Neuropsychology is considered to be a new discipline within the field of psychology. The modern field of neuropsychology emerged in the twentieth century, which includes objective observation of behaviour and the use of statistical analysis to differentiate functional abilities and define impairment in neuropsychology. Osler was the first who used the term ‘Neuropsychology’ in 1913 while addressing in a hospital and expressed the hope that ‘time may be found for general instruction of the senior class in the elements of neuropsychology’ (Bruce, 1985). In January 1963, the journal Neuropsychologia contained an editorial in which the term ‘Neuropsychology’ was defined as a particular area of neurology of common interest to neurologists, psychiatrists, psychologists and neuropsychologists. It is a broad term which includes a wide area of clinical and scientific activity. This area of neuropsychology encompasses the study of the structure and functions of the brain related to specific psychological processes (emotions, personality, thinking, learning and memory) and how behaviour may influence the brain and related physiological processes and vice-versa. Here, knowledge about the relationship between brain and behavior is obtained through the study of both healthy and damaged brain system. Neuropsychology is a structured, objective, and scientific method for peeking into the brains of individuals, by way of formally observing behaviours. It is scientific in its approach and shares an information processing view of the mind with cognitive psychology and cognitive science.

The history and origin of neuropsychology can be traced back to the “Third Dynasty of ancient Egypt” (Finger & Stanley, 2000). In 3500 B.C., Imhotep, an esteemed priest, is considered to be the major pioneer in the history of understanding the brain. He provided information on different forms of trauma and abnormalities in the brain and body. Hippocrates in 5th century B.C. explained the connection between brain and behaviour and turned the focus of the researchers from heart to brain. According to Hippocrates, “The brain exercises the greatest power in the man.”
Earlier, in the Seventeenth century, French Philosopher, Descartes explained about the localization of human soul in a specific structure of brain, i.e. the pineal gland. In 1861, Broca, Wernicke, and Dax focused on the phenomenon of language i.e. how speech is understood and produced. Broca (1861) discovered that loss of language abilities is related to left hemisphere of the brain. He was the first to describe the concept of cerebral dominance of language in the left hemisphere. In Eighteenth century the concept of localization of function was popularized with the work of Gall; who proposed the phrenological theory that explained the relation between damage to specific brain areas and certain adaptive behaviours.

During the First World War, neuropsychology did not get much attention because of the major changes in the field of psychology and neurology, when Watson (1913) proposed his behaviorism theory. Lashley (1938) was the first who systematically studied the neural basis of memory and proposed the theory of mass action. However, he could not identify any concrete localization after many years of animal experimentation and commented that “It is not possible to demonstrate the isolated localization of a memory trace anywhere in the nervous system” which was later conceptualized as the concept of equipotentiality.

The modern field of neuropsychology emerged after the Second World War. In the mid 1950’s, psychologists acknowledge that the structure and nature of mental information processing system could be assessed in more scientific ways. They developed and applied new cognitive processing models to explain experimental data from studies of speech and language. During the 1960’s, information processing was the leading approach in psychology for understanding mental processing which provided an important theoretical basis for cognitive neuropsychology. Two principle goals of neuropsychology were formulated by Luria (1968), where the first was to identify localized brain lesions and the other is to analyze psychological activities arising from brain functions through behavioral observation.

**Neuropsychological Assessment**

Neuropsychology, a field with its historical origin in both psychology and neurology, was influenced by the concept of mass action of brain function and the concept of localization of brain functions was considered as a secondary goal for the
assessments. The psychological tests focused on the simple examination of the presence or absence of brain damage. Neuropsychology developed as a field after the Second World War; when Halstead (1947) observed brain damaged individuals in natural conditions and identified certain specific characteristics of their behaviour and developed the Halstead-Reitan Neuropsychological Battery with his pioneer Reitan. Then Luria-Nebraska Neuropsychological Battery was developed by 1980, and was used in place of Halsted-Reitan Neuropsychological Battery. Although these two approaches provided different methods for determining the neural integrity, a flexible battery approach was used by the contemporary clinical neuropsychologists.

The main attention of neuropsychological assessment was towards diagnosis, before the emergence of neuro-imaging techniques. Since clinicians lacked non-surgical methods for directly observing brain lesions or structured abnormality in living patients, neuropsychological assessment was the only way to determine which part of brain was affected. In clinical settings, assessments of neuropsychological functions help in differentiating between neurological disorders and normal aging, and discriminate between neurological disorders. This assessment also helps in identifying the behaviors which could discriminate persons with localized brain lesions from those with other neurological problems (Lezak, Howieson, & Loring, 2004). Thus, neurologists are able to identify patterns of behaviours which are regulated by particular brain regions, thereby providing a behavioural index for estimating the location of anatomical dysfunction in the brain (Lezak et al., 2004).

Practitioners depend upon neuropsychological test scores (single session or compared across various occasions, which may be spaced annually or even after a longer period). Diagnoses made after single assessment are made by comparing an individual’s performance with established norms. Diagnoses which are made on the basis of repeated assessments at different time intervals provide a reliable index for identifying cognitive decline in a person. However, in this case the obtained scores are generally averaged and compared with the normative sample. Thus, the pattern of decline gets masked and the utility of the repeated measure is lost.

Neuropsychological assessment can provide critical information about the integrity of the central nervous system and give a detailed picture of neuro-cognitive
functioning across a wide range of abilities. This evaluation plays an important role in distinguishing neurogenic from psychogenic (psychological) conditions, and sort out how problems in one domain of functioning impact the other.

This area of neuropsychological assessment is differentiated from other forms of assessment because of its way to understand behavioral and psychological functioning in terms of brain-behavior relationships. It provides both general and specific information about current level of cognitive performance. The aim of neuropsychological assessment is to assess the extent of impairment to a particular skill and to attempt to determine the area of the brain which may have been damaged following brain injury or neurological illness. Miller (1992) explained three main goals of neuropsychological assessment, first to ascertain the nature of underlying problem, second to understand the nature of brain injury or resulting cognitive problem and its impact on the individual and the last is to measure change in functioning over time.

There is no specific method for diagnosing neuropsychological deterioration. Different techniques have been used over the years for neuropsychological assessment. These have been summarized in Table 1.1

Table 1.1

<table>
<thead>
<tr>
<th>Methods</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehensive Standardized</td>
<td>Luria-Nebraska battery, Halstead-Reitan neuropsychological battery,</td>
</tr>
<tr>
<td>Battery</td>
<td>Cambridge Neuropsychological Test Automated Battery (CANTAB),</td>
</tr>
<tr>
<td></td>
<td>and Multi-lingual Aphasia Examination</td>
</tr>
<tr>
<td>Specific Neuropsychological</td>
<td>Wechsler Adult Memory Scale (WMS), Wechsler Adult Intelligence Scale</td>
</tr>
<tr>
<td>Test</td>
<td>(WAIS), Luria-Nebraska Neuropsychological Battery, Halstead-Reitan</td>
</tr>
<tr>
<td></td>
<td>Neuropsychological battery, Boston Naming Test, Wisconsin Card</td>
</tr>
<tr>
<td></td>
<td>Sorting Test, and AIIMS Battery</td>
</tr>
<tr>
<td>Brain Scans</td>
<td>Magnetic Resonance Imaging (MRI), Brain Electrical Activity Mapping</td>
</tr>
<tr>
<td></td>
<td>(BEAM), functional Magnetic Resonance Imaging (fMRI), Position</td>
</tr>
<tr>
<td></td>
<td>Emission Tomography (PET), and Computed Axial Tomography (CAT),</td>
</tr>
<tr>
<td></td>
<td>and functional Position Emission Tomography (fPET)</td>
</tr>
<tr>
<td>Electrophysiological Measures</td>
<td>Electroencephalography (EEG), or Magnetoencephalography (MEG), Event-</td>
</tr>
<tr>
<td></td>
<td>Related Brain Potentials (ERP)</td>
</tr>
<tr>
<td>Computerized Tests</td>
<td>Cambridge Neuropsychological Test Automated Battery (CANTAB),</td>
</tr>
<tr>
<td></td>
<td>and California Computerized Assessment Package (CalCAP)</td>
</tr>
</tbody>
</table>
Brain Function Involved in Cognitive Processing

Brain is very complex and important organ of the human body. Cerebral cortex is one of the important parts of human brain that makes the individual unique from others. It plays a key role in cognitive functioning (memory, language, reasoning & other higher order functioning). Cerebral cortex consists of two hemispheres (Left hemisphere & Right hemisphere) where each is further distinguished into four lobes (Frontal lobe, Parietal lobe, Temporal lobe & Occipital lobe).

Left Hemisphere regulates the right side of the body and appears to be involved in language processing, logical reasoning, and functions of speech. On the other hand, Right Hemisphere controls the left side of the body and dominants in the visual-spatial skills, creativity and perception of direction.

Lobes of the brain

Cerebral cortex has four lobes related to various cognitive functions. A brief description of these lobes is as follows:

1. The Frontal Lobe is situated at the front part of the brain. It links and integrates all components of behaviour at the highest level. Frontal lobe is related with executive function, motor performance, abstract reasoning, expressive language, initiation and inhibition of behaviour, self-monitoring, awareness of abilities / limitations, mental flexibility and higher order cognitive function. It is associated with goal-directed behaviours and emotional modulation. Frontal lobe is considered to be the moral center of the brain. The frontal lobe is highly susceptible to injury.

2. The Parietal Lobe is placed in the middle area of the brain and processes the sensory skills specifically the tactile sensory information (touch, pressure, & pain), spatial perception, visual perception and academic skills. The somatosensory cortex present in this lobe is responsible for the processing body senses. Parietal lobe is largely involved in construction ability and language. Injury to the front part of this lobe may cause someone to lose sensations on some parts of the body and one may become disorientated.

3. The Temporal Lobe is placed at the bottom of the brain and is associated with sensory input including auditory information, language comprehension, perception and recognition of verbal material, naming and retention of short-term and long-term
memory. Hippocampus is placed in the temporal lobe; therefore the lobe is related with formation of memories. It is also related with emotional responses and regulation of biological drive of sexuality. The specific Wernicke’s and Broca’s area control speech comprehension and are related to production of speech.

4. *The Occipital Lobe* is situated at back section of the brain. It is the visual processing center of the brain that is related with interpreting visual stimuli and provides the information, related with reading, perception and recognition of words. Brain areas are associated with cognitive functioning and if there is any damage or injury in the brain areas it results in disturbance to the related cognitive domain. The observed problems are presented in Table 1.2.

Table 1.2

*Damaged Brain Areas and Related Disturbances in the Cognitive Functioning*

<table>
<thead>
<tr>
<th>Damaged Area</th>
<th>Observed Cognitive Disturbances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal Lobe</td>
<td>Disturbances of executive functioning, Rigidity of cognitive processing, Disturbance of abstract thinking and logical analysis, Disturbance in regulation of emotions, Disturbance of expressive language and focused attention, Personality changes, Changes in sexual habits, Disorganization of motor actions, Disturbance in memory functions, and Social inappropriateness</td>
</tr>
<tr>
<td>Parietal Lobe</td>
<td>Disturbance of sensory-perceptual processes, Disturbance in verbal memory, Language problem (receptive language), impaired location and topographical memory, Construction apraxia, and Spatial dyslexia and agnosia</td>
</tr>
<tr>
<td>Temporal Lobe</td>
<td>Defects of auditory-perceptual processes, visual organization disorders, Disturbance of short-term memory, Disturbance of receptive language, Aphasia, and Amnesic syndrome.</td>
</tr>
<tr>
<td>Occipital Lobe</td>
<td>Partial or total blindness, Disturbance in depth and colour perception, difficulty in tracking moving objects, and visual agnosia,</td>
</tr>
</tbody>
</table>

*Adapted from: Hallett (1993)*
Indices of Neuropsychological Assessment

The primary activity of a neuropsychologist is to assess the brain functioning through structured and systematic behavioural observation. A neuropsychological assessment consists of administering tests that evaluate a set of independent functional domains that are controlled by brain system. It is not bound to examine the measure of intelligence or achievement, but assesses other areas of functioning also. Neuropsychological tests are designed to assess a number of cognitive functions. Cognitive functions refer to the complex set of behavioral tasks served by the brain. Neuropsychology assessment, not only encompass the sensory and motor processes but the higher-order functions such as language, memory and thinking, organizational functions (problem solving, reasoning, & decision making), and executive function also; which are altered because of changes in nervous system. Neuropsychologists can make presumptions about the underlying brain function with the help of testing a number of cognitive functions and assessing patterns of performance in various cognitive areas. These cognitive functions which are likely to be assessed in neuropsychological assessment are as follows:

Motor Function: It is the ability to perform fine and gross motor tasks, and the ability to perform purposeful tasks of particularly significant interest in evaluating differences between the two sides of the body. In fine motor functions small movements (like writing, & tying shoe laces) are involved, whereas gross motor function are involved in large movements (such as walking, jumping, & kicking). Motor performances are carried out when brain, nervous system and muscles work together. Motor dysfunction appears when individuals are deficient in the ability to move in the way in which they intend to.

Perceptual-Sensory Processes: Sensation is concerned with the initial contact between organisms and their physical environment. It focuses on describing the relationship between various forms of sensory stimulation and how these inputs are registered by the sense organs (the eyes, ears, nose, tongue, and skin).

In contrast, the study of Perception is concerned with identifying the processes through which the information is interpreted and organized to produce the conscious experience of objects and relationships among objects. It is important to remember that perception is not simply a passive process of decoding incoming sensory
information. The dual processes of sensation and perception play a role in virtually all domains of cognition. However, all of the sensory information in the environment cannot be absorbed as processing capacity of humans is limited. Thus, an individual attends selectively to certain aspects of environment while relegating others to the background (Johnston & Dark, 1986).

Attention: This is the ability to focus and sustain concentration on a stimulus of interest. This is the capability to maintain simple accuracy in a sustained focus task, mental manipulation and control, and resistance to internal or external distraction. Selective attention has obvious advantages, in that it allows an individual to maximize information gained from the object of focus while reducing sensory interference from other irrelevant sources (Matlin & Foley, 1997). Although a person can focus his attention for a prolonged period, certain features, such as intensity of stimulus, novelty, contrast, colour, and sudden changes in the stimuli cause a sudden shift in attention.

Memory: Memory is the way in which individuals’ record the past for later use, in the future. Without memory, an individual would not be able to remember the past, retain new information, solve problems, or plan for the future. Memory is simply a blanket term for a large number of processes that form bridges between past and present. Baddeley (1990, 1996) explained that memory is an active system that receives, stores, organizes, alters and recovers information. Human memory must accomplish three basic tasks: (i) encoding – converting information into a form that can be entered into memory, (ii) storage – somehow retaining information over varying periods of time, and (iii) retrieval – locating and accessing specific information when it is needed at later times. Traditionally, memory can be divided into three types as sensory memory, short-term or working memory, and long-term memory.

Sensory memory is the ability to retain impressions of sensory information for the selection in attentional processes and permits the stimuli to enter into short-term memory. Short-term memory is the ability to remember and process information at the same time. Some part of the information passed to this part of the brain from sensory memory is converted into an appropriate code.

Long-term memory is the most complex because it stores several aspects of an individual’s experiences. It involved the process of consolidation in which short-term
memories become the long-term memories with rehearsal and meaningful association. Long-term memory can be further divided into two types: Retrospective, where the content which is to be remembered is in the past (declarative memory and procedural memory) and Prospective where the content which is to be remembered is in the future. It is defined as “remembering to remember” i.e. remembering to perform an intended action. It can be event-based or time-based and is triggered by an overt or covert cue, such as taking a prescribed medicine (action) at 8 am (cue), or remembering to convey a message (action) on meeting a specific person (cue). Declarative memory is the memory of events, facts, and concepts. Procedural memory is the unconscious memory of skills and habits and how to do things.

Language: it is an established fact that the ability to use language for communication differentiates human beings from other animals. Although elaborate communicating systems have been identified in many animals and insects (bees, ants, monkeys, apps etc) the humans are the only species who used symbols which are combined on the basis of a set of rules, thereby providing a mechanism for communicating information. It involves the use of symbols for communicating information. Therefore, information must be transmitted by symbols to be viewed as a language. Language is the ability to receive and express thought through different forms of symbolic manipulation. The words and sentences must carry meaning and the meaning of these combinations must be independent of the settings in which they are used. In other words, sentences must be able to convey information about other places and other times.

Executive Function: Executive functions are defined as “those capacities that enable a person to engage successfully in independent, purposive, self-serving behaviour” (Lezak, 1995, p. 45). This domain deals with a variety of higher-order functions such as thinking, reasoning, decision making and problem solving. It is a broader concept that involves regulations of motor activity or capacity for productivity of cognitive processes. It is also known as cognitive control or supervisory attentional system because this function manages the prioritized task, set and achieve goals, filter distractions and control impulses for the brain. It is the ability to achieve insight and self-awareness, to reflect on, to initiate, evaluate, and regulate (activate and inhibit)
thinking and behaviour, to think flexibly, and to make decisions integrating judgment and feedback. Executive functioning is controlled by the frontal lobe and basal ganglia of the brain. Therefore, if there is any impairment in these areas it will appear as executive dysfunction.

**Intelligence:** It is the general mental ability of abstract thinking, reasoning, to comprehension, to adaptation, to learn, to perceive information. “Intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment” (Wechsler, 1944). It is not a specific domain but a combination of various domains. Therefore, intelligence is included in neuro-functional assessment.

The neuropsychological functions and their domains of assessment are explained in the Table 1.3, which have been developed as a result of brain-behaviour relationships and empirical studies of specific disorders.

<table>
<thead>
<tr>
<th>Neuropsychological Functions</th>
<th>Domains of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Functions</td>
<td>Fine and gross motor coordination</td>
</tr>
<tr>
<td></td>
<td>Graphomotor Functions,</td>
</tr>
<tr>
<td></td>
<td>Praxis</td>
</tr>
<tr>
<td>Sensory-Perceptual Process</td>
<td>Visual-perceptual, visual-spatial, and visual-cognitive Functions,</td>
</tr>
<tr>
<td></td>
<td>Auditory, visual, and tactile-kinesthetic Perception, Finger agnosia</td>
</tr>
<tr>
<td>Attention</td>
<td>Selective Attention and Vigilance</td>
</tr>
<tr>
<td></td>
<td>Initiating, sustaining, and shifting of Attention</td>
</tr>
<tr>
<td></td>
<td>Inhibiting distractions</td>
</tr>
<tr>
<td>Memory</td>
<td>Working Memory, Short-Term Memory</td>
</tr>
<tr>
<td></td>
<td>Long-Term Memory (Episodic, Semantic and Procedural), Prospective Memory</td>
</tr>
<tr>
<td>Executive Function</td>
<td>Mental tracking and cognitive flexibility</td>
</tr>
<tr>
<td></td>
<td>Dynamic motor coordination and integration, concept formation, Alertness and arousal, Act impulsively, visual search and planning</td>
</tr>
<tr>
<td>Intelligence</td>
<td>Performance on intelligence measures</td>
</tr>
</tbody>
</table>

*Adapted from: Black & Stefanatos (2000)*
Causes of Neuropsychological Decline

Neuropsychological decline frequently starts during the early 30’s, starting with a decrease in processing speed. Although most individuals would be worried about the common diseases like obesity, high blood pressure and heart attack or stroke, but there is very less concern about the slowing or fatigued brain which is the reason behind the cognitive as well as physiological aberrations. Many individuals do not realize that their mood, level of anxiety, weight, depression and insomnia are all the physical manifestations of what is going on in the brain. Neuropsychological impairment has a wide range of causes including medical/physiological disorders, neuro-generative diseases, brain disorders, medications and even life style factors. Several health problems such as diabetes, hypertension, heart attacks, and strokes, which become more common with age-related changes in brain, increase the risk of neuropsychological deterioration. The various causes of neuropsychological decline are presented below:

Aging: Many people assume that neuropsychological decline is exclusively caused by aging. Older adults required more time to register and process information because there neural processing speed slows down as they age. Results of numerous available studies indicated that disease of virtually any physiological system can have deleterious effect on neuropsychological functions and these influences may be particularly pertinent to older adults, who experience an increased incidence and prevalence of disease (Elias, Elias, & Elias, 1989; Siegle & Costa, 1985). Further explanation of neuropsychological decline due to aging has been detailed in the next section on aging.

Trauma: Brain injury causes various cognitive, emotional, and physical disorders to the individual. Severity of the disorder depends upon the nature of the brain injury. Individuals having mild Traumatic Brain Injury (mTBI) show acute effects on attention, processing speed and short-term memory (Vincent, Roebuck-Spencer, & Cernich, 2014), whereas patients suffering with moderate-to-severe TBI show global chronic cognitive deterioration including impaired fine-motor speed, attention, learning, memory, processing speed, language, and executive function (Levin, 1993; Millis, Rosenthal, Novack, Sherer, Nick, Kreutzer, et al., 2001).
Cardiovascular disease: Neurologists agree that if there is something bad for our heart that is also bad for our brain. Medical conditions such as hypertension, diabetes, high cholesterol that have been related to heart disease, are also linked to neuropsychological deterioration.

Individuals with high blood pressure are more prone to neuropsychological decline specifically memory loss as compared to individuals with normal blood pressure. Hypertension may impair neuropsychological functioning by damaging the white matter of the brain. The white matter lesions are very small lesions in axons of the brain which affect cognitive functions particularly reasoning and memory (Dinesh, 2009; Lawson, 2003). Individuals with high total serum cholesterol have a higher risk for dementia and cognitive decline (Anstey, Lipincki, & Low, 2008).

Diabetes is considered to be a major risk factor for stroke and micro-vascular changes which are associated with vascular cognitive impairment. Therefore diabetes may increase the risk of Alzheimer’s disease (Wang, Lin, Sung, Wu, Hung, Wang, et al., 2012). Research has also indicated that both diabetes and hypertension cause global memory and neuropsychological dysfunction that is because of extensive impairment in lobe functions (Dinesh, 2009)

Malnutrition: Nutrition plays an important role in maintaining good health. Nutrients are bioactive molecules that are essential for human health and functioning (Morris, 2012). Malnutrition can ultimately cause neurological and psychological disorders. Deficiency of vitamin B1 (Thiamin) causes beriberi and Wernicke’s encephalopathy, vitamin B3 (Niacin) deficiency causes pellagra including dementia and depression. Children and elderly people have cognitive dysfunction due to lack of Folate (Folic acid). Vitamin B6 deficiency causes neuropsychiatric disorders including migraine, depression and chronic pain (Malouf & Grimley, 2006). One of the most important vitamins, vitamin B12 deficiency resulting in damage to the central and peripheral nervous system and cause age-related cognitive impairment (Schrag, 2006). Neurological disorders characterized by sensory loss, ataxia, and retinitis pigmentosa are observed in vitamin E deficient individuals (Aslam, Misbah, Talbot, & Chapel, 2004). Minerals like iron, zinc deficiency causes depression, delayed mental and motor development (Black, Baqui, Zaman, Persson, Arifeen, Li, et al., 2004).
**Hormonal Imbalance:** Hormonal imbalance also has an effect on the neuropsychological functioning. Parathyroidism can lead to the growth of calcification throughout the body and brain; and level of calcification in brain is associated with impaired brain processing speed. Therefore, hypothyroidism is associated with poor concentration, memory disturbances, depression, and decreased neuropsychological functioning (Braverman, 2007).

In women, levels of estrogen decrease very fast during menopause. Estrogen has been associated with the cholinergic system in the brain. Therefore, lower levels of estrogen effectively increase the possibilities of decline in neuropsychological functioning, specifically in memory. Women are at a higher risk of dementia at a younger age as compared to men (Anderson, Launer, Dewey, Letenneur, Ott, Copeland, et al., 1999; Braverman, 2007). There are some bio-identical hormones that may potentially impact neuropsychological decline such as Estrogen, Human Growth Hormone (HGH), Insulin, Progesterone, Calcitonin, Dehydroepiandrosterone (DHEA), Testosterone; Thyroid: T3 & T4, Melatonin, and Oxytocin.

**Pesticides:** Pesticides are associated with a number of health problems such as cancer, obesity, heart disease, brain degeneration and neurological disorders. Studies indicated that pesticides exposure usually generate acute and chronic neurological toxicity (Pingerli & Roger, 1995; Starks, Hoppin, Kamel, Lynch, Jones, Alavanja et al., 2012). Farmers who are in contact with pesticides have extensive long-term and short-term damage of the peripheral nervous system, white blood cells, liver, and kidney. Long-time contact with organophosphate pesticides causes the deterioration of neurological processes (Demers & Rosenstock, 1991; Steenland, Wesseling, Roman, & Juncos, 2013).

Various metals, toxins, and gases are also absorbed through the skin, resulting in brain damage, mental retardation, behavioral problems, and nerve damage. Children exposed to lead in prenatal and postnatal period experience impaired cognitive functions and mental development in their infancy and adolescence (Jedrychowski, Perera, Jankowski, Mrozek-Buzyn, Mroz, Flak, et al., 2009). Mercury exposure causes deterioration in nervous system, hearing, speech and vision (Jung-Duck & Wei, 2012).
Medicines also affect the activity of certain neurotransmitters in the brain which are important for neuropsychological functioning. Medicines such as narcotic pain killers, amantadine for Parkinson’s disease, chemotherapy for cancer, benzodiazepines for anxiety and beta blockers for hypertension, lead to deterioration in neuropsychological functioning.

The above evidences suggests that aging strongly affects the neuropsychological functioning as the influence of the other precipitating factors is moderated by aging. Adults with cardiovascular, cerebrovascular disease and untreated hypertension have reduced flow of blood and oxygen to the brain that cause the deterioration in neuropsychological functioning (Zelinski, Crimmins, Reynolds, & Seeman, 1998).

AGING

Aging is a multidimensional process of physical, psychological and social change. Muhammad, and al-Harawi (1582) explained about aging in his book Ainual Hayat. This book emphasized on the behavioural and lifestyle factors (diet, environment and housing conditions and drugs) which influence aging. Aging is considered an important aspect of human societies, as it not only reflects the biological change but also the social and cultural conventions.

Elderly people are the fastest increasing class of the population. According to the United Nations Population Fund (UNFPA), in 1900, about 3.1 million people or approximately 4 percent of the population, were aged 65 years and above; By 1990, it increased and reached 31.2 million or 12.6 percent of the total population whereas in 2010, approximately 524 million were aged 65 or older, 8% of the world’s population which will reach approximately 22 percent by 2050. Dychtwald (1990) explained that one out of every nine individuals in America is now 65 years or older. The strangest thing is that the oldest age group of the population has increased. The age group of 65 years to 74 years increased by 17 percent only whereas the population above the age of 85 years increased more than double among the years of 1980 and 2000. Clark and Weber (1996) explained the reason behind this growth was improved health care and disease prevention techniques used by the people.
According to the UNFPA (2014) report, India has the world’s highest number of young population aged 10 to 24 years, approximately 356 million which will be 30% or more by 2050. Presently India has around 90 million elderly people and is they are expected to increase to 315 million, constituting 20% of the total population (Alam, James, Giridhar, Sathayanarayana, kumar, Raju, et al., 2012). The health problems increase with age. The Global report of aging in the 21st century reinforces the observation made in India which indicated that there is multiple discrimination experienced by older adults, specifically older women, including problem in access to jobs and health care, subjection to abuse, lack of basic income and social security (UNFPA & Help Age International, 2012).

Stuart and Hamilton (2006) explained in their researches that aging is accumulation of changes in an individual over time. It is a consistent and predictable process which includes growth and development of the individuals. In aging, some dimensions grow and expand over time, while there is a steady decline of organ function and body system in aging. By the age of 65 years the brain undergoes a reduction in weight and protein content, approximately by five to seven percent i.e., probably due to the loss of neurons. However, not all areas of the brain are equally likely to lose cells (Marner, Tang, Nyengaard, & Parkkenberg, 2003). In the hippocampus and cerebral cortex, approximately twenty percent of the neurons and cell counts are lost with advancing age of the individual. These regions of the brain are important for learning, memory, and other neuropsychological functions.

Flood and Coleman (1988) found that physiological and psychological disorders related to aging cause the loss of particular cell types including hippocampal, locus of coeruleus and nucleus basal neurons. Aging depends on the genes, environmental influences, and the life-style. In aging brains, certain specific genes undergo changes, particularly in learning and memory deficit individuals, which were involved in stress and repair mechanism.

Studies indicate that the decline of physical ability that occurs with aging is due to reduced skeletal muscle function (Doherty, Brown, & Vandervoort, 1993). The deterioration varies among individuals; it may be fast or slow. Larsson (1982) explained that individuals’ age because of structural cell changes, which result in
reduced cell function, degeneration, and even death. Aging is considered to be the highest known risk factor for most common neuro-generative disease like dementia, mild cognitive impairment (MCI), Alzheimer’s disease (AD), and Parkinson’s disease (Dilllin, Gottschling, Nystrom, Gottschling & Nystrom, 2014). Darcy (2012) explained that between the ages of 65-74 years, approximately three percent individuals, between 75-84 years about nineteen percent and around fifty percent of individuals aged 85 years and above have dementia.

There are different factors including social support, religion and spirituality, active involvement with life, self-rated health, and cognitive activities which help the individuals to cope with the stressful life events which are concomitant with aging. As physical exercise helps to keep the body healthy and fit, mental activity goes a long way in maintaining the fitness and efficiency of the brain. The cognitive activities stimulate the brain, which results into long lasting positive effect on various neuropsychological functions such as reasoning, thinking, memory, and processing speed. Researchers have suggested three main dimensions of successful aging which include: (i) low probability of disease or disorders, (ii) high physical and cognitive function capacity, and (iii) active engagement with life (Rowe & Kahn, 1987).

Life-Span Development

In human beings development is the process of growth and maturity and of physical, physiological and mental processes. It is an ongoing process which starts from conception and continues till death. Growth is considered as physical change in the body, whereas development means psychological and social changes of an individual. The stages of life span are documented in Table 1.3.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Age (Years)</th>
<th>Biological Changes</th>
<th>Cognitive Changes</th>
</tr>
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<tbody>
<tr>
<td>Infancy</td>
<td>Birth-2</td>
<td>Height and weight, motor skills progress (walking, grasping), teeth appears</td>
<td>Structure of language learned, thinking process, sensory-perceptual ability, grasp conceptural categories develops, emotional responses, early personality traits develops,</td>
</tr>
<tr>
<td>Early Childhood</td>
<td>2-7</td>
<td>Physical strengths increase (running, jumping, hopping), brain attain 90 percent weight, Fine motor skills develop slowly</td>
<td>Use of mental representations and words, language ability develops, Meta-cognition formed</td>
</tr>
<tr>
<td>Childhood</td>
<td>8-12</td>
<td>Brain and physical growth slow, puberty starts, gender specific changes appear</td>
<td>Use analytical language more, logical principle ability develops, abstract thinking develops, long-term memory grows,</td>
</tr>
<tr>
<td>Adolescence</td>
<td>13-19</td>
<td>Body continues to grow in height and weight, motor performance increase, physical changes starts in boys and girls</td>
<td>Formal operational reasoning emerges, thinking becomes self-conscious and idealistic, fluid intelligence develops,</td>
</tr>
<tr>
<td>Early Adulthood</td>
<td>20-39</td>
<td>Body shape changes, sexual responsiveness remains high, wrinkles &amp; grey hair develop</td>
<td>Practical and dialectical thinking, short-term memory at top,</td>
</tr>
<tr>
<td>Middle Adulthood</td>
<td>40-65</td>
<td>Gradual changes continue in skin, hair, and body shape, menopause starts in women</td>
<td>Intellectual abilities and processing speed decline, short-term and long-term memory stable</td>
</tr>
<tr>
<td>Old Age</td>
<td>65 and above</td>
<td>Brain becomes smaller and less functioning, visual and hearing loss continues, immune-system and muscle strength decreases,</td>
<td>Short-term memory decline, memory and processing speed based language ability decline, intelligence decline,</td>
</tr>
</tbody>
</table>

Adapted from: http/www.learner.org/series/discoveringpsychology/development/7
Theories of Aging

Body organs change as the individual ages, unfortunately these changes are for the worse. Almost all the bodily functions are at their maximum capacity at the age of 25 years and after that a gradual decline starts. Age-related changes are not similar in all individuals; they age according to their body capacity. There are many theories to explain the aging process, but no single theory appears to fully explain the process of aging (Davidovic, Sevo, Milosevic, Despotovic, & Erceg, 2010). These theories are mainly divided into two types: Modern biological theories and Non-biological theories. Modern biological theories of aging can be divided into two types, i.e. Programmed theory and Damage or Error theory.

Programmed theory proposes that aging follows a biological timetable, possibly an extension of the one which modulate or control childhood growth and development. This regulation depends on changes in gene expression that affect the systems responsible for maintenance, repair, and defense responses; on the other hand error theories emphasize on environmental assaults to living organism that induces cumulative damage at different levels, as the cause of aging (Kunlin, 2010). The programmed theory is further divided into three sub-categories:

1. Programmed Longevity Theory emphasizes that aging is the result of a continuous switching on and off of specific genes, with senescence being defined as the time when age-related deficits are displayed. Davidovic and colleagues (2010) described the role of genetic instability in aging and dynamics of the process of aging.

2. Endocrine/Reproductive-Cell Cycle Theory implies that biological clocks work through hormones to control the aging process. This theory implies that reproductive hormones not only control reproduction and metabolism, but also modify the life and functions of cells.

3. Immunological/Autoimmune Theory proposed that immune system is programmed to decline over time; therefore auto-antibodies attack the body tissues which cause the increased vulnerability to infectious disease, and thus
aging and death. The effectiveness of immune system is at highest level at the
time of puberty and after that gradually decline with aging.

Damage or Error theory is divided in four types. These are as following:

1. Wear and tear Theory was proposed by Weismann in 1882. According to this theory the human body has vital parts in cells and tissues which wear out and cause aging.

2. Rate of Living Theory stated that higher the rate of oxygen basal metabolism of an organism, the shorter will be the life-span (Brys, Vanfleteren, & Braeckman, 2007).

3. Cross Linkage Theory proposed by Bjorksten (1942) explains that an accumulation of cross linked proteins damage cell and tissues of the body, slowing down bodily processes which results in aging.

4. Free-Radical Theory introduced by Gerschman (1954), and further developed by Harman in 1956 suggests that free radicals or generally reactive oxygen species or oxidative stress, which cause damage to the macromolecular components of the cell, giving rise to accumulated damage causing cells to stop functioning.

Non-Biological Theories are categorized in three types as:

1. Disengagement Theory was proposed by Cummings and Henry (1961). According to the authors, “Aging is an inevitable mutual withdrawal or disengagement resulting in decreased interaction between the aging individual and others in the society to which he belongs to.”

2. Activity Theory another theory to explain the psycho-social process of aging was proposed by Havighurst (1961). This theory emphasized the importance of ongoing social activity and explains that if older adults are more active and maintain social interactions then they are more likely to be satisfied with life and the process of aging is delayed.
3. Atchley (1971) proposed the Continuity theory and explained the view that older adults try to maintain continuity by adapting strategies that are connected with their past experiences. American Society of Aging (2007) suggested that older adults should maintain the same activities, behaviours, and relationships as they have in earlier years of life.

**Neuropsychological Effects of Aging**

By the time of young adulthood, brains are biologically mature and some neuropsychological functions, particularly higher level of abilities keep, growing until the middle age, but others start decline in the mid 30’s. A number of pathophysiological changes occur with aging that preferentially influence brain structure and individuals by causing age-associated executive difficulties. Salthouse (2009) explained that there is a steady decline in many neuropsychological processes across the life span. Stuart and Hamilton (2006) found individual variations in rate of neuropsychological impairment in terms of people having different lengths of life.

Everyday experiences and research studies converge on the observation that advancing age is often associated with a decline in recalling and recognizing new events and facts. Age-related changes in neuropsychological functioning may reflect many factors, including changes in social activities, modifications of daily practices, and alternations of emotional functioning. It is likely, however, that they reflect, in a larger part, biological changes in the neural systems that mediate cognition. Different brain activation patterns in young and older adults could reflect not only age-related changes in neural processes, but also age-related changes in vascular processes. Therefore, loss of cognitive acuteness with increasing age is a correlation that has been widely studied and accepted in society. An assessment of recent research on several areas of neuropsychology has indeed confirmed the presence of age associated neuropsychological changes. Studies have also shown that not all elderly are affected by age-associated changes in cognition in the same way and that intellectual stimulation can actually ameliorate some of this cognitive decline (Compton, Avet-Compton, Bachman, & Brand, 2003; Salthouse, McGurthy, Fristoe, & Hambrick, 1998; Smith, Lozito, & Bayan, 2005).
Some researchers have focused particularly on memory and aging and found that aging influences certain neuropsychological domains and memory forms more than others. In general, some studies indicated that when elderly individuals remain in good health they exhibit only a subtle decline in test performance involving memory, perception, and language. There is gradual deterioration in elements of memory, attention, and information processing, i.e., due to an overall slowing down in neuropsychological functioning. Perception also shows significant age-associated declines attributable mainly to sensory abilities. Higher level of neuropsychological functions such as language, processing and decision making may also be affected by aging.

Declines in attention can have higher negative effects on individual’s ability to perform adequately and efficiently. Older adults show significant impairments on attentional tasks that require dividing or switching of attention among multiple tasks which is associated with the frontal lobes. Older individuals show decline on the tasks which requires flexible control of attention.

Memory may be affected in different ways like reduction in the ability to encode new information, to retrieve old memories and to use working memory. Age-related decline in these functions are found to be the most in complex conditions and new tasks. Working memory, perceptual speed, and other aspects of neuropsychology as a consequence of aging has been found to vary from individual to individual. An individual at a specific age might exhibit and experience significant neuropsychological decline while others of the same age might not show any decline in neuropsychological functions (Compton et al., 2003).

Prospective memory, which is an intention of carrying out a future act, has also been studied by researchers. Subjective prospective memory has been found to be invariant across different age groups while objective prospective memory was found to decrease linearly with age. The age-related prospective memory deficits were found to occur concomitantly with neuropsychological decline in sensory-motor, language, memory and intellectual processes (Malik, 2012).

Older adults also exhibit decline in episodic memory. Older adults are not able to encode new information meaningfully and with more elaboration; therefore, the
memory traces are more similar to other traces. Hence it is more difficult to recall the information.

There is also some evidence that age-associated decline in neuropsychological functioning is lessened in highly educated individuals. Specifically, Compton et al. (2003) reported that a high level of education and continued intellectual stimulation attenuate age-associated decreases in working memory and perceptual speed.

Thus, research in the field of neuropsychology and aging supports the general perception that aging is associated with decreased neuropsychological performance.

A prominent theoretical explanation for the mechanism of normal aging which focuses upon age related motor deficits is the neural noise hypothesis (Crossman & Szafan, 1956; Li, Huxhold, & Schmiedek, 2004). According to this theory, aging results in an increase in random neural fluctuations resulting in interference in the transmission of information in central nervous system. The life-span perspective indicates that an individual is in constant fluctuation as a result of living in a dynamic environment (Nesselroade, 1991). Therefore, the study of developmental change has to include and expect variability in development (Nesselroade & Featherman, 1997). The relationship between age and variability in neuropsychological performance of an individual can be described by a U-Shaped curve i.e. children and older adults exhibited higher intraindividual variability (Williams, Strauss, Hultsch, Hunter, & Tancock, 2005).

**INTRAINDIVIDUAL VARIABILITY**

As early as 1862, Galton hypothesized a relationship between reaction time (RT) and general mental ability. Galton thought that measurement of quickness of reaction time would provide a good index of mental ability. Scientific interest in short term change and fluctuation in behavior began early in the history of psychological research (Wundt, 1897). Classical discussion of variability was introduced by Fiske and Rice (1955), Cattell (1957), Thouless (1936), and Woodraw (1932). It is a measure of the spread of a data set. Variability also refers as the extent to which the data points differ from each other.
The differential psychological approach describes two types of variability; one is interindividual variability and the other is intraindividual variability (IIV). These variability types are presented in the Figure 1.1

![Diagram of Variability](image)

**Figure 1.1 Types of Variability**

Interindividual variability can be defined as the diversity or difference between subjects in a group. Diversity is usually measured on a single task on a single occasion. Diversity is considered as noise which can be controlled with methodological designs that use very large groups or in single case studies (Smith, Hale, Poon, \& Myerson, 1988; Hultsch \& MacDonald, 2004).

The second type of variability named as intraindividual variability (IIV), is described as the changes that occur relatively quickly and over relatively short time frames and are temporary or reversible in cognitive performances (Nesselroade, 1991). Historically, intra-individual variability has often been considered as meaningless information about an individual, these are random fluctuations in behaviour, which have been referred to as error, noise, or regarding an individual’s behaviour (Luszcz, 2004).

Intraindividual variability is considered as a term describing two types of within-person variability; first, Inconsistency and the second is Dispersion (Hultsch \& MacDonald, 2004, Hultsch, Dixon, \& MacDonald, 2002).

The phenomenon of inconsistency refers to variability observed in a person’s performance on a single-task over short periods of time (i.e., minutes, hours, days). The term intra-individual variability is defined as the standard deviation which represents trial to trial variability of reaction time over a number of trials. This is an indicator of the developmental level of the responding system and can be assessed by
measuring the performance of the individual, on the same variable at different moments. However, inconsistency is also exhibited within as well as across sessions and it indicates the stability of performance over time. Inconsistency in performance speed is an early sign of neuropsychological impairment and ultimately impending death.

Studies of age differences in RT suggest that older individuals exhibited higher intraindividual inconsistency as compare to younger individuals for the same and different judgment RT tasks (Myerson & Hale, 1993; Salthouse, 1993). Some researchers have attributed these changes in RT to assess motor deterioration in older adults (Bielak, 2008). In case of inconsistency, higher IIV has been observed for older individuals when compared with younger individuals. Various researches indicated that inconsistency within trials on RT tasks increases with age (Bielak, Anstey, Bunce, & Cherbuin, 2014; Fozard, Vercruysse, Reynolds, & Quilter, 1994; Mayerson, Hale, & Robertson, 2007; Salthouse, 1993; Schmiedek, Lovden, & Lindenberger, 2009, 2013).

The second type of intra-individual variability, termed dispersion reflects the variability observed in a single person’s performance across different tasks. For example, if an individual were tested on a single occasion on neuropsychological assessment battery, which contains multiple subtests to measure a wide area of neuropsychological functions in adults. Dispersion or within person variability indicates the spread of each individual score. Dispersion has received relatively less research attention. Individuals exhibit some degree of dispersion among various cognitive abilities. However, the finding that cognitively healthy individuals may display substantial cognitive dispersion has important clinical implications making it necessary to identify the characteristics of normal/abnormal and healthy/unhealthy dispersion.

Dispersion of cognitive functioning in adulthood has been examined in very few studies and the pattern of results is not well established. Intra-individual variability among tasks was examined by Lindenberger and Baltes (1997), who reported that IIV did not differ with age for higher ability adults and actually decreased with age for lower ability adults. Dispersion in neuropsychological
functioning across tasks has been related to older age. It has been suggested that younger-old adults may exhibit increased cognitive variability with increasing age, whereas older-old adults show decreased cognitive variability as they approach the end of life (Hultsch et al., 2002). Studies indicated that lower cognitive performance and higher decline in cognitive functioning among older adults is associated with dispersion scores (Christensen, Jorm, Henderson, Mackinnon, & Jacomb, 1999; Hillborn, Strauss, Hultsch, & Hunter, 2009; Hultsch et al., 2002; Schretten, Pearlson, Anthony, & Munro, 2003). Hultsch and colleagues (2002) observed that dispersion was also linked with higher inconsistency, indicating that intraindividual variability observed at a lower level of functioning and over a faster time scale may uphold higher level processes and behaviour.

The study of IIV focuses on explaining the process i.e. how, and when and providing an explanation for why the individual changes over time (Baltes, Nesselroade, & Reese, 1977). Molenaar (2004) has considered this as a person-centered or idiographic approach. The major problems with this approach are that it does not clarify whether a unitary measure of an individual’s performance, measured at a specific moment in time, can be taken as representative of the person’s typical performance. Further can changes evidenced within individuals as they age are equated with the differences which are evinced between people of different ages.

In behavioral research, researchers have found that increased variability within a system is associated with increased age and poorer overall functioning. At the behavioral level, short-term, narrow ranged intraindividual variability can be described as indicative of adaptive ongoing processes in response to an ever changing environment where as, extreme or erratic fluctuations may reflect a decline in the homeostatic regulatory system (Nesselroade, Aggen, Featherman, & Rowe, 1996).

In psychological researches, researchers have focused on explaining the extent to which particular psychological constructs (affect, mood, self-esteem, personality, and intelligence) are marked by intraindividual variability. Now a day, researchers have shown an increased interest in examining the extent to which neuropsychological functioning in healthy older adults is characterized by intraindividual variability. Enoka (2003) and Wellford (1981) found in their studies
that older individuals showed higher variability as compared to younger adults, in perceptual and motor performance.

Overall a substantial amount of research has indicated that intraindividual variability in cognitive performance is a stable, endogenous characteristic of an individual. Some findings suggested that variability in performance appears to increase with chronological age, researchers, have speculated that increased intraindividual variability of a behavior or within a measured construct might be an indicator of a more general underlying self-regulatory deterioration in performance in that particular domain. Therefore, for neuropsychological functioning assessment intraindividual variability could be a better index rather than a particular score on a single task or mean performance score on a set of tasks which assess varied domains.

Over the last three decades, a large amount of researchers have been interested in the study of the nature of intraindividual variability (Hultsch & Macdonald, 2004; Hultsch, Strauss, Hunter, & MacDonald, 2008). Woodraw (1932) while examining the concept of intraindividual quotidian variability quoted many examples in which intraindividual variability was higher than inter-individual variability on the same attribute.

Although, the study of intraindividual variability in RT had been initiated in 1897 by Wundt, but extensive studies started in 1990’s. surprisingly this area which had important implication in RT-intelligence research was peculiarly neglected by experimental psychologists. The variability of an individual’s RTs over a number of trials was considered as experimental error in the RT literature which was generally balanced out by averaging the RTs. Recently, differential psychology of RT has paid attention to intraindividual variability in RT in relation to general mental ability (Jensen, 1992). Some researchers have given priority to intraindividual variability of RT over the mean RT (Eysenck, 1982, 1987; Jensen, 1982).

Since, periodicity in the nervous system, is a logical assumption, it implicates that mean score of speed of RT, averaged across individual measures can be considered as a consequence of variability in the performance of the individual on reaction time tasks rather than mean performance being considered as a determinant of the variability. Eysenck (1987) explained that random fluctuations in the
transmission of information occur in the central neural system; therefore low intelligence individuals have longer reaction times due to errors in the neural transmission of through the cortex, thereby leading to an increase in variability over trials. Jensen (1992, p 869) expressed his views about intraindividual variability as “robust phenomenon in which there are reliable individual differences that are manifested consistently across quite different RT tasks”. Horn (1972) established patterns of IIV across weeks which considered the differentiation of fluid intelligence and crystallized intelligence.

In recent years, the term intra-individual variability has been used to represent several different facets of within-person variability. From the last 45 years, intraindividual variability has been observed in a vast domains, including affect, emotion, mood (Larsen, 1987; Lebo & Nesselroade, 1978), cognitive abilities (Hampson, 1990; Horn, 1972), sensorimotor functioning (Li, Aggen, Nesselroade, & Baltes, 2001), stress (Neupert, Spiro, Almeida, & Mroczek, 2006), health and routine activities (Ghisletta, Nesselroade, & Rowe, 2002); but particularly within the cognitive aging domain (Hultsch& MacDonald, 2004; Iskender, 2010 Lovden, Shing, Li, & Lindenberger, 2007; Salthouse, 2012). Intraindividual variability studies mainly focuses on cognitive and neuropsychological performance.

Some researchers have found that, intraindividual variability is related to the level of performance and was uniquely predictive of neurological status, independent of level of performance. Results of the studies, suggested that intraindividual variability may be a behavioral indicator of compromised neurological mechanism (Hultsch, Lewy-Bencheton, MacDonald, Hunter, & Strauss, 2000), Traumatic brain injury (TBI; Burton, Strauss, Hultsch, & Hunter, 2002), Alzheimer’s disease (Caselli, Laboli, & Nichelli, 2009), and Attention deficit-hyperactivity disorder (ADHD; Klein, Wendling, Ruder, & Peper, 2006).

There are neuropsychological evidences to suggest that frontal lobe damage affects the IIV. Intraindividual variability is related to frontal cortex mediated processes and fluctuation in executive control. It has been suggested that individuals with frontal lobe dementia and focal frontal lesion exhibit high level of dispersion and inconsistency (Stuss, Binns, Murphy, & Alexander, 2003). The frontal lobes are more
sensitive to the effects of aging as compare to other regions of the neo-cortex (Moscovitch & Winocur, 1992; Raz, 2000). Older adults show high intraindividual variability on those RT tasks which required high demand on executive control (West, Armilio, Stuss, Murphy, & Craik, 2001). Researchers have hypothesized that age-related changes in variability arise from changes in frontal lobe function (Li, Frensch, & Lindenberger, 2000). This leads to the prediction that older adults should perform at lower levels and exhibit greater intra-individual variability than younger adults.

Recently, research interest has been drawn towards the irregular aspect of change with an individual and the possibility of a significant meaningfulness of intraindividual variability has been acknowledged. Researchers have found that increases in intra-individual variability in reaction time tasks predicted the degree of neuropsychological decline (Hillborn et al., 2009; Strauss, MacDonald, Moll, Hunter, & Hultsch, 2004). The measurement of intraindividual variability in neuropsychological performance over a shorter period of time may provide useful information in the diagnosis or identification of neuropsychological deterioration. Long-term changes in neuropsychological functioning within an individual as well as increasing differences in level of cognitive performances between individuals may be based on permanent alteration in intraindividual variability (Siegler, 1994).

The reported empirical findings about intraindividual variability hold a great promise, especially as some findings suggesting that this may function as a marker of age-related neuropsychological decline. However, the typical measures of assessment of intraindividual variability, as evident from majority of the current literature, are reaction time measures.

Thus, it appears that assessment of neuropsychological functioning in terms of overall level of dispersion (quantitatively) and in terms of the pattern or shape of an individual’s profile of abilities (qualitatively) could provide a better assessment of neuropsychology at a particular moment.
Intraindividual Variability as an Index of Neuropsychological Functioning

Since researchers have generally assessed variability in terms of reaction time; dispersion evinced in neuropsychological measures may help to account for differences in diagnostic groups that may not be accounted for by the reaction time measures and this could provide a better indicator of neuropsychological impairment (Christensen, Dear, Anstey, Sachdev, & Jorm, 2005; De Frias, Dixon, Fisher, & Camicioli, 2007). Although the within-person changes in neuropsychological measures have been explored in a limited number of studies, these studies have reported a significant intraindividual variability in neuropsychological performance (Bielak, Hultsch, Strauss, MacDonald, & Hunter, 2010; Holtzer, Verghese, Wang, Hall, & Lipton, 2008; Schretlen et al, 2003). Variability appears to be a more sensitive in predicting the incidence of dementia, in comparison to traditional assessments measures which advocated the use of mean performance scores (Bielak et al., 2010; Holtzer et al., 2008; Kalin, Pfluger, Gieti, Riese, Jancke, & Hock, et al., 2014). In several of the studies where a positive association between dementia and intraindividual variability has been reported, variability was assessed on only 1 or 2 cognitive domains, where one of the measure was reaction time (Burton, Strauss, Hultsch, Moll, & Hunter, 2006; Hultsch et al., 2000; Murtha, Cismaru, Waechter, & Chertkow, 2002). However, dementia has been diagnosed in clinical settings, by obtaining an objective measure of impairment in memory and neuropsychological assessments which reflect at least two more relevant cognitive domains (i.e. language, executive function, and problem solving).

Another additional issue which was evidenced in previous researches is the examination of variability across a limited number of measures. Although, an extensive neuropsychological battery (comprising of 15 measures) was used by Schretlen and colleagues (2003), they measured variability in terms of overall performance which was estimated by standardizing each measure and computation of the maximum discrepancy i.e. range between the highest score and lowest score obtained on a single measure. This kind of analysis does not provide an accurate assessment of how individuals may change on a particular measure across time.
Although in another study (Holtzer et al., 2008) multiple assessments were obtained on each of the neuropsychological measures, only three of these were examined. Therefore, it appears that further research is needed where variability is assessed on a comprehensive neuropsychological battery; where assessment is carried out on multiple occasions with relatively short inter assessment. However, as neuropsychological batteries are generally extensive, a more practical tool could be a screening test of neuropsychological. Further, studies related to intraindividual variability have either examined fluctuations in performance on one occasion (Schretlen et al., 2003) or an interval of one month between the sessions (Garrett, MacDonald, & Craik, 2012; Holtzer et al., 2008). Thus, there is a need for assessment of variability across several occasions with shorter between-occasion time intervals, in order to determine whether the assessment of variability in neuropsychological performance across different temporal occasions reveals similar results or it has better predictive validity.

Before drawing these conclusions, further research needs to explore whether the variability in neuropsychological measures can be comparable to the variability on reaction time measures. Research is also needed to determine whether some unique information about the performance of the individual is revealed by variability on neuropsychological, which was not reflected by the variability on the reaction time measures. If information in addition to that which was provided by reaction time measures about cognitive competency, is provided by variability on neuropsychological measures, then this may implicate a major utility of both global and specific assessment of neuropsychological abilities when accounting for neuropsychological functioning.

Generally neuropsychological functioning is assessed by the scores on particular task or test. However the validity of the obtained scores becomes questionable in view of the vast intra and interindividual differences in performance observed on different occasions. Therefore, the present research work focused on intraindividual variability which can be an index of deterioration in neuropsychological functioning of the individual.
Present chapter suggests that aging leads to changes in brain functioning and this is reflected by intraindividual variability in the performance of the individual. Neuropsychological batteries assess performance on specific domains and the global scores can be misleading, at times. Therefore, it seems that intraindividual variability could be used as an index of cognitive or neuropsychological functioning.

A review of researches, relating to intraindividual differences in neuropsychological functions with specific reference to aging and the viability of dispersion and inconsistency as indicators of cognitive/neuropsychological functions, was conducted. This has been presented in the next chapter.