Neuropsychology is a scientific, objective and structured method which shares an information processing view about the cognitive domains as well as brain functions. Neuropsychological assessment gives detailed information about the integrity of the brain functions and provides general as well as specific information regarding current level of cognitive performance. The main focus of neuropsychological assessment is to examine the various brain functions through systematic behavioural observation and the extent of dysfunction or impairment to a specific skill. In the field of neuropsychological assessment independent functional domains regulated by brain system are evaluated. Individuals have specific localized brain areas such as frontal lobe, parietal lobe, temporal lobe and occipital lobe placed in the hemisphere. These lobes regulate the cognitive or psychological functioning as well as behavioural aspect of an individual. These localized brain regions are related with cognitive functioning; if any of the brain region is damaged that causes disturbance to the associated cognitive function. Neuropsychological assessment encompasses various sensory-motor function, executive functions and other higher order cognitive domains including language, memory, and thinking.

Initially, in the area of neuropsychological assessment the techniques used were focused to assess only the specific region of brain and main attention was towards the diagnosis i.e. identification of neural decline or dysfunction by assessing specific psychological function. Neuropsychological assessment was based on the developed tests which assessed specific sensory or cognitive domains. Later on, comprehensive batteries (e.g. Halstead-Reitian and Luria-Nebraska) were used to assess the neuropsychological functioning. These comprehensive batteries provided a global measure of dysfunction which had better predictive and diagnostic value in comparison to specific cognitive tests. But here, the performance of the individual was considered as overall mean scores across cognitive domains. Now, recently neuro-imaging techniques are used for the assessment of specific brain areas which
provide accurate information about the lesions or damage to specific brain areas and
dysfunction in cognitive domains related to that region. Decline in cognitive
processing speed has been identified a sensitive, earliest marker of cognitive
deterioration (Craik & Salthouse, 2000). Neuropsychological dysfunction has various
causes such as neurogenerative disease, brain disorders, malnutrition, hormonal
imbalance and cardiovascular disease including diabetes, hypertension, and heart
attacks. However, aging is considered to be a main factor that moderates the effect of
these factors on neuropsychological dysfunction.

As age increases, performance on perceptual speed, explicit memory, source
recognition, episodic memory, working memory and executive functioning decreases
(Cabeza et al., 2002; Dixon et al., 2004; Gunnings-Dixon & Raz, 2000; Moris et al.,
2013; Kennedy & Raz, 2009; & Springer et al., 2005). Some studies have shown that
crystallized intelligence does not decline with age (Christensen, 2001, & Gunnings-
Dixon & Raz, 2000). Researchers have consistently shows that aging results in
cognitive decline, however, the qualitative and quantitative nature of dysfunction
tends to vary from individual to individual.

Scientific interest in short term change and fluctuation in an individual’s
behaviour began early in the history of psychological research (Wundt, 1897). Fiske
and Rice (1955), Cattell (1957), Thouless (1936), and Woodraw (1932) focused on
the classical discussion of variability. Although statistically, measure of central
tendency (averaged across multiple measures on the same variable) for inter and intra
individual measures provided invaluable information, the uniqueness of the particular
individual’s score is lost. Thus, assessment by the cumulative or mean scores of an
individual on a particular /multiple tasks, becomes questionable in view of inter and
intraindividual differences in performance of an individual.

Variability is a measure of the spread of a data set which can be examined in
two forms as inter-individual and intraindividual. Inter-individual variability is an
established fact and neuropsychological assessment has been based on this. Inter
individual variability emphasizes on the diversity or difference between groups.

Intraindividual variability was initially perceived as noise and meaningless
information regarding an individual’s behaviour. However, some psychologists have
considered intraindividual variability to be much important than inter-individual variability as it provides information about the probable fluctuations in an individual’s behaviour or performance. Nesselroade (1991) reported that performance of an individual is in constant fluctuation. Since performance of an individual on different occasions or on varied measures is never absolutely the same, it can be considered as a dispersion and intra individual variability could provide insight into transient as well as permanent changes in psychological/ physiological/ or neural functioning.

The term intra-individual variability (IIV) has been used to represent various aspects of within-person variability. A large number of researchers showed interest in intraindividual variability in the field of cognitive neuroscience (Hultsch& MacDonald, 2004; Lindenberger & vonOertzen, 2006; Lovden et al., 2007, MacDonald et al., 2003; Nesselroade, 1991). Researchers have found that increase in intraindividual variability predicted the degree of neuropsychological dysfunction (Bielak, 2008; Hultsch et al., 2000; Hultsch et al., 2002; Hillborn et al., 2009; Strauss et al., 2004).

Intraindividual variability can be assessed in two ways: intraindividual variability across varied cognitive domains (dispersion) and intraindividual variability across time i.e. sessions (inconsistency). Dispersion is the variability observed in a single person’s performance across different tasks which indicates the spread of each individual’s scores. Inconsistency is the variability observed in an individual’s performance on a single task over short time periods that can be minutes, hours or days.

Research attention has focused on average level of performance over time. In fact, research in the area of RT, which implicated RT as a sensitive and gross indicator of cognitive processing advocated the use variability (standard deviation) instead of averaging (mean) the reaction time scores across trials (Eysenck, 1982, 1987; Jensen, 1982).

Some researchers have proposed that variability across time i.e. averaged across different sessions could provide a better index of cognitive processing (Salthouse et al., 2006) as lower values of variability would reflect stability in cognitive processing and higher variability scores would be indicant of inconsistency
or instability of cognitive/neural dysfunction. Thus, it has been proposed that IIV in terms of inconsistency in RT might provide vital information about cognitive processing.

Considering in the same vein, researchers have suggested that variability in performance on qualitatively different tasks could provide a better index of neural functioning/dysfunction rather than assessment of performance on single task or averaging across different domains. This type of IIV has been termed as dispersion.

Although, research findings have shown that higher intraindividual dispersion was correlated with intraindividual inconsistency (Allaire & Marsiske, 2005; Hultsch et al., 2002; Nesselroade & Salthouse, 2004) intraindividual variability across neuropsychological measures could help in diagnosis of group differences which may not be accounted for intraindividual variability in reaction time measures, and, this might be a better indicator of neuropsychological impairment (Christensen et al., 2005; De Frias, et al., 2007). Recent researches indicate that IIV, both in terms of inconsistency and dispersion reflects deterioration that occurs at the neural level of the brain, and therefore both these measures may be beneficial as early indicators of underlying brain pathology (Kelly et al., 2008; MacDonald et al., 2006, 2009).

Intraindividual variability has been studied in various psychological domains including affect and emotion, (Larsen, 1987; Lebo & Nesselroade, 1978; Zevon & Tellegen, 1982), human abilities (Hampson, 1990; Horn, 1972), personality (Hooker, 1991; Hooker, Nesselroade, & Lerner, 1987), and cognitive performance (Hultsch & MacDonald, 2004; Nesselroade & Salthouse, 2004). In several aspects IIV is more predictive than mean scores on cognitive and neuropsychological measures in assessing the impact of normal aging, mild cognitive impairment, dementia, and developmental increases in brain variability and can better discriminate neuropsychologically impaired and clinical groups from normal individuals (Burton et al., 2002; Dixon et al, 2007; Fellows et al., 2015; Kalien et al., 2014; Kofler et al., 2014; McIntosh, Kovacevic, & Itier, 2008; Strauss et al., 2007). Even in case of reaction time, intraindividual variability in RT may reveal theoretically important aspects of neuropsychological impairment rather than measure of central tendency i.e. mean RT performance (Spieler, Balota, and Faust, 2000). Garrett and his colleagues (2010,
explained that brain signal variability is a more powerful predictor of aging than mean signal and highlights the functioning of a broad set of neural regions.

Neuropsychological dysfunction across aging could provide a very sensitive design for studying the efficacy of various indicators of neural dysfunction as neural decline is inevitable with aging. Researchers have examined the extent to which neuropsychological functioning in older adults is characterized by intraindividual variability. Several studies have reported age difference where older adults exhibited higher intraindividual variability across sessions (inconsistency) as compared to younger adults (Fozard et al., 1994; Hillborn et al., 2009; Lovden et al., 2007; MacDonald et al., 2003; Bielak et al., 2014; William et al., 2005). Age-based behavioural analyses of the Ex-Gaussian RT distribution explained that IIV effect is caused because of excessively slow within-person response latencies, which is possibly a result of momentary lapses in attentional control (West et al., 2002; Williams et al., 2005).

Intraindividual variability is easy for calculation and intuitively understandable to many. It can prove to be an effective and proxy measure for complex and dynamic influences and processes not only for psychological assessment, but may also provide a gross index which can be inferred from observable behavioural and functional aberrations. Therefore, from the above discussion it is evident that IIV may be of great practical importance than any other central tendency measure.

Three major reasons can thus be delineated for assessing intraindividual dispersion and inconsistency in neuropsychological measures. Firstly, this may provide a sensitive tool for neuropsychological dysfunction. Secondly, some discriminative information regarding neuropsychological functioning that is not evident from inconsistency measures of reaction time may be accessed. Thirdly, it might provide an explanation for inferring the meaning of variability across varied behavioural and neuropsychological abilities.

**Rationale of the study**

Neuropsychological dysfunction has been a major area of study of psychological and neural assessment of brain functions has become possible
during the recent past because of technological advancement and development in the area of imaging techniques. However, these procedures are not accessible to the masses because of paucity of resources both economic and infrastructural. Neuropsychologists opt for psychological assessment where batteries are used to obtain insight into brain function by assessing performance on varied sensory-motor cognitive domains. Majority of the neuropsychological batteries propose that scores, summated across the domains provide an index of brain dysfunction/ function. In view of the researches in the area of reaction time and psychological assessment where intraindividual variability in terms of inconsistency and dispersion has been opted for as an index of performance of an individual, it was felt that IIV could provide a viable index of neuropsychological functioning. Since RT provides an index of speed of cognitive processing the present researcher felt that variability in RT over an extended period could be an indicant of fluctuation in neural functioning which in turn could be a sensitive marker of neural function/ dysfunctions.

Further intraindividual variability in terms of dispersion in performance across neuropsychological domains could reflect cognitive functioning. Cognitive dysfunction, in the initial stage could have more severe impact on some domains while the other would be relatively resistant. Thus, at the onset of cognitive dysfunction, intraindividual variability across varied neuropsychological functioning would be more and it was decline as the efficacy of the entire system gets compromised. The present researcher felt a study of intraindividual dispersion across various cognitive domains, when considered across different age groups could provide insight into the efficacy of this measure for predicting cognitive dysfunction.

With this background thus the present research was designed to investigate the following problem:

**Problem:** To study “*Intra-Individual Variability as an Index of Neuropsychological Functioning.*”

**Objectives:** The following objectives were delineated for the study:
1. To assess the variation in neuropsychological functioning across different age groups.

2. To assess the variation in intraindividual variability across different age groups.

3. To ascertain the efficacy of intraindividual variability as an index of neuropsychological functioning.

**Hypotheses:**

1. Neuropsychological functioning would exhibit an inverted U shaped function in relation to age, with peak performance during adulthood (30-40 years).

2. Intraindividual inconsistency scores would exhibit a U shaped function in relation to age, with minimum variability during adulthood (30-40 years).

3. Intraindividual dispersion scores would exhibit a U shaped function in relation to age, with minimum variability during adulthood (30-40 years).

4. Intraindividual dispersion would be a better indicator of neuropsychological dysfunction than intraindividual inconsistency.

The design and methodology used to achieve the objectives of the present investigation have been described in the next chapter.