Chapter 2

Review of Literature
REVIEW OF LITERATURE

Past research works and its empirical results fosters new opportunity of creative thoughts which in turn paves the gateway for establishment of a research problem and creating its utility. Further, the research aims to highlight the direction of further exploration. The present research of executive function (EF) of persons with Autism and the persons with Borderline intellectual impairment is a scientific problem where investigation is not only limited to the executive functions but also an attempt is made for a further possible exploration of how far training of EF can be imparted to them. Executive Function is itself an exploratory domain that summons for scientific researches. Huges (2011) reviewed 20 years of developmental research on EF and chalked out the EF research issues: (i) uncovering typical and deviant groups, from infancy to adolescence; (ii) exploration in assessment tools and in statistical analysis; (iii) the relation and association between EF and other cognitive systems (iv) environmental factors having positive influence (e.g. training and intervention) and negative influence (e.g. neglect, traumatic brain injury) on EF. The review emphasizes both the correlates of EF and the nature of EF with its neural substrates and summons for research comparing the different groups like children with autism and ADHD. The above study also cited that EF does not spurt up suddenly but it gradually and steadily grows with the milestones of development from as early as infancy. This notion is also supported by an Indian study by Kar et.al., (2011) where 400 Indian school children (5–15 years of age) were investigated age-related differences in neuropsychological performance and EFs. Their study revealed that neuropsychological task performance and EF improved slowly between 5 and 7 years, moderately between 8 and 12 years and slowly between 13 and 15 years of age.
Studies relating EF and Autism

EF and autism along with other neurodevelopmental disorders seeks attention of the researchers probably because EF grows and improves gradually with developmental years and is hindered by the neurodevelopmental conditions. Several studies focused on the exploration of executive functions in autism and other neurodevelopmental disorders. Guasch et.al., 2013 assessed ten children with ASD through ENFEN and WISC-IV at three schools into a competitive research. The aim was to evaluate the performance of ENFEN as a tool to determine these executive functions (planning, inhibition response, working memory and mental flexibility) more related to the diagnosis with ASD. The results suggested that children with ASD showed lower performance in executive function, mainly planning and mental flexibility. Studies indicate that individuals with ASD exhibited reduced mental flexibility. It could reflect difficulty in shifting from a previously learned response pattern to a new response set. Miller et al (2015) in a study examined different types of error on a test of set-shifting performed by 60 individuals with ASD and nonverbal IQ-matched controls. Individuals with ASD were able to shift sets individually, but they showed difficulty in maintaining and responding to new response sets. They were of the opinion that difficulty with maintenance of set can be related to repetitive behaviours.

Another study by Lopez , Lincoln , Ozonoff & Lai . (2005) found some executive processes viz. mental flexibility, response inhibition and working memory is linked with the restrictive, repetitive symptoms of autism; whereas, some other executive process i.e., planning and fluency have least association with restricted, repetitive symptoms. The study further established an executive function module which is comprised of relative strengths and deficits that can be the best predictor of restricted, repetitive symptoms of autism. The executive function theory and its
implication on the core symptoms of autism were also discussed. This study was conducted with 17 adults with autism and was compared to control group. They were administered an executive function battery (Delis-Kaplin Executive Function Scales). Restricted, repetitive symptoms were measured by a variety of instruments (i.e., the Autism Diagnostic Observation Schedule, Autism Diagnostic Interview-Revised, Gilliam Autism Rating Scale, and the Aberrant Behavior Checklist).

Set-shifting in laboratory tasks requires successful switching between two tasks or sorting the same stimulus by different features. In a study Yerys and his colleagues (2009) examines: (1) set-shifting in 6- to 13-year-old children with and without high-functioning ASDs using the Intra dimensional/Extra dimensional (ID/ED) Shift Test from the Cambridge Neuropsychological Test Automated Battery, and (2) the relationship between set-shifting performance and core repetitive behavior/restricted interest symptoms in the ASD group. The study documents inefficient ED reversal shifting among high-functioning children with ASDs, and reinforces the utility of the ID/ED test in parsing specific components of set-shifting difficulty among individuals with ASD. Further this investigation establishes a link between ED reversal shifting and restricted interest/repetitive behavior symptoms used to diagnose ASDs.

Repetitive, stereotyped behaviors are the hallmark feature of autism but little is known about the neural correlates of these behaviors. To postulate regarding this, Shafritz Dichter, Baranak & Belger, (2008) used functional magnetic resonance imaging (fMRI) to investigate the neural correlates of shifts in behavioral response and cognitive set in 18 individuals with high-functioning autism and 15 neurotypical control participants. The participants were given a target detection task customized to distinguish shifts in response from shifts in cognitive set.
Individuals with autism exhibited lower accuracy on response shifting trials, independent of whether those trials also required a shift in cognitive set. The participants with autism in comparison to control participants showed reduced activation in frontal, striatal, and parietal regions during these trials. In addition, within the autism group, the severity of restricted, repetitive behaviors was negatively correlated with activation in anterior cingulate and posterior parietal region. The findings thus suggested that executive deficits and repetitive behaviors associated with autism might display a core dysfunction within the brain's neural executive circuitry.

Autism is often highly impairing neurodevelopmental condition, whose core behavioral symptoms are believed to be ingrained in neurocognitive processes, especially executive function. Researchers have predominantly focused upon understanding the causal relationship between difficulties in EF and autistic symptomatology. Pellicano (2012) in a review paper, rather considers, the effects of individual differences in EF. It plays a significant role in the daily and real life consequences of individuals with autism, including their social competence, everyday adaptive behavior, and academic achievement. It further considers the possible determinants of individual differences in EF, and makes further several recommendations for future research.

The neurocognitive impairments associated with EF in autism spectrum disorder (ASD) are not yet clear. However Griffith et al 1999 found a mixed result in studying young children with autism. Two studies are presented that compare the performance of preschoolers with autism (mean = 51 months/4.3 years of age) to a control group matched on age, and verbal and nonverbal ability. The first study (n = 18 autism and 17 control) found no group differences in performance on 8 executive function tasks but did find that children with autism initiated fewer
joint attention and social interaction behaviors. The second (longitudinal) study of a subset of the children \((n = 13\) autism and 11 control) from the first study found that neither groups' performance on Spatial Reversal changed significantly over the course of a year. The results of these studies pose a serious challenge to the executive dysfunction hypothesis of autism.

In the review study of Russo N (2007) individuals with autism exhibit impairments in measures of EF to typically developing comparison participants. EF though a holistic term, includes several processes like inhibition, working memory and set shifting which develops throughout the lifespan. Deficit in EF may appear early in developmental years and persist, or may represent more delay. The irregular cognitive profile of persons with autism display methodological challenges in understanding the development of EF. In this review, attempt is made to spilt the processes of EF within a developmental outlook that reflects how matching measures and comparison participants can influence the research findings.

In dealing with the components of executive function, Bebko & Christina (2000) examined memory strategy use in two problem-solving situations by children with autism. Two groups having autism: one is high functioning group and the other having moderate cognitive impairments were examined. Two experiments were conducted; one experiment used a serial recall task, and the other a recall readiness task. In contrast to previous studies, spontaneous memory strategy use was found on both memory tasks; particularly among the high-functioning group. The overall rate of strategy use for the children with autism was still not up to the mark as expected in normal group of children at per age. Thus, the results support an executive functioning deficit, but a deficit that is less extensive among high-functioning individuals.

Though executive function is itself an integrated combination of brain controlled functions mediating the cognitive abilities to work, its inter-relation to other theoretical constructs and
processes like theory of mind, central coherence, information processing system, sensory processing and language ability cannot be overruled. It gives a great deal of information regarding how EF is linked to those constructs, how it functions as well as gives new dimensions to explore neurodevelopmental issues in relating to EF.

Ozonoff and McEvoy (2008) examined the development of EF and Theory of Mind (TOM) over a period of 3 years in a longitudinal study comparing intellectually abled adolescents with autism with learning-disabled controls matched on age, IQ, gender, and socioeconomic status (SES). Both executive function and theory of mind impairment have been suggested as primary deficits of autism in the study with negligible improvement through the developmental years not reaching the optimal level of development.

There has been another research (Joseph & Tager-Flusberg, 2004) investigating the explanatory power of neurocognitive impairments in theory of mind and in executive functions with regard to autistic symptomatology. This study examined the degree to which individual differences in theory of mind and executive functions could explain variations in the severity of autism symptoms. Participants included 31 verbal, school-aged children with autism who were administered a battery of tests assessing the understanding of TOM (knowledge and false belief) and executive function skills. The findings are discussed in terms of cognitive–linguistic aspects of theory of mind and related executive control skills.

To investigate the relationship between theory of mind (TOM) and executive function (EF) Yang Zhou Yao Su & McWhinnie (2009) studied a sample of 20 individuals with autism spectrum disorders (ASD) along with 26 children with Attention Deficit Hyperactivity Disorder (ADHD), and 30 normal control subjects were compared on two batteries of TOM tasks and EF tasks. The
results of the ASD group revealed impaired (TOM) relative to the other controls. TOM was correlated with inhibitory control, a component of EF. Performance on inhibitory control tasks did not influence performance on TOM tasks.

In the longitudinal study of another paper of Pellicano (2010) the accuracy of multi-deficit of autism were assessed by tasks tapping components of theory of mind (TOM), executive function (EF), and central coherence (CC) were assessed involving 37 children with autism (\(M\) age = 67.9 months) and 31 typical children (\(M\) age = 65.2 months) before and again after 3 years later. In group assessment, children with autism demonstrated poor false-belief task, planning ability, and set-shifting, at both time points. In case level analysis; however, the profile was varied and different from universal notion at either in the beginning or follow-up after 3 years. Moreover, children with autism exhibited changes over time in TOM and EF, but not CC, over the 3-year period.

In another study (South, Ozonoff, McMahon, 2007), participants included 19 individuals (ages 10-19) with high-functioning autism spectrum disorders (ASD group) and typically matched control group were examined on the performance on neuropsychological tests of executive function and central coherence. The association between EF, central coherence and everyday repetitive behavior was established. There was limited support in the ASD group for the connection between repetitive behavior and executive performance (the Wisconsin Card Sorting Task). There was no connection between repetitive behavior and measures of central coherence (Gestalt Closure test and the Embedded Figures Test).

The study by Zingerevich and LaVesser (2008) reveals that executive functions contribute to participation in school activities of children diagnosed with ASD ages 6–9 years (n=24) over and
above the contribution of sensory processing. Particularly the abilities to resist impulsive responses, to stop behaviour at the appropriate time, and to regulate emotional responses contributed to such participation. Thus the study suggests, EF as more significant construct in dealing with regular activities over the contribution of sensory processing in the same.

Landa and Goldberg (2005) examined language and executive functions (EF) in high-functioning school-aged individuals with autism and individually matched controls. The inter-relationships between executive function, language ability, and social functioning were investigated. Participants with autism showed difficulty on measures of expressive grammar, figurative language, planning, and spatial working memory. A mixed profile of impaired and increased abilities was revealed in set-shifting.

Studies so far delineated the developmental trajectories of executive functioning (EF) in individuals with autism spectrum disorders (ASD) in clinical or lab based settings. But EF skills are not limited to accomplish only when a task is assigned. It is regulated in daily living skills. Few studies directly measured how EF skills in everyday settings vary at different ages. In a study (Rosenthal, Wallace, Lawson, Wills, Dixon, Yerys & Kenworthy, 2013), the researchers seeks to explore age-related differences in parent-reported EF problems (everyday problems requiring EF skills, BRIEF scale was used) during childhood and adolescence in a large cross-sectional outfit of children with ASD (N = 185). Participants were divided into four groups based on age (5–7, 8–10, 11–13, and 14–18-year-olds). The four age groups did not differ in IQ, sex ratio, or autism symptoms. There were significant age effects i.e. everyday EF skills are inversely proportional to age (i.e., reduced scores with increasing age). Older children with ASD
exhibit greater EF problems compared with the normative sample than younger children with ASD.

In a study Gioia et al., 2002 found individuals with autism spectrum disorders (ASDs) also struggle to shift their attention during daily activities.

Thus the studies so far suggestive of evaluation of EF and its skills in autism; the connectivity of EF with the core symptomatology of autism and association of EF with other inter-related processes and theoretical construct in autism. The above literature leads a scope of further evaluation of EF skills in autism as integrated functioning and EF profiling in autism. That is what is taken up in the present study.

**Literature of EF in other neurodevelopmental disorder**

EF research in autism expanding further relates to other neurodevelopmental condition and like developmental language disorder, attention deficit hyperactive disorder and other developmental psychopathologies.

Liss and his colleagues (2001) investigated executive functioning in 34 children with developmental language disorder (DLD) and 21 children with high-functioning autism matched on full scale IQ, nonverbal IQ, age and SES. The participants were administered Wisconsin Card Sorting Test (WCST), the Mazes subtest from the WISC-R, the Underlining test, and the Rapid automatized naming test. In addition, they were administered the Vineland Scales of Adaptive Functioning and the Wing Diagnostic Symptom Checklist in order to assess autism. The results indicated that the two groups differ on the cognitive tasks in perseverative errors on the WCST. Executive functioning was strongly related to all IQ variables in the DLD group and particularly
related to verbal IQ in the high functioning autism group. The findings challenges the common notion that impaired executive functioning is a commonly associated feature of autism, rather it is not universal in autism and is unlikely to cause behaviours specific to autism or deficits in adaptive function.

Pennington & Ozonoff (1996) considered executive functions (EFs) and their possible role in developmental psychopathologies in a review study. The general theoretical and measurement issues involving EF and four developmental psychopathologies: attention deficit hyperactivity disorder (ADHD), conduct disorder (CD), autism, and Tourette syndrome (TS) are considered in the study. The review suggested that EF deficits are consistently found in both ADHD and autism but the profile of EF differs across them. The severity in EF deficit is more prominent in autism than ADHD. EF deficit is not prominent in CD (without ADHD) or in TS.

In support of the severity in EF deficit in autism Goldberg and his colleagues (2005) compared EF in children (8-12 years) with high functioning autism (HFA, n = 17), attention deficit-hyperactivity disorder (ADHD, n = 21) and healthy controls (n = 32). Their findings suggest that spatial working memory is though impaired in both ADHD and HFA; the severity is more prominent in the latter.

Quite a reverse findings were suggested in the study conducted by Happé, Booth, Charlton, Hughes (2006) where less severe and persistent EF deficits in ASD (including Asperger Syndrome) were found than in ADHD. To be more specific, in the study the ADHD group exhibited greater inhibitory problems on, while the ASD group was worse performer on response selection/monitoring in a cognitive estimates task. Also the age-related improvements were clearer in ASD than in ADHD. The ASD group outperformed the ADHD group at the older ages.
Thus mixed findings were suggested in EF comparing the other neurodevelopmental disorders with autism.

**Research concerning EF in Intellectual disability and intellectual impairment**

Among the other neurodevelopmental disorders intellectual disability can be a comorbid condition to any other neurodevelopmental condition like ADHD or in Autism. The concept of Borderline intellectual impairment (IQ 71-84, DSM-IV-TR) have no clear demarcation till date; is also an important and frequently unrecognised comorbid condition relevant to the diagnosis and treatment of any other neurodevelopmental conditions and psychiatric disorder as well (Wieland & Zitman 2015). In many studies individuals falling in the IQ range of 85 is referred to as Intellectual Disability (ID) (Wieland & Zitman 2015). Hill 2004 reviewed the complexity of investigating executive functions in autism, the possible influence of IQ on executive performance and the possibility of overlap between performances on tests of executive function in other neurodevelopmental disorders.

In a longitudinal study of 5 years by Danielsson (2010) executive functions in adults with borderline intellectual impairment (IQ higher than 85) is compared to a closely matched control group. Three types of tasks of executive functions were assigned on two occasions, with 5 years between testing sessions: The Tower of Hanoi executively loaded dual task versions of word recall, and verbal fluency. Adults with intellectual impairment showed significant deficit on verbal fluency and on the executively loaded dual task. There were no group differences found on the Tower of Hanoi task.
In another study by Numminen, Lehto & Ruoppila (2001), persons with intellectual disability (ID) have been found to accomplish the visuo-spatial problem solving task of Tower of Hanoi (TOH) but they lack more in their efficiency than their mental age would suggest. Incompetent performance can be attributed to the inability to use complex problem solving strategies because of restricted working memory capacity and deficient inhibitory control. However, persons with ID violated the rules of the TOH more often, and needed more trials to solve the TOH problems than the matched group. The study further suggested that for persons with ID, TOH performance is determined by individual differences in fluid intelligence, controlled attention, and inhibition ability.

The present study involves working memory (WM) and mental set shifting the two most important processes of executive functions in comparing autism and borderline intellectual impairment. Until very recent years there were dearth of studies concerning EF in Intellectual Disability. In recent years, there has been increased research interest in the functioning of working memory in people with intellectual disabilities. In one such study Van der Molen (2007) examined working memory in children with mild ID (IQ 55–85) within the framework of the Baddeley model, fractionating working memory into a central executive and two slave systems, the phonological loop and visuo-spatial sketchpad. The investigation of working memory was conducted in three groups, 50 children with mild ID (mean age 15 years 3 months), 25 chronological age-matched control children (mean age 15 years 3 months) and 25 mental age-matched control children (mean age 10 years 10 months). All the groups have undergone multiple assessments of the phonological-loop and central-executive components. The children with mild ID had an intact automatic rehearsal, but deficient performances were found on phonological-loop capacity and central-executive tests in comparison with the matched group.
The study thus suggests consistency of the result pattern with the developmental delay account of mild ID.

The research concerning working memory of individuals with intellectual disabilities (ID) has established clear deficits but there are few investigations which have distinguished weaker working memory skills between different degrees of intellectual disability. Schuchardt Gebhardt & Maehler (2010) attempted to such distinction in working memory capacity between the different levels of Intellectual disability. In a 5-group design, the working memory performance of a group of 15-year-olds with mild intellectual disability (IQ 50–69) was compared with that of two groups of children (aged 10 and 15 years) with borderline intellectual disability (IQ 70–84) and with that of two groups of children with average intellectual abilities (IQ 90–115) matched for mental and chronological age (aged 7 and 15 years). All children were administered a comprehensive battery of tests assessing the central executive, the visual-spatial sketchpad, and the phonological loop. The results revealed that these deficits increased with the degree of intellectual disability.

Numminen Service and Ruoppila (2002) investigated WM capacity, WM task requirements, as well as effects between WM, skills, knowledge base, and intelligence were explored in two groups with matched fluid intelligence: adult persons with ID and normally developing children aged 3–6 years. The ID groups performed equally well as the children in WM tasks based on familiar semantic information and were significantly better on all measures reflecting skills and knowledge base. The Child Group performed better in phonological and visuo-spatial WM tasks including non-semantic information, respectively. In particular, it appeared that the groups differed in their WM performance although they were matched for fluid intelligence. The study
hypothesize that the ID Group depended more on knowledge support from long-term memory whereas the Child Group could benefit more from efficient online WM processes.

The researches cited in this section mainly focus on evaluation of working memory and TOL performance of intellectually impaired individuals. Here also it leaves a scope of further exploration of EF and its profiling. Most importantly all the literature referred so far leaves a massive scope to establish the credibility of EF in training or intervention in intellectually challenged group and in autism.

**Assessment of EF and its trainability**

The above of the literature also widely suggested varied assessment tools and tests of different components of EF and measurement of EF as whole. The assessment of executive function holistically in autism is supported by using tower tasks(TOH,TOL) by many researchers (Hughes, Russell, Robbins, 1994; Joseph & Tager-Flusberg 2004). There is also a study discussing the Functional and Anatomical Cortical Under connectivity in Autism where Just and his colleagues (2007) conducted an fMRI study on executive function task using Tower of London task. The brain activation of a group of high-functioning participants with autism was measured using functional magnetic resonance imaging during the performance of a Tower of London task, in comparison with a control group matched with respect to intelligent quotient, age, and gender. The 2 groups generally activated the same cortical areas to similar degrees excepting three indications of under connectivity in the group with autism. Firstly, the degree of synchronization i.e., the functional connectivity between the frontal and parietal areas of activation was much lower for the autism group than the control group. Secondly, through which many of the bilaterally activated cortical areas communicate in corpus callosum, were smaller in cross-
sectional area in the participants with autism. Lastly, within the autism group but not within the control group, the size of the genu of the corpus callosum was correlated with frontal–parietal functional connectivity. The results support to a new theory of cortical under connectivity in autism, which suggests a deficit in integration of information at the neural, cognitive and executive levels. This study also adds on to the neural basis of executive functions.

The use of Trail Making Test (TMT) in evaluating mental set shifting task of EF is quite common. Arbuthnott & Frank 2010 studied TMT Part A & Part B and compared other set switching task with it and provided direct evidence that TMT yields an index of executive function. Cubillo et.al., 2009 investigated the cognitive mechanism behind the use of TMT. They treated 41 healthy participants with numerous neuropsychological and cognitive tests and provided evidences that working memory, inhibition, task switching ability and visuo-motor speed are the underlying mechanism of performing TMT task. In disability field, Lloyd 2010 has used Delis-Kaplan Executive Function System (DKEFS) where TMT is used as a common neuropsychological test in assessing EF of adult male with ADHD.

For Visuospatial working memory test, use of block span is widely used in many research. Like in a study, Issacs & Khadem 1989 used both digits and blocks consisting of forward and backward recall components in assessing developmental course of working memory. Both types of span task showed developmental increases. In the disability field, there are also researches referring the use of block span task as an evaluation tool of Visuospatial Working Memory (Joseph & Tager-Flusberg 2004).

However, both the tests of TMT n Block span though well establishes its validity for assessing EF skills, it is little used in autism and in other disability field to foster research in EF. Thus in
the present study TOL, TMT and Block span test (NIMHANS Visuospatial Working Memory Test) for assessment of EF skills in autism and BII.

The theories and studies so far, well establish the research problem of the present study i.e. the investigation of executive functions in autism and borderline intellectual impairment (BII) and the assessment of EF in both groups by standardized tests. And in most of the cases the studies revealed deficit in EFs. There is scarcity of studies in training of executive functions in autism and BII. To meet the research gap the most important part of the present study is the training of executive functions in the two groups and the transfer of training. It is well established that executive functions can be improved by training but little is known that how far EF training can be imparted to autism and borderline intellectual impairment.

The study suggested by Fisher & Happé (2005), investigated the relationship between theory of mind and executive functioning in children with autistic spectrum disorders through a training study. In the intervention program, two groups each having ten children, the first group received training in theory of mind and the second one was trained in executive function. Seven children were assigned to a control group, receiving no intervention. The training programs were administered individually one to one interaction, lasting for 25 minutes per day for 5–10 days. The training program followed a pre-test and the post-test where children were tested before training, after training and proceeded at a two-month follow-up. Remarkable improvements were evident in performance on theory of mind tasks in both trained groups, against the control group which exhibited no improvement. The intervention showed no improvement on the executive function tasks in any of the groups.

Kirk, Gray, Riby & Cornish (2015) reviewed cognitive training programs that aim to improve EF, focusing intervention for children who have intellectual disabilities. They are of the opinion
inconsistencies in intervention effects can be attributed to the shortcomings in both program and study design. They discuss the steps needed to address these limitations and to facilitate interventions of cognitive training for children with intellectual disabilities.

Kouijzer, de Moor, Gerrits, Congedo & Schie (2009) applied neurofeedback treatment to 7 children with autism that aimed to improve their level of executive control. It successfully reduced children's heightened theta/beta ratio by inhibiting theta activation and enhancing beta activation over sessions. The treatment enhanced executive capacities greatly relative to pre-treatment assessment on a range of executive function tasks. The additional improvements were found in social and communicative behaviour. The findings thus suggested basic executive function impairment in autism that can be reduced through specific neurofeedback treatment.

Training is effective when the training-related benefits can be transferred to other tasks, or whether this transfer can be modulated by the type of training. A research paper (Karbach & Kray 2009) suggested near transfer of task-switching training in all age groups, especially in children and older adults. Near transfer was enhanced in adults and impaired in children when training tasks were variable. They also found substantial far transfer to other executive tasks and fluid intelligence in all age groups, pointing to the transfer of relatively general executive control abilities after training.

But little to no studies suggests training and its transfer in executive functions skills in autism and borderline intellectual impairment and intellectual disability or other neurodevelopmental disorders. The present research thus focuses on the assessment, training and transfer of training of executive functions in autism and borderline intellectual impairment. The study further proceeds to establish an EF profile of the two groups and the implications of such profiling are further discussed.