CHAPTER-II
REVIEW OF LITERATURE

This chapter presents a detailed account of researches related to the major variables of the present study. The present study focuses on intraindividual variability (IIV) as an indicator of neuropsychological dysfunction. Although researchers have focused on identifying the correlates and predictors of current and future impairment in neuropsychological functions, only few researchers have paid any attention to the contribution of intraindividual variability in the diagnosis or prediction of neuropsychological decline. In past researches, IIV in neuropsychological performance was considered as meaningless information and random errors in an individual’s behaviour (VanZomeren & Brouwer, 1987). However, some researchers have implicated intraindividual variability as a stable and quantifiable index of neuropsychological functioning (Allaire & Marsiske, 2005; Hultsch et al., 2002; Salthouse et al., 2006). In most of the researches, it has been argued that measures of central tendencies provide statistical variance to the generalizability of the data. Although these measures provide invaluable information, the uniqueness of the individual’s performance on particular score is not provided. Therefore, a growing body of literature has considered IIV as useful and an informative method to identify the neuropsychological dysfunction of the individual.

For the present review, initially an abstract based search was performed where an abstract based review was conducted through internet by utilizing the widely used search engine like Science Direct, Google, Pub Med, NCBI, Jama, and Archives etc. The obtained abstracts provided the ground for a journal based search for the compilation of the primary sources. For this purpose, university library of Maharshi Dayanand University, Rohtak and Delhi University, Delhi were consulted. The articles related to intraindividual variability, aging and neuropsychological functioning were collected. The major journals consulted were Journal of Gerontology, Neuropsychology, Neuropsychologia, Journal of Aging, Neuropsychology and Cognition, Psychology and Aging, Journal of International

The review was collected from 1976 to 2015. The review of researches presented in this chapter, focus on neuropsychological functioning in relation to two types of intraindividual variability i.e. dispersion and inconsistency. For convenience and comprehensive understanding of earlier work, researches have been described under separate headings.

**Aging and Neuropsychological Functioning**

Various pathophysiological changes occur during the aging process that preferentially influence brain structures and cause executive difficulties. Beyond individual differences, aging influences certain cognitive domains. The reviews presented in this section are related with neuropsychological function and aging process.

Elias, D’Agostino, Elias, and Wolf (1995) explored the relationship of three blood pressure variables (systolic and diastolic pressures and chronicity of hypertension) and age to cognitive performance on the Kaplan-Albert Neuropsychological Test Battery, in a sample of 1695 stroke free participants of the Framingham Heart Study. They obtained multiple blood pressure measurements over four to five examinations, extending over 8-10 years and neuropsychological testing was conducted 12-14 years after the final blood pressure measurement. They found that blood pressures and chronicity of hypertension were inversely associated with performance on visual and verbal memory tests of the Kaplan-Albert Battery and age was inversely associated with performance on all tests in the battery. Generally, the odds of performing poorly were higher for age than for blood pressure variables.

O’Brien, Ames, Demond, Schweitzer, and Tress (1997) examined the neuro-radiological correlates of age-related cognitive decline. To find out the outcomes, 40
individuals above the age of 55 years were tested for cognitive assessment measure i.e. Cambridge Cognitive Examination (CAMCQO) and for Hippocampal and Amygdala atrophy (HA), periventricular lesions (PVL) and deep white matter lesions (DWML). Results revealed that individuals who exhibited low scores on cognitive measures, exhibited hippocampal and amygdala atrophy and not with PVL and DMWL, which indicated that atrophy in hippocampal and amygdala is related with impaired memory performance in older adults.

Gunning-Dixon and Raz (2000) conducted a review based study to find out the association between differences in the MRI appearance of the cerebral white-matter which were a consequence of aging and cognitive performance in non-demented adults. This quantitative review was based on 57 publications collected through computerized search, across volumes of relevant journals and the bibliographies; which measured the occurrence and severity of white matter hyperintensities (WMH) in non-demented adult respondents. These studies used measures of global cognitive functioning, intelligence (crystallized and fluid), speed of cognitive processing, executive functions, memory (immediate, recent, and delayed) and fine motor movements. Results indicated an association of higher WMH scores with attenuated performance on global cognitive measures, speed of cognitive processing, explicit memory and executive functioning whereas indices of intelligence and fine motor-cognitive functioning did not show reliable association with WMH. Further, a relationship was also reported between the occurrence and extent of age-related alterations evinced in WMH and decline in global cognitive processing.

Christensen (2001) conducted a Meta analytic study in which a sample of 887 subjects ranging from 70 to 93 years (assessed earlier in 1991, 1994, 1998, & followed up in Canberra Longitudinal Study) were studied. She delineated the risk factors for cognitive decline which were based on a review of 34 studies and summarized that cognitive speed and memory declined with age as compare to crystallized intelligence. There were risk factors such as poor health, less education, less activity, and blood pressures which predicted faster cognitive deterioration.

Cabeza, Anderson, Locantore, and Maintish (2002) compared the age-related changes in brain activity. Subjects performed on a battery of memory tasks. On the
basis of these scores, participants were divided into three groups i.e. young adults age ranged from 20 to 30 years; older adults (63 years to 78 years) who performed lower than younger adults were named as low-old (n=8), and older adults who exhibited better performance were named as high-old (n=8). Subjects were assessed in two sessions of PET screening (recall condition and source recognition). Results indicated that in younger adults and low-old group source memory was related with right prefrontal cortex regions (PFC) activity as compared to recall memory whereas high performing older adults engaged PFC regions bilaterally. Therefore, results indicated that old-high adults exhibited a reduction in hemisphere asymmetry during the most demanding memory task i.e. source recognition.

Dixon, Hertzog, Wahlin, Hultsch, and Backman (2004) conducted a study based on two longitudinal sample of older adults, assessed two times over 3 year interval, using episodic memory indicators. Four hundred subjects were taken from Victoria Longitudinal Study and 168 from the Kungshomen Project, with an age range of 54 to 94 years. Subjects were tested for episodic memory tasks including word lists, story recall and random word lists. Results revealed that for normal older adults, average memory decline was moderate and gradual. It was also suggested that there is a tendency of higher decline for cued recall which may be especially sensitive to late-life changes.

Springer, McIntosh, Winocur, and Grady (2005) examined the relationship between education and brain activity during memory tasks and the effect of aging on this relationship. To find out this association 33 individuals were studied in two age groups, where age of young adults ranged from 18 to 30 years (n=14) and for older adults age ranged from 65 years and above (n=19). Subjects were assessed for MRI and for various cognitive measures including immediate recall, delayed recall, recognition, vocabulary, WAIS information, digit symbol, MMSE and for an experiment of black line drawing of nameable objects and words. Results revealed that young adults were more accurate as compared to older adults for recognizing stimuli which indicated the evidence for age related decline in recognition memory. Results also suggested that the brain regions were associated with education. Education was negatively correlated with frontal lobe activity in young adults and
positively with older adults. Therefore, findings suggested that frontal cortex is engaged in older adults specifically, in highly educated as an alternative network engaged to aid cognitive functioning.

Lindenberger and Ghisletta (2009) conducted a study on cognitive and sensory declines in old age. They studied the senescent brain changes and its effect on sensory-perceptual and cognitive processes; covering six occasion of repeatable measurement distributed over up to 13 years of longitudinal observed. The longitudinal sample included 516 older adults from Berlin Aging Study, with age range of 70 to 103 years. Subjects were assessed for 8 cognitive measures and 3 sensory functioning. Results revealed that individual differences in cognitive decline were highly associated with a single factor accounting for by 60% of the variance in cognitive change.

Kennedy and Raz (2009) examined the relationship among various indices of cognitive skills sensitive to aging and of white matter integrity. Fifty two healthy adults, age ranging from 19 to 81 years were assessed for various cognitive measures and for white matter integrity measures (fractional anisotropy and apparent diffusion coefficient). Results indicated that age and specific regional white matter integrity differentially influenced cognitive performance. Age-related deterioration in anterior brain regions was related with decreased processing speed and poor working memory. Poor episodic memory was related with age related differences in middle white matter areas. Therefore, results supported the view that age-related cognitive functioning is not decline due to a single cause.

Morais, Neth, and Hills (2013) conducted a study to determine whether semantic recall sequencing in healthy old aged and dementia respondents is more consistent with a static or dynamic model. The animal name fluency data was selected from Berlin longitudinal Aging Study. Data consisted of 424 individuals with age range of 69 to 103 years. Subjects were assessed in two groups as normal intellectual functioning old age group and very old age group diagnosed with dementia; for semantic representation of animals name and for model framework similar to item-level recall probability equation. Results suggested that age was related with recalling
fewer items and both the groups were associated with decline in the number of retrieved item for memory.

Papp, Moscufo, Kaplan, Springate, Wakefield, Guttmann et al., (2014) assessed the relationship between the speed of processing in normal aging and white matter hyperintensities (WMH) and hippocampal volume. Study was conducted on 81 non-demented older adults, whose age ranged from 75 to 90 years. Subjects were assessed for Brain imaging, image analysis and for neuropsychological test battery (RBANS), form B, trial making test A and B, stroop colour and word test, CalCAP, Grooved Pegboard Test (GPT), Controlled Oral Word Association Test (COWAT), semantic and phonemic verbal fluency test and the Wechsler adult reading test. Findings of the study indicated that when age was controlled, both higher WMH and smaller hippocampal volume were associated with slower neuropsychological performance on almost all the measures except CalCAP in which only WMH volume was correlated with slower RT. Results also revealed that white matter integrity and hippocampal volume independently influence cognitive decline on processing speed and executive functioning independent of age.

Taken together, the above studies showed that white matter integrity and prefrontal cortex region of the brain was related with age-related cognitive decline (Cabeza et al., 2002; Gunnings-Dixon and Raz, 2000; Kennedy and Raz, 2009; Papp et al., 2014; Springer et al., 2005). O’Brien and colleagues (1997) found that hippocampal and amygdala atrophy causes the age related cognitive decline. Studies presented in this section, indicated that as age increased performance on perceptual speed, explicit memory, source recognition, episodic memory, working memory and executive functioning decreased (Cabeza et al., 2002; Dixon et al., 2004; Gunnings-Dixon & Raz, 2000; Kennedy & Raz, 2009; & Springer et al., 2005). Some studies showed that crystallized intelligence does not decline with age (Christensen, 2001, & Gunnings-Dixon &Raz, 2000). A consistent finding of all the studies was that aging resulted in changes in brain activity which in turn was associated with neuropsychological and cognitive decline.
Aging and Intraindividual Variability

Behavioural research into the intraindividual variability of psychologically relevant construct draws on the extensive research in physiology, biology, medicine and allied disciplines. Intraindividual variability within a homeostatic regulation is one defining characteristic of biological system. In the behavioural aspect narrow ranged (homeostatic regulation) IIV was considered to be indicator of adaptive ongoing processes in response to an ever changing environment (Nesselroade et al., 1996). Opposite to this, IIV characterized by extreme or erratic fluctuation may reflect a breakdown in homeostatic regulatory system. In psychology, research in the area of IIV have focused on examining the extent to which specific psychology constructs (affect and mood, self-esteem, personality) were characterized by IIV. A brief review of literature in this area is as follows:

Anstey (1999) examined the relationship between biological markers of aging and performance on various measures of reaction time (RT) i.e. speed, accuracy, and IIV. He studied 180 older women, whose age ranged between 60 to 90 years, in three age groups (60-69 years, 70-79 years, & 80-89 years). They were examined with the battery of Sensorimotor and physiological function which measured visual acuity, hearing, grip strength, vibration sense and forced expiratory volume, along with the measures of simple and complex reaction time (auditory and visual) . He found that older subjects show higher dispersion on simple and complex auditory task. Sensorimotor and physiological variables were associated with measures of speed, accuracy and intra-individual variability, thereby indicating that dispersion is significantly related with aging.

Wegesin and Stern (2004) examined the variability in memory performance, effect of estrogens intake and aging on variability. For this purpose 64 women, age ranging from 16 to 80 years, were studied in four age groups i.e. younger women (age=18-28 years) and postmenopausal group (age=60-80 years) who were subdivided into three groups as estrogens users group, estrogens and progestin users group and non-users group. All the participants were examined for the recognition memory test which included 16 blocks. Results indicated that older women exhibited higher level of dispersion on the memory task as compared to the younger women. In
this study inconsistency was measured in 16 blocks which was also similar to the dispersion results i.e. older women were more inconsistent as compare to younger women. Results of estrogens indicated that women who intake estrogens exhibited less inconsistency as compare to estrogens and progestin users and non users.

Scholz, Schuz, Nagy, and Ziegelman (2008) conducted a study to find out the role of motivational and volitional (will) factors for self-regulated behavioural change in running training program across various occasions. For this purpose 30 subjects of a running training program were assessed for 11 monthly questionnaires of motivation and volitional variables and self-reported running. At the end running time of marathon was obtained. Results indicated that self-efficacy was associated with intentions on between and within person levels. Researchers concluded that IIV in volitional variable, intentions and self-efficacy was consistently related with IIV in self-regulated running training over time and with successfully running marathon. Therefore, this study provided a relationship between IIV in motivation, volitional and behaviour characteristics.

Stawski, Sliwinski, Almeida, and Smyth (2008) focused on how age differences and global perceived stress was associated with exposure and emotional reactivity to daily stressors. They assessed 183 individuals in two groups age ranging from 18 years to 85 years in two groups of younger (n=67) and older (n=116) adults. Subjects were assessed for a daily stress diary, global perceived stress, measure of Positive affect and Negative Affect on 6 days over a 14 day period. Findings of the study indicated that reported exposure to daily stressors was reduced and was related with global perceived stress in old age. Results also revealed that IIV in number and severity of stressors reports was related with increased negative affect only in younger age group.

Rocke, Li, and Smith (2009) examined the age differences in IIV of Positive and Negative Affect. For the assessment 37 subjects in two age groups i.e. young and older adults, age ranging from 20 to 80 years, were studied for contingencies among daily affect, daily stress and daily event over 45 days. Results showed that older adults significantly exhibited less variability in Positive and Negative affect as compared to younger adults. Findings from the multilevel modeling showed that
younger adult’s Positive affect was higher on days with a positive event and vice-versa.

Garrett, MacDonald, and Craik (2012) examined the effects of motivation and performance based feedback, age and education on trial to trial intraindividual variability. Researchers expected that feedback would lessen IIV in highly educated individuals by providing motivation and focusing attentional resources of the task. To find out, these aspects 91 subjects were examined, in which 41 healthy undergraduate adults (18 to 34 years) and 57 healthy older adults (60 to 82 years) performed a four choice RT task in four block of trial over 15 minutes; each block having 40 trials. Feedback was provided to half of each group immediately after each block. Results revealed that in the younger age group, there was no significant impact of feedback and education on inconsistency; whereas in highly educated older adults substantial reduction in inconsistency was found because of block-by-block short, incentive based, interactive visual and auditory feedback. Although previous researches considered inconsistency as a stable within person trait, this study explained inconsistency as certainly modifiable even with a short period of feedback and testing session. This study also indicated that inconsistency as compared to mean, provided differential and unique information about the individual’s performance because the mean was less sensitive to block to block changes in this study.

The above review indicates that intraindividual variability in various psychological and behavioural domains has been considered as an index for assessing the functioning of the respective domain and is associated with physiological changes. Anstey (1999) revealed that Sensorimotor and physiological variables were associated with speed accuracy and IIV. One study by Wegesin and Stern (2004) indicted that woman who intake estrogens exhibited less inconsistency as compared to progestin users and non users and higher dispersion was associated with higher inconsistency. Studies of affect showed that older adults significantly exhibited less variability in IIV of Positive and Negative affect as compared to younger adults (Rocke et al., 2009; Stawski et al., 2008). Studies also revealed that IIV is also associated with motivation, volitional and behavioural characteristics (Scholz et al., 2008).
Neurological Impairment and Intraindividual Variability

Intraindividual variability which is an important indicant of cognitive performance has two potential sources. The first is an endogenous influence (neurological), in which variability may be represented as a dysfunction in the activity of the central nervous system, such as a random release of neurotransmitters. The second source is an exogenous influence (behavioural), which may represent changes associated with factors in the external environment. The behavioural source of variability are generally stable over short intervals, while neurological sources are transient and show rapid changes from moment to moment, and therefore measurement has to be done over extremely short intervals.

Generally speaking, individuals who have a neurological condition or disease tend to exhibit higher level of intraindividual variability in their behavioural responding than healthy individuals. Reviews related to this view were made in 1926, when Head describes intraindividual variability in behaviour as a consequence of brain function. According to him, “an inconsistent response is one of the most striking results produced by a lesion of the cerebral cortex.” A number of clinical pathologies including neuro-generative disease, head injuries, and impending disease has been explored and examined in relation to intraindividual variability. Recently researchers have empirically examined the proposal that intraindividual variability is an indicator of neurological disturbance.

Stuss, Pogue, Bondar, Buckle, Donald, and Jay (1994) began this trend of assessing intraindividual variability in individuals with traumatic brain injuries (TBI). Subjects were assessed on 3 visual discrimination tasks. Inconsistency was assessed in two groups of individuals; one was patients with varying severity of traumatic brain injury and other was matched control subjects. Results were compared for group and individual variability. TBI group showed significantly higher group (between-subject) variability. In this study researchers found that TBI patients were highly inconsistent on RT tasks as compared to the controlled group. Specifically, TBI patients showed higher variability if their injury was more recently.

In 1996, Hetherington, Stuss, and Finlayson conducted a study to examine the reaction time and intraindividual in individuals with post traumatic brain injury (TBI).
Reaction time tasks, with increasing complexity, were administered on three groups of individuals, in which first group was post traumatic brain injury adults, second group was 5 year post traumatic brain injury adults and third was controlled group adults. Hetherington and colleagues found that mean RT was related to age and task demands only in the TBI groups. Older adults of these groups showed less RT as compared to controlled group. Inconsistency was significantly lower in the individuals with 5 year post-TBI as compared to two other groups of TBI.

Hultsch, Hunter, MacDonald, Lewy-Bencheton, and Strauss (2000) examined the intraindividual variability in cognitive performance across both trials and occasions. They examined 45 older adults in three groups, whose age ranged from 57 years to 87 years. Group 1 had 13 individuals, diagnosed with mild dementia; Group 2 consisted of 17 older adults with arthritis and Group 3 included 15 healthy older adults. Subjects were assessed for two reaction time i.e. simple reaction time (SRT) and choice reaction time CRT) tasks and two episodic memory (word & story recognition) tasks on four occasions. Results revealed that adults diagnosed with mild dementia, on an average, exhibited twice the amount of intraindividual variability in performance as compared to neurologically intact individuals. Mild dementia group exhibited higher dispersion variability for all the tasks except SRT. Similarly, demented group was more inconsistent as compared to other two groups. Results also indicated that higher intraindividual variability in the form of dispersion and inconsistency was correlated with slower and less accurate performance. Therefore, results suggested that intraindividual variability may be a behavioural index of compromised neurological mechanism.

Walker, Ayre, Cummings, Wesnes, McKeith, and O’Brien et al. (2000) examined intraindividual variability in patients with Lewy-Body Dementia (DLB), Alzheimer’s dementia (AD) and vascular dementia (VaD). Walker and colleagues used attentional measures of IIV in cognitive functioning and EEG markers to differentiate healthy, cognitively intact older adults from Alzheimer and Lewy-body dementia patients. To examine this aspect a total sample of 155 subjects was taken, in which 61 of AD subjects, 37 of DLB, 22 of VaD and 35 controlled elderly subjects participated. Subjects were clinically assessed for variability in cognition with the
help of a semi quantified measure and choice reaction time and vigilance reaction time (VIGRT), which were also measured for 90 seconds. During these 90 seconds, 40 subjects were evaluated for EEG frequency. Results revealed that DLB patients exhibited higher inconsistency on measures of reaction time. EEG trials showed second to second fluctuations in patients of Lewy-Body dementia. Therefore, DLB patients had a higher prevalence of IIV in their cognitive functioning as compared to patients with Alzheimer or Vascular dementia. Walker and colleagues also found that vascular dementia (Frontal lobe) patients showed higher IIV in cognitive functioning as compared to Alzheimer’s patients. Therefore, it was concluded that Lewy-Body dementia and frontal lobe dementia cause higher deterioration in frontal lobes as compared to Alzheimer’s which indicated that inconsistency is a better index of decline in frontal brain regions.

Burton, Hultsch, Strauss, and Hunter (2002) examined intraindividual variability in the physical functioning and emotional functioning of traumatic brain injury adults. Subjects were examined in three groups as mild head injury group, severe head injury group and healthy controlled group on ten occasions. Results indicate that higher IIV was exhibited by the individuals with head injury on the finger dexterity and right grip strength tasks as compared to healthy controlled individuals which revealed that individuals with head injury exhibited higher IIV in physical functioning across occasions. Burton and colleagues also found that increased IIV tended to be related with lower performance in both within and across task and higher level of IIV on one task was associated with higher IIV on the other tasks.

Murtha, Cismaru, Weachter, and Chertkow (2002) examined whether intraindividual variability may be a specific attribute of frontal lobe pathology. They assessed 23 subjects in two matched groups for 5 weeks. Group one consisted of 10 normal older adults whereas in group two, 8 patients with Dementia of the Alzheimer’s Type (DAT) and 5 patients with Frontal Lobe Dementia (FLD), participated. Subjects performed 3 Stroop tasks and 3 reaction time measures. Results revealed that subjects having FLD exhibited higher inconsistency on both the task;
specifically, task demanding more attention (choice reaction time). Frontal lobe
dementia patients did not show any significant increase in dispersion. Therefore, this
finding suggested the view that intraindividual variability, particularly inconsistency,
was higher in individuals having frontal lobe dementia.

Stuss, Binns, Murphy, and Alexander (2003) examined the view that patients
with focal frontal brain lesions showed higher IIV and more complex tasks required
more executive control. In this study a total of 48 subjects participated in which 12
were controlled subjects, 25 were patients with focal frontal lesion, and 11 were non-
frontal patients. Subjects were divided into five groups on the basis of their primary
lesion and then these were compared with the controlled group individuals. All the
subjects were examined for the measure of IIV (inconsistency& dispersion) on 4 RT
tasks; simple RT, easy choice RT, complex RT and Redundant RT. Subjects also
performed the National Adult Reading, digit span forward, Boston Naming Test and
Beck Depression Inventory. Measures were administered in three testing session
approximately with an interval of one week. Only frontal lesion patients were
examined for the measure of Dispersion. Results revealed that focal frontal lesion
patients exhibited higher intraindividual variability (inconsistency and dispersion) in
their performance because of the fact that damaged frontal lobes impairs the stability
of cognitive performance. Results also indicated significantly higher IIV on RT tasks
in frontal injury patients but the effect were not same across all frontal regions. Stuss
and colleagues concluded that individual differences, inconsistency over repeated
testing and inter-trial variability are important indicator of cognitive deterioration.

McCoy (2004) conducted a study to study inconsistency in memory
functioning of older adults, with and without mild cognitive impairment (MCI). Total
68 subjects, age ranging from 65 years to 87 years, were assessed in two groups in
which 15 subjects had mild cognitive impairment and 53 were non-MCI or normal
subjects. Subjects were examined on the measures of attention, working memory,
immediate and delayed episodic memory and processing speed for 31 days
continuously. In line with previous studies, results indicated that older adults with
MCI exhibited higher level of IIV as compared to non-MCI older adults. In most of
the studies higher IIV was related to low cognitive performance but in this study MCI patients did not show higher IIV on all the tests of cognitive battery.

Rapp, Sano, Schnaider-Beeri, Silverman, and Haroutunain (2005) examined age-related changes and the relationship between functional disability and dispersion cross-sectionally across cognitive tasks performance; in a very old institutionalized sample and community dwelling older adults. In this study total 580 subjects were examined from which 204 very old subjects (M=82 years) from nursing home institution and 376 community dwelling older adults (M=87 years) participated. To evaluate the relationship, subjects were examined for six neuropsychological tests (measuring memory and fluid abilities) and for Clinical Dementia Rating (CDR) scale. Results revealed that dispersion was positively associated with age in institutionalized individuals and negatively related to age in community dwelling individuals. Dispersion overall was higher in the institutionalized older adults. Cross-domain variability was related with functional disability which indicated that dispersion may serve as an index of neuropsychological dysfunction.

De Frias, Dixon, Fisher, and Camicioli (2007) conducted a study to find out intraindividual variability in neuro-cognitive speed of patients with Parkinson disease (PD). Ninety eight subjects whose age ranged from 65 years to 84 years, were examined in three groups of matched healthy older adults group (n=48), Parkinson disease patients and Parkinson disease patients with Incident Dementia (n=50). Subjects performed 50 trials of four RT tasks; one simple RT and three complexes RT (CRT-2, CRT-4, and CRT-8) and also for the task measuring executive functioning, Finger tapping, and Gait speed. Results showed that PD patients exhibited higher inconsistency as compared to healthy older adults on CRT-8 that was the most complex task. They were also slow on all three RT task and there was no correlation between IIV and tapping and gait speed which requires fewer demands on executive control. In the entire sample (healthy older adults, mild PD patients and severe PD patients) weak executive functioning was related to slow neuro-cognitive performance. Therefore, executive functioning and neuro-cognitive speed, or in other words IIV, may be a better indicator of clinical markers for progress of Parkinson disease.
Holtzer, Wang, Verghese, Hall, and Lipton (2008) investigated whether IIV predicts dementia or not. Subjects were taken from a longitudinal study of aging and dementia i.e. Einstein Aging Study (EAS). Originally 1797 subjects participated in the EAS from the year 1993 to 2007. Holtzer and colleagues included 897 subjects (age 70 years & above) from this longitudinal study. Subjects were assessed for the measures of verbal IQ, attention, executive function, and memory for 12 to 18 months. They performed on WAIS-R, Digit symbol substitution test and for Free and Cued Selective Reminding Test (FCSRT). To examine the relationship between neuropsychological tests and dementia 3 Cox proportion hazards regression analyses was conducted. Results revealed that during the follow-up period 61 subjects developed incident dementia, out of which 26 were in the highest quartile of IIV, 47 developed Alzheimer dementia and 18 subjects developed Vascular dementia. The Cox analyses model revealed that high scores of two neuropsychological tests (FCSRT and Digit Symbol Substitution) were associated with less possibilities of developing dementia whereas WAIS-R was not related with that. Intraindividual variability across neuropsychological test was significantly correlated with incident dementia after adjusting for sex, education, and medical illness which indicated that higher IIV predicts the risk of dementia. Results also indicated that independent of neuropsychological performance (test scores controlled) IIV was significantly associated with development of dementia.

Gamaldo, Yang, and Zonderman (2012) conducted a study to find out whether IIV in cognitive domains differentiate cognitively unimpaired individuals from those who subsequently develop dementia, specifically many years earlier than the onset of cognitive decline. The sample of 270 subjects included in this study represents the data collected in Baltimore Longitudinal Study of Aging (BLSA) in which 3036 participants were examined from 1970 to 2006. In this study, out of 270 subjects, 135 were diagnosed with dementia and 135 cognitively unimpaired subjects (non-demented) were examined, based on sex and age during the first testing session. To assess the cognitive performance a cognitive battery included measures of verbal memory, short-term visual memory, attention, executive function, speed, language, semantic memory, and global mental status was used. Cognitive performance of the
individuals was assessed from baseline to 5 years before the cognitive deterioration. On the basis of the results, Gamaldo and colleagues suggested that cognitively impaired individuals (demented) had greater IIV on the trial making test, category fluency, and Boston naming which measures the attention, executive function, semantic memory and language at least 5 years before the onset of their cognitive decline as compared to cognitively unimpaired (non-demented) individuals. Therefore, IIV may be an indicator of maladaptive cognitive functioning. The cognitively impaired individuals however, had less IIV on visual memory measures as compared to cognitively unimpaired group.

Kofler, Alderson, Raiker, Bolden, Sarver and Rapport (2014) examined the relationship between working memory tasks and RT variability in children with ADHD and developing children. In this study, 37 boys, 22 with ADHD and 15 typically developing children, were assessed for two RT tasks (CRT & Ignore-tone CRT) measuring RT variability (Ex-Gaussian, tau, & sigma) and for two central executive (CE) working memory (phonological & visuospatial) tasks across two weeks. Results indicated strong inter-relation between the central executive working memory and RT variability indices; CE working memory accounted for 80% to 100% of ADHD related inconsistency across models. On the other hand, inconsistency (RT variability) accounted for 10% to 29% of between group differences in CE working memory. This study explained that ADHD related inconsistency may be secondary to underlying deficits in central executive working memory.

Shin, Kim, Shin, Jung, Hur, and Byun et al. (2013) assessed IIV in schizophrenia patients and individuals At Risk Mental State (ARMS), with the help of response inhibition task to find out whether increased amount of IIV could predict the early stage of schizophrenia or not. Subjects for the ARMS and schizophrenia were taken from the hospitals of Seoul. A total of 102 subjects were examined in three groups as ARMS for psychosis group (n=27), schizophrenia patients group (n=37), and healthy controlled group (n=38). Subjects performed on a test of Cambridge Computerized Neuropsychological Test (CANTAB) named as Stop-Signal Response Task (SSRT). Test was conducted in five blocks and these five blocks were further divided into four sub-blocks with 16 trials in each. In every sub-block out of 16 trials,
trials were go and 4 were stop trials. Results showed that there were significant group differences in IIV in the inhibition process (stop process). Results indicated that ARMS subjects and schizophrenia patients exhibited greater intrindividual variability for both ‘go’ and ‘stop’ processes i.e. execution and inhibition process as compared to healthy controlled individuals. The correlation was examined for IIV and SSRT with psychotic system in schizophrenia. Results revealed that longer SSRT (impaired inhibition-execution process) was related with negative symptoms in schizophrenia. Hence, patients with higher number of negative symptoms need larger time to respond. ARMS subjects were not significantly correlated with IIV or SSRT on this positive-negative symptom aspect. Therefore, schizophrenic patients showed greater intrindividual variability.

Kalin, Riese, Pfluger, Gieti, Jancke, and Nitsch et al. (2014) compared within and across domain intrindividual variability of Alzheimer patients (AD), Mild Cognitive Impairment (MCI) patients and healthy individual to implicate IIV as an early indicator of Prodromal Alzheimer’s disease. The sample was selected from the Memory Clinic of the division of Psychiatry Research and Psycho-geriatric Medicine Study. A total sample of 206 subjects, in which 26 Alzheimer’ patients, 31 MCI patients, and 149 normal controlled adults, were selected. Subjects performed 6 cognitive tasks for measuring across and within domain IIV (3 tests for each). To measure across domain IIV, digit span forward, word list learning, and category fluency and for within IIV, letter fluency task, trial 3 stroop task, and five-point test were used. These tests measured the memory, verbal learning, semantic knowledge and executive function aspects of cognitive functioning. Results of the study found greater IIV across tasks in patients of Alzheimer disease as compare to MCI and normal adults and IIV was affected by age also. Therefore, beginning of Alzheimer disease in MCI patients can be recognizing with across domain IIV. On the other hand, within domain IIV was higher in both the Alzheimer and MCI patients. Specifically MCI patients exhibited higher IIV as compared to normal adults in within domain only. Hence within IIV tapped cognitive functioning (executive control) more closely than across IIV, therefore it appeared to be better indicator for detection of Prodromal Alzheimer disease at MCI stage.
Fellows, Schmitter, Edge, and Comble (2015) evaluated the relationship between cognitive dispersion and performance of functional abilities in older adults. In this study, 156 older individuals were examined in two age groups in which 126 were healthy older individuals and 30 were adults with MCI. Subjects were assessed for cognitive measures including memory assessment scale (list learning), trial making test A and trial making test B, symbol digit modalities (written & oral), CLOX 1, letter number sequencing, temporal order sequencing task and zoo map subtest; for letter number span task, and for day out task (DOT). Results indicated that dispersion on cognitive measures was correlated with the DOT multitask. Dispersion was inversely correlated with neuropsychological global scores, means lower dispersion was associated with better cognitive performance. Results revealed that higher cognitive dispersion was correlated with more simultaneous task that predicted poor task sequencing and accuracy. Study also indicated that individuals with low dispersion, increased multitask was related with better task performance and vice-versa.

Considered together, the above review indicates that recently researchers have begun to empirically examine the notion that intraindividual variability may be an indicator of neurological disturbance or deterioration. Findings suggested that TBI patients exhibit higher intraindividual variability than healthy individuals and more the severity of injury higher will be the intraindividual variability (Burton et al., 2002; Hetherington et al., 1996; Stuss et al., 1994). Higher intraindividual variability has also been observed in schizophrenia (Shin et al, 2013), mild cognitive impairment (Fellow et al, 2015; Kelin et al, 2014; Mccoy, 2004), Alzheimer’s disease (Gamaldo et al, 2012; Holtzer et al, 2008; Kelin et al, 2014; Rapp et al, 2005; Walker et al, 2000) and in ADHD (Kofler et al., 2014). Some researchers found that focal frontal lesions and frontal lobe dementia patients exhibited higher intraindividual variability than healthy older adults (Murtha et al, 2002; Stuss et al., 2003) and Parkinson’s disease patients had weak executive function as compared to healthy adults (De Frias et al., 2007). Walker and colleagues (2000) found Lewy-Body dementia and frontal lobe dementia caused higher deterioration in frontal lobes as compared to Alzheimer’s which indicated that inconsistency is a better index of decline in frontal brain regions.
Some studies indicated that cross-domain variability was related with functional disability which indicated that dispersion may serve as an index of neuropsychological dysfunction (Rapp et al., 2005). Hultsch and colleagues (2000) found that intraindividual variability in the form of dispersion and inconsistency was correlated with slower and less accurate performance and therefore, may be a behavioural index of compromised neurological mechanism. Therefore these findings suggested that intraindividual variability is a sensitive marker of neurological decline.

**Intraindividual Variability in Neuropsychological Functioning**

Some researchers have studied intraindividual variability across tasks as well as across sessions. Reviews related to both types of intraindividual variability, i.e. inconsistency and dispersion are presented in this section.

Shammi, Bossman and Stuss (1998) examined intrindividual variability in both younger and older women. The age ranged between 20 to 35 years for the younger women and 60 to 75 years for the older women. Subjects were assessed on two psycho-motor tasks i.e. finger tapping and choice RT and a time-estimation task. A time interval of 40 second was given between the test sessions and within session consistency was assessed by comparing the performance in that time interval. Across session inconsistency was also assessed by dividing the testing sessions about one week approximately. Shammi et al. found that older subjects showed greater intraindividual variability between the two sessions on psychomotor tasks and time estimation task as compared to the younger adults.

Rabbit, Moore, Osman and Stollery (2001) investigated whether variability within a testing session is a stable characteristic of individual differences and mean RT reflects that variability. This study was conducted on a sample of 98 subjects, age ranging from 60 to 80 years, in three age groups. Subjects were tested on letter categorization tasks, Cattell Culture Fair Intelligence test and reaction time task over a 36 week period. Researchers found that older adults who scored lower on Cattell Culture Fair Intelligence test had slow choice reaction time and higher magnitude of within session variability on all tasks. They explained that if subjects show variance on CRT task within testing session; then between session variability (day-to-day) also
vary because their performance is affected by state change. They concluded that both trial to trial variability within a session and variability in between sessions were correlated.

West, Armilio, Murphy, Stuss and Craik, (2001) examined the transient nature of lapses of intention and age-related increases in performance variability in task conditions requiring executive control processes. For this purpose 40 individuals were assessed in two groups as younger adults (age ranged 19 to 29 years) and older adults (age ranged from 65 to 83 years), for four days in two sessions; morning session and evening session. Subjects performed a Digit-immediate response: I-back task in four conditions as target isolated immediate response condition, target-distracter immediate response condition, target isolated I-back condition, and target-distracter I-back condition. These four conditions of tasks were performed in four blocks of trials; each block consisted of 50 trials. Results indicated that dispersion was higher in I-back conditions (more executive control demanding task) than immediate response condition and in all conditions older adults were slower as compare to younger adults. Results also revealed that older adults as compare to younger adults exhibited more inconsistency on I-back condition than immediate response condition. Therefore, findings suggested that age-related increase in performance variability were limited to the task conditions which require active involvement of executive control.

Hultsch, MacDonald, Stuart and Dixon (2002) examined the relationship between age differences and intraindividual variability. In this study, a total of 862 subjects (546 women & 316 men) were examined in four age groups. Younger adults group (n=99) ranged from 17 to 36 years, the young-old age group (n=178) ranged from 54 to 64 years, the mid-old age group (n=361) ranged from 65 to 74 years and the old-old age group (n=224) ranged from 75 to 94 years; were assessed on four measures of Reaction Time i.e. simple reaction time (SRT), Choice Reaction Time (CRT), Lexical Decision, and Semantic decision and measures of Perceptual Speed, Working Memory, Episodic Memory and Crystallized Abilities. The results indicated that older adults, specifically 75 years and above, showed more trial to trial variability (inconsistency) in their performance than the younger adults on RT tasks. Older adults were also more variable in their performance across the four RT tasks (dispersion) as
compared to the younger adults. They found significant inter correlation between inconsistency and dispersion i.e. ranging from .12 to .47 which indicated that individuals with more variability across the tasks (greater dispersion) showed higher variability across the time i.e. higher inconsistency. Their results also indicated that higher inconsistency on RT tasks was associated with lower performance on the cognitive tasks. Therefore, inconsistency can be a predictor of cognitive performance.

Allaire and Marsiske (2005) conducted this study to determine the extent to which intraindividual variability was associated across multiple cognitive abilities and intraindividual variability itself remained a stable attribute in a repeated measurement. In this study, 36 subjects were assessed, age ranging from 60 to 87 years, for a self administered cognitive assessment, twice a day for 60 consecutive days. Cognitive measures examined the inductive reasoning, perceptual speed and memory tests, 14 alternate forms for three cognitive measures were used so that the familiarity effect of the test can be minimized. The results of the study indicated that intraindividual variability was not correlated between the cognitive measures rather intraindividual variability was strongly inter-correlated within a task (i.e. trait like consistency), specially for list memory and perceptual speed. Results also indicated that higher mean performance on the cognitive measures was associated with greater intraindividual variability performance on those measures. The follow-up analyses of the study showed that higher level of intraindividual variability is positively correlated with the magnitude of an individual’s practice related improvement on a specific measure. Allaire and Marsiske argued that there may be practice-related (adaptive) as well as inconsistency-related (maladaptive) intraindividual variability present, within the same individual over time.

Salthouse, Nesselroade, and Berish (2006) examined mainly two issues in their study firstly, they examined the magnitude of within-person variability in different measures of cognitive performance and secondly the nature of intraindividual variability, that it is a random noise or a meaningful indicator of individual difference characteristic, was examined. For this purpose Salthouse and colleagues examined four distinct cognitive abilities. To measure these abilities a total of 143 adults were examined in three age groups and their age ranged from 18 years
to 97 years. The subjects were administered different versions of 13 cognitive tests in three different sessions. Results of the present study indicated considerable within person variability in each measure of cognitive functioning. In this study researchers found high ratio of within person variability to between person variability on three measures of cognitive functioning i.e. vocabulary, fluid intelligence and episodic memory than that of perceptual speed. Negative correlation was found between within person mean and across-session variability which indicates that higher performance was associated with lower across-session variability. Researchers also found that short-term inconsistency is substantial in accuracy measures of cognitive functioning. The presence of moderate to high level of inconsistency in all 13 cognitive tasks shows that single assessment may not be very informative about an individual’s actual level of cognitive functioning. Therefore, within-person variability (inconsistency) in cognitive functioning has important implications for the evaluation of change.

Hillborn, Strauss, Hultsch, and Hunter (2009) examined the relationship between aging and dispersion of cognitive function, quantitatively as well as qualitatively. They conducted a cross-sectional study on 304 subjects, who were divided into two age groups; young-old (64-74 years) and old-old (75-92 years). Subjects performed a nine paper and pencil task for measure of dispersion in which three measures of perceptual speed, one measure of fluid reasoning, three measures of episodic memory and two measure of semantic memory. To measure inconsistency, two indicators of reaction time were used. Results indicated that older-old group show higher dispersion than the younger-old group which may be an indicator of cognitive deterioration. Results indicated positive correlation between dispersion and inconsistency, which means that individuals with high intraindividual variability across time (i.e. inconsistency) also exhibited high intraindividual variability across task (i.e. dispersion). Hillborn and colleagues explained that intraindividual variability of dispersion (across task) and inconsistency (across time) is a meaningful indicator of individual differences.

Iskender (2010) investigated intraindividual variability and time of day for verbal fluency and the relationship between short-term fluctuations and cognitive aging. This study is a part of large research project on performance variability, aging
and executive function conducted at Baycrest Centre. To examine both aspects of IIV i.e. dispersion and inconsistency, data collected from Baycrest project was used. A total of 40 subjects were taken, in which 20 younger (19 to 29 years) and 20 older adults (65 to 85 years) were investigated. The participating subjects were in good physical health and did not have any neurological disorders. Subjects were tested on verbal fluency tasks i.e. letter fluency and category fluency, on four consecutive days, with two morning sessions and two evening sessions. Results indicated that older adults made more mistakes on letter fluency task on all occasion than younger adults. The findings of the study indicated that older adults and younger adults did not show differences in the dispersion level within each verbal fluency measure whereas younger adults were less consistent in the number of switches in both verbal fluency task as compared to older adults. This study also showed that older adults performed better on category fluency task in the morning than evening time whereas result of younger adult was in opposite direction. Contrary to expectations, results did not indicate any overall differences between age groups in consistency of performance across days or in dispersion within a task on an occasion.

Salthouse (2012) conducted a study to investigate the properties of IIV in accuracy of cognitive performance i.e. magnitude, structure (inter correlation of IIV in different variables), longitudinal stability, and correlation of IIV with change in cognitive abilities. To find out these properties, 1725 adults age ranging from 18 years to 95 years, were assessed in two age groups in three session measurement at first occasion. Five hundred seventy nine subjects were assessed for second measurement after an interval of approximately 2.5 years. Subjects performed on a set of 16 tests measuring 5 cognitive domains i.e. vocabulary, inductive reasoning, spatial visualization, episodic memory and perceptual speed, of individuals cognitive functioning. Contrary to previous researches, results indicated that IIV in accuracy across session was higher. It was one fourth the magnitude of between person variability in average performance. Results revealed that correlations between age and IIV measures were relatively small (-.14 to .08), the measures of cognitive functioning had very low stability across time and the correlations with longitudinal change in cognitive abilities were near zero.
Above researches concluded that intraindividual variability increases with age i.e. older age individuals exhibited higher IIV than younger adults (Hultsch et al., 2002; Shammi et al., 1998; West et al., 2001). A number of studies indicated that higher variability across tasks i.e. dispersion was correlated with greater variability across sessions i.e. inconsistency (Hillborn et al., 2009; Hultsch et al., 2000, 2002; Nesselroade & Salthouse, 2004; Rabbitt et al., 2001). West and colleagues (2001) emphasized that individuals exhibited higher dispersion on the tasks which required more executive control. Hillborn and colleagues (2009) found that intraindividual variability of dispersion and inconsistency is a meaningful indicator of individual differences. Findings also suggested that higher inconsistency on RT tasks was correlated with lower performance on cognitive tasks; therefore, it can be a predictor of cognitive performance (Hultsch et al., 2002). Thus, the above studies suggested that IIV can be a good indicator of age related cognitive decline and age differences.

**Intraindividual Inconsistency and Neuropsychological Functioning**

Researchers have shown that there is considerable stability in inconsistency i.e. amount of inconsistency in cognitive performance has been shown to be a relatively stable characteristic of an individual. This section of review is related to inconsistency in cognitive and neuropsychological functioning in relation with aging.

Hertzog, Dixon and Hultsch (1992) conducted a longitudinal study to assess the patterns of intraindividual change and intraindividual variability in story (text) recall. In this study, seven old women were assessed weekly for 2 years. They found that performance of subjects were highly variable across the 2 years. They found that 20% of the inconsistency in performance was reliable variability and not because of practice, different stories or any other systematic change related to the study. Researchers found significant inconsistency after adjustment for text effects, which indicated that subject’s memory was influenced by the weekly fluctuations in the psychological states.

Fozard, Vercrysen, Reynolds, and Quilter, (1994) investigated the age differences and RT changes in Baltimore Longitudinal Study of Aging (BLSA). The cross-sectional analysis was conducted on 1265 volunteer subjects in whom 833 males and 432 females were repeatedly assessed over the period of 8 years. Subjects’
age ranged from 17 to 96 years and they were tested for an auditory reaction time in which Simple Reaction Time (SRT) and discrimination Reaction Time (DRT, go-no-go) tasks were used for an interval of 2 years. Results of the study revealed that SRT and DRT increased with age in both males and females, specifically DRT is slower than SRT. The number of errors and inconsistency (within-person variability) also increased with age. Results indicated that men were faster than women consistently across age and visits. Therefore, results explained that slowing of behaviour is characterized by age-associated increase in IIV and due to the degree of involvement by higher order functions in central nervous system (CNS).

Li, Aggen, Balets, and Nesselroade (2001) studied intraindividual variability (inconsistency) in older adults sensorimotor functioning and their relation to individual differences in memory. In this study 24 subjects were assessed, age ranged from 64 to 86 years (M= 75.71 years). Li and colleagues used the measurement battery of Corwall Manor Study from which 12 variables measuring sensorimotor functioning, verbal and spatial memory were analyzed. Subjects’ verbal memory was assessed by memory span and text memory in which Wechsler Adult Intelligence Scale (WMS) for the memory span and for story text developed by Hertzog et al (1992) was used. Sensorimotor functioning was assessed by three walking tasks which included the duration and number of steps taken to walk a 360° circle, to walk 10 feet in normal and fast speed. The Sensorimotor performance was examined on alternate weeks for upto 7 months approximately and memory tasks were conducted every week for 25 weeks. The results of this study indicated that the magnitude of inconsistency in the level of performance in most Sensorimotor and memory tasks were substantial i.e. half or more of the magnitudes of inter-individual differences. Inconsistency increased with age and negatively correlated with Sensorimotor and spatial memory performance. Therefore, this study indicated that inconsistency in older adult’s performance can be an important factor for understanding sensory and cognitive aging.

MacDonald, Hultsch, and Dixon (2003) conducted a longitudinal study over 6 years to examine the change in inconsistency and further expanded their study to find out whether inconsistency could predict the change in level of cognitive functioning
or not. In this Victorian longitudinal study, 446 older adults were divided into three age groups i.e. young old (55-64 years), mid-old (65-74 years) and old-old (75-94 years). Subjects performed 4 RT tasks and cognitive tasks measuring working memory, processing speed, episodic memory, fluid reasoning and crystallized verbal abilities in 3 occasions over a time period of 6 years. The study revealed the same results as earlier cross-sectional researches that marked increment in inconsistency was observed only for the older adults not for the other two age groups. Second, MacDonald and colleagues demonstrated that inconsistency significantly attenuated decline on cognitive test by an average of 93%. They found a significant association between IIV change and changes in cognitive scores over a period of 6 years. Results indicated that individuals who showed higher inconsistency, performed low on cognitive tasks and the relationship was significant for five cognitive measures out of six. Therefore, the study supports the view that inconsistency serves as a significant marker of cognitive deterioration.

Bunce, Stuart, MacDonald, and Hultsch (2004) examined age differences in RT inconsistency. They investigated mainly three issues in this study. Firstly, whether inconsistency is a general characteristic or is specific to particular elements of the information processing system, secondly to relate the age differences in inconsistency as a result of time-on-task and the lastly to find out the association between inconsistency and task demands. For this purpose, they examined 48 subjects in two age groups i.e. younger age group (24 subjects) ranged from 20 to 30 years and older age group which ranged from 60 to 85 years. Subjects performed the Wechsler Adult Intelligence Scale – R for the verbal intelligence and Serial Choice Reaction Time task. A total of 300 trials in 2, 4, and 8 choice RT conditions were recorded for the decision and motor RT repeatedly. The result of the study indicated that age differences in inconsistency dissociated for the decision RT means older adults showed higher inconsistency specifically during the last blocks of the trials which indicated that effect of higher task demand and fatigue increased the inconsistency in older adults. Bunce and colleagues found that neurobiological mechanism that underlies behavioural measures of inconsistency becomes more variable as fatigue
level increases. This study support the previous research work focused on apparent lapses in attention during continuous mental work.

Nesselroade and Salthouse (2004) investigated three types of variability i.e. between persons, within person across trials and within person across the occasion of the task on perceptual-motor performance and related it to age. This study was conducted on a sample of 204 subjects, whose age ranged from 20 to 91 years. Subjects were taken from three age groups, i.e. 18-39, 40-59, and 60-91 years. Subjects were administered two perceptual motor tasks in three separate sessions for an interval of two week. The results indicated that intraindividual variability is 37% to 53% of the between person variability which means that any single occasion of measurement might not represent the performance of an individual exactly. Another finding of the study was that age was associated with increased variability in sessions and increased inconsistency was negatively correlated with cognitive performance.

Ram, Rabbitt, Stollery, and Nesselroade (2005) examined individual differences in intraindividual variability and intraindividual change. They examined intraindividual variability of 91 older adults (age 52-79 years) weekly. To measure reaction time a multi-trial memory speed task (letter recognition) was used for 36 weeks. Using multivariate techniques, they examined the level of inconsistency of an individual across weeks and correlation between that change and interindividual difference in age and intelligence. Results revealed that there is no evidence of regular state like patterns. They explained that inconsistency is a construct different from the underlying performance. Further Ram and colleagues discovered that the magnitude of inconsistency within an individual was negatively correlated with the intelligence; which means as the level of inconsistency increased level of intelligence decreased.

William, Hultsch, Strauss, Hunter, and Tancock (2005) studied inconsistency in RT across the lifespan. A total of 273 subjects, age ranging between 6 to 81 years were examined for choice reaction time task in four age groups. In their results William and colleagues found a U-shaped curve in inconsistency i.e. greater inconsistency for youngest age group and older adults but there is sharp decrease in adolescence and young adulthood. They explained that differences in inconsistency were independent of practice, fatigue and age-related differences.
Lovden, Shing, Li, and Lindenberger (2007) used a structural equation model specifically Dual Change Score Model (DCSM), to investigate whether intraindividual trial-to-trial variability (inconsistency) predicts subsequent negative longitudinal changes in cognitive performance. Inconsistency precedes and predicts cognitive deterioration can be empirically examined with the help of DCSM. Lovden and colleagues used the Berlin Aging Study (BASE) data from which 447 subjects age ranged from 70 years to 102 years were selected for 14 session assessment. For this study subjects performed the tasks related to fluency, digit letter, and identical pictures; to measure the inconsistency, perceptual speed, and ideational fluency. Results revealed that longitudinal changes in trial to trial variability were significantly correlated with changes in categories (-.82) and digit letter (-.68). Specifically, older adults show higher decrease in digit letter and increase in variability. Also, individuals with suspected dementia and closer proximity to death performed low on digit letter performance. Therefore, results indicated that higher trial to trial variability reliably precedes and predicts greater decline in cognitive performance in perceptual speed and ideational fluency. This study was in line with previous researches that found that inconsistency independently predicts chronological age, cognitive functioning decline and disease status.

Myerson, Robertson and Hale (2007) examined whether older individuals were more variable as compared to younger adults or not when differences in learning rates and response speed were considered. Researchers also studied the Skewness of RT distribution of the individuals. In this study 18 subjects were studied, divided into two groups of young (19 to 22 years) and old (70 to 78 years). Subjects were administered the same-different judgment serial-choice reaction time task in which 1917 experimental trials were taken in three sessions with an interval of 15 minutes. Results indicated that in the first session older adults tended to be more variable in reaction times than younger adults. The response speed improved by the second session for both the age groups. The accuracy of responses also improved with practice. Researchers explained that younger and older adults RT distribution were examined using Quantile-Quantile plots and by Ex-Guassian and Weibull functions; there was no consistent results which shows more skewed RT distribution for older
adults as compare to younger adults. More importantly results indicated a positive linear relation between RT and inconsistency for both within subjects and between subjects. Therefore, results revealed that greater inconsistency of older adults primarily reflects their greater mean RTs.

Bielak (2008) examined the relationship between inconsistency and long term cognitive change with the help of two studies of intraindividual variability in a longitudinal context. For this purpose a total of 304 older participants were examined. Their age ranged from 64 years to 96 years in which 208 women and 96 men participated between 1 to 6 waves of annual testing over a period of 5 years. Subjects were divided into two age groups; one was young-old group aged 64-74 years and other was old-old group aged 75-92 years at the first occasion of the study. Subjects were examined during seven sessions scheduled over three months approximately, on various cognitive measures and reaction time task. Cognitive ability was measured through 5 tests which are perceptual speed, reasoning, episodic memory, verbal fluency, and vocabulary task. Inconsistency was measured through various multi-trials computer-based RT tasks in which finger tapping, choice reaction time (CRT), choice reaction time I-Back (BRT), arrow task, shape, colour and task switching were performed. Results of the first study included the longitudinal nature of inconsistency and its relationship with cognition in older adulthood. Individual’s level of inconsistency significantly predicted their cognitive functioning level 3 years later. Results indicated higher proportion of inconsistency on the letter series, digit symbol, and word recall whereas on similarities and vocabulary tasks, inconsistency was low which shows that it may be a better predictor of cognitive functioning that rely on fluid and processing abilities as compared to crystallized abilities. These fluid and processing abilities (speed, memory, & reasoning) tend to decline with age whereas the crystallized abilities were not affected in later older adulthood. Results also indicated that older age group (i.e. 75-92 years) showed greater intraindividual variability on all RT tasks as compare to young-old age group (64-74 years) subjects. The second study investigated whether IIV could predict cognitive decline, mild cognitive impairment or determinable health outcomes 5 years later. Results showed that inconsistency on all RT tasks at wave 1 was sensitive to the changes reflecting
the early behavioural characteristics of dementia including episodic memory, cognitive status and attrition. All the cases which show higher level of inconsistency were associated with a higher possibility to be in maladaptive category 5 years later. IIV on moderate to high cognitively challenging tasks was predictive of the rate of attrition comparable to neuropsychological tasks.

Dux (2009) assessed older adults spanning four decades through inconsistency. The author examined the relationship between inconsistency on cognitive and sensory aspects and mean level on verbal and nonverbal memory. He was also interested to find out whether IIV on cognitive tasks was related to self reported negative effect or not. In the present study 102 healthy adults were examined, whose age ranged from 45 to 89 years. In order to examine the relationship between degree of inconsistency and age, subjects were repeatedly assessed for sensory functioning and processing speed in a single testing session whereas verbal and non verbal memory tasks were administered only once. Self reported questionnaire of subjective memory, sensory functioning and negative affect (depression, anxiety, and general negative affectivity) were also administered. Results indicated that both processing speed and sensory –motor functioning significantly reduces the amount of age related inconsistency in measures of memory; particularly processing speed appeared to be a stronger mediator for this age related inconsistency as compare to sensory functioning. Results showed that there was no relationship between inconsistency on processing speed and sensory functioning tasks. Moreover, results did not indicate any association between inconsistency and self reported affect.

Schmiedek, Lovden, and Lindenberger (2009) conducted a study to find out the relation of mean RT and SDs in working memory domain. For this purpose they examined 204 individuals in two groups, i.e. younger (n=101, age 20-31 years) and older (n=103, age 65-80 years), where age range from 20 years to 80 years. Subjects were assessed on the spatial 3 back task for 192 days in 101 testing sessions. In every session four trials of the task were taken. Results indicated that inconsistency was higher for older adults as compare to younger adults whereas in overall mean RT performance older adults showed improvement as compared to younger adults.
Bielak, Strauss, Hultsch, MacDonald, and Hunter (2010) conducted a study on the basis of previous researches which suggested that inconsistency in RT is highly sensitive to subtle changes in cognitive ability. Bielak and colleagues examined whether inconsistency predicts the changes in cognitive outcomes such as cognitive impairment no dementia (CIND) and attrition 5 years later of the testing. To find out these outcomes 212 older adults, whose age ranged from 64 to 92 years, performed reaction time task. The subjects remained in the study for 5 years. Participants were divided into two groups on the basis of their fluctuation in CIND over time i.e. stable intact group and stable CIND group. Researchers found that inconsistency significantly distinguished among both the groups and average level of inconsistency was also predictable for attrition; which means that higher level of inconsistency was related to higher possibilities of being in a maladaptive or deteriorated group after 5 years. Mean RT was a comparable predictor of cognitive change in individuals whereas individuals who showed higher inconsistency in their performance were at higher risk of being in a maladaptive outcome group.

Vanderhill, Hultsch, Hunter and Strauss (2010) examined the self-perceived cognitive inconsistency of older adults. They assessed 94 older adults, age ranged from 70 to 91 years; for the Cognitive Variability Questionnaire (CVQ) measure of self-reported cognitive inconsistency, Mini-Mental Status Exam (MMSE), WAIS-R digit symbol substitution task, letter series test, word recall task, controlled association test, recognition vocabulary test, and for a set of five RT tasks over 4 to 5 sessions. Results indicated increase in perceived inconsistency over time. Greater inconsistency and higher 5 years increase in inconsistency were related with non cognitive, meta-cognitive, and neuropsychological measures. Small correlations were observed between self-rated inconsistency scales and performance based reaction time cognitive inconsistency measures. Results revealed correlations between self-reported inconsistency and neuropsychological performance were attenuated. Therefore, self-perceived inconsistency may be a field of interest in assessing older adults for neuropsychological decline.

Papenberg, Backman, Chicherio, Nagel, Heckerman, Li et al. (2011) examined the effect of inconsistency on forgetting and dedifferentiation of memory functions in
older adults. In the first portion, the association between inconsistency in RT and long term episodic forgetting was examined and then the relationship between inconsistency and dedifferentiation of memory functions by comparing the factor correlation between episodic memory and working memory measures was assessed in the second part. A total of 574 healthy older adults, whose age ranged 60 years to 71 years were examined in two cognitive sessions with an interval of 1 week. Subjects were assessed in two groups as low and high variability group for a cognitive test battery which measured episodic memory, working memory, executive functioning, perceptual speed and intelligence. Results revealed that individuals with high inconsistency forgot more memory tasks over a one week retention interval as compare to the low inconsistency group individuals. Whereas slow RT speed was related to weaker episodic memory but forgetting was not found. Correlations found in the study between episodic memory and spatial working memory was considerably large in the higher inconsistency group (i.e. .63) as compare to lower inconsistency group (i.e. .25). The results of the study were showing that deficits in dopamine modulation may underlie increases in RT variability i.e. inconsistency. Results were in line with the several animal studies showing that infusion of DA impairs only long term memory but short term memory remains intact.

Kennedy, Taylor, Noda, Lazzeroni, and Yesavage (2013) examined whether intraindividual variability predicts age related changes in flight performance over time and performance on a cognitively complex real-world task. A total of 236 pilots, participants in a longitudinal Stanford Aviation Study, ranged from 40 to 69 years of age were completed two 75 minutes simulated flights in a flight simulator and 40-60 minute of cognitive tests. Task included symbol digit coding task, executive function measures, and processing speed measures. Inconsistency measured through sequencing and visual scanning, shifting attention and divided attention tasks with an interval of 3 weeks. Results were calculated in 4 models which included model 1- age, model 2- processing speed and age, model 3- basic inconsistency and age and model 4- processing speed, inconsistency and age. Results indicated that inconsistency on basic reaction was a significant predictor for all initial measures of flight performance including measures of mean RT and executive function. Contrary to the expectation,
mean RT explained a higher proportion (58%-70%) of age related variability as compare to inconsistency (15%-22%). Whereas after including processing speed, basic inconsistency explained age related variance additionally, 8%-12% in flight performance. Therefore, results suggested that inconsistency in RT had an adverse effect on the ability of pilot to maintain the control of the aircraft, which indicated that inconsistency may affect the driving particularly in middle and old aged individuals.

Bielak, Bunce, Cherbuin, and Anstey (2014) conducted a longitudinal study to assess possible age group, sex, and task differences in inconsistency across adulthood over 8 years. Education, diabetes, hypertension, anxiety, and depressive symptoms of the individuals were controlled. With the help of multi-level modeling, 7485 subjects in three age groups (i.e. 20-24 years, 40-44 years, and 60-64 years at baseline) were examined in three testing session over 8 years. Subjects were assessed on a questionnaire measuring socio-demographic characteristics, mental and physical health, and cognitive functioning at each testing session. Two reaction time task i.e. simple reaction time (SRT) and choice reaction time (CRT) were conducted for the measure of intraindividual variability. Results indicated significant age group and sex differences in baseline inconsistency on RT tasks; i.e. individuals of age group 60 years and above showed higher inconsistency than other individuals. Only oldest age group represented a positive slope in inconsistency for simple reaction time across 8 years whereas for CRT, both groups of older adults (40 years & 60 years) showed greater inconsistency than younger age group; which indicated the fact that on cognitively complex task older individuals represent significant increase in inconsistency over time. Therefore, inconsistency is believed to be sensitive behavioral indicator of neurological integrity. Results also provided the facts of sex differences i.e. on SRT females had higher level of inconsistency as compare to males in all the age groups whereas contrary to previous researches, for CRT sex differences were reduced, only the younger age group females were show greater inconsistency on CRT than males. Therefore, increase in inconsistency is a fundamental behaviour related with growing older even in healthy adults.

From the above reviewed studies it is apparent that inconsistency is notably higher at the two extreme stages of life span i.e. childhood and older adulthood. Using
cross sectional data Williams and colleagues (2005) found cognitive inconsistency was highest for the younger adults decreased in adolescence and then again slowly increased in middle and older adults. Most of the longitudinal studies also suggested that inconsistency increased with increasing age (Bielak et al., 2014; Fozard et al., 1994; Lovden et al., 2007; MacDonald et al., 2003; & Schmiedek et al., 2009). Studies indicated that inconsistency was negatively correlated with cognitive performance i.e. if the inconsistency increased cognitive performance decreased. In view of this notion some studies indicated that inconsistency serves as a significant marker of cognitive deterioration (Bielak, 2008; Bielak et al., 2010; Lovden et al., 2007; & MacDonald et al., 2003) and trial-to-trial inconsistency can better predict the cognitive decline (Lovden et al., 2007). Research has also shown significant amount of inconsistency present in other functioning domains, presumed to be stable. Li and colleagues (2001) found sensorimotor inconsistency was negatively correlated with performance on walking tasks. Bunce and colleagues (2004) found that as the fatigue level increase, inconsistency also increased. Self-perceived inconsistency related with neuropsychological decline (Vanderhill et al., 2010)

One study was in contradiction to the previous studies, where Kennedy and colleague (2013) found that mean RT explained a higher proportion of age-related variability as compare to inconsistency.

**Intraindividual Dispersion and Neuropsychological Functioning**

A large number of researchers have examined the extent to which neuropsychological functioning in healthy older adults is characterized by intraindividual dispersion. Results indicate that there is a significant relationship between neuropsychological functioning, intraindividual dispersion and age.

Fozard, Thomas and Waugh (1976) examined age differences in inter and intraindividual variability of Choice Reaction Time (CRT) and frequency of stimulus repetitions. In this study, a total of 123 males age ranged from 25 years to 79 years were studied in five groups (34, 40, 50, 58, & 69 to 79 years) to obtain the two-choice reaction time. The trials were presented in discrete sequences in which proportion of occasion (same stimulus presented twice in succession) varied from .25, .50, and .75 or from .75, .50, and .25. They found that subjects in all age groups responded faster
to the stimulus alteration than the stimulus repetitions. The between subject variability was higher in oldest age group (69 to 79 years) as compare to other groups. In both conditions of stimulus presentation (alternated and repeated) dispersion was also higher for the oldest age group. The results indicated that reaction time (RT) was affected by pre-existing expectations for stimulus alterations as well as expectations for stimulus repetitions during the investigation. In this study researchers found that both mean RT and dispersion in performance increased with age. They also found dispersion in decision making aspect of RT whereas psycho-motor aspect of RT increased with age.

Salthouse (1993) reported that processing speed may be slower with increased age because of longer duration attentional blocks. He examined the relation between age and parameters of the intraindividual (dispersion) RT distribution. He conducted a study on 784 adults (participated in earlier study) in four data sets age ranging from 18 years to 87 years. Subjects performed two RT tasks i.e. digit- digit and digit symbol; four paper and pencil task (two for motor speed & two for processing speed), and three computerized cognitive tasks. Results revealed that there was low or no independent age related dispersion in the slowest RTs after controlling for the variance in the fastest RTs. Results also indicated that age related slowing was related with a shift in the whole RT distribution and was not attributable to a selective influence on the individual’s slowest response.

Lindenberger and Baltes (1997) examined dispersion in psychometric measures of intelligence in two age groups i.e. old and very old. Data was comprised from Berlin Aging Study and consisted of 516 subjects, whose age ranged from 70 years to 103 years. Subjects were examined for 14 test measuring five cognitive abilities including reasoning, memory, perceptual speed, knowledge, and fluency. Results indicated that intellectual abilities had a linear association with age. More pronounced age decline in reasoning, memory and perceptual speed was found as compare to crystallized abilities (knowledge and fluency). Sensory-sensorimotor variables predicted 59% of the total reliable variance in general intelligence.

Christensen, Mackinnon, Jorm, Henderson, and Jacomb (1999) conducted a longitudinal study to examine the dispersion in various cognitive domains as a
function of age. Seven hundred and sixty community dwelling elderly individuals were examined in two groups; age ranged 70 years and above; for a cognitive tasks series which measures crystallized intelligence, speed, memory, and spatial functioning. Dispersion scores were measured by the within person standard deviation of overall ability score and by discrepancy method i.e. by evaluating the within individual standard deviation for crystallized intelligence scores for speed memory and spatial functioning. Results indicated that dispersion scores were higher in older individuals as compared to young-old adults and dispersion scores increased in both the groups over a 3.5 years period but not at a faster rate. Results were also correlated with education. The authors explained that the sub sample of 427 individuals diagnosed with dementia showed positive correlation with age. They also found that higher dispersion was correlated with faster decline in memory and processing speed.

Economou (1999) conducted a study to find out the rarity size and direction of dispersion between immediate and delayed recall and working memory. Three hundred and twenty two normal healthy individuals with age range 47 to 88 years were assessed on three subtests of WMS-3rd edition (Wechsler, 1997) logical memory-I (LM-I), logical memory and letter-number sequencing (LNS) in a single session. Results indicated that recall and working memory were correlated with age, education and discrepancy between recall and working memory fluctuated as a function of both age and education. The results also revealed that educated older adults exhibited greater discrepancy scores for recall and working memory as compared to less educated group. Therefore, this study indicated that dispersion (within person variability) in memory increased as education increased.

Schretlen, Munro, Anthony, and Pearlson (2003) investigated the dispersion measure of IIV in advancing age. They examined normal healthy 197 individuals, whose age ranged from 20 to 92 years. Subjects were assessed for 15 different neuropsychological tests measuring memory, crystallized and fluid abilities of cognitive functioning. The scores of the individuals were evaluated on Z scale and measure of dispersion assessed on the basis of discrepancy between each individual’s maximum and minimum scores on cognitive task. Researchers found that maximum discrepancy ranged from 1.6 to 6.1 SDs which indicated that individuals exhibited
lowest discrepancy have 1.6 standard deviation and highest discrepancy exhibited by
the individuals was 6.1 standard deviation. Sixty six percent of the sample population
produced marked quantitative discrepancy which exceeded 3 SDs and 27% of the
subjects exhibited maximum discrepancy more than 3 SDs. They also found modest
inverse correlation between IQ an IIV i.e. individuals who have high IQ exhibited
lower level of maximum discrepancy. The data of the study indicated that IQ and
increasing age was markedly associated with intraindividual variability.

On the basis of previous research, Robertson, Myerson and Hale (2006)
examined age differences in dispersion (intraindividual variability) in working
memory performance. They examined 60 subjects in two age groups i.e. younger
adults (18-22 years) and older adults (71-81 years) for the working memory and
reaction time. Working memory included three tasks of simple letter number span,
letter number sequencing task and colour naming span task whereas reaction time was
measured through same-different judgment response task. Results of the study
indicated that older adults were stable on working memory task but showed higher
dispersion on RT task. Unexpected finding of the study was that younger adults
showed more dispersion as compared to older adults on the complex colour naming
span task of working memory.

Sosnoff and Newell (2006) investigated the generalizability of the amount and
structure of intraindividual variability across a subset of perceptual-motor task as a
result of aging. They examined 48 subjects in three age groups i.e. young (20-29
years), young-old (60-69 years), and old (70-79 years). The subjects performed four
motor task i.e. finger postural tremor task, single digit isometric force task and two
and three digit grip tasks. Results revealed that older adults showed higher dispersion
in motor output in all tasks excluding index finger postural tremor. There was a
significant correlation (.696) between two digit and three digit force task. Therefore,
findings of the study explained that older adults had higher magnitude and structure of
perceptual-motor intraindividual variability across tasks than younger adults. In old
age group, moderate correlation was found between magnitudes of intraindividual
variability across task and the structured measures of IIV showed higher correlation
across the task which increased with age.
Jeffy (2010) conducted a study to find out the level of dispersion on a neuropsychological test battery in highly intelligent healthy individuals and to identify which cognitive domain was most variable. He also examined whether highly intelligent individuals have neuropsychological impairment or not. Study was conducted on a sample of 25 healthy individuals with high level of education. Their age ranged from 23 years to 32 years in which 9 male and 16 females were administered a neuropsychological test battery measuring level of cognitive functioning of each individual. The neuropsychological test battery consisted of 12 subtest of selective attention, trial making, digit span, judgments of line orientation, verbal learning test, oral word association test, vocabulary test complex figure task, Wisconsin card sorting test, Grooved pegboard test (GPT), wide range achievement test, reading trial and block design. Results indicated marked discrepancy across all cognitive abilities in healthy high-level functioning individuals. Results also represented a marked reduction of discrepancy scores between an individual’s premorbid IQ (intelligence) and all cognitive test performances. Findings of the study suggested that healthy high intelligent individual showed more intraindividual variability on test scores measures of construction and verbal memory aspects of cognitive functioning. Therefore, it may be of interest to clinical neuropsychologist who might base clinical inference about the presence of cerebral dysfunction because patients suffering from a mild traumatic brain injury (mTBI) had significantly low scores on the measures of construction domain.

Thaler, Duff, Hill, Mold, and Scott (2015) conducted a study to find out the relationship between dispersion and pathological changes (cognitive and functional deterioration) with the help of a single Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). They assessed 699 individuals (neurological illness) whose age ranged from 64 to 94 years; for five indexes of RBANS and self reported functioning, mean cognitive performance, and death. Results indicated that increased dispersion and low mean performance predicted self-reported memory problems. Individuals having high dispersion at baseline had higher rate of death nine years later. Therefore, increased RBANSA dispersion is an early indicator of health problems and beneficial index of functional decline and death.
Findings from the above studies indicate that dispersion is significantly related with age and decline in neuropsychological functioning specifically in memory and processing speed. Fozard et al. (1976), Robertson et al. (2006), and Salthouse (1993) used RT tasks and found significant age effect on dispersion. Christensen et al. (1999), Lindenberger and Baltes (1997), and Schretlen et al. (2003) examined dispersion in intellectual abilities and found that dispersion remains stable and may decreased with age. Researchers also considered whether individuals who have high IQ exhibited lower level of dispersion. Opposite to Schretlen and colleagues, Jeffy (2010) found individual with high IQ level exhibited more intraindividual variability on test scores. Some studies also considered the effect of education on neuropsychological functioning (Christensen et al., 1999 & Economou, 1999). They found that educated older adults showed higher discrepancy for memory tasks as compare to less educated. In contrast with the other findings, Robertson et al. (2006) found that younger adults exhibited higher dispersion as compare to older adults on working memory tasks.

Considered together, the present review indicates that changes in brain activity are evinced as a result of aging and these in turn are associated with neuropsychological and cognitive decline. However, no decline in crystallized intelligence as a consequence of aging was reported. Intraindividual variability in various psychological and behavioural domains has been found to be associated with physiological changes and IIV has been implicated as an important parameter for assessing the functioning of the respective domain. Studies reveal that IIV is associated with motivation, emotion, volitional and behavioural characteristics.

Intraindividual variability has been implicated as an important indicator of cognitive performance and there are two potential sources of intraindividual variability in cognitive performance. Intraindividual variability can stem from neurological (endogenous) or behavioural (exogenous) influences. Variability due to behavioural sources occurs over short intervals, while rapid changes are the result of neurological factors. Persons suffering from a neurological condition or disease exhibit higher intraindividual variability in their behavioural response as compared to healthy individuals. Research in this area has indicated that intraindividual variability
can be a sensitive indicant of neural disturbance, dysfunction or decline and may be used as a behavioural index of compromised neural mechanism.

Two kinds of intraindividual variability, inconsistency and dispersion, have been the focus of cognitive and neuropsychological researchers. With regard to inconsistency, researches have shown considerable stability in inconsistency, as amount of inconsistency in cognitive performance has been found to be a relatively stable characteristic of an individual. At the two extreme stages of life span i.e. childhood and older adulthood, inconsistency is notably higher. Cross sectional researches have indicated that cognitive inconsistency decreases from adolescence to adulthood after which there is a slow increase from middle to older adults. Longitudinal studies also suggested that inconsistency increases with age and a negative correlation has been reported between inconsistency and cognitive functions. Significant amount of inconsistency has been reported in other domains, which are presumed to be stable. A temporary fluctuation such as fatigue level is found to be associated with an increase in inconsistency while self-perceived inconsistency is related to neuropsychological decline.

Researchers have examined the relation between dispersion and neuropsychological functioning in healthy older adults and reported a significant relationship of intraindividual dispersion with neuropsychological functioning, and aging. Reaction Time tasks have been used to study dispersion and a significant age effect has been reported. However, examination of dispersion in intellectual abilities revealed that it remains stable and may decrease with age. In fact, younger adults, educated older adults as well as individual with high IQ level exhibited higher intraindividual variability dispersion as compare to older and less educated adults. Since, neuropsychological and cognitive assessments generally consider performance in terms of score on a specific task or averaged, in terms of mean, across a number of tasks, intraindividual variability could provide a more sensitive and viable alternative index for assessing cognitive and neuropsychological decline.

The focus of the present research is on assessing the efficacy of intraindividual variability as an indicator of neuropsychological functions. The problem and objective of the investigation have been delineated in the next chapter.