm) affects activation of sensorimotor cortex, but not parietal cortex. Awareness of performance — explicit learning — is correlated with activation of the prefrontal cortex and preSMA, but not sensorimotor cortex.

Related behavioral studies also suggest that different brain areas control different aspects of motor learning. With practice, accuracy of performance was acquired earlier than speed of performance. Accuracy was effector-unspecific, in the early learning stage, whereas the speed was effector-specific. Learning occurred independently for the kinematics—the spatial reference—of movements and for the dynamics — the load bearing — of movements (Krakauer et al., 1999). These results suggest that motor skill learning may be the integrative product of multiple neural mechanisms, each contributing to a different aspect of learning.
To understand the nature and mechanisms of motor skill learning, it is necessary to integrate such diversity of information into schemes or models. To make such attempts realistic, the concepts of coordinate transformation and loop circuits must be incorporated. For simple reaching to a visual target, for example, the target position is first coded in spatial coordinates — for example, centered around the eye, head or object — and then converted to motor coordinates — for example, joint angles or muscle forces. This coordinate transformation process may roughly correspond to the intracortical connections from the association cortices to the motor cortices. The frontoparietal cortices and the motor cortices form loop circuits with different regions in the BG and the CB.

1.5 DYNAMICS OF BRAIN HEMISPHERE IN MOTOR SKILL

With respect to motor behaviour in humans, the issue of hemispheric specialization is closely tied to handedness and therefore linked to asymmetric brain function. Left hemisphere dominance for skilled movement has been attributed to anatomical and functional asymmetries of the primary motor cortex (M1) and descending pathways (Amunts, 1996 and Volkmann, 1998) as well as to secondary motor and association areas.

The more extensive connectivity of the left M1 with associated cortico spinaltracts is further supported by new MRI techniques that correlate functional and anatomical information using functional MRI (fMRI) and diffusion tensor imaging (Guye, M. et al., 2003). Furthermore, on the basis of transcranial magnetic stimulation data, it has been suggested that excitability of the corticospinal system of right-handers is
higher in the left than in the right hemisphere. The asymmetry of secondary motor and association areas, which probably reflects a consequence of specialized regions implementing distinct functions, is particularly evident from clinical work. Patients with left hemisphere lesions, especially of parietal areas, are likely to show impairments in producing skilled actions with either hand, whereas comparable right hemisphere lesions produce deficits that are largely restricted to the contralateral hand (Wyke, M., 1971). Further evidence for hemispheric asymmetry of association areas is provided by neuro imaging work in healthy participants.

The role of the right hemisphere in motor organization is less well defined. With respect to M1, there is evidence for a reduced representation in the right compared with the left hemisphere in right-handers, which relates to decreased dexterity of the less-preferred hand. Regarding association areas, functional specializations related to higher-order planning do not seem to be strongly developed, although spatial response selection has been linked with the right hemisphere (Schumacher, et al. 2003). This restricted involvement might be due to the right hemisphere requiring strong external cues to select a particular motor representation from various options or to a selection mechanism that involves mainly exploratory processing of novel situations. The latter argument concerning novel situations would be in line with a theory of hemispheric control that assumes that the left hemisphere controls open-loop aspects of the movement (based on well established motor programmes), whereas the right hemisphere is crucial for closed loop aspects of the movement (dependent on sensory feedback)48. However,
recent research in patients does not support this clear dichotomy of hemispheric asymmetry.

Nonetheless, various lines of evidence convincingly support a dominant role for the right hemisphere in various spatial functions, such as spatial memory, learning and orienting (Jonides, J. et al. 1993). It has been suggested that this right-sided dominance is due to preferential encoding of global features in contrast to the specialization of the left hemisphere for processing local features. Computationally, this distinction possibly results from the differential sensitivity of the hemispheres to spatial frequency information: amplification of low spatial frequencies underscores information at the global level whereas intensification of high spatial frequencies highlights information at the local level. Alternatively, a right hemisphere specialization for spatial functions might relate to its involvement in the control of spatial attention for both the left and right visual fields (Mesulam, M. M., 1999, or a monitoring function that especially becomes apparent in conflict situations61, as when experiencing a mismatch between motor intention, proprioception and/or visual feedback62.

**Task-related characteristics**: Movement type-related processing evidently has an important role in the mechanisms of control of skilled actions. In particular, sequential representations and their resources are associated with the left hemisphere, independent of the performing hand. In view of this, the left hemisphere may be especially involved in the planning of sequential acts that implicate notable response selection, preparation and/or retrieval. For goal-directed reaching, each hemisphere is proposed to contribute in a distinct manner to controlling the
specification of the trajectory and final position. The distinction is due to the left hemisphere’s contribution in the planning of the limb dynamics whereas the right hemisphere is essential for specifying the final position of the reaching movement through sensory regulation (Weissman, D. H. & Banich, M. T. 2000).

The contribution of each hemisphere is also modulated by movement complexity. Whereas a simple movement such as unimanual finger tapping is organized by a local neural circuit, more complex actions such as those involving a sequence of finger movements engage distributed (often bilateral) networks. In this respect, recruitment of both hemispheres might be affected by augmented attentional or executive control requirements, or by the use of operations that are specialized in each hemisphere. It is assumed that interhemispheric pathways allow for relevant coupling or decoupling of information (Taylor et al., 1980). That input is indeed communicated between both hemispheres is evident, for example, from motor transfer studies, which address intermanual information transmission when a specific task is practised with one hand. In general, performance benefits are found to occur in the trained as well as the untrained hand.

**Performer-related characteristics**: Goldberg et al. (1994) proposed that right hemisphere processing is driven by the external environment, whereas left hemisphere processing is guided by internal representations. This line of thinking is consistent with observations from patients with spatial neglect, following right parietal injury, who show a severe shift of exploratory movements towards the right side that becomes markedly attenuated when goal-directed movements are performed. It suggests
that both types of action necessitate differential input or supporting processes, with a distinctive contribution from both hemispheres. These functional differences between the two sides would suggest a right-to-left shift of hemispheric importance as expertise develops. Indeed, skill development is often associated with a partial transition from externally to internally generated movement control. For example, when learning to accomplish a difficult bimanual task, activation in the right hemisphere decreases over time, whereas left hemisphere activation becomes more prominent. The former might be due to a reduced requirement for monitoring spatial features of the movements, whereas the latter probably

1.6 INTELLIGENCE:

“Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience.” (L. Gottfredson, 1993)

While intelligence is one of the most talked about subjects within psychology, there is no standard definition of what exactly constitutes ‘intelligence.’ Some researchers have suggested that intelligence is a single, general ability, while other believe that intelligence encompasses a range of aptitudes, skills and talents.

According to L. Gottfredson, 1993, “Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience.”
“Intelligence is a property of mind that encompasses many related mental abilities, such as the capacities to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn.” (Wikipedia, 4 October, 2006)

“Intelligence is not a single, unitary ability, but rather a composite of several functions. The term denotes that combination of abilities required for survival and advancement within a particular culture.” (Anastasi, 1992)

E.L. Thorndike (1927) has divided intelligent activity into three types i.e. (1) Social intelligence, or ability to understand and deal with persons; (2) Concrete intelligence, or ability to understand and deal with things as in skilled trades and scientific appliances, (3) Abstract intelligence, or ability to understand and deal with verbal and mathematical symbols.

To the layman, the intelligence quotient is not identified with a particular type of score on a particular test, but is often a shorthand designation for intelligence.

One group of definitions places the emphasis upon adjustment or adaptation of the individual to his total environment, or to limited aspect of it. According to definitions of this type, intelligence is general mental adaptability to new problems and situations of life or in other words, it is the capacity to reorganize one’s behaviour pattern so as to act more effectively and more appropriately in novel situations.

“Intelligence is not a single, unitary ability, but rather a composite of several functions. The term denotes that combination of abilities
required for survival and advancement within a particular culture.” (Anastasi, 1992)

“An intelligence is the ability to solve problems, or to create products, that are valued within one or more cultural settings.” (Gardner, 1993).

“Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework …There can be no doubt either, that mental life is also accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements.” (Piaget, 1963)

There are some studies in which speed of processing has been directly linked to central nervous system functioning and to intelligence (Vernon, P.A, & Mori, M. (1992). Intelligence, Reaction times and peripheral nerve conduction velocity as cited in Bee, H. (2000). The developing child. (9th ed.). Boston: Allyn and Bacon). Research shows that the speed with which people are able to retrieve information is related to intelligence. In general people with higher IQ scores react quickly on the information processing and perceptual task (Hunt,1997). Studies have shown that during perceptual tasks, right hemisphere is more activated so intelligent people may have more specialized right hemisphere (Barlow, 2001). Intelligence is not a consistent construct from the birth till the death. There are different factors, which contribute to the inconsistent nature of IQ.
1.7 THEORIES OF INTELLIGENCE:

Spearman’s Theory:

According to Spearman, intelligence is the faculty to understand the complicated relationships between different things and ideas. The more intelligent the person, the greater will be the number of relations he sees in them. He will be able to understand those relationships which others can not understand easily. According to Spearman, a person has two kinds of faculties - ‘G’ factor or general factor and ‘S’ factor or specific factor. Spearman stated that every individual possesses general factor up to some extent. The greater the amount of general factor in a person, the higher the intelligence he possess. According to Spearman’s theory, besides general factor a person has also some specific factors. It is possible that a person without much general factor may acquire higher skill in some specific sphere, but had he received the same amount of support from his general factor, he would have done much better in that specific sphere too.

Thorndike’s Theory:

According to theory proposed by Thorndike, intelligence is of three kinds: mechanical, abstract and social. This Thorndike also finds lack of general element in nature of intelligence. As per this particular theory, attention, retention power, memory, recognition, organisation, induction, deduction and the faculty to learn and acquire knowledge are the necessary parts of intelligence.

Thurstone’s Theory

According to Thurstone, intelligence consists of nine primary mental abilities i.e. visual or spatial ability, perceptual ability, numerical
ability, logical or verbal relation ability, fluency in dealing with words, memory, inductive ability, deductive ability, and ability to restrict the solution of a problem. Thurstone propounded that a person uses in a combined manner all these abilities according to his/her needs.

**Guilford’s Theory:**

Guilford is of the view that each intellectual ability has its own uniqueness and some kind of intellectual ability in necessary for executing some task. Therefore, Guilford contends that that each intellectual ability should be measured separately. Guilford places intelligence into three broad categories:

1. **Process or operation:**
   - (i) Cognition
   - (ii) Memory
   - (iii) Divergent thinking
   - (iv) Convergent thinking
   - (v) Evaluation

2. **Material and Content**
   - (i) Figure content
   - (ii) Symbolic content
   - (iii) Semantic content
   - (iv) Behavioural content

3. **Product**

   Units: To grasp sensory perceptions into their uniqueness.

   Classes - The ability to categorise ideas.
Relations: The ability to understand the relation existing between things.

Systems: The ability to group ideas or problems into space or the ability to structure problems for solutions.

Transformations: The ability to give suggestions for the necessary transformation or the ability to predict the future shape of a certain object or situation under a certain circumstance.

Implications: The ability to understand the implied meaning.

Howard Gardner - Multiple Intelligences:

One of the more recent ideas to emerge is Howard Gardner’s theory of multiple intelligences. Instead of focusing on the analysis of test scores, Gardner proposed that numerical expressions of human intelligence are not a full and accurate depiction of people’s abilities. His theory describes eight distinct intelligences that are based on skills and abilities that are valued within different cultures. The eight intelligences Gardner described are: Visual-spatial Intelligence; Verbal-linguistic Intelligence; Bodily-kinesthetic Intelligence; Logical-mathematical Intelligence; Interpersonal Intelligence; Musical Intelligence; Intrapersonal Intelligence and Naturalistic Intelligence

Verbal/Linguistic Intelligence: Verbal/linguistics intelligence demands susceptibility to spoken as well as written languages, the potential and capability to use language theory to achieve particular goals. It is the effective use of language (Christion and Kennedy, 1999). This is concerned with written and spoken expression. It is the
manipulation of language and communication of words skillfully (Mbuva, 2003).

A person having sound verbal/linguistics intelligence background not only listens to but also responds carefully to sounds, rhythm, colour and variety of the spoken words. Similarly, he/she acquires and learns through the practice of listening, reading, writing and discussing. Likewise, his or her listening is strong as he or she understands through, expresses the meaning in a better way, elucidates and can recall what he or she has listened to; more over he/she studies and speaks clearly, explains, explicates or clarifies and brings to mind what he or she has read, and last but not the least, he or she shows the potential to become proficient in other languages and uses the skills of listening, speaking, writing and reading and thus to convey and explain in order to convince others.(Laughlin, 1999).

Logical/Mathematical Intelligence : It requires reasoning whether deductively or inductively. It also uses and identifies intellectual patterns and links. It is relevant to those who enquire into different issues and try to reach at scientific conclusion (Gardner, 1999:42). It is the capability to create sequence in solving a problem to make scientific analysis of a problem, recognize patterns and to use numbers and do mathematical operations easily and to deal with different phenomenon successfully. The person, endowed with high degree of Logical/mathematical intelligence shows expertise while solving logical problems. Similarly, he is fond of complex operations i.e. computer programming and research methods. Even his anticipation and points of view are based on
mathematics. Moreover, his interest lies in different professions such as computer technology, law, engineering and chemistry (Laughlin, 1999).

Different kinds of people show a high-level of this kind of intelligence. For example, scientists, mathematicians, philosophers, logician, computer programmer, accountants. Apart from this, there are many instances of such people throughout the ages who showed this kind of logical or mathematical intelligence.

**Visual/Spatial Intelligence** : It is the potential to produce visual spatial representation of the world and move that representation either mentally or concretely. It promotes the capability to identify and operates the shape of wide space as well as the shape wide none restricted ones (Gardner, 1999: 43). It involves manipulating objects mentally in order to deal with and solve problems successfully. A person who possesses a high degree of visual/spatial intelligence acquires skills through observation, identifies different objects, shapes, colours, scenes and other necessary details and for this purpose he makes use of visual images in calling to mind those information. He also produces solid or visual representation of information. Moreover demonstrates liking for becoming artist, photographer, engineer, architect and designer (Laughlin, 1999).

**Musical/Rhythmic Intelligence** : It involves the potential to perform, compose or appreciate the pattern of music (Gardner, 1999). It also incorporates or covers susceptibility to pitch of sound or rhythm of sound. In addition, it is also responsive to emotional suggestions to these elements. Any person, blessed with visual/spatial intelligence generally
listens to different sounds and gives positive response (White, 1995). He likes and tries to find out favorable time to listen to music or sounds of the environment, replies to music by dancing, collects information regarding music and tries to enhance the ability of singing and play the musical instruments. He often likes to play with sounds, he can also conclude musical phrases in a song and he or she may have a great intention for career such as singer, instrumentalist or sound engineer (Laughlin, 1999).

Usually composers, instrumentalists, vocalists and bird singing lovers possess a high level of this intelligence.

**Bodily/Kinesthetic Intelligence**: It is the potential to use different organs of the body adroitly to convey ideas and feelings. It is the capability to use different types of equipments, objects and apparatuses competently. Examples of this type of intelligence are body acting, carving, sports, drawing, calligraphy, dancing, medical operations, and scientific laboratory skills. People with high Bodily/kinesthetic intelligence discover environment through touch and movement, learn well by direct participation and remember what was done rather than what was said, enjoy learning through activities and practical experiences, remains sensitive to physical gestures, exhibits interest in athletics, dancing, acting etc.

**Interpersonal Intelligence**: It indicates a person’s magnitude of understanding other people such as their wishes desires etc. and as a result works efficiently and diligently with other people (Gardner, 1999). It is the potential to know ideas, intentions, feeling and motivation of
other people and to channelize and use them properly. It is the ability to understand the importance and establishing interrelationship with people. Any individual who is endowed with interpersonal intelligence forms social links and makes use of different ways to communicate to others, discerns and recognizes the feelings, thoughts and behaviors of others, it has an impact on opinions and actions of others, comprehends and imparts effectively, modifies behavior according to different situations, conditions or groups, conveys and shows enthusiasm in socially oriented careers such as politics, administration, guidance, social work and teaching, (Laughlin, 1999).

**Intrapersonal Intelligence**: It demands the ability to comprehend one’s own wishes, fears and abilities. Furthermore, it also refines the use of that information which is helpful in supervising or managing one’s own life (Gardner, 1999). It includes the understanding of own thoughts, imagination, interests, strengths, weaknesses and innermost feelings. People who are intra personally intelligent opt for self actualization.

**Naturalistic Intelligence**: According to Gardner (1999), Naturalistic Intelligence is the ability to recognize different things according to their prominent common characteristics and attributes among them. This capability is decisively concerned to the creation of meaningful classification of both living and non-living things. Therefore, categorization tasks of this type would appear to be of highest importance and measure of the naturalistic intelligence.
1.8 ROLE OF INTELLIGENCE IN MOTOR LEARNING:

Recent research on variables include (a) the effects of a model’s skill level during observation, (b) how augmented feedback is provided to a learner and (c) how practice conditions are arranged when learning multiple tasks. The results of research in these areas suggest that cognitive processes play an important role during the early stages of skill acquisition. Moreover, the effort by which these cognitive processes are undertaken is influenced by practice variables. Motor learning is enhanced when these variables are manipulated to promote cognitive effort by a learner.

Early theoretical views of motor learning suggested that the motor commands and the sensory feedback that resulted from the movement were all that needed to be stored in memory for learning to occur (Adam, 1971). By this view, thinking was not too important for purposes or motor learning. More recent views stress the role of cognition in motor skills (Magill, 1993b; Schmidt, 1988). In general, cognition refers to a collective group of thought processes. The hockey goalie tries to predict the direction of a shot by searching for perceptual clues that provide advance information. The golfer without a clear shot to the green tries to remember how to hit a controlled fade. The figure skater about to perform a triple axle jump followed immediately by a triple toe loop must prepare for this combined action with the flexibility in mind to change the plan if something goes wrong. All of these are examples of decision making processes regarding the anticipation, planning, regulation and interpretation of motor performance.
Accepting that cognition plays an important function in performing motor skills, the question of the role of cognition during practice takes on more importance. Motor learning involves more than storing sensory and motor information that arises as a consequence of movement. Skill is highly cognitive (Starkes & Allard. 1993), and the cognitive processes that subserve movement must be practiced as well.

Proper perception and cognition about a skill play an important role in its acquisition. This process has many facets, for example, the ability of the learner to perceive things correctly, to pay desired amount of attention to the on-going activity, to discriminate between relevant and irrelevant cues, to assimilate vital information, and translate important ideas into practice it has been noticed that young children find it difficult to absorb too much of theoretical information because they are naturally very active and concentrate on “doing” things rather than attending to often boring dialogues. Much better results can be expected when children watch a crisp, perfect and neat demonstration of a skill adequately. Too much theorizing falls flat on their ears. Those who have learnt the gross elements of a skill have also developed the cognitive ability to process information about fine elements of the skill. Therefore, demonstration – whether live or through visual media - is of utmost importance in projecting skills as they should be performed by children. It serves as a model for the students to imitate by using their insight, skill of observation and mental abilities.

Most motor skills need no theorizing. They are practical activities and involve a few practical procedures; observing the skills, imprinting their image on the mind-screen using insight to understand the
movement-sequence, performing the sequential movement to the point of automatization, improving performing efficiency by gradually removing blocks in the transmission channels, an using feed-back loop to bring about correct and adequate practice.

While scanning related literature it was found that Vermon P.A. (1982), Julie F.H. et al (1992), Mier van H. et al (1998), Kenneth M. Heilman et al (2000), Ramnani N. (2000), Eisenmann J. (2003), Planinsec J. (2006), in their studies explored various aspects of brain hemisphericity and its effect on motor coordination, intelligence and style of learning and thinking but so far no study in Indian context was found to be conducted in which effect of brain hemisphere domination and intelligence was ascertained on motor educability of adolescent Indian boys and girls. Thus, in the present study effect of brain hemisphere dominance on motor educability of adolescent boys and girls was explored in relation to their intelligence.

1.9 OBJECTIVES OF THE STUDY:

Researches pertaining to association of motor educability with dominant right or left brain hemisphere and intelligence are far and few, therefore present study has been taken into the consideration.

The aim behind this study is -

1. To assess effect of brain hemisphere domination on motor learning of adolescent boys and girls.
2. To assess the effect of intelligence on motor learning of adolescent boys and girls.
3. To assess the joint effect of brain hemisphere domination and intelligence upon motor learning among adolescent boys and girls.
1.10 **STATEMENT OF THE PROBLEM:**

It is not always possible for researcher to formulate his problem simply, clearly and completely. He may obtain rather general, defuse, even confused notion of the problem. This is in the nature of the complexity of scientific research. It may even take an investigator years of exploration, thought, and research before he can clearly say what question he has been seeking answer to. Nevertheless adequate statement of the research problem is one of the most important parts of research. Hurlock mentioned that the problem is stated in interrogative form, the simplest way is here the best way. Also note that the problem states a relation between variables. (Kerlingar, 1983)

In order to materialize the objective of the present study stated in this chapter, as per canons of scientific enquiry, the best way is to frame relevant and research-worthy problems and that too in the form of an interrogative statements (Kerlingar, 1965), and to seek scientific solution to those problem through empirical verification of the related and research-worthy hypothesis. Therefore, an attempt has been made to frame the pinpointed problems in a question form. The same are registered, here as under:

1. Do motor educability in adolescents is dependent upon their brain hemisphere dominance?
2. Do intelligence has any role in influencing the motor educability of adolescents?
3. Does brain hemisphere domination and intelligence, alone or in interaction with each other, create variance upon motor educability in adolescents.
1.11 DELIMITATIONS:

It is to be registered here that this piece of research should not be over-generalized as they are delimited to the population from which the sample will be drawn.

The study is delimited to motor educability, intelligence, brain hemisphere dominance and one demographic variable sex of the selected subjects. The study is delimited to know the effect of brain hemisphere domination and intelligence on motor educability of adolescent boys and girls of age group 12-15 years respectively.

1.12 LIMITATIONS:

In present study some factors like socio economic status, mental imagery, parental influence on children, depth perception, personality, attention, concentration and memory were not be taken into consideration and these factors were beyond the control of investigator and might affect the results.

With an intention to offer a scientific solution to above-mentioned problem in the light of previous findings, the following hypotheses have been proposed for verification.

1.13 HYPOTHESES:

Differential Hypotheses:

1. Significant differences will be observed in motor educability of selected subjects with right, left and integrated brain hemisphere dominance.

2. Significant positive relationship will be observed in motor educability of selected subjects with their cognitive ability i.e. intelligence.
3. Significant differences will be observed in verbal intelligence of selected subjects with right, left and integrated brain hemisphere dominance.

4. Significant differences will be observed in non-verbal intelligence of selected subjects with right, left and integrated brain hemisphere dominance.

5. Significant differences will be observed in intelligence quotient of selected subjects with right, left and integrated brain hemisphere dominance.

6. Significant differences will be observed in motor educability of selected subjects on the basis of urban-rural belongingness.

7. Significant differences will be observed in verbal intelligence of selected subjects on the basis of urban-rural belongingness.

8. Significant differences will be observed in non-verbal intelligence of selected subjects on the basis of urban-rural belongingness.

9. Significant differences will be observed in intelligence quotient of selected subjects on the basis of urban-rural belongingness.

10. Significant differences will be observed in motor educability of selected subjects on the basis of their caste.

11. Significant differences will be observed in verbal intelligence of selected subjects on the basis of their caste.

12. Significant differences will be observed in non verbal intelligence of selected subjects on the basis of their caste.

13. Significant differences will be observed in intelligence quotient of selected subjects on the basis of their caste.
14. Age will show its positive association with motor educability of adolescent boys.
15. Age will show its positive association with verbal intelligence of adolescent boys.
16. Age will show its positive association with non verbal intelligence of adolescent boys.
17. Age will show its positive association with intelligence quotient of adolescent boys.
18. Age will show its positive association with motor educability of adolescent girls.
19. Age will show its positive association with verbal intelligence of adolescent girls.
20. Age will show its positive association with non verbal intelligence of adolescent girls.
21. Age will show its positive association with intelligence quotient of adolescent girls.

**Interaction Oriented:**

21. Brain hemisphere dominance and intelligence quotient (IQ) will show its joint effect on motor educability of adolescent boys.
22. Brain hemisphere dominance and intelligence quotient (IQ) will show its joint effect on motor educability of adolescent girls.
23. Brain hemisphere dominance and gender will show its joint effect on motor educability of selected subjects.
24. Brain hemisphere dominance and caste will show its joint effect on motor educability of adolescent boys.
25. Brain hemisphere dominance and caste will show its joint effect on motor educability of adolescent girls.

26. Brain hemisphere dominance and urban-rural belongingness will show its joint effect on motor educability of adolescent boys.

27. Brain hemisphere dominance and urban-rural belongingness will show its joint effect on motor educability of adolescent girls.

1.14 SIGNIFICANCE OF THE STUDY:

The present study will reveal valuable information in the following areas of interest:

- The findings obtained from this research work related to motor educability of adolescent boys and girls with relation to their brain hemisphere dominance will be helpful for physical educators to include various modes of motor educability programs while designing a curriculum on the basis of brain hemisphere dominance.

- The role of intelligence in enhancing motor educability of the adolescents can be ascertained properly through the data obtained from this research work.

- The study will also provide valuable information on motor educability in terms of brain hemisphere domination and gender.

- Apart from this, effect brain hemisphere dominance and intelligence upon motor educability together, can be ascertained by the results of the present study.