EFFECT OF COGNITIVE TRAINING ON EXECUTIVE FUNCTIONS AMONG CHILDREN WITH AUTISM SPECTRUM DISORDER

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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MZU REGISTRATION NO.: 2200624

Ph.D. REGISTRATION NO.: MZU/Ph.D./2025 of 14.08.2021

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SCHOOL OF MEDICAL AND PARAMEDICAL SCIENCES

OCTOBER, 2025

EFFECT OF COGNITIVE TRAINING ON EXECUTIVE FUNCTIONS AMONG CHILDREN WITH AUTISM SPECTRUM DISORDER

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In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Clinical Psychology, Mizoram University, Aizawl

Dated: 13th October 2025

CERTIFICATE

This is to certify that the present research work titled **"Effect of Cognitive training on Executive Functions among Children with Autism Spectrum Disorder**" is the original research work conducted b**y Ms. P. Kalaivani** under my supervision. This research work is being submitted for the Award of the degree of Doctor of Philosophy in the Department of Clinical Psychology, Mizoram University.

It is also hereby certified that this particular research work conducted by **Ms. P. Kalaivani** has not been submitted in support of an application to this or any other University or an Institute of Learning.

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DECLARATION

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I **P. Kalaivani** hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the **Degree of Doctor of Philosophy in Clinical Psychology.**

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ACKNOWLEDGMENT

First and Foremost, I would like to thank the Almighty whose blessings have endowed me with the strength and courage throughout the course and complete this Research.

I am grateful and would like to express my heartfelt gratitude to my supervisor Dr. Laxmi Narayan Rathore, Associate Professor, HOD, Department of Clinical Psychology. His constant support, guidance, and sharing of wisdom was remarkable which helped me to progress each stage of my Research work. Both as my supervisor and HOD, I would like to thank sincerely for his mentorship and guidance and being instrumental for my both personal and professional development.

My sincere heart thanks to all the faculties of the Department of Clinical Psychology for their mentorship and guidance throughout this course. I also wanted to thank the Non-teaching staffs and the Institution for their warm welcoming assistance and support, which made my journey more easy and memorable.

I express my sincere appreciation and gratitude to National Institute for Empowerment of Multiple Disabilities (NIEPMD), Chennai for their support to conduct the research. My heartfelt gratitude for all the participants who selflessly participated in the study and this work would be incomplete without their cooperation.

I am grateful to my mother and my family, and especially my son

M. Visweswaran, for their support and sacrifices to pursue my academic goals and achieve my fullest potential. I would also like to thank my colleagues and friends who were also offering me constant support and assistance throughout my journey.

(P. KALAIVANI)

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INTRODUCTION

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition marked by substantial heterogeneity in presentation and severity across individuals. Its core features include persistent difficulties in social skills and communication skills, limited reciprocal interaction, and the presence of restricted and repetitive patterns of behavior and interests (American Psychological Association, 2023). ASD can often be detected early in life, with behavioral markers observable by 18 months of age. Early signs may include limited eye contact, reduced response to name, minimal social reciprocity, challenges in pretend play, and difficulties forming peer relationships. These symptoms gradually progress and impede communication and social skills. The appropriate communication expected at this stage will not be present, and the child may not be able to speak single words until the age of one and a half years. They may also exhibit deficits in other social skills, such as a lack of pointing and imitating actions. Play activities include lack of imitative play and preference for playing alone. The child may exhibit insistence on sameness and become distressed even with small changes. Sensory stimuli such as fascination with light, avoidance of certain foods and textures, and aversion to sounds are commonly reported in early childhood. The early signs remain unnoticed most of the time, and the extent of these symptoms directly influences adaptive skills, academic engagement, and optimal functioning across school, work, and daily life domains. While the child is in middle childhood, the child has significant difficulty, such as interpreting language and cannot understand jokes, sarcasm, etc. Making intimate friends age appropriately cannot be found, and this affects socialisation in school. The child would often be found to be alone and has difficulty adjusting to social contexts. The child has academic challenges, such as difficulty in reading and writing, and sensory sensitivity persists. When the child enters the adolescence period, navigation of symptoms begins. The child becomes aware of the social differences and may become distressed or more withdrawn. They have difficulty forming peer relationships and identity formation and may develop camouflaging or masking of behaviours to fit in and this is especially seen in girls. They are more rigid in thinking, and the executive function difficulties, such as planning, organising, and time management, become more evident. There is an elevated risk for other mental health problems like anxiety, depression, and obsessive-compulsive disorder in adolescence. The symptoms occur in adulthood as well, like challenges in social reciprocity, empathy, and communication. They have difficulty in employment or independent living due to executive dysfunction. They may benefit from a structured support environment, may exhibit high adaptability, and may focus in certain specialized areas.

Epidemiological studies report increasing recognition of ASD worldwide. A community-based study in India estimated a prevalence of 15 per 10,000 (0.15%) among children aged 10–15 years (Raina et al., 2017). Meta-analytic findings suggest slightly higher prevalence rates in rural settings compared to urban ones (Chauhan et al., 2019). Consistent with international trends, males are more frequently diagnosed with ASD than females (Maenner et al., 2023). The Global Burden of Disease study also states that ASD is diagnosed in males four times more than in Girls (Baxter et al., 2015). These are explained in relation to brain structures, phenotype theories, and the female protective effect. The presentation of symptoms in females and males varies, and the risk of being undiagnosed in females is higher than in males. It has been reported in a study that females present with more internalizing symptoms than males, and they may be confused with comorbid conditions such as anxiety or depression (Fusar-Poli et al., 2022)

Leo Kanner published in 1943 *"Autistic Disturbances of Affective Contact"* describing symptoms of eleven children with profound social and communication deficits, insistence on sameness, and restricted interests. He differentiated from schizophrenia, emphasizing it as "Infantile Autism". In 1944, Hans Asperger described children with normal intelligence but having social difficulties and circumscribed interests, which was later termed Asperger Syndrome. The psychodynamic theories in the 1950s were dominating and attributed autism to "refrigerator mothers" or lack of maternal warmth. Later, the diagnostic manuals emerged, and it was classified in DSM-I (1952) as Childhood Schizophrenia and in DSM-II (1968) as childhood psychosis, and it was not classified separately. In DSM-III (1980), it was included as a distinct disorder as Infantile Autism, in which the criteria focused on social, communication, and behavioural symptoms. In DSM-III R (1987), the criteria were refined and it was broadened to Autistic Disorder, and it emphasises that the onset should be before the age of 3 years. In DSM-IV (1994), Pervasive Developmental Disorder was introduced, and it existed in separate diagnostic categories such as "Autistic Disorder, Asperger's Disorder, Rett's Disorder, and Childhood Disintegrative Disorder". Lately, in DSM-V(2013), these were consolidated under the umbrella term "Autism Spectrum Disorder.," ICD-9 (1977) classified childhood autism under "Psychosis of Childhood". In ICD-10 (1992), it has been classified under Pervasive Developmental Disorders" (PDDs), which includes "Childhood Autism, Asperger's Syndrome, Atypical Autism, Rett's Syndrome, and other specified/unspecified PDD". The ICD-11version (2018), in alignment with DSM-V, had excluded all subtypes and had unified them under Autism Spectrum Disorder as a single category. The ICD-11 criteria included symptoms under two domains, such as Deficits in social communication & interaction and restricted behavior patterns, interests or activities, which cause significant impairment in areas of personal, social, family, education, and occupational functioning. Symptoms are typically lifelong, though the degree of impairment and specific manifestations may shift with developmental stage and support systems.

1.1 **Clinical Features**

The classical clinical picture of ASD involves a triad of impairments in (1) speech and language development, (2) reciprocal social interaction, and (3) repetitive or restricted behaviors with onset typically occurring before age three. The symptoms include:

- Persistent difficulty in reciprocal communication and socialization outside of what is expected for the person's age and developmental level.
- Have restricted stereotyped interests or activities and repetitive behaviors that are atypical for the developmental age and sociocultural context.
- Sensory issues such as overly sensitive or less sensitive to sounds, light, touch, or textures.

The individuals with autism have deficits in social relationship and reciprocity. They avoid eye contact and cannot act according to the social norms. Gazing is found to be peculiar like looking sideways or looking sideways. They lack social smile and social response when interacting with others. They are often found to be aloof, self-absorbed, and is not responsive to others. They involve mostly in solitary play activities and do not engage in group oriented activities. They do not initiate contact or conversation with others and have difficulty in relating to people appropriately as expected for their age. Taking turns in social relationships and maintaining peer relationship also remains hard for them. Communication challenges include difficulties initiating and maintaining conversation, interpreting nonverbal cues, and engaging in reciprocal emotional exchanges. Children may not appropriately respond to others' feelings, struggle with modulating behavior based on social context, and display limited or atypical use of gestures. Emotional responses may be inappropriate or exaggerated, and episodes of self-directed speech, unexplained agitation, or excessive anxiety can occur. They involve in self-stimulating emotions such as involving in self-talk and smiling to self.

Repetitive behaviors is found across various domain such as motor, verbal, and sensory areas and they represent as stereotyped movements, echolalia, insistence on routines, strong attachment to objects, and sensitive to sensory stimuli. They respond to objects by smelling, tasting, or touching. Sensitivity to pain also varies as some of them may over react to pain or hardly react to it. Children may resist changes in environment or routines and often display intense focus on specific topics or objects. Behavioral concerns including hyperactivity, tantrums, aggression, and self-injury, are also frequently reported (Aldabas, 2020). Difficulty in arousing attention is very common and they cannot concentrate while doing the tasks. The other special ability reported among children with autism are unusual memory such that they remember unusual things which most people often do remember. Unusual abilities are also reported among children with autism.

1.2 Comorbid Factors of ASD

Comorbid conditions are highly prevalent in individuals ASD and coexistence often contributes to a greater clinical burden. The comorbid conditions could be related to several biological and perinatal factors such as premature birth, birth-related hypoxia, and fetal alcohol exposure. Commonly reported comorbidities include epilepsy, sleep disturbances, gastrointestinal issues, toileting difficulties, behavioural problems, attention deficit and /hyperactivity disorder as well as anxiety and depressive disorders (Bougeard et al. ,2021).

The accurate diagnosis becomes difficult and complicated due to the presence of comorbid conditions. Differentiating between the primary and secondary conditions and assessment also becomes difficult as the clinical manifestations of comorbidities are frequently atypical. Awareness of comorbid conditions in ASD is crucial as the symptoms overlap with each other. Some of the clinical features of ASD is also similar to the presentations of other disorders. For example, the hyperactivity and restlessness which is also the features of Autism overlaps with comorbid condition such as ADHD and similarly stereotyped pattern of behaviour, such as following the rigid routines overlap with conditions such as OCD.

Psychological comorbidities commonly observed in ASD are “ADHD, obsessive compulsive disorder, anxiety disorders, sleep problems, and intellectual disabilities”. Among these, ADHD shows a particularly strong overlap with ASD, as both share neurological and behavioral features. Studies indicate that approximately 70% of children and adolescents with autism present with at least one comorbid disorder, with social anxiety being among the most frequently observed symptoms (Simonoff, E., 2008). A systematic review done by Lai et al. (2017) states that the eight most frequently reported psychiatric comorbidities in ASD are ADHD, impulse control and conduct disorders. Other psychological problems such as anxiety, sleep problems, depression, mood disorder such as bipolar disorders and schizophrenia disorders are also reported, In addition to psychiatric comorbidities, physical health issues are also widespread. Obesity is more commonly seen in individuals with ASD (Hill, 2015), along with gastrointestinal difficulties such as constipation and feeding-related challenges. Day-to-day stressors including social isolation and impaired communication further heighten the risk of developing anxiety and depression. Intellectual disability and medical conditions such as epilepsy and gastrointestinal dysfunction add makes the care more difficult. The presence of multiple co-morbidities not only complicates treatment strategies but also disrupts daily functioning to a greater extent.

1.3 **Etiological Factors of ASD**

There are many etiological factors for Autism Spectrum Disorder in which the interplay of genetic and environmental factors proved to be a very significant role. Several conditions such as Rett's syndrome, fragile x syndrome, and MECP2 duplication syndrome are highlighting the role of genetic contributions and heritable influences. Environmental factors, including advanced parental age, maternal nutrition, prenatal infections, stress during pregnancy, and exposure to toxins, also play a significant role in development of Autism. In many cases, the combination of genetic susceptibility and environmental factors influences determines the severity and presentation of ASD symptoms.

Recent research has increasingly focused on brain development and function in ASD. Neuropathological studies have reported conditions in children aged 1 to 4 years such as atypical brain growth patterns, increased head circumference and intracranial volume (Haar, 2016). Structural differences have also been observed in multiple regions of brain which includes occipital lobe, pericentral areas, medial temporal lobe, basal ganglia, and the right parietal operculum (Nickl-Jockschat et al., 2012). However, these differences appear less pronounced in older individuals, leading to the hypothesis that brain overgrowth in ASD at earlier stage may be followed by periods of arrest in growth or degeneration (Courchesne et al., 2011). Neurotransmitter systems and neural connectivity patterns are also implicated, although the precise mechanisms remain under investigation.

1.3.1 **Neural Theories of ASD**

The neurological basis of the cognitive, social, and behavioral traits observed in Autism is explained by neural theories and the key brain regions involved are frontal lobe, temporal lobe, and cerebellum (Schroeder et al., 2010). Functional studies often reveal under activation within temporo-limbic and fronto limbic networks, as well as reduced activity in the medial and ventro lateral prefrontal cortices, temporo-parietal regions, and amygdala (O'Nions et al., 2014). These neural disruptions are thought to underlie difficulties in social cognition and emotional processing. The “social brain” network integrates multiple structures, including the frontal and temporal cortices, amygdala, and basal ganglia, supporting emotion processing, motivation, and reward. Executive functions, which is under the prefrontal cortex relies on interactions between the striatum for motivation, amygdala for emotional regulation, thalamus for sensory integration (Fernandez, 2021). Recent research has reported weakened connectivity between socially relevant brain regions in children with ASD, with lower connectivity correlating with reduced social competence (Wang et al., 2023). Frontal lobe dysfunction in ASD is associated with both cognitive and motor impairments, reflecting the interdependence of higher-order cognitive processes and motor control (Hampson& Blatt, 2015). Prefrontal deficits may contribute to challenges in inhibiting inappropriate movements or social behaviors (Fernández et al., 2019). Frontostriatal network dysfunction further contributes to restricted interests, repetitive behaviors, and social-communication deficits (Langen et al., 2011; Delmonte et al., 2013).

Language and social cognition are also affected by abnormalities in specialized regions of the frontal lobe. The language impairment in ASD might be related to Broca’s area which is responsible for speech production (Broca, 1861). The orbitofrontal cortex plays a crucial role in theory of mind and social reasoning (Powell et al., 2010) and processing of social information. The inferior frontal gyrus, a key component of the mirror neuron system, is involved in imitation, empathy, and the understanding of others’ actions (Johnson-Frey et al., 2004; Oberman&Ramachandran, 2007). The hippocampus, critical for memory, spatial reasoning, and social interaction, exhibits structural and functional differences in individuals with ASD. Atypical hippocampal development corresponds with the age at which core ASD symptoms typically emerge, around 2 years of age (Banker et al., 2021). Hence, the neural alterations underscore the pivotal role of frontal and temporal brain regions in shaping the behavioral and cognitive manifestations of ASD.

1.3.2 **Cognitive Theories of Autism**

1.3.2.1 Theory of Mind (ToM)

Theory of Mind refers to the capacity of understanding other's mental states, beliefs, intentions, and perspectives (Premack& Woodruff, 1978). It encompasses skills such as interpreting implicit social cues, recognizing intentions behind communication, and understanding deception or false beliefs in social contexts. ToM develops gradually, beginning around 14 months and continuing through childhood across multiple stages (Low &Perner, 2012). Early developmental milestones include tracking moving objects, establishing joint attention, imitation, symbolic play, emotion recognition, and perspective taking abilities (Kimhi 2014; Fletcher-Watson et al., 2014).

Individuals with ASD often demonstrate marked deficits in ToM, particularly in assessing false beliefs, conflict inhibition, appearance-reality distinctions, and knowledge access (Carlson et al., 2002; Hamilton et al., 2016). Compared with typically developing peers, children with ASD display atypical development of ToM. While older children may eventually pass standard false-belief tasks, they often continue to experience difficulties in other ToM-related domains, with the level of impairment varying according to age. ToM abilities are also associated with the severity of autism symptoms, particularly in "social communication and restricted/repetitive behaviors" (Jones et al., 2018), intellectual functioning (Baker et al., 2014), language development (Steele et al., 2003), and executive functioning (Carlson et al., 2002).

1.3.2.2Central Coherence Theory

The weak central coherence theory, first proposed by Frith and Happe (1989), describes a cognitive processing style in which individuals with ASD tend to focus on local details at the expense of global integration and process information in a detail-focused way, sometimes at the expense of integrating details into a broader, meaningful whole. Central coherence refers to the ability to synthesize diverse information to form higher-level meaning within context (Frith&Happe, 1994). Weak central coherence is evident in perceptual and attentional domains, explaining phenomena such as superior performance on tasks requiring analytical detail (e.g., Block Design) and lower performance on tasks requiring integration of contextual information like sentence completion. (Jarrold& Russell, 1997). Beyond perceptual tasks, this processing style contributes to challenges in generalizing social behaviors, understanding and applying social norms, engaging in symbolic play, pragmatic language, and recognizing emotions (Plaisted 2001; Baron-Cohen 1989). Weak central coherence can result in difficulty understanding stories, deriving meaning from social situations, and integrating verbal and non-verbal cues, leading to overly literal interpretations and difficulties with generalization

1.3.2.3Empathizing-Systemizing Theory

The empathizing-systemizing theory, proposed by Baron-Cohen (2002), suggests that individuals with autism often exhibit deficits in empathizing, understanding, and responding appropriately to the mental states of others, while showing strengths in systemizing, the drive to analyze and predict structured systems.

Empathizing involves two key components:

1. Cognitive empathy – the ability to attribute mental states to oneself and others, facilitating understanding of behaviors.
2. Affective empathy – emotional responsiveness to the feelings and perspectives of others.

Deficits in empathizing are central to the social and communicative difficulties observed in autism and are part of the so-called “triad of deficits,” which also includes impairments in social interaction and perspective-taking (Baron-Cohen 1988; Tager-Flusberg 1993). Conversely, systemizing represents a cognitive strength in autism, encompassing the analysis of technical, natural, and abstract systems to identify regularities and predict outcomes. Individuals with ASD often display systemizing abilities at or above their mental age, which may underpin a “triad of strengths” in specific cognitive domains (Baron-Cohen & Belmonte 2005). This dual profile illustrates that while autism is associated with deficits in social cognition, it can confer cognitive advantages in structured, rule-based problem-solving and analytical tasks.

1.4 Executive Function Deficits in ASD

One of the most widely accepted cognitive accounts of ASD implicates deficits in executive functions (EF) - the set of higher-order processes responsible for goal-directed behavior. EF includes response inhibition, working memory, cognitive flexibility, and planning (Russo et al., 2007). These skills are primarily mediated by the prefrontal cortex and its neural networks. Research has shown that autistic children often experience difficulties in planning (as seen in Tower of Hanoi tasks), set-shifting (Wisconsin Card Sorting Test), and working memory tasks (Lin et al., 2025). EF deficits are closely related to social-communication difficulties, repetitive behaviors, and adaptive functioning (Pugliese et al., 2015; Rajendran& Mitchell, 2007). Inhibitory control impairments have been linked to perseverative behaviors, while working memory weaknesses relate to challenges in language and social reciprocity (Lopez et al., 2005). EF can be divided into “cool” EF (abstract, logical, decontextualized processing) and “hot” EF (emotionally salient decision-making). Both domains may be disrupted in ASD (Brunsdon et al., 2015), contributing to difficulties in self-regulation and flexible adaptation to changing situations.

1.4.1 Inhibitory Control

Inhibitory control, a core component of executive functioning, refers to the ability to regulate attention, behavior, thoughts, and emotions in order to suppress strong internal impulses or external distractions. This skill allows individuals to engage in goal-directed actions rather than being automatically driven by environmental stimuli or habitual responses. Inhibitory control encompasses multiple domains:

- Behavioral inhibition: the ability to suppress impulsive actions.
- Cognitive inhibition: the capacity to resist irrelevant or intrusive thoughts and memories, often described as interference control (Anderson & Levy 2009).
- Attentional inhibition: the ability to selectively focus attention on relevant stimuli while ignoring distractions.
- Self-control: the regulation of emotions and behaviors, including delaying gratification for greater rewards (Mischel et al., 1989).

In typically developing individuals, inhibitory control steadily improves from childhood through adolescence into adulthood (Davidson et al., 2006). In individuals with Autism Spectrum Disorder (ASD), deficits in inhibitory control are frequently observed and are linked to repetitive behaviors. Neurocognitive studies suggest that disruptions in the frontostriatal system, which supports voluntary behavioral inhibition, contribute to difficulties in suppressing repetitive responses (Rubia et al., 2007; Christ et al., 2003). Research indicates that impaired response inhibition and reduced cognitive flexibility play a role in the repetitive behaviors commonly observed in ASD (Cárcel-López et al., 2025).

Studies examining different types of inhibition in ASD have reported mixed findings. Some indicate impairments across all inhibitory domains, while others show variability depending on age and type of inhibition assessed. Prepotent response inhibition, which involves suppressing previously learned or dominant responses, is often more impaired in ASD than resistance to distractor interference, which entails ignoring irrelevant information (Geurts et al., 2014). Developmental patterns suggest that prepotent response inhibition may improve with age, while difficulties in resisting interference tend to decrease after age twelve (Christ et al., 2011). Proactive interference, or the ability to manage previously learned information that interferes with new tasks, appears to follow a similar developmental trajectory in ASD and typically developing individuals between ages 8 and 18 (Christ et al., 2011). Overall, inhibitory control deficits in ASD contribute to core behavioral characteristics, including repetitive actions, impulsivity, and challenges in adapting to changing environmental demands

1.4.2 Working Memory and Its Role in Social Cognition

Working memory (WM) is a crucial cognitive functioning which temporarily holds and manipulates information which is necessary for complex tasks such as reasoning ability, learning, and problem solving. Beyond its role in academic skills, WM is fundamental to social cognition, enabling individuals to decode emotional expressions, interpret social cues, and label emotions accurately. Both phonological loop and visuospatial sketchpad model of Baddley's Working Memory has been found to be impaired in children with autism (Habib et al., 2019). This impairment may partly explain why many children with ASD struggle to process and respond to social-emotional information. Research also links WM to emotion recognition and social functioning. Bankó et al. (2009) proposed that difficulties in high-precision short-term memory storage of emotional information may contribute to emotional processing deficits observed in psychiatric conditions, including autism. Similarly, Phillips et al. (2008) emphasized that identifying emotions from facial expressions places substantial demands on working memory, as it involves retaining visual information while simultaneously comparing it with stored emotional representations. Consequently, WM supports not just cognitive problem-solving but also the ability to manage social interactions, balance personal needs with others' expectations, and navigate dynamic social situations.

Multiple studies have consistently reported working memory (WM) deficits in individuals with ASD. A study done by Gentil-Gutiérrez et al. (2022) findings also indicated that participants with ASD had greater difficulties across executive function domains, including working memory, inhibition, planning, and cognitive flexibility. Gilotty et al. (2002) further found that WM deficits were closely associated with lower adaptive functioning, particularly in communication and socialization domains. These findings strengthen the view that WM impairments contribute to the core social-communication difficulties seen in autism.

1.4.3 Planning and Goal-Directed Behavior

Planning is another key executive function, enabling individuals to generate strategies, sequence actions, and monitor progress toward achieving a goal (Hill 2004; Ward & Morris, 2005). It is an essential skill for carrying out everyday tasks such as organizing routines, scheduling activities, and evaluating one's own behavior. Planning is inherently dynamic, requiring constant monitoring, re-evaluation, and adjustment as situations unfold. Research indicates that planning is often compromised in individuals with ASD and it may reinforce rigid behaviors and insistence of sameness. The planning ability has been found to be poor in many of neuropsychological assessment done such as Tower of London (Lopez et al., 2005). Hill (2004) and López et al. (2005) both reported significant planning deficits among children with autism, which negatively affect their capacity to perform daily life activities efficiently. Van den Bergh et al. (2014) confirmed these findings, reporting that poorer planning performance was significantly associated with higher symptom severity in ASD. Additionally, Bolte et al. (2011) found that lower planning ability correlated with increased stereotypic and ritualistic behaviors, suggesting that impaired planning may exacerbate restricted and repetitive behavior patterns. The planning ability can impair their daily life activities such as organizing their daily life activity, social activities, and time management (Ozonoff et al., 2004).

1.4.4 Cognitive Flexibility and Symptoms of ASD

Cognitive flexibility refers to the capacity to switch between different mental tasks, strategies, or perspectives, and to adjust behavior in response to changing environmental demands. It is considered a fundamental aspect of executive functioning and plays a vital role in supporting flexible, goal-directed behavior. A key component of cognitive flexibility that has been extensively studied is set-shifting, which involves transitioning from one set of rules or responses to another in order to complete a task (Dajani&Uddin2015; Yerys et al., 2015). Difficulties in cognitive flexibility are commonly reported among individuals with ASD and are linked to several central challenges. Research suggests that reduced flexibility is associated with increased social difficulties (Berger et al., 2003). The study also further reiterates that it impairs the ability to understand perspectives of others, adapting during conversational strategies, responding appropriately during social interactions and social situations. The cognitive flexibility is also found to be associated with more pronounced restricted and repetitive behaviors (Faja& Darling, 2019), as well as higher rates of co-occurring conditions such as anxiety and depression (Crawley et al., 2020; Ozsivadjian et al., 2021). These impairments can have far-reaching consequences, affecting academic performance (John et al., 2018), adaptive functioning (Bertollo et al., 2020), and overall quality of life (de Vries&Geurts, 2015).

Importantly, the meta-analytic findings have identified cognitive flexibility as one of the most consistent executive function difficulties in ASD. The study done by Lai et al. (2017) reported moderate effect size for cognitive flexibility impairments, which remained significant even after controlling for IQ and the presence of ADHD, suggesting that these deficits are not merely secondary to comorbid conditions but represent a core cognitive feature of autism.

1.5 Factors Influencing Executive Function Impairment in ASD

Several variables have been found to contribute to the severity and presentation of EF deficits in autism:

- Severity of ASD Symptoms: Greater symptom severity has been correlated with poorer EF performance (Seng et al., 2021).
- Restricted and Repetitive Behaviors: High levels of repetitive behaviors are linked to reduced flexibility and overall EF difficulties (Seng et al., 2021).

- Co-occurring Conditions: The presence of intellectual disability or ADHD can exacerbate EF impairments (May & Kana, 2020).
- Verbal Ability: Children with stronger verbal skills often perform better on EF tasks, suggesting that language ability may serve as a protective factor (May & Kana, 2020).
- Age: Some aspects of EF may improve with age, though deficits often persist relative to neurotypical peers (May & Kana, 2020)

1.6 Treatment Approaches

Treatment approaches for ASD involve a combination of behavioral, developmental, educational, social, pharmacological, and complementary therapies tailored to individual strengths and needs. Behavioral therapies focus on modifying behaviors by understanding their triggers and consequences. Applied Behavior Analysis is the most widely researched and accepted method, using reinforcement to encourage adaptive behaviors. Discrete Trial Training and Pivotal Response Training are also other forms of ABA-based techniques targeting specific skills and generalization to natural settings. There are other approaches, such as Early Start Denver Model, which combines developmental psychology principles and Applied Behavioral analysis to teach new skills. Behavior modification principles, which involve contingency management and operant conditioning principles, also help to modify the undesirable behaviors to desirable behaviors among children with autism.

Early detection and interventions are very significant as development of cognitive and social skills enhances language abilities, intellectual and adaptive functioning (Eikeseth et al., 2012). The early intervention for children with autism typically centres on evidence based approach from Applied Behavior Analysis, the Early Intensive Behavioral Intervention (EIBI). This method is most effective when started between ages of 1 to 5, harnessing a child’s heightened neuroplasticity to foster meaningful developmental gains (Reichow et al., 2018)

The other mode of therapy involves pharmacological management for comorbid problems such as hyperactivity, aggressive behaviors, depression, anxiety or sleep disturbance. Speech-language therapy improves verbal and non-verbal communication, often incorporating alternative communication strategies if needed. Occupational therapy assists with sensory issues, motor coordination, and daily living skills. Parent-mediated and family therapies empower caregivers to implement strategies and support social and daily routines. Alternative therapies include special diets, sensory-based therapies, creative arts therapies, animal-assisted interventions, and mindfulness which were also found to be effective for improving symptoms among children with autism.

1.6.1 Cognitive Interventions for ASD

Cognitive remediation is a very promising approach to address cognitive deficits such as attention, memory, executive function, and processing speed across several neuropsychiatric conditions, including schizophrenia, attention deficit hyperactivity disorder (ADHD), and traumatic brain injury, and may provide significant benefits for individuals with Autism as well (Eack et al., 2013). The cognitive training principles are grounded in neuroscience, learning theory, and evidence-based practices to promote durable and meaningful improvements in cognition and daily functioning. The effectiveness of cognitive training is based on principles of neuroplasticity and the repeated intense practice makes the cognitive skills as a more automatic process increasing efficiency and durable gains. Over the time, the effectiveness of cognitive training is transferred to gains of real-world tasks requiring the targeted cognitive functions. Brain function therapy states that increased activity in certain regions of brain reestablishes functions in new areas. Whenever the cognitive training tasks are planned, it should be adapted and modified to the learner's level of performance and making it harder as skills improve moving from simpler to more complex tasks.

Cognitive interventions are generally divided into two broad categories namely process-specific (restorative) and compensatory approaches (Ylvisaker et al., 1998).

1.6.1.1 Process-based (Restorative) Approaches

These interventions aim to enhance fundamental processing capacities, such as working memory, speed of processing, and executive functions, thereby facilitating the more efficient operation of higher-order cognitive processes. Evidence suggests that process-based interventions are not only effective but can also transfer benefits to untrained cognitive domains (Karbach et al., 2014; Buschkuehl et al., 2008; Brehmer et al., 2012). Although damaged neurons cannot be replaced, surviving neurons may form new connections through mechanisms such as axonal sprouting and synaptogenesis (Berlucchi, 2011; Kane & Ward, 2021; Murphy & Corbett, 2009). Repeated exposure to relevant stimuli may reshape neural connectivity patterns, and drill-based training has been shown to strengthen functional networks and promote neuroplasticity (das Nair et al., 2016; das Nair & Lincoln, 2012). According to Kleim and Jones (2008), principles of neuroplasticity includes salience, intensity, repetition, and progressively challenging tasks — are critical for maximizing outcomes. Through these mechanisms, restorative training can produce both broad and specific behavioral gains (Sohlberg et al., 2003; Mishra &Gazzaley, 2014).

1.6.1.2Compensatory Approaches

Compensatory approaches are an important component of cognitive interventions, supporting independence and functional skills in both children and adults, and are particularly effective when used alongside direct remediation (Livingston &Happé, 2017). The literature also suggests that compensatory processes may occur at multiple levels, including molecular and genetic pathways; for example, synaptic plasticity may act to counterbalance atypical neural connectivity observed in ASD (Bourgeron, 2015). Compensatory approach based interventions focus on teaching individuals to work around existing cognitive deficits by adopting problem-solving strategies or environmental adaptations. This approach aims to help individuals perform daily tasks more effectively by learning new skills or leveraging intact cognitive abilities (Mateer et al., 1999; Morrison &Chein, 2011). Rather than repairing impaired processes, compensatory strategies focus on optimizing functioning in real-world contexts. It involves modifications in behavior, the learning environment by use of tools and supports. Examples include using checklists, external reminders, structured routines, or prompting systems to manage attention, memory, or organization difficulties. It helps to teach alternative social, communication, or executive function strategies for situations where core skills may be weaker (Livingston & Happé, 2017). It includes explicit social scripts, visual schedules, or technological aids for social communication and self-regulation and it helps to improve adaptation when core deficits are present, but may not eliminate the underlying difficulties.

1.6.1.3Technology-Assisted Cognitive Training

Over the recent years, there has been increasing interest in delivering cognitive interventions through computer-based platforms due to their accessibility, ease of administration, and ability to individualize training. Currently, a wide range of cognitive training tools are available, including downloadable programs, logic puzzles, paper-and-pencil exercises, and virtual reality simulations, offering flexible options for tailoring interventions to individual needs.

Evidence suggests that computer-based EF training can be effective across diverse developmental and neurological populations (Macoun et al., 2021). Some interventions have incorporated video game components to make learning more engaging and motivating (Whyte et al., 2015). However, research indicates that many existing game-based programs show limited evidence of generalization to untrained skills (Whyte et al., 2015). To optimize their effectiveness, game-based cognitive interventions must provide a sufficient number of learning trials, adapt task difficulty appropriately, and offer immersive, meaningful learning contexts (Catalano et al., 2014; Whyte et al., 2015).

1.7 Efficacy of Cognitive Interventions in ASD

Individuals with ASD frequently exhibit neurocognitive impairments, particularly in executive functions (EF), which are strongly predictive of adaptive functioning (Hudepohl et al., 2015). These difficulties are present even among those without intellectual disability (Eack et al., 2013), highlighting the importance of targeting EF as a key intervention domain (Keshavan et al., 2014). Because EF deficits can significantly disrupt daily life skills, direct intervention on EF through evidence-based cognitive training has the potential to improve both functional outcomes and symptomatology in ASD. In autism, the cognitive interventions would mainly focus on executive functions such as inhibition, working memory, cognitive flexibility, and planning. Training attention al skills have also proven to be effective.

Children with ASD often show increased engagement with computer-based interventions, though research suggests that non-computerized programs may also yield significant benefits when appropriately applied. Moreover, interventions conducted in naturalistic settings and involving parents, peers, and practitioners are more likely to promote generalization and sustained behavioral change (Wass&Porayska-Pomsta, 2014).

Several studies have demonstrated the effectiveness of cognitive interventions in enhancing executive functions and related skills among children with ASD. Hajri et al. (2019) reported significant improvement in his study following cognitive training on working memory and cognitive flexibility which was measured using Digit Span task and verbal/semantic fluency tasks, respectively. Similarly, interventions targeting cognitive set-shifting have been shown to enhance behavioral flexibility and reduce repetitive behaviors (Saniee et al., 2019). Executive function (EF) training has also been found to have positive indirect effects on social skills, highlighting the interconnected nature of cognitive and social functioning (Kenworthy et al., 2014; Fisher et al., 2005).

In a follow-up study, Hajri et al. (2019) observed that cognitive remediation therapy not only improved school performance but also reduced ASD symptom severity which was measured by the Childhood Autism Rating Scale (CARS). Fisher (2005) reported that children who received EF-focused interventions demonstrated lasting improvements in real-life social skills. Saniee et al. (2019) further showed that set-shifting puzzle games reduced perseverative responses and generalized the skills to broader behavioral contexts, with effects maintained even one month post-intervention.

Moreover, Eack et al. (2018) documented enhancements in emotional regulation, social cognition, and perceptive social behavior among participants following cognitive training. Kenworthy et al. (2014) found that EF training produced gains comparable to social skills training, emphasizing the value of flexible, individualized interventions. Another study (Sun et al., 2017) confirmed that executive function stimulation led to improvements in communication and social cognitive performance in children with ASD.

The link between executive function deficits and autism symptom severity is well established. EF impairments in children with ASD are associated with challenges in emotional regulation, social skills, communication, and adaptive behavior. Specifically, response inhibition and cognitive flexibility deficits are related to repetitive and impulsive behaviors. It is further noted that working memory and sustained attention deficits affect social interactions, communication, and contribute to restricted behavioral patterns. Planning difficulties impair the ability to sequence, anticipate, and organize tasks, affecting academic performance and daily living skills.

These executive function challenges often co-occur with behavioral difficulties such as irritability, temper tantrums, anxiety, and difficulties with transitions. Therefore, interventions targeting executive functions are crucial in therapeutic programs for children with ASD, not only to improve cognitive abilities but also to enhance adaptive functioning and overall symptom management. Given the established relationship between executive functions and ASD symptom severity, as well as the documented efficacy of cognitive interventions, the current study aims to evaluate the effect of targeted executive function training on children with ASD. Improving EF through structured cognitive interventions may support better academic, social, and adaptive outcomes, providing meaningful improvements in daily functioning. The role of executive functions and it's relation to autism symptom severity is well established and has been proven in many studies. The deficits in executive functions are linked to emotional regulation, social skills, and overall adaptation in children with ASD. It is also related to social relationship impairment and the communication ability of children. The behavioural problems, such as repetitive behaviour patterns, are also found to be related to cognitive functions such as response inhibition and cognitive flexibility. Impulsivity was found to be correlated with difficulty in inhibition. The sustained attention and deficits in working memory are related to impairment in social relationships, communication, and a restricted pattern of behaviour. The planning ability of the children is found to be impaired, which impacts their ability to sequence the tasks, anticipate, and organize tasks, which are required for daily living functioning. This causes impairment in academics as well as their adaptive functioning. Hence, these difficulties in executive functions might co-occur with symptoms such as difficulty in transition, regulating emotions and being irritable, throwing temper tantrums as well as anxiety. Hence, adopting training to improve executive functions is significant in therapeutic interventions for children with autism to improve their symptoms as well as their adaptive functioning and the previous literature has also emphasized the role of cognitive interventions and their efficacy among children with autism. Hence, the current study aimed to test the effect of cognitive training on executive functions among children with ASD.

Executive functions (EF) refer to a set of higher-order cognitive processes that enable goal-directed behavior, including working memory, cognitive flexibility, inhibitory control, planning, and problem-solving and these functions are critical for daily life, academic achievement, and social interactions. As discussed in the previous chapter, children with ASD have impairment in these executive functions and it manifest as difficulties in attention, memory flexibility, inhibition, and planning which can significantly impact their learning skills, social and communication skills and overall development, which might influence the severity of the symptoms.

Cognitive training has emerged as a promising intervention aimed at enhancing executive functions in children. These interventions target specific cognitive skills to improve neural plasticity, improve their executive functions and it turn which will help to improve their adaptive skills. While research in neurotypical populations has demonstrated the effectiveness of cognitive training in improving EF, evidence among children with ASD remains varied, necessitating a systematic exploration of the existing literature.

CHAPTER-II

REVIEW OF LITERATURE

2.1 Executive Function Impairment among Children with Autism

Ko et al. (2024) explored the difference in executive functions between preschoolers with ASD and typically developing individuals (TD), to investigate correlations between executive function and autism symptoms in preschoolers with ASD and to examine the effect of executive function on symptoms of autism. The study included participants of preschoolers (4–6 years) with ASD (24 boys, 20 girls) according to DSM-5-TR criteria and TD (24 boys, 20 girls). BRIEF-P (Behavior Rating Inventory of Executive Function-Preschool Version) and CASD-C (Checklist for Autism Spectrum Disorder-Chinese Version) were used as measurement tools. The results found that executive functions were significantly lower in preschoolers with ASD than in preschoolers without ASD; the greater the executive dysfunction, the greater the autistic symptomatology, and executive dysfunction predicted 57 % of the variability of autism symptoms. The study concluded that preschoolers with ASD have more executive dysfunction than those without ASD and recommends incorporating executive function into clinical assessment programs to understand how executive function is related to autism symptoms.

Gentil-Gutiérrezet al. in 2022 conducted a study that compares the Executive Functioning deficits of children and adolescents diagnosed with Autism and neurotypical children in the school context. The population of the study comprises of professionals in the field of education who were the informants for the children and adolescents aged 6 to 18 years. The study participants worked in regulated centers of primary and secondary education. The sample comprises of 121 participants in which 70 participants were professionals working with children having autism and 51 were teachers working with neurotypical children. The results of the study indicated that individuals diagnosed as autism had significant higher scores on Behaviour Rating inventory of executive function (BRIEF) in comparison with neurotypical children. The study confirms the hypothesis that children and adolescents with autism experience greater challenges in EF such as cognitive flexibility, planning, working memory and inhibition.

In a meta-analysis study done by Benallie et al. 2021, he studied EF of Children with ASD and the comorbid diagnosis of ID and ADHD. The analysis was done on 26 studies from 24 journals which revealed that severity of deficits in EF was high among comorbid diagnosis of ASD rather than ASD itself. Children with ASD and ADHD displayed deficits in flexibility, shifting, inhibition, and attention, which were distinct from children with ASD and ID. Among children with ASD and ID, differences were observed in planning and organizing, flexibility and shifting, attention, behavior regulation, and global EF skills compared to control groups. However, these findings varied depending on the type of assessment used.

In the study conducted by Carotenuto et al. (2019), a sample of 50 children participated ranged between 2.7 and 3.5 years. The study sample was subdivided into two groups: 25 ASD children and 25 typically developing children as a control group. All participants were administered the BRIEF-P test to assess executive functioning. The two groups were counterbalanced for age and gender. Comparison analysis between the two groups revealed significantly higher scores in ASD children in two subscales of BRIEF-P: inhibition and shifting. These data evidenced significant impairments in several dimensions of executive functions in ASD children.

In a study done by Golshan et al. (2019), he included 15 children with high functioning autism along with 15 typically developing (TD) children for the control group. The participants selected have IQ > 80 and the children were between eight to 12 years old. The assessment he used was NEPSY-II test to assess executive functions and “CHEXI” questionnaire in order to evaluate individual’s executive functions in the form of a parent report. Each participant's performance on 3 subtests of “NEPSY-II” (Inhibition, design fluency and animal sorting) was assessed individually. In addition, the parents were made to fill out the questionnaire on their evaluation of their children's executive function subscales inhibition, working memory, planning and self-regulation. The results showed that children with high functioning autism performed significantly weaker in executive functions compared to typically developing children.

Demetriou et al. (2018) did a meta analysis study in which his primary objective is to analyze executive functions performance in ASD, the fractionation across EF subdomains, the clinical utility of EF measures and the influence of multiple moderators like age, gender, diagnosis, and other measurable characteristics. The databases such as Embase, Medline and PsychINFO were searched to identify peer-reviewed studies published since the inclusion of Autism in DSM-III (1980) up to end of June 2016 that compared EF in ASD with neurotypical controls. A total of 235 studies comprising 14 081 participants were included (*N*, ASD=6816, Control=7265). A moderate overall effect size for reduced EF was found with similar effect sizes across each domain. The majority of moderator comparisons were not significant although the overall effect of executive dysfunction has gradually reduced since the introduction of ASD. This study confirms a broad executive dysfunction in ASD thatis relatively stable across development.

Garonet al.(2018).In this study the authors assessed simple and complex components of three EF functions, working memory, inhibition, and shifting using a novel battery, the Preschool EF Battery (PEFB). The participants were 34 preschoolers diagnosed with ASD and 255 typically developing preschoolers. Results revealed that there is significant difference between the two groups in the three EF abilities, but specific findings were moderated by mental and chronological age. This study suggested the presence of early EF deficits in preschool children with ASD. The study also highlighted the importance of considering how EF develops during early life in typically developing children in order to design sensitive EF measures.

Wanget al. (2018) investigated the relationship between executive functions and visuospatial working memory (VSWM) in children with Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD). The study included three groups of participants: 21 children with ASD, 28 children with ADHD, and 28 typically developing (TD) children as controls. All participants completed the Wisconsin Card Sorting Test (WCST) to assess executive functioning and the Corsi Block Tapping Test to evaluate Visuospatial Working memory. The findings revealed that children with ASD performed significantly worse in VSWM compared to both the

ADHD and TD groups. The study emphasized the importance of interventions targeting working memory and executive functions to enhance cognitive capacity in children with ASD.

Lai et al. (2017) conducted a meta-analysis to examine deficits in various components of executive functioning in children and adolescents with high-functioning Autism Spectrum Disorder (HFASD). The results indicated that individuals with HFASD exhibited moderate impairments in verbal working memory, spatial working memory, flexibility, planning, and generativity, while inhibition appeared relatively intact. Subgroup analyses further demonstrated that these deficits particularly in flexibility, generativity, and working memory—remained significant even in ASD participants without comorbid ADHD. This meta-analysis confirmed the presence of executive dysfunction in children and adolescents with HFASD and highlighted that these deficits cannot be solely attributed to comorbid ADHD or general cognitive ability. The findings provide valuable insights for clinical understanding and the development of targeted interventions to address executive functioning deficits in this population.

Pellicano et al. (2010) conducted a longitudinal study involving thirty seven cognitively able children with Autism Spectrum Condition (ASC) to examine the development of Theory of Mind (ToM), executive functions (EF), and central coherence (CC). The participants were assessed at the beginning of the study and again three years later using tasks measuring planning ability, cognitive flexibility, inhibitory control, and false-belief understanding. The findings indicated that children with ASC demonstrated difficulties in false-belief attribution, planning, and set-shifting, alongside enhanced local processing, at both assessment points. However, performance varied considerably among individuals, showing that these patterns were not universal. Importantly, the study found that executive function and central coherence skills were longitudinally predictive of changes in Theory of Mind performance, independent of age, language ability, nonverbal intelligence, and initial ToM skills. These results underscore the role of EF and CC in the developmental trajectory of social cognition in children with autism.

Chan et al. (2009) examined neurophysiologic activities, executive functions and their association in children with ASD. Thirty-eight normal and 16 children with ASD participated with parental consent. Executive functions were measured using neuropsychological tests and parent ratings, and neurophysiologic activities were measured using EEG. The results showed that children with ASD showed significantly poorer executive functions in everyday activities as shown on the Behavior Rating Inventory of Executive Function (BRIEF), and had lower frontal perfusion patterns than normal children as shown in the neurophysiologic cordance measures. Frontal cordance values were found to be significantly associated with executive dysfunctions.

Robinson et al. (2009) examined executive functions in a group of 54 children with Autism Spectrum Disorder (ASD) who had an IQ above 70, comparing them with a typically developing control group matched for age, gender, IQ, and vocabulary. The study found significant impairments in inhibition of prepotent responses, measured by tasks such as the Stroop Test and Junior Hayling Test, as well as in planning ability, assessed using the Tower of London. In contrast, participants with ASD showed preserved performance in mental flexibility, evaluated through the Wisconsin Card Sorting Task, and in generativity, measured by verbal fluency. These findings suggest that children with ASD display a specific profile of executive dysfunction, particularly in planning, inhibition, and self-monitoring, while some EF domains remain intact.

O'Hearn et al. (2008) highlighted that executive functions, which develop gradually into adolescence and rely on the integration of widely distributed brain networks, are affected in autism. Evidence from studies investigating response inhibition and working memory indicates that while core components of executive function are impaired, compensatory mechanisms may allow for relatively normative performance in some contexts. Additionally, age-related improvements in executive functioning from childhood to adolescence suggest neural plasticity in ASD, indicating a prolonged period during which interventions could be effective. Overall, executive function deficits in autism appear to reflect atypical functioning across distributed brain networks, leading to difficulties in processing complex information across multiple domains.

2.2 Relationship between Executive Functions and Autism Symptoms

Fernandez-Prieto et al. (2021) conducted a study that explored the mediating link between Executive functioning, sensory processing and behavior among 79 children and adolescents with autism. The informants were given Child Sensory Profile (CSP-2), Child Behavior Checklist (CBCL) and three executive function domains derived from CBCL was used in the study. The three Executive function domains were working memory, planning, emotion regulation and control. The results of the study indicated that there is a significant association between Working memory and repetitive/obsessive behavior and aggressive behaviors. There was a strong mediation effect of EF concerning how sensory processing and behavioral outcomes interact. Specifically, Executive functions, particularly in the domain of emotion regulation and control, played a mediating role in the relationship between sensory processing abnormalities and behavioral problems.

Yu et al. 2021 studied the mediating role of Cool EF and verbal comprehension in explaining the relationship between Executive Function (EF) and Theory of Mind (ToM) among children with Autism Spectrum Disorder (ASD) average intellectual functioning. The sample comprises of 97 children with ASD aged 6 to 12 years. The researchers measured the children's cool EF, hot EF, and verbal comprehension using specific tasks, and assessed ToM with the Theory of Mind Task Battery. The results showed that there was a significant correlation between Hot EF and ToM which is reflected in the ASD core symptom such as impaired perspective taking ability, emotional dysregulation which is manifested as inappropriate emotional response, exaggeration of emotions.

Ghosh et al. (2020) conducted a case series to assess executive functioning and social skills in five male children diagnosed with autism spectrum disorder (ASD), aged 6 to 12 years. The study utilized various neuropsychological assessments, including the Color Trail Test, Animal Cancellation Test, Design

Fluency Test, Maze Test, and the Autism Social Skills Profile. Results indicated significant impairments in executive functioning domains such as planning, cognitive flexibility, visual fluency, and selective attention, as well as deficits in social skills. The findings underscore the importance of addressing executive function and social skill deficits in early interventions for children with ASD.

Faja & Nelson Darling (2019) studied the relationship between inhibition, flexibility, and specific behavioral characteristics in 102 school-aged children (between 7 – 11 years) with ASD who had average or above-average cognitive abilities. The assessments to assess intellectual functioning, executive functions and behavior rating scale were administered. The results of the study indicated inverse relationship between Restricted and Repetitive patterns of behavior and Executive function deficits in the areas of inhibition and set shifting. Moreover, the study found that the ability to proactively slow down reaction time to respond more carefully was linked to restricted and repetitive behaviors. These results emphasized the importance of differentiating between higher-order and sensorimotor symptoms in ASD, as they have distinct relationships with executive functioning abilities.

Ellis Weismer et al. in year 2018 assessed Executive Functions using nonverbal tasks of inhibition, shifting, and updating of Working Memory (WM) in school-age children with ASD. It also evaluated the association between children's receptive and expressive language abilities and EF performance. EF abilities in children with ASD (*n* = 48) were compared to typically developing controls (*n* = 71) matched on age, as well as when statistically controlling for group differences in nonverbal cognition, socioeconomic status, and social communication abilities. Six nonverbal EF tasks were administered to evaluate inhibition, shifting, and Working Memory. Language abilities were assessed using a standardized language measure. Language and EF associations were examined for the ASD group as a whole and subdivided by language status. The results exhibited significant deficits in all components of EF compared to age-mates and showed particular difficulty with shifting after accounting for group differences in nonverbal cognition. Moderate amount of association was observed between language (especially comprehension) and EF skills.

Jones et al. (2018) investigated cognitive abilities in a sample of 100 adolescents with Autism Spectrum Disorder (ASD). The study employed ten tasks to assess theory of mind (ToM) and executive function (EF), and examined how these cognitive abilities related to parent-reported measures of social communication difficulties and restricted and repetitive behaviors (RRBs). The findings indicated that ToM performance was significantly associated with both social communication challenges and RRBs, while executive functioning was positively correlated with ToM. These results highlight the interconnected nature of executive function, theory of mind, and core autism symptomatology, suggesting that EF may play a crucial role in supporting social cognition in adolescents with ASD.

Van Eylen et al. (2015) studied the relation between executive functions and autism symptoms. The performance of 50 individuals with Autism Spectrum Disorder (ASD) was compared with that of age, gender and IQ matched typically developing (TD) individuals. The effects of group (ASD versus TD), age (children versus adolescents) and gender were examined, as well as the correlation between age, IQ, ASD symptoms and executive functions. Individuals with ASD showed impairments in all executive function domains, but deficits were more pronounced in open-ended compared to structured settings. It was found that executive functions correlated with both social and non-social ASD symptoms.

In a study done by de Vries and Geurts(2015), he studied if intelligence, early language development, autism traits, and daily Executive Functions (EFs) were related to Quality of life (QoL) among children among children with Autism. The study was conducted among children aged 8–12 years with ASD (N = 120) and typically developing (TD) children (N = 76). The results showed that children with ASD have lower QoL than TD children and the lower QoL was related to higher levels of autism traits and EF deficits. Moreover, specific autism traits and EFs were related to specific QoLsub domains. The autism characteristics such as social motivation was related to executive functions such as shifting ability and emotional control were related to QoL subscale Emotional Functioning. The autism characteristics such as Social Cognition and Social Communication and executive function symptoms such as Inhibit, Shift, and initiate were related to QoL subscale social functioning. The study concluded that the low QoL and aggravating effects of autism traits and EF deficits indicate a potential to identify and target such factors in treatment to improve QoL.

In a cross-sectional study, Shiri et al. (2015) examined 50 children with high-functioning autism who were selected through convenience sampling. The Gilliam Autism Rating Scale (GARS) and the Autism Spectrum Screening Questionnaire was administered to assess the autism symptoms. Further, neuropsychological tests including the Stroop Test, Continuous Performance Test, and Shift Attention tasks were used to assess the cognitive functions. The results revealed significant positive relationships between selective attention and communicative and social interaction symptoms, sustained attention and social interaction difficulties as well as repetitive behaviors, and shifting attention with communication, social interaction, and repetitive behaviors. These findings underscored the important role of executive functions in autism symptoms and suggest that interventions aimed at improving executive function could be beneficial for children with ASD.

Leung et al. (2014) investigated the association between executive functioning, social impairment, and overall autism symptomatology in children and adolescents with and without ASD. The study included 70 participants with ASD and 71 typically developing controls. Executive functioning was assessed using the Behavioral Rating Inventory of Executive Functioning (BRIEF), social function was measured with the Social Responsiveness Scale (SRS), and overall autistic symptoms were evaluated using the Autism Diagnostic Observation Schedule (ADOS). The findings indicated that behavioral regulation executive process such as inhibition, shifting, and emotional control predicted social functioning in all children. In contrast, metacognitive executive processes including initiation, working memory, planning, organization, and monitoring predicted social functioning only in children with ASD. These results highlighted specific link between metacognitive executive functions and social deficits in ASD, emphasizing the need for targeted interventions that address both executive processes and associated behavioral symptoms.

Boyd et al. (2009) studied the relationship between repetitive behaviors and sensory processing issues in school-aged children with high functioning autism (HFA). Children with HFA (N = 61) were compared to healthy, typical controls (N = 64) to determine the relationship between these behavioral classes and to examine whether executive dysfunction explained any relationship between the variables. The study found that executive deficits were correlated with repetitive behaviors among the children with Autism.

South and McMahon (2007) examined how executive functioning and central coherence were related to repetitive behaviors in individuals with high-functioning autism spectrum disorder (ASD). The study found that impairments in executive functions—such as planning, cognitive flexibility, and inhibitory control—were closely linked to the intensity of repetitive and restrictive behaviors. Furthermore, difficulties in central coherence, or the ability to integrate information into a coherent whole rather than focusing on isolated details, were associated with challenges in processing contextual information. These findings indicate that the cognitive characteristics of individuals with high-functioning ASD contribute significantly to the manifestation of repetitive behaviors. This emphasizes the need to address both executive and perceptual processing abilities when developing interventions aimed at enhancing adaptive functioning and reducing maladaptive behaviors in this population.

Lopez et al. (2005) utilized the executive function theory to examine the relationship between cognitive process and the restricted, repetitive symptoms of Autistic Disorder (AD). Seventeen adults with AD were compared to 17 nonautistic controls on a new executive function battery (Delis-Kaplin Executive Function Scales). Restricted, repetitive symptoms were measured by with Autism Diagnostic Observation Schedule, Autism Diagnostic Interview-Revised, Gilliam Autism Rating Scale, and the Aberrant Behavior Checklist. The study replicated the executive function profile that has been reported in adults with Autism. In addition to the replication findings, the study found several executive processes (i.e., cognitive flexibility, working memory, and response inhibition) were highly related to the restrictive, repetitive symptoms of AD whereas, other executive process (i.e., planning and fluency) were not found to be significantly correlated with restricted, repetitive symptoms. The study also found that executive function model consists of relative strengths and the deficits were the best predictor of restricted, repetitive symptoms of autism.

Gilotty et al. (2002)examined the relationship between executive abilities and adaptive behavior in 35 children with Autism Spectrum Disorder using two parent reports of everyday functioning, the Vineland Adaptive Behavior Scales (VABS) and the Behavior Rating Inventory of Executive Function (BRIEF). The results indicated that the Initiate and Working Memory domains were negatively correlated with most domains of adaptive behavior. Also, the Communication and Socialization domains of VABS were negatively correlated with several areas of executive functioning suggesting impairments in executive abilities are strongly associated with the deficits in communication, play and social relationships in children with autism.

2.3 Effect of Cognitive Training Interventions on Symptoms of Autism

Maurya and Khan (2022) aimed to ascertain the effect of cognitive training program to improve the cognitive functioning of children with autism spectrum disorder. A total of 20 children with autism spectrum disorder were placed in this study. A quasi-experimental single subject pre-post design was used to investigate the effectiveness of the cognitive training program to improve the child's cognitive functioning. The Colored Progressive Matrices was used to measure the child's IQ, and Indian Assessment of Autism Scale was used to assess the autism level of the child. The Cognitive Skills Assessment Scale was administered to measure the pre-post assessment of the child's cognitive functioning. The cognitive training module was administered to the children. It comprised executive functioning, cognitive mental state and central coherence tasks. Total 12 sessions of the cognitive training program were provided to the children and the results showed significant improvement in executive functioning, understanding cognitive mental states, and central coherence. The results showed that cognitive skills training program positively influenced the children's cognitive functioning.

In the study done by Pasqualotto et al. (2021), he reviewed the effectiveness of randomized controlled trials or quasi-experimental studies of executive function interventions delivered to children and young people up to 23 years old with a diagnosis of ASD. A special focus was dedicated to document the effectiveness of computerized and non-computerized cognitive training on executive functions and on ASD symptomatology and social skills. Of 2601 studies retrieved, it was found that most of the interventions identified were effective in enhancing executive functions and reducing symptoms in children and young people with ASD.

Zhao et al. (2021)analyzed the effect of cognitive training based on Virtual Reality on children with autism spectrum disorder (ASD). The Autism Behavior Checklist (ABC), Childhood Autism Rating Scale (CARS) and Clancy Autism Behavior Scale (CABS) were used to assess the severity of symptoms and treatment effectiveness of cognitive training based on Virtual Reality on children with ASD. The results showed that the cognitive training based on VA was very attractive to children with ASD and it also significantly improved the typical symptoms like social communication skills, speech retardation, narrow interest and rigid behavior of children with ASD and perfected the Autism Behavior Checklist (ABC), Childhood Autism Rating Scale (CARS) and Autism Behavior Scale (CABS) during 4 weeks after treatment.

The pilot study done by Macoun et al. (2021) investigated the efficacy of a game-based cognitive training program (*Caribbean Quest*; CQ) for improving attention and executive function (EF) in school-aged children with Autism Spectrum Disorder (ASD). Twenty children diagnosed with ASD (ages 6–12 years) completed 12 hours of intervention in schools over 8–10 weeks that was facilitated by a trained Research Assistant. Pre-post testing indicated near transfer gains for visual working memory and selective attention and far transfer effects for math fluency. Exit interviews with parents and school staff indicated anecdotal gains in attention, EF, emotion-regulation, flexibility, communication, and social skills.

Chen et al. (2020) designed Comprehensive Attention Training System (CATS), and tested the effect of EF intervention for children with ASD in a small-sampled randomized controlled trial. Twenty-five children with ASD aged six to twelve were randomly assigned to either the CATS or the control training and were assessed pre- and post-training. The CATS group improved on EF as measured by the trail-making test avoiding perseverative errors and forming conceptual responses in the Wisconsin Card Sorting Task. There were also indications that CATS contributed to long-term communication skills as measured by the Vineland adaptive behavior scales.

Hajriet al. (2019) aimed to assess the effectiveness of the cognitive remediation program CRT (Cognitive Remediation Therapy) on executive abilities and school results, in children and adolescents with ASD. The CRT program was conducted individually at the rate of one session per week of 45 minutes each. Outcome measures were intellectual abilities, cognitive flexibility, working memory and school performance. The results showed that out after completion of CRT, patients showed significant improvement on intellectual abilities, phonemic fluency, animal category of semantic fluency, working memory and school results.

Rabi et al. (2019).This study was conducted to investigate the effects of cognitive training in improving executive functioning skills among children with autism. The study focused on skills in attention, working memory, transitioning, emotional regulation, abstract planning, impulse control, flexibility, and problem solving skills. This case study was conducted at National Autistic Society of Malaysia involving 10 children, age range between four to 12 years old. This study used the Cognitive Training Program which was designed for the purpose to train cognitive skills in children with autism. The data collection period was four months. Data collection methods used was observation, interviews and document analysis. The observation was conducted five times during the training session. The findings showed that this training successfully improved executive functioning skills among participants but it depends on their ability to response to the training. The overall findings showed that participants improved after executive functions training. The study also concluded that cognitive training program helped children with autism to improve executive functioning skills effectively. Research implications indicated that cognitive training program should be promoted and expand to parents, teachers, caretaker and anyone who are engaged with autistic children as an alternative intervention to be practiced systematically.

In the study done by Saniee, et al. (2019), she developed a training condition set-shifting improvement tasks (SSIT) to improve set-shifting ability and investigated the possible effects of it. A training program involving a computer game (Tatka, a puzzle game) with some home-based tasks was developed. Then, in a quasi-experimental design, the effects of SSIT tasks were studied on children with high-functioning autism. Outcome measures (pretraining, post-training and a six-week follow-up) were assessed using Modified Wisconsin Card Sorting Test, Bender-Gestalt Test and Behavioural Flexibility Rating Scale. A significant change was observed in both cognitive, behavioural difficulties, and also in repetitive behaviours.

Eack et al. (2018) took 54 verbal adult outpatients with Autism Spectrum Disorder and they were randomized to an 18-month single-blind trial of Cognitive enhancement therapy (CET), a cognitive remediation approach that integrates computer-based neurocognitive training with group-based training in social cognition, or an active enriched supportive therapy (EST) comparison focused on psychoeducation and condition management. The primary outcomes were focused on changes in neurocognition and social cognition. The results indicated that CET produced significant improvement in neurocognitive functions when compared to EST.

In a pilot study done by Sun et.al. (2017), study was designed to explore the potential benefits of a program of stimulation of executive functions (SEF) on the functional aspects of language and communication. Twenty children, aged 5–12 years, with a diagnosis of ASD participated in the study. Two stimulation programs were offered over the period of ten to twelve weeks. The findings suggested that there were differences between the children's pre- and post test performance. Significantly different performances were observed in the areas of occupation of communication space, communication interaction, and social cognition.

Miyajima et al. (2016) adopted cognitive remediation therapy using the frontal/executive program in persons with autism spectrum disorders. Frontal/executive program was administered to the intervention group for about six months. The groups were evaluated using BACS-J, WCST, and CPT for cognitive assessment; SCoRS-J, GAF, and LASMI for social functioning; and GSE for self-efficacy. The results showed that both the groups had lower scores for cognitive functioning than normal individuals at baseline. After completion of frontal/executive program, the intervention group showed improved performance on BACS-J for overall score, digit sequencing, verbal fluency, and Tower of London tasks. Improvements were also seen on SCoRS-J and LASMI scales of social functioning. The study concluded that frontal/executive program is effective in improving impaired executive functioning in autism spectrum disorder patients and may also lead to improvements in some aspects of social functioning.

Hajri et al. (2016) study investigated whether cognitive remediation therapyimproves cognitive function and, in turn school performance in children with autism spectrum disorder. Children meeting the Diagnostic and Statistical Manual for Mental Disorders (DSM-5) criteria for autism spectrum disorderfollowing a regular school curriculum were recruited and individual cognitive remediation therapy was delivered over a period of six months with one session per week. The main outcome measures were intellectual abilities, cognitive flexibility, working memory, clinical symptoms and school results. The children showed significant improvement on intellectual abilities, phonemic fluency, animal category of semantic fluency, working memory, clinical symptoms and school results.

In the study done by Kenworthy et al. (2013), he used the Unstuck and On Target (UOT) an executive function (EF) intervention for children with autism spectrum disorders (ASD) targeting insistence on sameness, flexibility, goal-setting, and planning. To evaluate the effectiveness of UOT compared with a social skills intervention (SS), 3rd-5th graders with ASD received interventions delivered by school staff in small group sessions. Measures of pre-post change included classroom observations, parent/teacher report, and direct child measures of problem-solving, EF, and social skills. Children in both groups improved with intervention, but mean change scores from pre- to post intervention indicated significantly greater improvements for UOT than SS groups in problem-solving, flexibility, and planning/organizing. Also, classroom observations revealed that participants in UOT made greater improvements than SS participants in their ability to follow rules, make transitions, and be flexible. Children in both groups made equivalent improvements in social skills. The study concluded that the study supported the effectiveness of the EF intervention for children with ASD.

Hence, all the review of literature highlights that children with Autism Spectrum Disorder (ASD) frequently experience deficits in executive functions, which significantly affect their cognitive, academic, behavior regulation, and social development. These studies also explained how executive functioning is related to various aspects of autism symptoms and the extent to which these functions influence symptom severity. These deficits underscore the need for targeted interventions to support adaptive functioning and enhance overall quality of life. Cognitive training represents as a promising approach, with evidence suggesting its potential to improve specific executive function domains such as working memory, inhibitory control, planning and cognitive flexibility.

However, the literature also reveals several gaps and inconsistencies, including variability in intervention protocols, outcome measures, and study designs. The heterogeneity of ASD further complicates the generalizability of findings. Despite these challenges, existing research provides a strong theoretical and empirical foundation for exploring cognitive training as an intervention for children with ASD.

In summary, this chapter establishes the importance of investigating the effect of cognitive training on executive functions in this population. It identifies the need for systematically designed studies that can clarify which cognitive training approaches are most effective for children with autism. This review, therefore, provides a clear rationale for the present study, guiding its design and emphasizing its potential contribution to both research and clinical practice.

CHAPTER-III

STATEMENT OF THE PROBLEM

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by persistent deficits in social communication and interaction, as well as restricted, repetitive patterns of behavior, interests, or activities. Children with ASD often exhibit impairments in higher-level cognitive functions such as executive functions (EFs), which includes working memory, cognitive flexibility, planning, and inhibition which are essential for goal-directed behavior. Researches consistently demonstrate that deficits in EF can significantly impact the academic performance, social adaptability, and daily living skills of children with ASD. Deficits in EF are not only prevalent, but are also highly associated with the severity of ASD symptoms such as their skills to initiate conversation with others, reciprocate appropriately in social situations and exhibiting appropriate emotional responses. The EF deficits are found to be related to their behavioral problems such as poor attention and being restless. The stereotyped pattern of behavior among children with ASD is associated with EF functions such as poor cognitive flexibility and working memory. Hence, exploring the impairment in executive functions is more recommended.

Evidence suggests that cognitive interventions can positively influence both behavioral outcomes and core symptomatology. Therefore, targeting executive functioning through structured, evidence-based cognitive interventions has become an essential area of focus. Among various approaches, the cognitive training method encompassing diverse intervention techniques are particularly promising in enhancing behavior, symptom management, and socio-adaptive functioning. However, studies investigating cognitive training in individuals with ASD are still scarce within the Indian context.

. The existing traditional behavioral interventions may not sufficiently address the underlying cognitive deficits that contribute to these behaviours and hence incorporating cognitive interventions along with behavioral approaches provides a more comprehensive framework for intervention. Although there is growing literature on EF training in typically developing children and children with ADHD, relatively few studies have focused on cognitive training as a standalone or adjunct intervention for ASD. All theses evidences points towards the need to explore and validate cognitive training as a method to enhance executive functions in children with ASD, as, addressing EF deficits may have futuristic implications for the child's learning, behavior, and quality of life.

Moreover, the limited existing studies often vary in methodology, training content, duration, and outcome measures, making it difficult to draw firm conclusions. Recognizing this gap, the present study was designed to examine the implications of neurocognitive interventions as an effective means of supporting children with ASD. This study might contribute to the existing literature focusing on cognitive interventions for neurodevelopmental disorders and might expand the scope of implementing cognitive based interventions in the rehabilitation process of children with ASD. . There is thus a need to evaluate structured cognitive training programs specifically tailored to the executive functioning profiles of children with ASD.

From a policy standpoint, it supports the development of inclusive educational practices and the prioritization of early, evidence-based cognitive support within therapeutic settings. If proven effective, cognitive training interventions can be integrated into school curriculum, clinical therapy sessions, and home-based programs, fostering a holistic support system for children with ASD. Moreover, cognitive training studies in individuals with ASD are very limited in Indian settings and hence studying the implication of neurocognitive interventions which is increasingly gaining importance would be more helpful and appropriate to help the children with ASD and with this understanding, present study has been planned by the researcher.

Aim

The present study aimed to investigate the effect of cognitive training on Executive Functions among children with Autism.

Objectives of the Study

- To assess the executive functions of children with Autism.

- To examine the effect of cognitive training on executive functions of children with autism.
- To examine the effect of cognitive training on symptoms of Autism.

Hypotheses

1. There will be significant impairment in executive functions in children with Autism.
2. Cognitive training will significantly improve the executive functions (attention and cognitive flexibility, working memory, inhibition, and planning ability) in children with Autism.
3. Cognitive training will significantly reduce the symptoms of Autism.

CHAPTER-IV

METHODS AND PROCEDURES

The study participants were selected from National Institute for Empowerment of Persons with Multiple Disabilities (NIEPMD), Chennai, Tamil Nadu, India. The present study was carried out on 40 children aged between 12 to 16 years both male and female (*UNICEF (n.d.)* Convention on the Rights of the Child. *https://www.unicef.org/child-rights-convention)* already diagnosed with Autism Spectrum Disorder (ASD) by the qualified mental health professional either Clinical Psychologist or Psychiatrist. The participants were selected who are attending Out Patient Services from NIEPMD. The participants were selected based on the inclusion and exclusion criteria. After the procedure was clearly explained and informed consent was obtained, they were alternatively assigned to two equal groups, namely, Intervention group and Control group.

Inclusion criteria for participants

- Children diagnosed with Autism as per ICD-11.
- Children having mild symptoms severity as per Indian Scale for Assessment of Autism.
- Children of both male and female gender aged between 12 to 16 years.
- Children obtaining below average, average, and above average intellectual functioning in SPM.
- Children who can comprehend and speak Tamil or English language.

Exclusion Criteria for participants

- Children having moderate to severe level of Autism symptoms as per Indian Scale for Assessment of Autism.
- Children falling in the category of 'intellectual impairment' in SPM.
- Children having any other comorbid neurological disorders/ psychiatric disorders.
- Children with any major medical disorder.
- Children having any other co-morbid physical disability.

- Children who are already attending any mode of cognitive interventions.

Design of the study

Pre Post Control Design

Psychological Tools: The following tools were used in this study:

1. Socio-demographic sheet

A specially designed data sheet was used to collect information on various socio-demographic and clinical variables like age of the child, gender, education, socioeconomic status, parent's age, type of family, history of any other medical illness, history of any other psychological disorders, and details of any other therapies undertaking.

2. Standard Progressive Matrices (SPM) (Raven, 1938)

SPM was originally developed in mid 1930's by Raven and it was revised and standardized in Ipswich in 1938. It was designed for use in homes, schools, and workplaces as well as in laboratories. The correlations between item difficulties for different ethnic groups ranged from .97 to .99 in British standardization. Majority of the split-half internal consistency coefficients in the literature exceeded .90. SPM was designed to cover the widest possible range of mental ability and to be equally useful with all persons of all ages, education, nationality or physical condition. Calvert and Waterfall reported retest reliabilities from .83 to .93. The tool was used to assess the intellectual capacity of children with autism since it is easy to administer and it is a nonverbal test.

3. Indian Scale for Assessment of Autism (ISAA) (Ministry of Social Justice and Empowerment, 2008)

This tool was used to assess the severity of autism. As there was no Indian scale to diagnose or measure autism, the National Institute for Mentally Handicapped (NIMH) developed the Indian Scale for Assessment of Autism (ISAA) for diagnosing and measuring the severity of autism in 2009. This scale was based on CARS and has 40 items divided under six domains – social relationship and reciprocity; emotional responsiveness; speech, language and communication; behavior patterns; sensory aspects and cognitive component. The items are rated from 1 to 5, increasing score indicating increasing severity of the problem. A score of <70 indicates no autism, 70-106 (mild autism), 107-153 (moderate autism), and >153 (severe autism). It takes about 15 to 20 minutes for administration of ISAA. The ISAA was devised with the aim of quantifying the severity of autistic symptoms so as to enable measurement of associated disability. ISAA had a sensitivity 93.3, specificity of 97.4, positive and negative likelihood ratios 85.7 and 98.7 and positive and negative predictive values of 35.5 and 0.08, respectively. Reliability was good with validity in sub-optimal range. (r low, in 4/6 domains).

4. Tests for focused attention and cognitive flexibility

Color Trail Test (D'Elia et al., 1996) was developed by WHO and it is test which is free from language and cultural barriers. It has been used to assess focused attention and cognitive flexibility. It also measures cognitive tracking. It has two parts Part A and Part B. The Part A contains circles in two colors namely yellow and pink. The subject is required to serially connect the numbers from 1 to 25 which is randomly placed irrespective of the colors. In Part B, the numbers from 1 to 25 has to be serially connected between two colors yellow and pink. Time taken to complete the task for both trails and errors of both omissions and commissions were recorded. The test contains test-retest reliability of color trails test is reported as .64 for Trail A and .78 for Trail B.

5. Tests for Response inhibition

The Stroop Color-Word Test (Stroop, 1935)-"The Stroop effect" was first described in 1935 by John Ridley Stroop (Stroop, J. R. (1935). Response inhibition measures the perceptual set which can be shifted to conjoin demands by suppressing habitual response in favour of unusual one. The brain area involved in response inhibition is prefrontal cortex. The Stroop test contains color names "Blue", "Green", "Red", and "Yellow" printed in a paper. The subject is asked to read the stimuli column-wise as fast as possible. The time taken to read all the columns is noted down. Then, the subject will be asked to name the color in which the color is printed instead of reading the colors, where the subject is required to inhibit the response. The time taken to name all the colors is noted down. The reading time was subtracted from the naming time to get the Stroop score to assess their performance.

6. Working Memory

Wechsler Intelligence Scale for Children (WISC-IV) constructed by Wechsler. D. (2003) is a test used for assessing cognitive functions in children aged 6–16 years. It is a test used to measure academic potential test in children. WISC-IV consists of 15 subtests, of which 10 are core subtests. It consists of four indices namely Verbal comprehension index, Perceptual Reasoning Index, Working Memory Index and Processing Speed Index. WMI consists of verbal Working Memory tasks (Digit Span and Letter-Number Sequencing) and it was used to measure working memory. Working memory is one of the cognitive domains under executive function and it is an ability to hold information and perform tasks with it. It is essential for comprehension, learning, and reasoning ability. In the Digit span task, the subject is required to repeat the digits in forward and backward given. It consists of two trails and if both the trails are failed, the task is discontinued. It contains the other task, Letter Number Sequencing, in which the subject is given series of numbers and alphabets in random order and the subject is required to sequence both the letter and numbers in order. This requires holding information and manipulating to produce the current sequence of numbers and alphabets given. The total number of correct responses given is considered for scoring.

7. Planning

Porteus Maze Test (Porteus, 1965) –This test used in Malins Intelligence Scale for Children (MISIC) developed by Dr. Arthur J. Malin (1949) which is the subtest of performance scale was administered to assess the planning ability of the child. Porteus Maze test is a measure of planning ability and foresight. The test requires the subject to trace through the maze and reach the end point. The test has 10 mazes of which two were for ages 5 years to 9 years old , four copies for 12 years and 14 years as well as the adult maze. The children version consists of 12 different mazes in which the difficulty increases for each age level from 3 years to 12 years, 14 years, and for adult maze. The child is allowed two trails from 5 years to 9 years of age and four trails for 12 years, 14 years old and for the adult maze. The test is discontinued when the child makes errors on all trails and also if fails in three successive ages. This is not a timed test and the child is required to trace the maze from the starting point to the goal without entering the blinding and not lifting the hand. At each of these mazes completed, success in the first trial gets an addition of one year while success in the second year, addition of half year is credited to the basal age of 4 years.

Cognitive Training Module

The cognitive training module has been used to improve the executive functions of the children in the intervention group. The module includes certain tasks aimed to increase the efficiency of cognitive functions such as attention and cognitive flexibility, inhibition, working memory, and planning ability. The task, which aimed to improve attention and cognitive flexibility, included a colour cancellation and numbers joining task. For inhibition, coloring within the designs and Go-no-task which involves inhibiting automatic response and executing the other task was used. The tasks which focuses on working memory includes task of memorizing pictures from the board and memorizing the sequence of tokens. Mazes of different complex level were used for planning ability. The modules were delivered for two sessions per week for the period of six months. The module comprises of nonverbal and paper pencil tasks which are more feasible and friendly for children with Autism.

1. **Attention and Cognitive Flexibility**– Targeted with cancelling specific target colored squares and joining numbers which is randomly placed.

a. Color Cancellation **(*Hegde et al., 2012*)-**Color cancellation test is a measure of sustained attention which is used in the NIMHANS Neuropsychological Battery (Kapur, 1974). For training purpose, A4 sheet with different colored squares were provided and the participants were asked to strike out the squares of any two colors. The tasks contain three levels of difficulty. The level 1 contains less number of colored squares namely the four colors red, yellow, purple, blue and green and the subject is given target of the two colors. The time taken as well as number of omissions and commissions while doing the task is calculated. When there is adequate performance i.e., if the child is able to complete the task with improvement in means of time and number of errors, the child is then given three colors and then four colors as target to increase the complexity. If there is significant improvement in continuous two sessions, the level of task is increased to increase the complexity. The Level 2 task comprises of printed colored squares which is more in number compared to Leve1 1. The Level 2 comprises three sessions and one level is progressed to another level when there is significant improvement in the primary level in means of time taken and number of errors. The complexity of the level is increased by increasing number of colors as targets. Similarly, the level is increased to Level 3, which comprises more number of colored squares printed compared to the other two levels. The target colors were increased to increase complexity of the task and each level was continued for three sessions.

b. Number connection (Hegde et al., 2012)-The task involves serially connecting numbers randomly placed on sheet. The time taken to complete the performance was noted. The decrease in amount of time taken to complete the task is considered as the prognosis of the task. The difficulty of the level was increased by increasing the sequence of numbers to be connected. It comprises three levels of difficulty. The Level 1 comprises of 1 to 10 in number which is randomly placed and the subject has to connect the numbers in sequence for which the time taken is accounted. If there is significant reduction in time taken, the complexity is increased to Level 2 which comprises of number 1 to 15, which is randomly placed and the Level 3 comprises of numbers from 1 to 50 in number which is randomly placed. Each level will be given for minimum of three sessions.

2. Working Memory-Targeted with Memorizing pictures and sequence of colored tokens (Sun et al., 2017)

a. Memorizing Pictures-The working memory task was administered in which the participants were first shown a set of picture cards, which is presented for 5 seconds and then was instructed to memorize them. After a brief interval, a second set of pictures was presented, and participants were asked to identify the images that had appeared in the initial set. To increase the complexity, the number of pictures presented was increased. The different pictures which comprises of different objects were presented before the subject. In Level 1, four pictures which comprises different objects were presented to the child for about five seconds and subsequently, one intruder picture was presented along with the initially presented pictures and the child has to recognize the correct pictures presented. In the Level 2, the number of pictures presented increased to seven in number and three target pictures were introduced as intruders. The Level 3 comprises of 10 and the 5 pictures were set as intruders and the subject has to correctly recognize the first displayed pictures. The errors in means of omissions and commissions were accounted. Pictures not been recognized and recognizing the picture which has not been presented are considered as errors. If the number of errors occurred significantly decreases, the complexity of the task will be increased from one level to the other.

b. Memorizing sequences of colored tokens (Sun et al., 2017).To increase the complexity, the number of colored tokens presented was increased. The subject is shown sequence of colored tokens from four colors to eight colors. In level 1, the subject is shown four different colored tokens in sequence for e.g., red, green, blue, and yellow. The sequence is displayed for five seconds and then the subject is asked to reproduce the same sequence produced. The errors were noted during the task. If there are no errors in consecutive two sessions, the complexity of the task is increased to level 2 where the subject is shown five colors in sequence and then the level 3, the sequence is increased to seven colors. Total number of minimum six sessions was required for the training.

3. Inhibition-Targeted with coloring the presented shapes and Go-No-Go task

a. Design Coloring (Hegde et al., 2012). The task involved coloring a design using color pencils. The evenness in pressure on the strokes and strokes not crossing the borderline of the design were emphasized. The participants were asked to color within the different shapes given in the A4 sheet. The complexity was increased by increasing the number and types of shapes used in the sheet. The level 1 comprises of single shape i.e., the circle, square or triangle, of eighteen rows. The subject is asked to color the shapes within the border and the time taken for completing the task is calculated. The prompts given during the tasks were also noted down. The level is given for minimum of three sessions and if there is significant improvement in the time taken to complete the tasks for consecutive two sessions, then the complexity of the task will be switched over. The Level 2 comprises of three shapes which comprises of four columns. The subject is asked to color the shapes and time taken to complete the task was noted down. If there is significant improvement in time taken for consecutive two sessions, then the complexity level was increased to Level 3. The level 3 comprises of six columns of shapes, the circle, square, and the triangle. The number of shapes to be colored was significantly higher in the level 3 and the time taken for coloring the shapes was noted down to note down the improvement. Each level was conducted for minimum three sessions and hence total number of nine sessions taken was nine.

b. Go-No Go task- The Go/No-Go task requires an individual to withhold a response entirely as opposed to generating an alternate response (Drewe, 1975). The child has to clap the hands when red color is presented and not to clap the hands when blue color is presented. To increase the complexity the number of target colors and sequence were increased. The task involves three levels in complexity. The child is given two target colors to execute a task. The errors were noted in means of commissions and omissions. If the child executes the task for wrong color instead of the target color is considered, and if the child did not execute the task for the given color, is also considered error. The number of errors while doing the tasks denotes the level of performance of the task. If the child shows improvement in the given task, then it is increased to the next level where the number of number of color is three in number and the child has to execute three different tasks for three different colors. For e.g.,If blue color is presented, the child has to clap once, for red color the child has to clap twice, and for the yellow color, the child does not have to clap the hand. The errors were calculated similarly as the previous task and if the number of errors is significantly reduced, the task is switched to level 3 which comprises of four colours and four different tasks. For e.g., Blue color, has to clap once, for red color has to clap twice, green color three claps, and for yellow color, need not clap the hands. Total number of minimal sessions taken was six sessions.

4. Planning

Maze completion task (Hegde et al., 2012)- Mazes of different complex levels were used for training purpose to increase the efficiency of planning ability (Porteus, 1995). This task also helps the child to have better visual tracking and patience as well. Beginning with the start point, the child has to trace the way in the maze without tracing into a blind alley. Different complex level of mazes was used for cognitive training from fewer grids to more number of grids in mazes. The size of the maze also varies depending upon the complexity. The level 1 mazes' width is smaller in size and has fewer grids to reach the target. The level 2 and level 3 have more number of grids and more paths to be traced. Time taken and errors occurred such as crossing the blind alley and not finding the path correctly were noted down. Different types of mazes were used for each session. When there is significant improvement in the performance in means of time taken and reduction of errors, the complexity of the levels were increased. This tasks involved minimum of five sessions in total.

Procedure

The present study involved use of cognitive restructuring module on children with ASD with an aim to see the effectiveness of cognitive training on various executive functions and symptoms of children with autism. The ethics clearance for this work was obtained from the Mizoram University Human Ethics Committee (MZUHEC). The study was conducted in to two phases, the Pilot and the Main phase.

Pilot Phase

A small pilot study was conducted to see the feasibility and applicability of the training module. Five children aged between 12-16 years and diagnosed with ASD by qualified mental health professional, were selected for the pilot phase of the study. After obtaining the informed consent from the parents of children with ASD, baseline functioning of the executive functions and symptoms severity of each domain were assessed with ISAA. The planned cognitive intervention module was given for the selected samples at a frequency of 2-3 sessions per week with session duration of 45 minutes. Henceforth, 20 sessions were carried out, spanning for a period of two months. During the pilot phase, it was observed that children were facing problems in the 'rapid naming sequence of colors task', and hence this task, which was kept in the training module earlier, was changed to 'Go-No-Task', as this task does not require any verbal response and only inhibition of motor response is involved. This change has been made since it was found that the children are more comfortable in inhibiting the motor response rather than naming certain responses which is required in Rapid Naming Sequence of colors. Moreover, it was more effective for them as children with Autism may also have limitation in verbal expression. Apart from this, all other tasks which were kept in the original training module were found to be applicable on the children with ASD in addition to the ease of imparting instructions. Thus, the pilot phase has helped the researcher to finalize the different tasks in the training module.

Main Phase

After the pilot phase was completed, the recruitment of the samples for the main study was started. Sample was selected from National Institute for Empowerment of Persons with Multiple Disabilities, Chennai who are attending services at outpatient department. The Rehabilitation professionals on duty at the OPD of the NIEPMD, Chennai, Tamil Nadu, were approached and briefed about the purpose of study and criteria for sample inclusion and were requested for referrals who match the inclusion criteria. As and when the sample was referred to the researcher, the diagnosis of ASD was corroborated using clinical interview. After this, the guardians of the child were briefed about the study and they were asked to sign the informed consent. After the informed consent is obtained, the participants were screened on ISAA and SPM, to assess the symptoms severity of autism and to assess the level of intellectual functioning respectively. Only those Children who obtained average, below average, and above average intelligence on SPM and who have mild severity of autism features were finally enrolled for the study. In this manner a total of 40 participants with ASD were selected and were assigned to two groups, namely the ‘Intervention group’ and the ‘Control group’ having equal number of participants (n=20 each), in an alternatively manner such as the first participant was included in the ‘Intervention group’ and the available second participant was assigned to the ‘Control group’. Neuropsychological Assessments was done for executive functions at the Baseline (Pre training) level for all participants of both groups, using Color Trail Test, Stroop Test, WISC-IV Letter Number Sequencing, Digit Span, and Porteus Maze Test. After the baseline assessment of executive functions level, all the participants of the ‘Intervention group’ were administered the Training module. The training involved 60 sessions which was given for a period of six months at a frequency of two sessions per week, with session duration of about 45-60 minutes. However, no training sessions were demonstrated to the participants of the Control group and they were kept in waiting before the second assessment. The brief outline of the training sessions has been presented below:

Cognitive functions	Activity Given	No of sessions
Attention and Cognitive Flexibility	Color Cancellation a. Level 1 (3 sessions) b. level 2(3 sessions) c. Level 3(3 sessions) Numbers joining	18 sessions

	a. Level 1(3 sessions) **b.** Level 2(3 sessions) **c.** Level 3(3 sessions)	
Working Memory	Memorizing pictures from board a. Level 1 (2 sessions) b. Level 2 (2 sessions) c. Level 3 (2 sessions) Memorizing sequence of colored tokens a. Level 1 (2 sessions) b. Level 2(2 sessions) c. Level 3 (2 sessions)	12 sessions
Inhibition	Coloring within shapes a. Level 1 (3 sessions) b. Level 2(3 sessions) c. Level 3(3 sessions) Go-No Go task a. Level 1 (2 sessions) b. Level 2 (2 sessions) c. Level 3 (2 sessions)	15 sessions
Planning	Maze activity	15 sessions
Total Number of sessions		60 sessions

Session Plan of a Typical Session

The session was initiated after rapport building with the participant and acquiring adequate cooperativeness from the child. The participants were given the tasks and their baseline performance was noted, basically the time taken to complete the task and number of errors committed during the task. Each session was carried out for 45 minutes. The complexity of the task was only increased after continued improvement in performance of the task in means of number of errors and time taken reduces for consecutively two sessions. The session was ended with appreciation from the therapist for their efforts. Secondary reinforcements like giving them tokens were also used for children depending upon their cooperativeness level. The cognitive interventions were carried out as planned for the period of six months. Post assessment of the executive functions and symptoms of Autism was assessed after the intervention period for both the groups. For the participants in the intervention group, debriefing was conducted about the results and feedback were collected from the participants and further follow up sessions were planned on weekly once basis for the participants who needed further interventions. The participants in the waitlist group would be implemented similar interventions for the period of two months, which were implemented in the experimental group.

Statistical Analysis

The data collected were statistically analyzed using SPSS 20. Descriptive analysis was done and the normality of the sample was found using Kolmogorov-Smirnov Test which revealed that distribution of the samples were not normally distributed and hence nonparametric tests were used for further assessment. The significant difference between the two groups based on socio-demographic characteristics such as age was tested using Mann-Whitney U Test and other categorical variables such as gender, family type, and level of intellectual functioning was tested using Chi-Square test. The significant difference between baseline assessment and post training assessment of the intervention group and control group was used using Mann-Whitney U Test. Pre and post training comparison of intervention group and control group was assessed using Wilcoxon Signed-Ranks Test.

This chapter presents the results of the study examining the effect of cognitive training on executive functions among children with Autism Spectrum Disorder (ASD). The purpose of this chapter is to report the findings derived from the data analysis in relation to the research objectives and hypotheses formulated in the previous chapters.

The results are organized systematically to provide a clear understanding of both descriptive and inferential statistics used in the study. Descriptive statistics summarize the demographic and baseline characteristics of the participants which includes their age, gender, family type, and level of intellectual functioning of both groups offering an overview of the sample distribution. Inferential statistics are then presented to examine the impact of cognitive training on specific domains of executive functioning, including, attention and cognitive flexibility, working memory, inhibitory control, and planning ability.

1) Sample Characteristics:

Table 1.1: Comparison between the participants of Intervention Group and Control Group based on Age

Group Variable	Intervention Group (N=20)		Control Group (N=20)		Mann-Whitney U Test Mean Rank		U	Z
	M	SD	M	SD	Intervention Group	Control Group		
Age (Years)	12.55	2.06	12.10	2.15	21.98	19.03	229.50	0.429

Table 1.1 shows that the Mean Age is 12.55± 2.06 for the participants of Intervention group and 12.10±2.15 for the participants of Control group. The Table further indicates that both compared groups do not differ significantly on ‘Age’.

Figure 1

Distribution of samples of Intervention group based on Age.

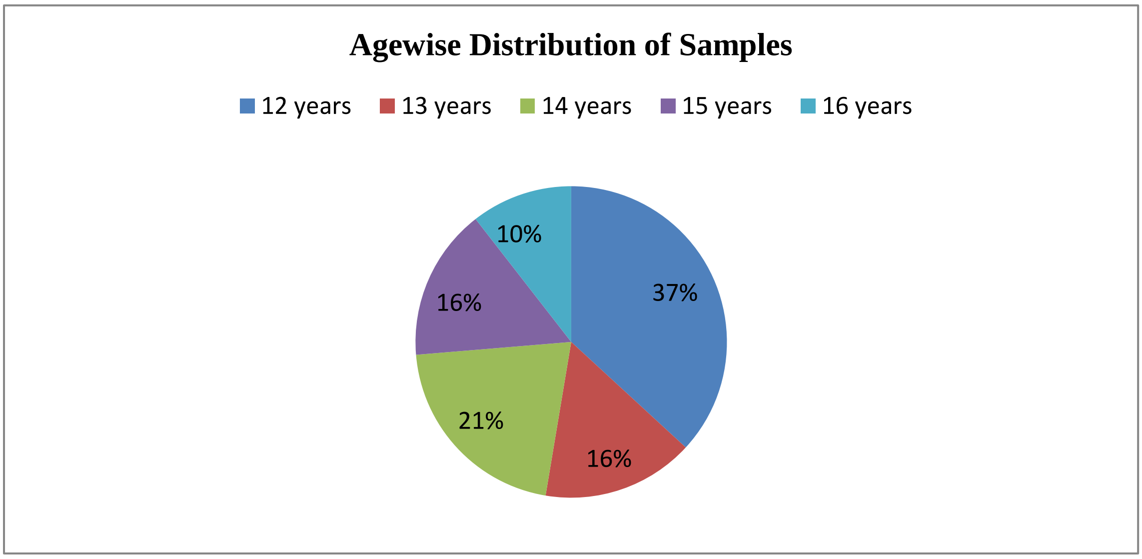


Figure 2

Distribution of samples of control group based on Age,

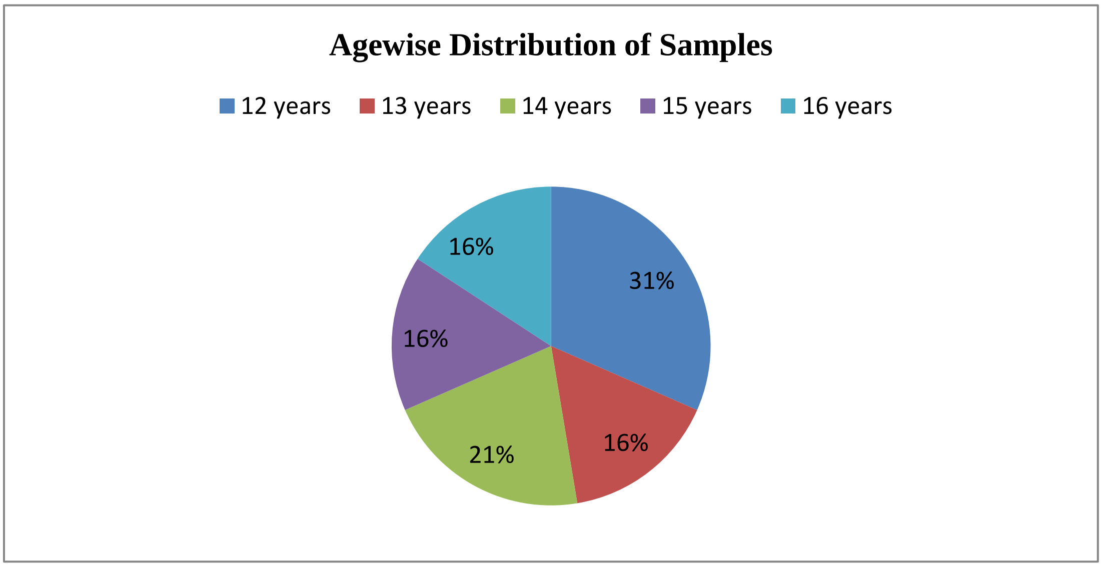


Table 1.2: Comparison between participants of Intervention and Control Group based on Gender.

Group		Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
		Frequency/ Percentage	Frequency/ Percentage	
Variable				
Gender	Male	17(85)	18 (90)	0.63
	Female	3(15)	2(10)	

The data in Table 1.2 exhibits comparison in terms of Gender and level of intellectual functioning between participants of Intervention and Control Group. The data presented in the table depicts that in terms of Gender, 85% of the participants were male and 15% were female in Intervention group as compared to 90% male and 10% female participants in the control group. The data shows that both the compared groups did not significantly differ in means of ‘Gender’.

Figure 3

Distribution of Intervention Group samples based on Gender.

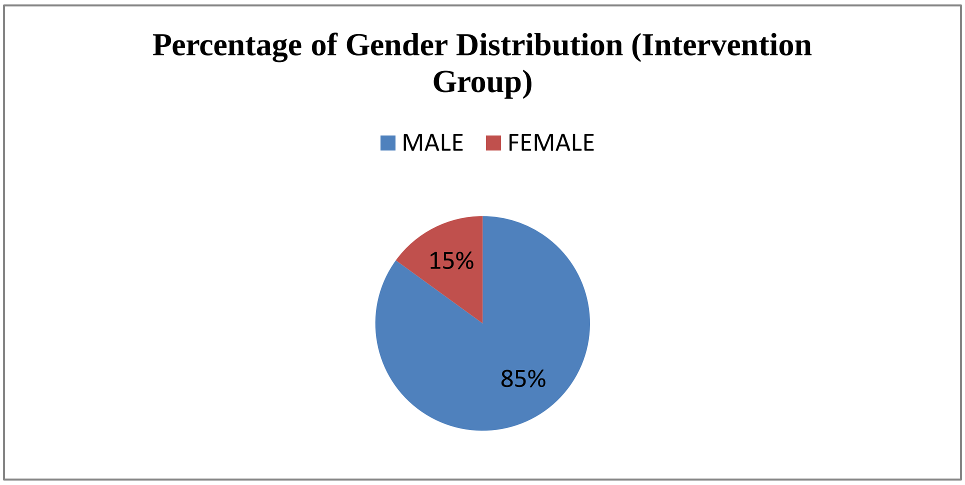


Figure 4

Distribution of Control Group samples based on Gender.

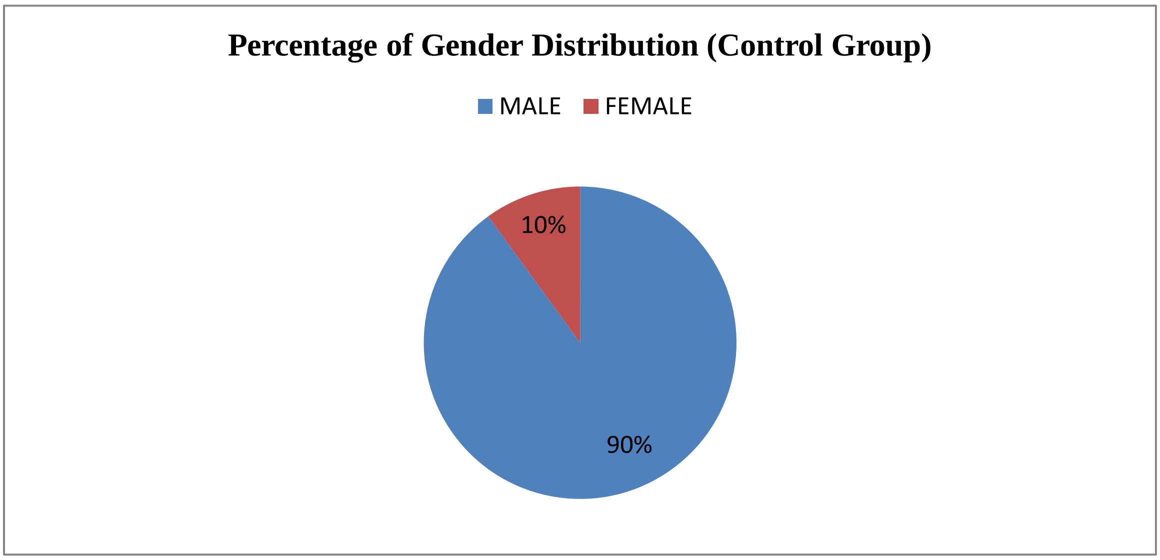


***Table 1.4: Comparison between the participants of Intervention and Control Group based on Level of Intellectual Functioning*.**

Group		Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
		Frequency/ Percentage	Frequency/ Percentage	
Variable				
Level of Intellectual Functioning	Above Average	0 (0)	1 (5)	0.484
	Average	13 (65)	11 (55)	
	Below Average	7 (35)	8 (40)	

The data in Table 1.4 exhibits comparison in terms of level of intellectual functioning between participants of Intervention and Control Group. The data presented in the table depicts that 65% of the participants in the intervention group were having average level of intellectual functioning and 35% were having below average level intellectual functioning. However, in the control group, 55% of the participants had average level of intellectual functioning and only 40% of them had below average and 5% were having above average level of intellectual functioning. The data shows that both the compared groups did not significantly differ in means of ‘Level of intellectual Functioning’.

Figure 5

Distribution of Intervention Group based on Level of Intellectual Functioning.

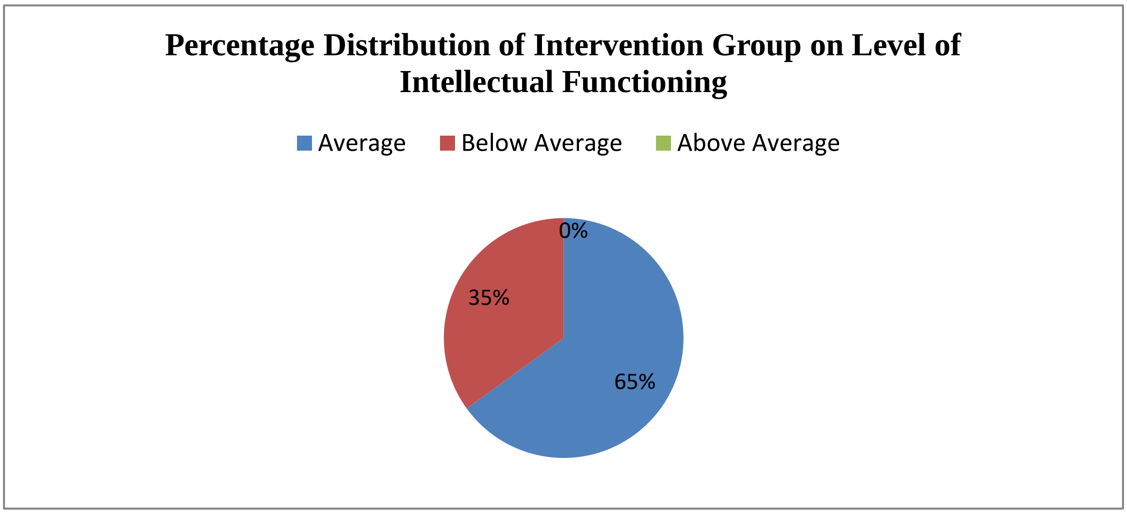


Figure 6

Distribution of Control Group based on Level of Intellectual Functioning

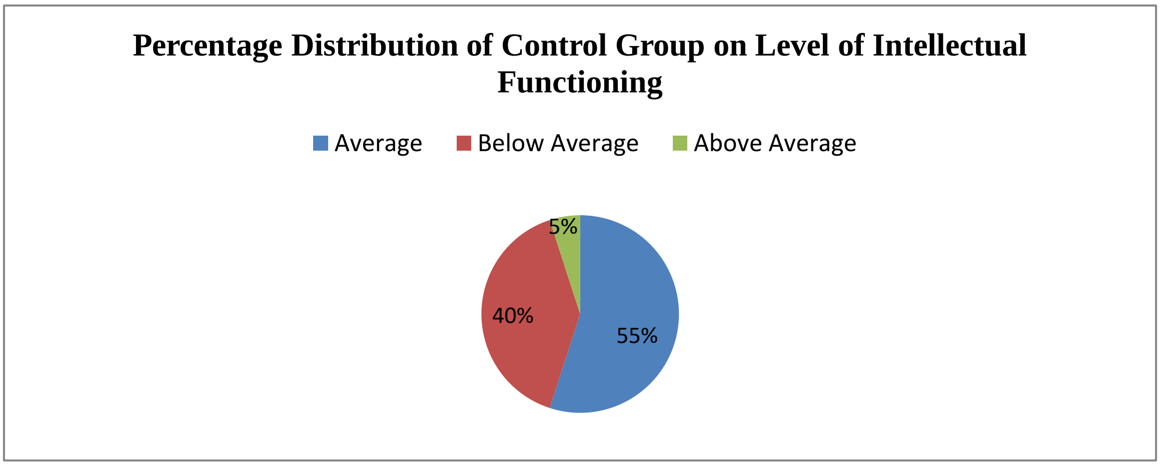


Table-1.5: Comparison between participants of Intervention and Control Group based on Family type.

Group		Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
		Frequency/ Percentage	Frequency/ Percentage	
Family Type				
	Nuclear	14 (70)	16 (80)	0.465
	Joint	6(30)	4 (20)	

The data in Table 1.5 exhibits comparison in terms of types of family between participants of Intervention and Control Group. The data presented in the table depicts that 70% of the participants in the intervention group belonged to nuclear family type and 30% of them belonged to joint family type. However, in the control group, 80% of the participants belonged to Nuclear family type and 20% of the participants belonged to Joint Family type. The data shows that both the compared groups did not significantly differ in means of “Family type”.

Figure 7

Distribution of Intervention Group based on Family Type

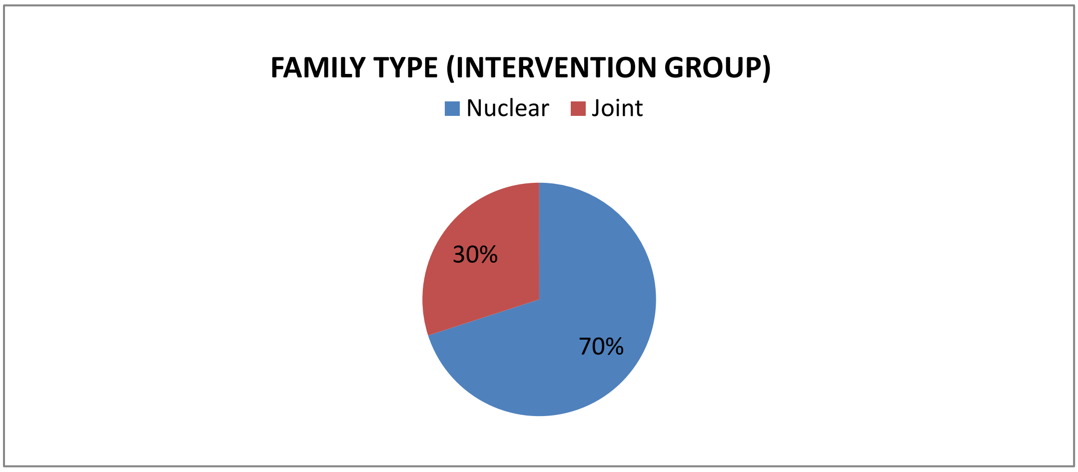
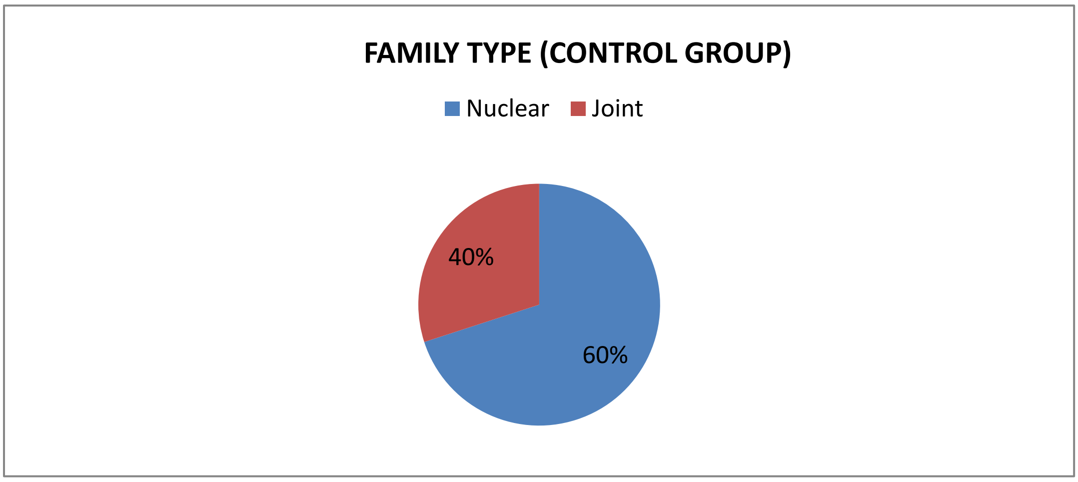


Figure 8

Distribution of Control Group based on Family Type



2) Baseline Comparison between Participants of Intervention and Control Group on ISAA Domains and Executive Functions.

Table 2.1: Baseline Comparison between Intervention and Control Group Participants on Various Domains of ISAA.

ISAA Domains	Intervention Group		Control Group		Mann-Whitney U Test				
	Pre-Test		Pre-Test		Mean Rank		U	Z	*p*
	Mean	SD	Mean	SD	Intervention Group	Control Group			
Social relationship & Reciprocity	22.8	4.41	21.20	3.38	22.53	18.48	240.5	1.099	.277
Emotional Responsiveness	11.8	2.11	9.70	2.18	25.88	15.13	307.5	2.933	<.01
Speech Language & Communication	17.9	3.55	17.45	4.10	21.35	19.65	217.0	0.462	.659
Behavior Patterns	13.10	1.92	12.35	3.70	21.05	19.95	211.0	0.299	.779
Sensory aspects	8.80	1.91	9.25	1.48	17.98	23.03	149.5	1.400	.174

Cognitive Component	9.40	2.19	8.40	2.21	22.43	18.58	116.5	1.056	.301

Note **p value significant at .01 level

Table 2.1 presents the comparison of baseline ISAA domain scores between the intervention and control groups using the Mann–Whitney U test. The results indicate that the two groups did not differ significantly on most ISAA domains, including Social Relationship & Reciprocity (*z*= 1.099, *p* =.277), Speech, Language & Communication (z=0.462, *p* =.659), Behavior Patterns (*z*=0.299, *p*= .779), Sensory Aspects (*z*=–1.400, *p*= .174), and Cognitive Component (*z*= 1.056, *p*=.301). But, there was significant difference noted between Intervention Group and Control Group in the domain of Emotional Responsiveness (*z*= 2.933, *p*<.01) respectively.

Figure 9

Comparison on mean value of ISAA symptoms of both Intervention and Control Group

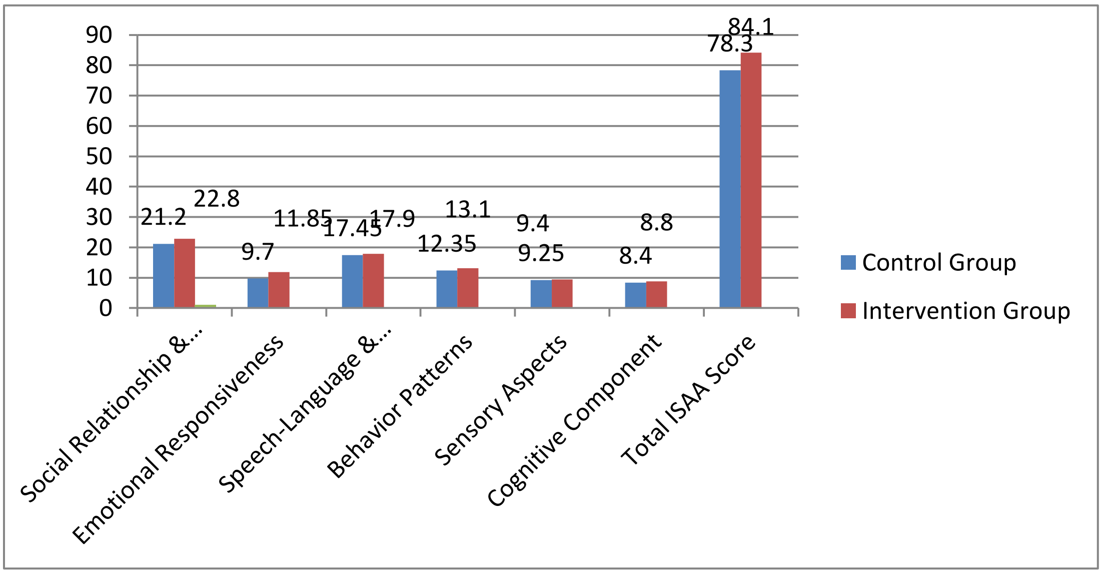


Table 2.2: Baseline Comparison between Intervention and Control Group Participants based on Executive Functions.

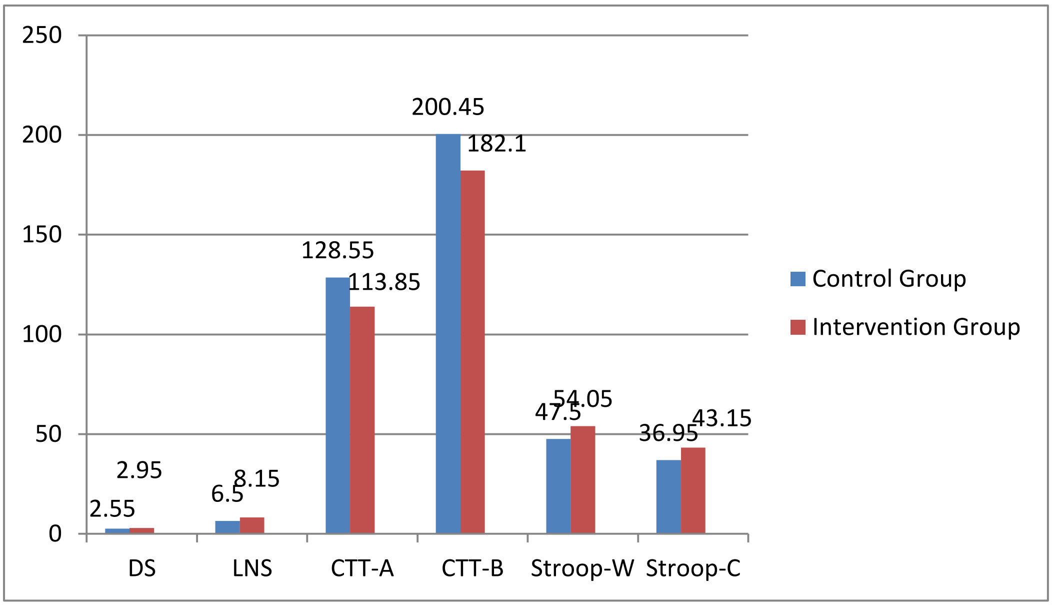
Executive Functions	Intervention Group		Control Group		Mann-Whitney U Test				
	Pre-Test		Pre-Test		Mean Rank		U	Z	*p*
	Mean	SD	Mean	SD	Intervention Group	Control Group			
DS	2.95	2.28	2.55	1.67	21.03	19.98	189.50	0.293	.779
LNS	8.15	5.82	6.50	7.19	22.20	18.80	166.00	0.941	.369
CTT-A	113.85	48.58	128.55	74.13	19.70	21.30	184.00	0.433	.678
CTT-B	182.1	64.68	200.4	88.3	18.85	22.15	167.00	0.893	.383
Stroop-W	50.30	16.84	47.50	23.6	21.33	19.68	216.50	0.447	.659
Stroop-C	39.60	20.46	36.95	18.0	22.00	19.00		0.812	.429
Stroop-CW	30.20	45.18	20.30	11.5	23.70	17.30	264.00	1.734	.086
Maze	6.70	1.53	6.80	1.96	20.35	20.65	197.00	0.082	.947

Table 2.2 shows that mean of DS as 2.55 ±1.67 and 2.95 ±2.28 on DS, LNS as 6.50 ±7.19 and 8.15 ±5.82, CTT-A as 128.55±74.13 and 113.85 ±48.58, CTT-B as 200.45±88.32 and 182.10±64.68, Stroop-W as 47.50±23.66 and 50.30±16.84, Stroop-C as 36.95±18.02 and 39.60±20.46, Stroop CW as 20.30 ±11.55 and 30.20 ±45.18, and Maze as 6.80±1.96 and 6.70±1.53 for the participants of ‘Control’ and ‘Intervention group, respectively. The mean scores of both groups reveal that all cognitive domains under executive functions are impaired. Overall, the presented

data exhibits no significant difference between both the groups in their levels of Digit Span (z= 0.293, p=.779), Letter–Number Sequencing (z=0.941, p=.369), Color Trail Test–A (z=0.433, p=.678), Color Trail Test–B (z=0.893, p=.383), Stroop Word (z=0.447, p= .659), Stroop Color (z=0.812, p=.429), Stroop Color–Word (z=1.734, p=.086), and Maze Test (z=0.082, p=.947). The deficits were found in all the cognitive domains under executive functions among the participants belonging to both the Intervention and Control group.

Figure 10

Shows comparison of executive functions mean value of both Intervention and Control Group



3) Pre-Post Comparison on ISAA Domains and Executive Functions

Table 3.1: Within Group (Pre-Post Training) comparison on ISAA domains of the Intervention Group

ISAA DOMAINS	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z	*p*
Social Relationship & Reciprocity	22.80	4.41	20.82	3.48	3.937	<.01**
Emotional Responsiveness	11.85	2.11	10.55	2.14	3.095	<.05*
Speech & Communication	17.90	3.55	17.50	3.43	2.138	<.05*
Behavior Patterns	13.10	1.92	10.30	1.78	3.966	<.001***
Sensory Aspects	8.80	1.91	8.65	1.79	0.775	.439
Cognitive Component	9.40	2.19	7.15	2.41	4.029	<.001***
Total ISAA Score	84.10	7.68	74.0	5.75	3.933	<.001***

Note. *** p value significant at .001 level ** p value significant at .01 level* p value significant at .05 level

Table 3.1 results shows Pre-Post training of intervention group on ISAA domains which exhibits mean of 22.80±4.41 and 20.82±3.48 on Social Relationship and Reciprocity, 11.85±2.11 and 10.55±2.14 on Emotional Responsiveness, 17.90±3.55and 17.50±3.43 on Speech- Language &Communication, 13.10±1.92 and 10.30 ± 1.78 on Behavior Patterns, 8.80±1.91 and 8.65±1.79 on sensory aspects, 9.40±2.19 and 7.15±2.41 on cognitive component, 84.10±7.68 and 74.0±5.75 on Total ISAA score. The results of the Wilcoxon Signed-Ranks Test further indicates significant improvements following the intervention in domains of Social Relationship & Reciprocity (z=3.937,p<.01), Emotional Responsiveness (z=3.095, p<.05) Speech & Communication (z=2.138, p<.05), Behavior Patterns (z=3.966, p<.001), Cognitive Component (z=4.029, p<.001), and Total ISAA Score (z=3.935, p<.001). But, there was no significant difference was observed in the Sensory Aspects domain (z= 0.775, p =.439).

Figure No 11

Pre-Post comparison on ISAA domains of Intervention Group

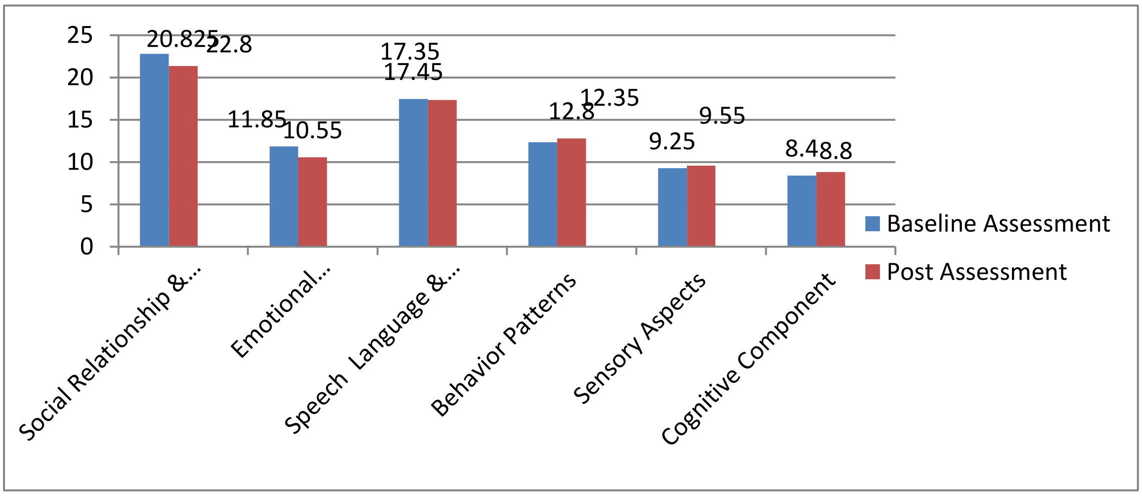


Table 3.2: Within Group (Pre-Post Training) Comparison on Executive Domains of the Intervention Group

Executive Functions	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z	*p*
DS	2.95	2.28	5.80	1.40	3.847	<.001***
LNS	8.15	5.82	10.25	4.91	3.364	<.01**
CTT-A	113.85	48.58	97.10	40.21	3.921	<.001***
CTT-B	182.10	64.68	155.05	55.99	3.920	<.001***
Stroop-W	50.30	16.84	54.05	20.28	2.868	<.01**
Stroop-C	39.60	20.46	43.15	23.51	2.958	<.01**
Stroop- CW	30.20	45.18	35.65	51.37	3.948	<.001***
Maze	6.70	1.53	8.20	1.77	3.197	<.01**

Note *** p value significant at .001 level ** p value significant at .01 level ** p value significant at .05 level

Table 3.2 presents the results of the Wilcoxon Signed-Ranks Test comparing baseline and post-intervention executive function scores in the intervention group. Significant improvements were observed across all executive function measures following the intervention. Specifically, participants showed higher post-test scores on Digit Span (z= 3.847, p<.001), Letter–Number Sequencing (z=3.364, p<.01), and Maze Test (z=3.197, p<.01). Similarly, significant reductions in completion time were found for Color Trail Test–A (z=3.921, p<.001) and Color Trail Test–B (z=3.920, p<.001), as well as improved performance on Stroop Word (z=2.868, p<.01), Stroop Color (z=2.958, p<.01), and Stroop Color–Word (z=3.948, p<.001).These findings indicate significant post-intervention gains in attention, working memory, cognitive flexibility, and inhibitory control among the participants.

Figure 12

Pre-Post comparison on executive functions of Intervention Group

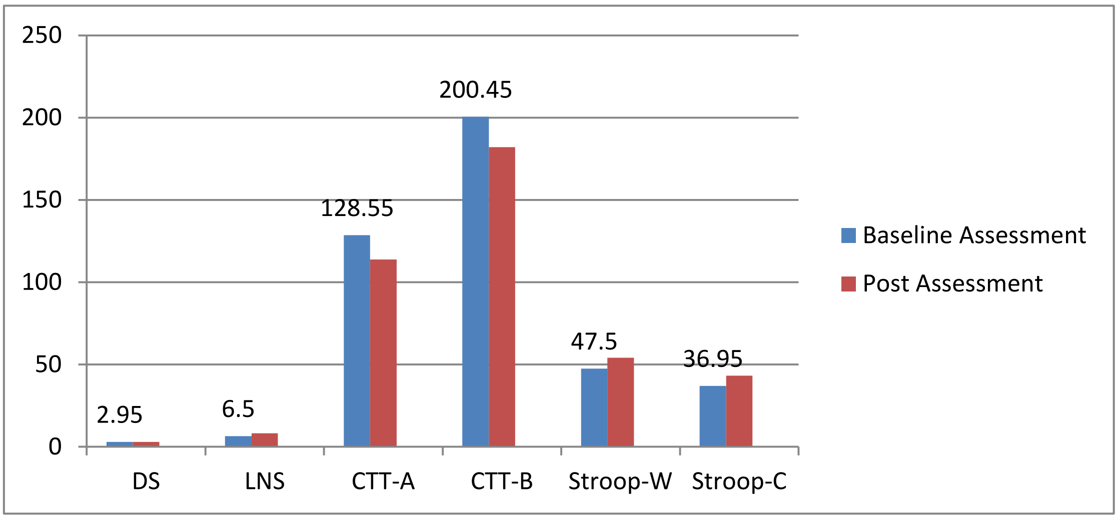


Table 3.3: Within Group (Pre-Post Training) comparison on ISAA Domains of the Control Group

ISAA DOMAINS	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z	*p*
Social Relationship & Reciprocity	21.20	3.38	21.00	3.12	1.875	.061
Emotional Responsiveness	9.70	2.18	9.80	2.75	0.390	.697
Speech Language & Communication	17.45	4.10	17.35	3.95	0.447	.655
Behavior Patterns	12.35	3.70	12.80	3.35	1.617	.106
Sensory Aspects	9.25	1.48	9.55	1.54	1.500	.134
Cognitive Component	8.40	2.21	8.80	2.09	1.496	.135
Total ISAA Score	78.30	7.41	80.0	7.14	2.624	<.01**

Note: **p value significant at .01 level

Table 3.3 shows Pre-Post comparison of control group on ISAA domains, which exhibits mean of 21.20±3.38 and 21.00±3.12 on Social Relationship and Reciprocity, 9.70±2.18 and 9.80±2.75 on Emotional Responsiveness, 17.45±4.10 and 17.35± 3.95 on speech- language & communication, 12.35±3.70 and 12.80± 3.35 on behavior patterns, 9.25 ±1.48 and 9.55±1.54 on sensory aspects, 8.40 ±2.21 and 8.80± 2.09 on cognitive component, 78.30±7.41 and 80.0±7.14 on total ISAA score. The results showed difference in the domain of Total ISAA Score (z=2.624, p<.01) after the intervention which indeed has increased post intervention indicating there is no improvement in the Autism symptoms. There was no statistically significant difference in other domains including Social Relationship & Reciprocity (z=1.875, p=.061), Emotional Responsiveness & Reciprocity (z=0.390, p=.697), Speech, Language & Communication (z=0.447, p=.655), Behavior Patterns (z=1.617, p=.106), Sensory Aspects (z=1.500, p=.134), and Cognitive Component (z=1.496, p=.135) among the participants of the control group.

Figure 13

Pre-Post training comparison on ISAA domain of Control Group

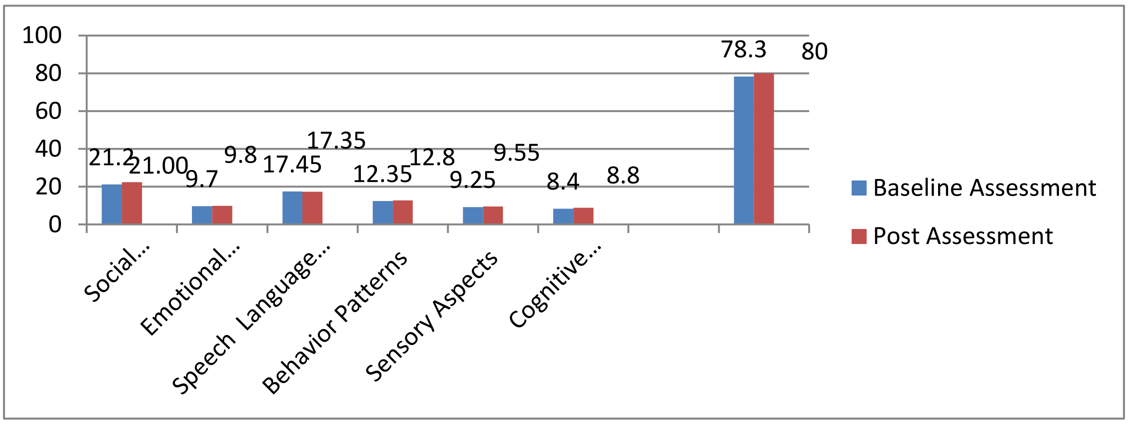


Table 3.4: Within Group (Pre-Post Training) comparison on Executive Domains of the Control Group

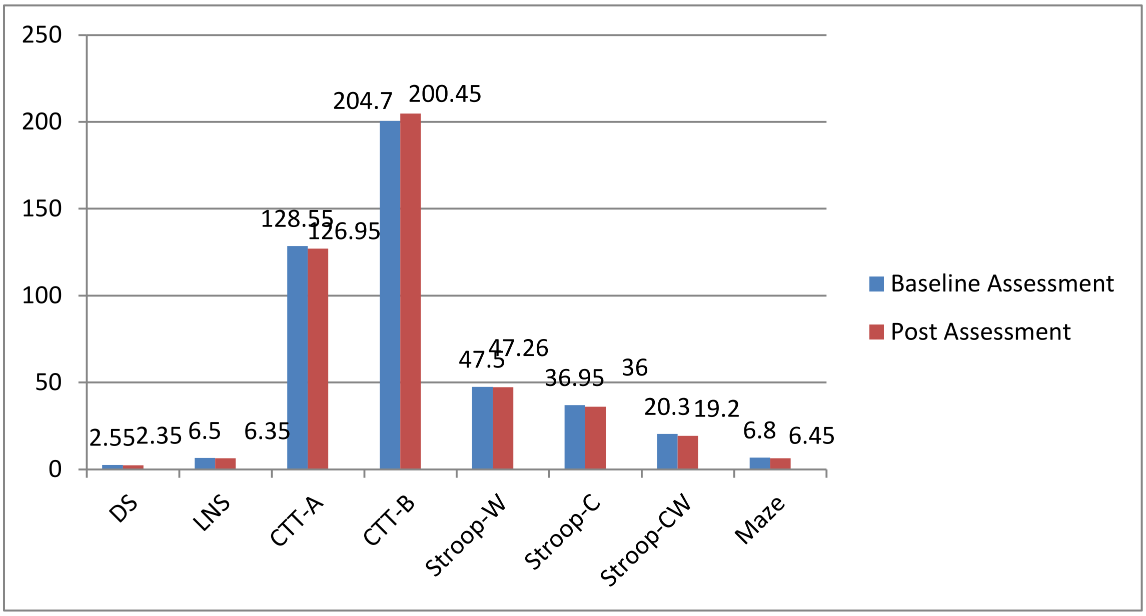
Executive Functions	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z	*p*
DS	2.55	1.67	2.35	1.42	0.816	.415
LNS	6.50	7.19	6.35	6.77	0.485	.628
CTT-A	128.55	74.13	126.95	77.51	0.618	.537
CTT-B	200.45	88.32	204.70	92.54	1.740	.082
Stroop-W	47.50	23.66	47.26	23.19	3.001	<.01 **
Stroop-C	36.95	18.02	36.00	18.01	1.327	.185
Stroop-CW	20.30	11.55	19.20	11.16	1.932	.053
Maze	6.80	1.96	6.45	2.04	1.294	.196

Note. ** p value significant at 0.01 level

Table 3.4 results shows Pre-Post training comparison of control group on executive functions which exhibits mean of 2.55±1.67and 2.35± 1.42 on DS 6.50 ±7.19 and 6.35± 6.77 on LNS, 128.55±74.13 and 126.95±77.51 on CTT-A, 200.45±88.32 and 204.70± 92.54 on CTT-B, 47.50±23.66 and 47.26±23.19 on Stroop-W, 36.95±18.02 and 36.00±18.01 on Stroop-C, 20.30±11.55 and 19.20±11.16 on Stroop-CW, 6.80 ±1.96 and 6.45± 2.04 on Maze. Overall, the data exhibits no significant difference between baseline assessment and post assessment of DS (z=0.816, p=.415), LNS, (z=0.485, p=.628), CTT-A (z=0.618, p=.537), CTT-B, (z =1.740, p=.082), Stroop-C (z=1.327, p=.185), Stroop-CW (z=1.932, p=.053), and Maze (z =1.294, p=.196) among the participants of the control group. There is significant difference in Stroop-W (z=3.001 at p<.01 level) which indicates indeed there is decrease in scores indicating mild decrease in performance on Stroop-W during post assessment.

Figure 14

Pre-Post training comparison on executive functions of the Control Group



4) Between Group Comparison on ISAA Domains and Executive Functions at post -Training Level.

Table 4.1: Between Group Comparison (Post Training) of Intervention and Control Group on ISAA Domains

ISAA Domains	Intervention Group		Control Group		Mann-Whitney U Test				
	Post-Test		Post-Test		Mean Rank		U	Z	***p***
	Mean	SD	Mean	SD	Intervention Group	Control Group			
Social relationship & Reciprocity	20.82	3.65	21.00	3.12	14.78	26.23	85.50	3.11	<.01 **
Emotional Responsiveness	10.55	2.14	9.80	2.75	22.58	18.43	158.50	1.133	.257

Speech Language & Communication	17.50	3.43	17.35	3.95	20.93	20.08	191.50	0.231	.817
Behavior Patterns	10.30	1.78	12.80	3.35	16.05	24.95	111.00	2.428	<.05 *
Sensory aspects	8.65	1.79	9.55	1.54	17.53	23.48	140.50	1.634	.102
Cognitive Component	8.80	2.09	8.80	2.09	16.33	24.68	116.50	2.281	<.05 *
Total ISAA Score	74.0	7.40	79.25	7.14	15.30	25.70	96	2.829	<.01 **

Note:, **p value significant at .01 level, *p value significant at .05 level

Table 4.1 shows post training comparison of various domains of ISAA and Total Score between Intervention and Control Group participants. Significant differences were observed in Social Relationship & Reciprocity (z =3.11, p<.01), Behavior Patterns (z=2.428, p<.05), Cognitive Component (z=2.281, p<.05), and Total ISAA Score (z=2.829, p<.01), indicating improvement in symptoms of these domains compared to the pre-assessment. But, there was no significant difference noted in Emotional Responsiveness (z=1.133, p=.257), Speech, Language & Communication (z=0.231, p=.817) and Sensory Aspects (z=1.634, p=.102) indicating that these domains did not have improvement post training.

Figure 15

Post training comparison between participants of Intervention and Control group on ISAA domains

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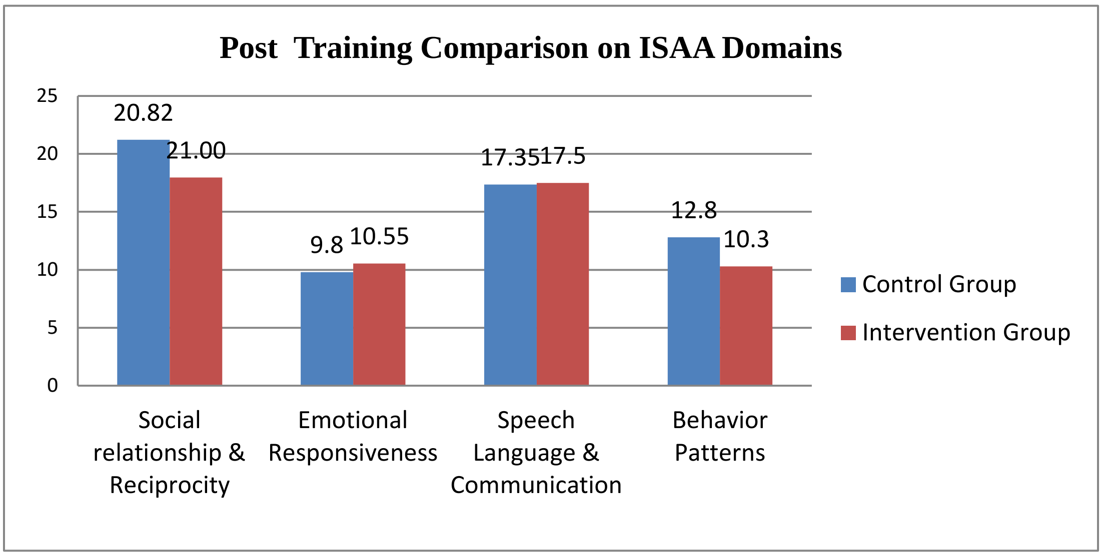


Table 4.2: Post Training Comparison between Participants of Intervention Group and Control Group on Executive Functions.

Executive Functions	Intervention Group Post-Test		Control Group Post-Test		Mann-Whitney U Test				
					Mean Rank		U	Z	*p* value
	Mean	SD	Mean	SD	Intervention Group	Control Group			
DS	5.80	1.40	2.35	1.42	29.65	11.35	17.00	4.995	<.001*** <
LNS	10.25	4.91	6.35	6.77	24.30	16.70	124.00	2.070	<.05 *
CTT-A	97.10	40.21	126.95	77.51	18.55	22.45	161.000	1.055	.291
CTT-B	155.05	55.99	204.70	92.54	16.75	24.25	125.00	2.029	<.01 **
STROOP- W	54.05	20.28	47.26	23.19	20.18	19.82	186.500	0.098	.922
STROOP-C	43.15	23.51	36.00	18.01	21.08	19.93	188.500	0.311	.755
STROO	35.65	51.37	19.20	11.1	22.10	18.90	168.000	0.867	.386

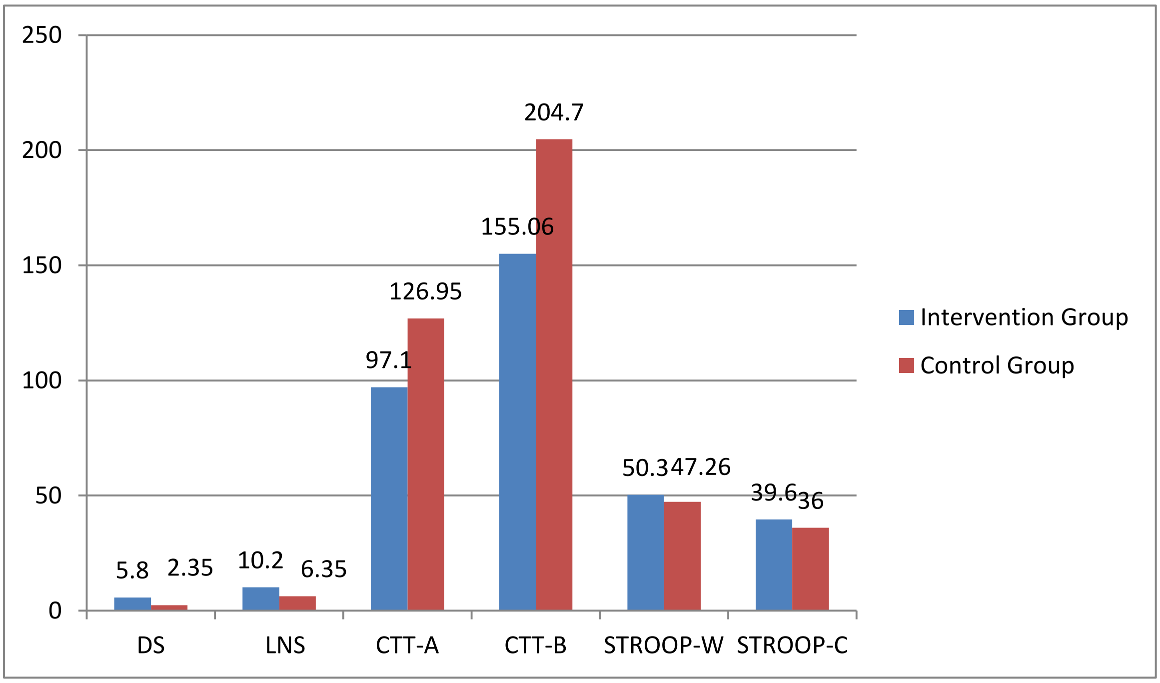
P-CW									
MAZE	8.20	1.77	6.45	6 2.04	25.25	15.75	105.00	2.602	.<01**

Note. *** p value significant at .001; ** p value significant at .01 level; *p value significant at .05 level

Table 4.2 shows the post training comparison between Intervention and Control Group on executive functions. The data indicates a mean of 5.80±1.40 on DS, 10.25±4.91 on LNS, 97.10±40.21on CTT-A, 155.05 ± 55.99 on CTT-B, 54.05±20.28 on STROOP-W, 43.15±23.51 on STROOP-C, 35.65±51.37 on STROOP-CW, and 8.20±1.77on MAZE for participants of the Intervention group and 2.35±1.42 on DS, 6.35±6.77on LNS, 126.95±77.51on CTT-A, 204.70±92.54 on CTT-B, 47.26±23.19 on STROOP- W, 36.00 ±18.01on STROOP-C, 19.20±11.16 on STROOP-CW, and 6.45±2.04 on MAZE for participants of the control group. Results further reveals significant difference between both compared groups on DS (z=4.995 at p<.001 level), LNS (z=2.070 at p<.05), CTT-B (z=2.029 at p<.05) and maze (z=2.602 at p<.01), but no difference was noted in other domains such as CTT-A (z=1.055, p=.291), STROOP-W (z=0.098,p=.922), STROOP-C (z=0.311, p=.755) and STROOP-CW (z=0.867, p=.386).

Figure 16

Post Training Comparison between Participants of Intervention and Control Group on Executive Functions



DISCUSSION

The chapter thoroughly examines relevant findings from the statistical analysis based on the study's hypothesis. The results obtained are interpreted and discussed alongside conclusions from previous research. As discussed, the study aimed to study the executive functions among children with autism spectrum disorder, as well as the effect of cognitive interventions on Autism symptoms.

CHAPTER-V

RESULTS AND DISCUSSION

5.1 Discussion related to Methodology

5.1.1Sample

The sample of the study included children aged between 12 and 16 years, both male and female, who were pre-diagnosed with Autism. In this study, the number of samples included more boys than girls. The research has well proven that the prevalence of ASD is higher in boys than in girls. Most epidemiological studies have demonstrated that the general ratio of boys and girls is 4:1. Research has proven that biological and genetic factors play a role, making boys more susceptible to autism than females. Females have a higher threshold than males (Werling & Geschwind, 2013). The previous research done by Werling (2013) also stated that the prevalence of autism is higher in males when compared to females, especially in individuals with intact intellectual functioning. A female protective theory also states that females have a higher threshold, and the symptoms in females are also under diagnosed due to the manifestation of subtle symptoms than in males, contributing to lower prevalence. Hence, the current study also included more boys than girls.

Both males and females were included in the study because literature evidence indicates no significant differences in executive functions between them. A study done by Demetriou et al. (2018) concluded that executive dysfunction in ASD is relatively stable across development with no evidence for fractionation by sex or other moderators. This suggests that males and females with ASD generally show similar EF profiles, and therefore, including both genders in the interventions would not impact the results. The effect of cognitive training did not show a significant difference in many studies, and it has been proven effective in both males and females. The survey, which did brain imaging studies, has identified subtle differences in brain connectivity and adaptive behaviors, but they may not consistently affect the efficacy of cognitive training (D'Aiello et al., 2023). Hence, the difference in the number of male and female samples would not affect the study's outcome, as previous findings justify.

In this study, although both nuclear and joint family types were included, there was a greater prevalence of atomic family types. This is because the current study was conducted in an urban area where the nuclear family type is prevalent. Hence, a larger number of children from atomic families could be attributed to this factor. Joint families may offer multiple caregivers and extended social interactions, which can provide more opportunities for practicing executive function skills like planning, memory, and cognitive flexibility. Nuclear families, while having fewer caregivers, may offer more individualized attention and focused support during cognitive training. However, the training was conducted individually as one-to-one sessions during therapy only, and no homework sessions were given. Hence, no monitoring or reinforcement strategies were required for the successful completion of the cognitive training. Moreover, the quality of interactions, communication, and support within the family may play a more significant role than the family structure itself. However, the emotional, motivational, and practical support is very substantial for engaging in cognitive training. Hence, parents were psycho-educated about their involvement and the significance of the cognitive training before the session started. Therefore, the impact of the family type on the outcome of cognitive training would be very meager in this current study.

The current study involved children in the adolescent period because executive functions are somewhat well-formed during this stage. Although rapid development occurs during the preschool years, it is at a rudimentary stage during early childhood. Adolescence is marked by the maturation of more complex executive functions such as abstract reasoning, planning ability, and inhibition, unlike children below 12 years. Therefore, considering the age group from 12 years and above is more reasonable. The previous research evidence has proved that attention skills and working memory mature more across adolescence (Crone & Dahl, 2012). Another study by Steinbeis and Crone (2016) has also supported the current research, reiterating that cognitive flexibility in adolescents for decision-making when accomplishing novel tasks was found to increase. Moreover, the EF difficulties, such as flexibility, inhibition, and planning, are interwoven with autism features, and it is challenging to delineate them into distinct domains and differentiate them from symptoms of ASD and EF difficulties. Especially in young children with ASD, capturing EF deficits may be still more difficult. The psychological assessments of EF functions would be more difficult for young children to comprehend and execute compared to older children. Considering all the demands and restrictions, the children aged 12 years and above were included in the study.

In terms of intellectual functioning, the children whose intellectual level was dull (below) average, average, and above average were only included in the study because the children with intellectual impairment would have impairments in other cognitive functions as well and there would be a high discrepancy in performance on executive functions when compared with children having average intellectual functioning. Moreover, cognitive training among children with autism who have any intellectual disability may not be feasible, as they would have difficulty comprehending and executing the task, which would be one of the significant limitations in carrying out the study. The outcome results of children with intellectual disability will have more discrepancies with children having average intellectual functioning because of the baseline differences in their executive functions. The study by Benyakorn et al. (2018) found that while executive cognitive training for children with autism spectrum disorder was beneficial, they required additional accommodations, such as extended weeks beyond the training period and longer task durations. Hence, the current study excluded children with intellectual disability. According to the survey done by Memisevic & Sinanovic (2014), the children with ID had significant deficits in EF. The meta-analysis study done by Spaniol & Danielsson (2022) also concluded that problems in executive functions are more common in individuals with intellectual disability than in standard age-matched controls. Hence, all these studies justify the need for excluding the children with intellectual impairment in the current study.

Regarding the severity of symptoms, children with a Mild level of symptom severity on ISAA were only included in the present study. Research done by Petrolo et al. (2025) proposed that children with severe ASD have more impairment in executive functions, particularly in inhibitory control, compared to flexibility. This suggests that as autism symptom severity increases, deficits in basic self-regulation, like impulse control, become more pronounced. Another study done by Valeri et al. (2020) also observed that children with severe Autism showed greater impairments in inhibitory control and further suggested there is a potential association between inhibitory control and the severity of autism symptoms. There are many feasibility challenges while adopting cognitive training in children with severe symptoms of autism, such as having more difficulty in attention, comprehension, and following instructions independently. The study done by Liu et al. (2023) also stated that the generalization and adaptability of trained skills to new situations are very limited in children with severe symptoms of autism. The cooperation and motivation issues during the cognitive training among children with severe autism symptoms have also been reported in the study, which would be another challenge if including the children with severe symptoms of autism. The translation observed during cognitive training to improvements in real-world situations, such as daily living, social interaction, or adaptive functioning, might be limited due to pronounced communication and behavioral difficulties. Hence, this study included only children with mild autism, considering the limitations and practicality issues during the intervention period.

5.1.2 Tools Used

In the present study, tests with proven efficacy have been used to assess the executive functions of the participants. For assessment of executive functions, the color trail-making test was used to evaluate focused attention and cognitive flexibility. The digit span and letter-number sequencing were used to assess working memory. The Stroop test was used for inhibition, and the maze test was used for planning. All these tests were nonverbal in nature, and it is more feasible for children with Autism. The color trail-making test evaluates visuomotor ability, tracking speed, sustained attention, and cognitive flexibility, which are the core domains mainly affected in children with autism. The test is non-verbal, requiring the participant to use only colored numbers and circles, which do not demand language, making it more accessible and feasible for children with ASD. This test can also be administered to children who do not have literacy in English, and the time required to complete the test is also significantly less, about 5 to 7 minutes. The child must connect the numbers in sequence and then alter the sequences between colors and numbers, which involve attention, cognitive flexibility, and psychomotor speed. The other tests, which assess cognitive flexibility using verbal fluency tasks, may not be appropriate for children with autism. The test used by Pastor-Cerezuela et al. (2016) accounted for the fact that language proficiency in semantic fluency tasks might influence the test's performance in children with autism. The test can be used with nonverbal instructions, further supporting its use among children with Autism. Moreover, the normative and validation data of the test also include children with neuropsychological disorders, enriching the appropriateness of using this test in children with ASD to distinguish the altered neuropsychological functioning among children with autism. The color trail making test was considered to have less cultural bias and has the potential to be an effective research and clinical tool in neuropsychological assessment (Williams et al., 1995).

The Stroop test is widely used to assess selective attention, cognitive control, processing speed, and inhibitory control, which are key components of executive functioning. The Stroop test requires individuals to suppress the automatic reading response and name the color of the ink, which directly measures inhibition and interference effects. This test is more appropriate for these children because of its simplicity, the time it takes, and its attractiveness with color words. This test does not require more linguistic ability, and it is easy to administer among children with autism. This test was used for inhibition in the study conducted by Hill and Bird (2006) among children and adults with autism. It was reported that their performance did not differ significantly from controls on traditional card versions of this task. In another study, typical interference effects were reported in children with autism whose intelligence was within the normal range on the Go/No-Go task, the Stop-Signal task, and the negative priming tasks (Ozonoff&Strayer, 1997; Schmitz et al., 2006). In another study by Hill & Bird (2006), the Stroop test for inhibition was also used to assess executive functions.

In this study, Progressive Matrices was used to assess intellectual functioning because it is a nonverbal test of intelligence that can better tap the potential of children with Autism compared to verbal tests. It measures the general intelligence, identifies patterns, and forms analogies. It involves more visual reasoning rather than verbal reasoning. The studies have reported that children with autism have more nonverbal and visuospatial ability (Dawson et al., 2007). It has also been noted in studies that children with autism have excellent attention to detail, as they are hypersensitive and have good pattern recognition. The progressive matrices involve only pattern recognition and identifying the rule, which is more structured and would be more compatible for children with autism. In a study by Hajri et al. (2016) on the effect of cognitive remediation therapy in children with ASD, intellectual efficiency was evaluated using the Raven Progressive Matrices (CPM) for general non-verbal intellectual abilities. The ISAA scale was used to assess the severity of symptoms, which is a standardized tool for Indian Children. Hence, all the tools used for assessment were applicable for children with autism,as supported by previous studies.

5.1.3 Procedure

After selecting the samples, the cognitive intervention module was chosen based on previous research, particularly that by Hegde S. (2012), which has demonstrated its efficacy in improving executive function through tasks. The participants were divided into an intervention group, which received the cognitive interventions, and a control group, which did not. The interventions were planned twice a weekfor 6 months. For significant behavioral and cognitive changes, sustained practice is required, and six months is considered sufficient for the participants to internalize new strategies and demonstrate measurable improvements. If the intervention is prolonged further, there is a higher chance of dropouts due to the overly long program duration. If interventions are planned for a shorter duration, they may not provide enough time for meaningful or stable change to occur. As the cognitive training principle says, more time period and repeated exposure is required for the neuroplasticity changes to occur. A six-month period aligns with the timeframe and is sufficient to provide both short-term improvements and medium-term consolidation during this period of intervention. A six-month period allows monitoring both immediate gains and maintenance of changes, providing more substantial evidence for intervention effectiveness compared to shorter trials. This has been documented in a study by Hajri (2019), which found that using noncomputerized interventions, one session per week for six months, showed significant positive effects on neurocognition and clinical symptoms. Hence, the cognitive intervention planned for about six months was imparted considering its effectiveness in previous literature.

The protocols used for attention involved coloring the given colors and gradually increasing the number of colors. This task is nonverbal, and using colors would be more attractive and engaging for children. This task involves visual scanning, sustained attention, and concentration, and it must be completed within a time frame. For children, bright and distinct colors are more engaging. This task involved canceling bright colors like red, blue, green, yellow, and purple, which would help the children sustain motivation and compliance. Especially for children with autism, using language components like numbers or letters can be a more demanding task. The other task involves serially connecting randomly placed numbers. This also involves fine motor coordination, visual scanning, sequencing, and sustained attention. This task is especially suitable because the rule-based nature of joining numbers aligns well with children with autism, as they prefer more structured and routine tasks. It also enhances visual scanning and spatial organization, which is more commonly difficult for them. It also strengthens working memory and planning ability, which is also part of the core executive functions. The task does not require any language ability to comprehend or execute. It is a more child-friendly and structured task that enhances their attention and other cognitive functions.

For inhibition, coloring within shapes was used, which involves hand-eye coordination, sustained focus, and self-regulation. It supports rule following and strengthens the fine motor skills as well. Avoiding crossing boundaries also helps to improve selective attention. The children are allowed to use colors of their choice, which helps them express themselves while adhering to rules and structure. The working memory task involves the child remembering the sequence of colored tokens. This task involves more visual processing than verbal processing, as most children with autism have stronger visual skills, which helps to leverage and utilize that strength. It needs the ability to hold and manipulate information, which is crucial for adaptive functioning and learning ability. The non-verbal, color-based nature of this task is again more feasible for children with autism. Memorizing pictures from the board is also a nonverbal task and would be effective, similar to the previous task, which focuses on working memory.

The inhibition tasks involved the Go-No-Task, where the child had to execute a motor task while withholding the natural response. This task is more activity-based, involves motor activity, and does not involve any language component to comprehend. This task is more suitable for children with varying levels of language ability. This helps to improve their impulse control and self-monitoring, which is essential for social behaviors and daily adaptive behaviors. The maze test is used to improve planning ability, which is a nonverbal task involving visual processing, a strength in children with autism. It enhances perseverance to complete the task and requires cognitive flexibility to adjust strategies when encountering obstacles or dead ends, thereby strengthening adaptive problem-solving skills. The task is friendlier because it is more engaging for children with autism. Hence, all the tasks planned in the cognitive training module are more feasible and effective for children with autism.

5.1.4 Statistical Analysis

The data collected were statistically analyzed using SPSS 20. Descriptive analysis was done, and the normality of the sample was found using the Kolmogorov-Smirnov Test. The test evaluates whether the distribution of the sample is significantly deviating from the normal distribution. This test is more appropriate when the sample size is small. It provides a clear idea and objective criteria for assessing whether parametric assumptions are met. It is simple to compute and widely implemented in statistical software. The accessibility and the interpretability make it a practical choice in research, especially in psychology and social science. The tests revealed that the distribution of the samples was not normally distributed, and hence, nonparametric tests were used for further assessment. The significant difference between the two groups based on socio-demographic characteristics such as age was tested using the Mann-Whitney U Test, as this test is used when the population is not normally distributed. Other categorical variables, such as gender, family type, and level of intellectual functioning, were tested using the Chi-Square test, which is more appropriate to determine whether there is a significant difference between the two variables. If the data is nominal, the chi-square test is a more appropriate test used to analyze frequency distributions. The significant difference between the baseline and post-training assessments of the intervention and control groups was assessed using the Mann-Whitney U Test. The Mann-Whitney test is the appropriate test for comparing differences between two independent groups when the assumptions of parametric tests are not met, and tests such as the t-test cannot be used. This test focuses more on the median or rank order rather than the mean, making it more suitable when the data is not normally distributed. It can be used with ordinal data and is hence more applicable in clinical and psychological research. The pre- and post-training comparison of the intervention and control groups was assessed using the Wilcoxon Signed-Rank Test, which is more appropriate when a paired t-test cannot be used and the assumption of normality is not met. Moreover, it is also more useful when the sample size is small, skewed, and has ordinal measurements. Hence, all the tests used for statistical analysis were found to be more appropriate, and the results obtained are more reliable.

5.2 Discussion related to Results

5.2.1 At Baseline Level - on ISAA Domains and Executive Functions

The existing literature has strongly revealed that children with Autism have impairment in executive functions, which has been described in various perspectives including genetic abnormality, theory of mind, and biological perspectives, over time. The biological perspective is gaining importance, and various studies have explored the biological abnormalities related to ASD with neuroimaging studies. It has been described that abnormalities were observed in cortical volume and thickness in both frontal and other cortical brain regions (Demetriou, DeMayo, & Guastella, 2019). Aberrant functional network connectivity influencing EF has also been reported between prefrontal and other cortical and subcortical areas in another study done by Libero et al. (2015). Another study by Nomi & Uddin (2015) also stated that there is aberrant functional network connectivity between the prefrontal cortex and other cortical and subcortical areas, which influences executive functions. These biological abnormalities paved the way for research to explore and profile the cognitive domains of these structures. In alignment with this, a meta-analysis study by Demetriou et al. (2018), which included 235 studies, attempted to identify the cognitive profile of executive functions, confirming executive dysfunction in children with ASD. They are linked to difficulties in social cognition, adaptive functioning, and goal-oriented behavior, and it also states that it can exacerbate core ASD symptoms such as rigidity, repetitive behaviors, and challenges with daily living skills (Petrolo et al, 2025).The study done by Valeri et al. (2020) observed that children diagnosed with severe ASD showed greater impairments in inhibitory control compared to flexibility, and it also suggested a potential association between impairments in inhibitory control and the severity of autism symptoms. A longitudinal study published by Lupi et al. (2023) also reported that executive functions at two years of age were linked to the severity of autism symptoms as well as emotional and behavioral problems. In another study done by Gentil-Gutiérrez et al. 2022 Executive Functioning deficits of children and adolescents diagnosed with Autism were compared with those of neurotypicalchildren in the school context. The results of the study indicated that individuals diagnosed with autism had significantly higher scores on the Behavior Rating Inventory of Executive Function (BRIEF) in comparison with neurotypical children, and they had greater challenges in EF, such as cognitive flexibility, planning, working memory, and inhibition.

In the current study, the results revealed that the total average ISAA score of both the control group and the intervention group had mild levels of autism symptoms. They had deficits in all the domains, which included social relationships and reciprocity, emotional responsiveness, speech, language and communication, behavior patterns, sensory aspects, and cognitive components. The executive functions of both groups were found to have deficits, which include Digit Span, Letter Number Sequencing, Color Trails Test and Maze Test. The Stroop test performance did not showed significant impairment and it lies above the 30th percentile. The results of the inhibition test in autism are mixed and some researches have revealed that there is no significant difference between the normal typical children and autism in the inhibition test. The similar results were found in the study done by Geurts H et al. 2004. The results of the normative study conducted by Dugbartey et al. in 2000 reported a mean time for children and adolescents ranging from 60 to 120 seconds for CTT-A and from 120 to 180 seconds for CTT-B. However, the children with Autism in both the control group and the intervention group showed significantly higher times than the normal data, showing significant impairment in CTT, which assesses attention and cognitive flexibility. In a study conducted by Ghosh, Samajdar, and Halder (2020), the Maze Test was administered to assess executive functioning in children with Autism, and the findings indicated significant impairment in executive functioning and social skills. In the current study, it was found that working memory was impaired in both groups, as assessed using Digit Span and Letter Number Sequencing. This aligns with the previous study by Mayes & Calhoun (2008), which used the Digit Span and Letter Number Sequencing of the WISC-IV to measure WM in high-functioning autism, indicating impairment in WM. The impairment observed cannot be attributed to the verbal nature of the study, as the study conducted by Rabiee et al. (2018) aimed to examine working memory through nonverbal tasks. This study revealed that nonverbal working memory was impaired among participants with high-functioning ASD. This result clearly emphasizes that persons with Autism have deficits in working memory, and it does not depend upon the nature of the test used. In a study by Rabiee et al. (2020), it was found that there is impairment in working memory, and there is a relationship between working memory tasks and social interaction and stereotyped behaviors. Hence, a considerable number of studies have reported working memory deficits among children with Autism and their relationship to Autism symptoms, as well, which is also reported in the current study.

5.2.2 Pre-post Comparison -on ISAA Domains and Executive Functions:

Considering the impairment in executive functions and its relationship to autism symptoms in various studies, the importance of training executive functions is also recommended in many studies. In a study conducted by Maurya and Faijullah Khan (2022), it was demonstrated that Cognitive training programs can lead to significant improvements in executive functioning, understanding of cognitive mental states, and central coherence in children with ASD. These cognitive gains often translate into better social skills, such as increased social communication and more appropriate social interactions. In light of this, many studies have attempted to study the effect of executive functions in children with Autism and have proved its effectiveness. A study done by Petrolo et al. (2025) highlighted the importance of early interventions targeting EF domains in children to improve social, emotional, and adaptive functioning of individuals with ASD. The baseline and post-training comparison of ISAA symptoms and executive functions in the control group, who did not undergo cognitive training, did not show any significant differences in ISAA symptoms or cognitive domains. There was a mild increase in the ISAA score, but the symptoms of Autism —such as emotional responsiveness, speech-language and communication, behavior patterns, sensory aspects, and cognitive component —did not differ from baseline to post-assessment among children in the control group. This clearly indicates that the children who did not undergo cognitive training did not experience any improvement in their symptoms or executive functions. Indeed, there was a mild decrease in the Stroop-Word score, indicating a decline in performance during the post-assessment among the participants of the control group. This clearly proves that even though the children were attending other therapies, such as speech and occupational therapy, it did not impact their cognitive functions, particularly the executive functions, which demonstrates the efficacy of cognitive training.

The results of comparison between baseline and post-training of the intervention group have revealed that there is a significant reduction in ISAA symptoms, such as social relationships and reciprocity, emotional responsiveness, speech, language and communication, behavior patterns, and cognitive component, and total ISAA score post-training, which is in alignment with the previous studies. There was improvement in all the ISAA symptoms except the sensory aspects. This might explain why the sensory issues of Autism, such as sensitivity to sensory stimuli, insensitivity to pain, unusual vision, and responding to objects and people by smelling, touching, or tasting, are more related to biological factors. There is very scarce evidence supporting the effectiveness of cognitive training on sensory issues as well. Interventions specifically targeting sensory issues, such as sensory integration therapy, have only demonstrated effectiveness in improving sensory processing and related skills in children with autism (Weitlaufet al., 2017). The executive functions have been effective not only in improving EFs but also in reducing autism symptoms in children and young people with ASD, as found in another important study done by Pasqualotto et al. (2021). In a study done by Kenworthy et al. (2014), it was noted that executive functions training has positive effects and improves the social skills of children with ASD. In another study by Sun et al. (2017), stimulation of executive functions demonstrated improvements in communication, interactivity, and social-cognitive performance. This is also aligned with the current study, which has shown effectiveness in improving social and communication areas. The cognitive training module showed notable gains in executive functioning, understanding cognitive mental states, and central coherence, all of which are linked to behavioral regulation in children with ASD, according to a study by Maurya and Faijullah Khan (2022). In this study, the behavior pattern among the intervention group has also demonstrated significant improvement compared to the control group. This finding aligns with the literature, as most studies have reported improvements in behavior patterns, such as regulating behaviors in Autism, after cognitive training.

5.2.3At Post-Training Level - on ISAA Domains and Executive Functions:

The comparison between the intervention and the control group, post-training, revealed a significant difference in Social Relationship & Reciprocity, Behavior patterns, Cognitive components, and as well as total ISAA score. However, there is no difference in symptoms such as Emotional Responsiveness, Speech Language & Communication and Sensory aspects. These results partially support the hypothesis that there will be significant improvement in the ISAA symptoms. The results revealed a significant improvement in social responsiveness, which aligns with previous findings by Sun et al. (2017) and Miyajima et al. (2016). Both studies demonstrated that cognitive training programs targeting executive functions led to notable enhancements in social cognition and social functioning among individuals with Autism Spectrum Disorder (ASD).Our observed improvements in social relationship and reciprocity are consistent with Nejati et al.'s 2024 study as well which concluded that cognitive-level training can produce functionally relevant social gain.

There is improvement in the cognitive component post training when compared between the two groups. The training module adopted mostly involves color cancellation, joining random numbers, coloring designs, rapid naming, memorizing a sequence of colored tokens, and a maze targeting multiple cognitive domains of executive functions, it primarily focuses on attention and concentration. Hence, this could be the attributing factor for significant improvement in the cognitive component domain, which involves attention and concentration in ISAA. There was marked improvement in children's level of attention and concentration, which was reflected in their academic skills as well. Spaniol et al. (2018) also report in their study that attention training is considered a feasible and practical approach in children with ASD. The results of the study also revealed significant improvements in behavioral patterns, such as hyperactivity, aggressive behavior, temper tantrums, and self-injurious behavior. Most of the cognitive training programs in other research have shown marked improvement in the behavioral problems and attention, which is the primary problem for most children with Autism. In the meta-analysis study by Pasqualotto et al. (2021), the review highlighted that improvements in executive attention and related EF domains can indirectly lead to better behavioral regulation and reduce behavioral problems. Enhanced executive skills help children with ASD cope more effectively with daily demands, which can reduce the frequency and severity of behavior problems. In a meta-analysis study done by Pasqualotto et al. (2021), the results revealed that most of the interventions were effective in enhancing executive functions and reducing symptoms in children with ASD which supports overall improvement in the Autism symptoms in the current study. At the same time, the other symptoms such as emotional responsiveness, speech, language, and communication, which involve improving expressive skills like initiating conversations with others, avoiding stereotyped and repetitive language, and avoiding meaningless words did not show significant improvement. The finding may be explained by the nature of cognitive interventions, which primarily target higher-order cognitive processes such as attention, working memory, and cognitive flexibility, rather than the affective components of social functioning. Emotional responsiveness, which involves spontaneous affective expression, empathy, and recognition of others' emotions, is mediated by deeper socio-emotional and neurobiological mechanisms that are less amenable to short-term cognitive practice (Hill, 2004; South & McMahon, 2007).The sensory patterns did not show a significant difference between the pre and post-training of the intervention group. It can be understood that the sensory behavior of Autism children with autism is primarily biological in nature. Many studies support the idea that an imbalance between excitatory and inhibitory signaling in the brain contributes to sensory processing differences in ASD. This is often linked to dysfunction in the gamma-aminobutyric acid system, which is crucial for regulating neural activity. Reduced GABA levels have been observed in the sensorimotor cortex of children with ASD, correlating with altered tactile sensitivity and detection thresholds (Balasco et al., 2020). Neuroimaging studies indicate that individuals with autism may have increased local brain activity but impaired long-range connectivity. This can affect how sensory information is processed and integrated across different brain regions (Marco et al., 2011). Hence, improvement in these symptoms might require a longer duration of interventions to become significant.

The comparison of pre and post-training assessments of executive functions in the intervention group showed significant differences in DS, LNS, CTT-B, and maze. However, there is no difference in other domains such as CTT-A, STROOP-W, STROOP-C and STROOP-CW. There is a significant improvement in assessments that focus on attention, working memory, and planning ability. However, there was no significant improvement in assessments that focus on inhibition. Research has shown that, on the classic Stroop test, participants with autism do not have impairment in comparison to typically developing participants, suggesting that inhibition as measured by the Stroop may not be a core area of deficit for many children with autism. As a result, cognitive training aimed at executive functions may not yield measurable improvements on the Stroop test for this group. The lower reading comprehension in children with ASD may mask any potential gains from cognitive training, and they further say that post-training improvements may not be detectable or relevant in this population. There is significant improvement in other cognitive domains, which has been well described in several studies. In the study done by Pasqualotto et al. (2021), the Trail Making Test (TMT) is recognized as a sensitive measure of cognitive flexibility and executive function. Post-intervention assessments using the TMT consistently showed that children with ASD can achieve faster completion times after cognitive training, reflecting improvements in their ability to shift attention, process information, and manage complex sequencing tasks. In another study conducted by Hajri, M. (2019), the results indicated significant improvement in working memory, as assessed with Digit Span and Letter Number Sequencing. In another study by Miyajima, M. (2016), there was a marked improvement in working memory, which led to better performance in digit sequencing. There was marked improvement in Maze performance, indicating better planning ability in children with ASD after cognitive training. The other researchers have also demonstrated similar effects on planning ability and cognitive flexibility, as assessed in the Maze test. In a study done by Maurya& Khan (2022), the cognitive training showed significant improvement in cognitive flexibility and planning ability in children with Autism.

5.3 Testing the Hypotheses

Hypothesis 1- "There is significant impairment in executive functions among children with Autism."

Status: Accepted

Hypothesis 2- "Cognitive training had significant effect on executive functions (attention and cognitive flexibility, working memory, inhibitory control, and planning ability) of children with Autism"

Status: Accepted

Hypothesis 3 – "There is significant reduction in symptoms of Autism"

Status: Accepted

CHAPTER-VI

SUMMARY AND CONCLUSION

6.1 Summary

The study aimed to investigate the executive functions among children with Autism and the effect of cognitive training on executive functions and Autism Symptoms. The study involved children aged 12 to 16 years having a Mild level of Autism and intact intellectual functioning. To conduct this study, the participants were divided into two groups. One group received twice-a-week cognitive training sessions for about six months, while the other group served as a control, with no cognitive training sessions provided to them. The assessment related to executive functions was conducted at both baseline and post-training levels, with the baseline assessments revealing that executive functions were impaired. Subsequently, the planned intervention module, which focused on attention and cognitive flexibility, working memory, inhibition, and planning ability, was administered for six months on a two-session-per-week basis. After the intervention was completed, the post-assessment of the executive functions and ISAA symptoms revealed improvement in most of the ISAA symptoms except the sensory pattern. The Stroop test did not show improvement during the post-assessment indicating no significant improvement in inhibitory control. Further, the comparison between the control group and intervention group on ISAA symptoms revealed significant difference in social relationship, reciprocity, behavior pattern, cognitive component domains, and ISAA symptoms. The comparison between the control group and the intervention group on executive functions reveals significant improvement, except for the inhibition task. These results indicate that there is a high need to incorporate the cognitive training methods with other formal and traditional approaches of treating children with ASD. Overall, the study findings could be summarized as:

1. The children with Autism had significant impairment in executive functions in the areas of focused attention, cognitive flexibility, working memory, and planning ability.

2. The participants of the intervention group exhibit significant improvement after cognitive training sessions, in domains of focused attention and cognitive flexibility, working memory, and planning ability.

3. The group that received six months of cognitive training exhibits significant improvement in ISAA symptoms in terms of social relationship and reciprocity, emotional responsiveness, speech and communication skills, behavior pattern, cognitive component, and total ISAA score.

4. The comparison between the intervention group and control group on ISAA symptoms after the cognitive training showed that there is a significant difference in social relationship and reciprocity, behavior patterns, cognitive components, and total ISAA score.

5. The comparison between the intervention group and control group on executive functions showed that there is a significant difference in focused attention and cognitive flexibility, working memory, and planning ability.

6.2Conclusion of the Study

The study concluded that there is significant impairment in executive functions and demonstrated the effectiveness of cognitive training, showing significant improvement in the performance of executive functions and Autism symptoms. These findings align with the growing body of research indicating that targeted cognitive training interventions can significantly enhance executive functions in children with ASD. Improvements were observed in key domains such as attention, working memory, cognitive flexibility, inhibition, and planning ability. These areas are often impaired in this population and contribute to challenges in daily living and social skills.

The evidence suggests that cognitive training leads to measurable gains in executive functioning and also in the improvement of Autism symptoms. There was a significant improvement noted in the social relationship & reciprocity, behavioral patterns, cognitive abilities, and overall symptoms of children with Autism who underwent cognitive training. The pre- and post-comparison of the intervention group revealed significant improvement in ISAA symptoms, except for the sensory patterns, highlighting the importance of its effectiveness. The effectiveness of cognitive training should have general applicability in improving the socio-adaptive skills of children with Autism, as clearly demonstrated by the findings of the current study. Nevertheless, the benefits of these interventions may diminish once the training ceases, highlighting the need for sustained or repeated training to maintain improvements. In conclusion, cognitive training represents a promising avenue for supporting executive function development in children with ASD, with the potential to enhance their adaptive skills and quality of life. Future research should focus on optimizing intervention strategies, exploring long-term effects, and ensuring the ecological validity of training programs to maximize real-world benefits for children with autism.

6.3Clinical Implications

The current study demonstrated the effectiveness of cognitive training, particularly in improving executive functions and reducing symptoms of Autism, especially behavior problems and cognitive components like attention and concentration. These findings were noted to show generalization in other settings, including improvement in their adaptive and academic skills. This study helps to gain insight into the importance of adopting cognitive-based interventions along with other traditional behavioral methods for treating children with Autism. As the neuropsychological implication is gaining its importance and this study supports the previous literature, it further directs to explore more about including other individualized and developmentally appropriate cognitive intervention modules as well.

6.4 Limitations of the Study

- The methodological challenges include a small sample size, and hence a large number of samples is warranted for more reliability.
- Even though the qualitative feedback, as reported by the parents/guardians, showed improvement in many of their socio-adaptive skills, some of the variables did not show statistical significance, which might be due to the limited sample size.

- The age group of the children included in the study ranged from 12 years to 16 years old, which does not include a diverse age group, and hence, the general applicability of the current findings to all persons with Autism should still be explored.
- Long-term sustainability of improvements is not yet well established. The intervention protocol included in the study might not be promising enough to see long-term effects underscoring the need for further rigorous research.
- The characteristics of the samples, such as autism severity and baseline abilities, can vary, and this might affect the effectiveness of protocols.

6.5 Future Directions

- The study can be done as a longitudinal study to determine its long-term effectiveness.
- A larger number of samples to be included to prove the effectiveness of the study, as the current study's sample size is small.
- The study can include children of diverse populations, such as age, gender, etc.
- Children with only a mild level of Autism and intact intellectual functioning were only included in the study. Exploring the effectiveness in children with other severities of Autism can be considered for future studies.
- The therapy module can include other interventions to improve the executive functions, and computer-based interventions can also be considered for further studies, as they would be more feasible for children with ASD.

Appendix – I

<u>Socio demographic Data</u>

Name:

Age:

Sex:

Education

Language Spoken:

Socioeconomic status:

Area of residence: Urban/Rural/Tribal

Any other Comorbid Disability:

Current details of therapy undergoing:

Any other history of mental illness or physical illness:

History of any other neurological conditions:

History of taking any medications:

Informed Consent:

The data would be kept confidential and will be used only for research purpose. Individual data or identity won't be revealed at any cost.

Signature of Investigator

I confirm that I have read the above information and I understand that the data will be used for research and publication. I give consent for my child to participate in this research.

Signature of Parent

Appendix – II

Informed consent document

Patient / Participant information sheet

Title of the project

Effect of cognitive training on executive functions among children with Autism Spectrum Disorder.

Purpose of this study

To find out the efficacy of cognitive training on executive functions and its effect on symptoms of children with autism spectrum disorder

Procedure during the study

Children having mild to moderate level of autism with average or below average intellectual functioning would be included in the study. The children would be administered psychological assessments to assess their intellectual functioning and executive functions. Subsequently, they would be given cognitive interventions to improve their attention and executive functions. The session would last for 45 minutes to 60 minutes on the basis of two sessions per week. The total duration for the study is 6 months. Post assessment would be done to assess the effect of cognitive interventions on the executive functions and symptoms of Autism.This study doesnot involve any laboratory tests or any invasive procedure.

Expected duration of the subject participation:

45 minutes a day for 2 days per week. Total duration of the study would be 6 months including the tests and assessments.

Any risks expected from the study to the participant:

There would not be any physical or psychological harm or injury during the `participation of the study.

Maintenance of confidentiality of records

Personal details of your child like diagnosis of autism, its severity and his/her participation in this study will be kept confidential from public domain. Only members of the research team will know the name and other details. Your child's name will not appear in any report or publication. However, the overall results of the study will be published in the research journals.

Compensation for participating in the study: Participation in this study is totally voluntary and it does not cause any physical harm or hurt and may even help child with autism because of the interventions they are undergoing. Therefore, there will be no compensation for taking part in the study.

Freedom to withdraw from the study at any time during the study period without the loss of benefits that the participant would otherwise be entitled:

You are allowed to withdraw from the study anytime during study period without losing privileges or benefits of treatment you are receiving from the institute at any cost.

Undertaking by the Researcher

Your consent to participate in the above research by Ms. P. KalaivaniPh.D. Clinical Psychology Scholar, Mizoram University, Aizawal is sought. You have the right to refuse consent or withdraw participation of your child during any part of the research without giving any reason. In such an event, you will still receive the best possible treatment for your child, without any prejudice. If you have any doubts about the research, please feel free to clarify the same. Even during the research, you are free to contact the researcher.

The information provided by you will be kept strictly confidential.

CONSENT TO PARTICIPATE IN RESEARCH STUDY

		YES/ NO
I.	I confirm that I have had adequate explanation and have clearly understood the information sheet of the study and have had the opportunity to ask questions.	
II.	I understand that my child participation is voluntary & that I am free to withdraw my child from the study at any time without giving a reason, without treatment of my child being affected.	
III.	I understand that trained researcher will only do assessment and interventions for my child .	
IV.	I understand that all personal information I share will be kept confidential and will not be shared with anyone other than those involved in the research study.	
V.	I agree to take part in the above study voluntarily.	
VI.	I have received a copy of the study information sheet and consent form.	

Address and mobile number of the Investigator:

P. Kalaivani

Ph.D. Scholar, Department of Clinical Psychology

Mizoram University, Aizawal, Contact No: 9962622365

Signature of the investigator Signature of the parent/guardian:

Place: Date:

Assent Form for Children

***Study Title:* Effect of Cognitive Training on Executive Functions among Children with Autism.**

What is this study about?

You are being asked to take part in a study that looks at how a special type of activity-based training can help improve thinking skills like attention, memory, and planning in children with autism.

Why am I being asked to be in this study?

You are being asked because these interventions would be very much useful for you to improve your skills and lot of children like you have participated and benefited out of such training program.

Will it hurt or be uncomfortable?

No. The activities are not painful or harmful. Sometimes you might feel little tired or difficult, you can take breaks anytime.

Do I have to be in this study?

No. You don't have to be in the study if you don't want to. Saying "no" will not change how your teachers or therapists treat you.

Will anyone know what I say or do?

Everything you do in the study will be kept private. Your name will not be shared in any reports or papers.

Will I get anything for being in the study?

You may not get money or gifts, but the training might help you improve your skills.

Who can I ask if I have questions?

You can ask the researcher or your parents any questions before, during, or after the study.

Do I have to sign this form?

Yes, if you agree to take part, please sign your name below.

Child's Name: ____________________________

Child's Signature: _________________________

Date: ___________________

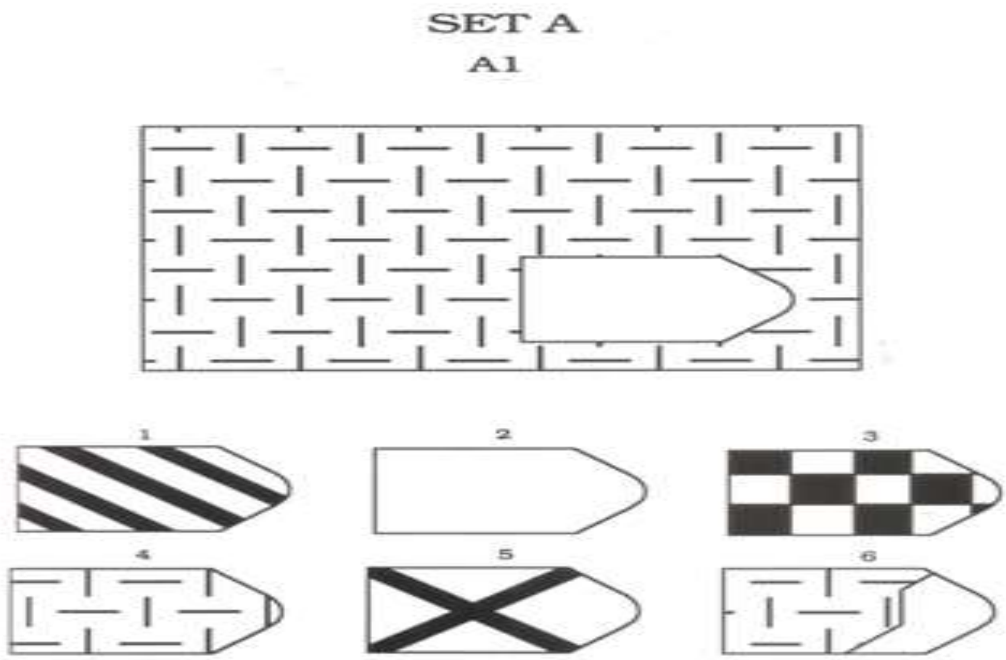
Name and Signature of the investigator _______________

Date: ___________________________

Appendix -III

TOOLS USED

Standard Progressive Matrices (SPM)



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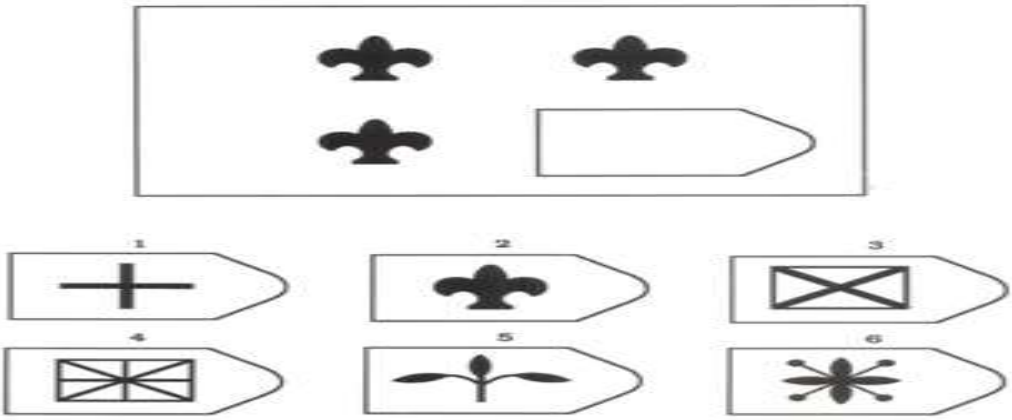

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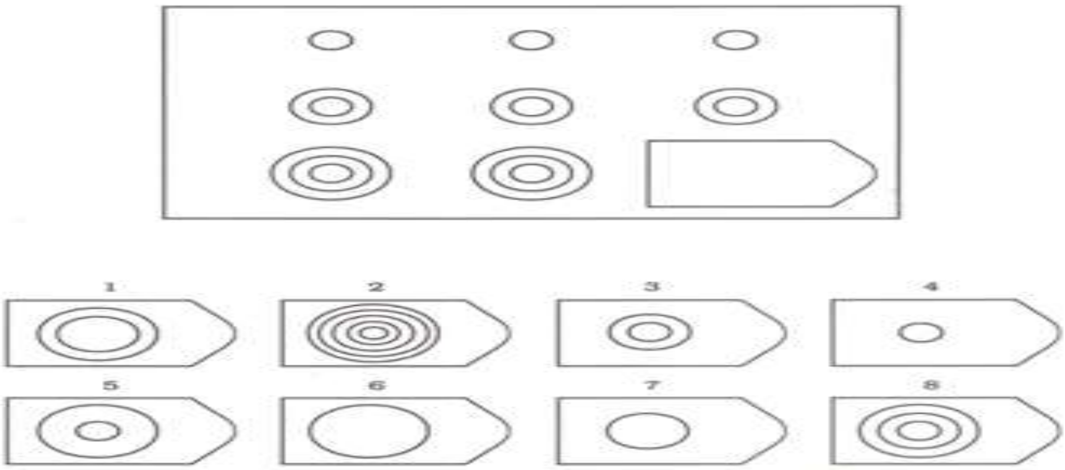

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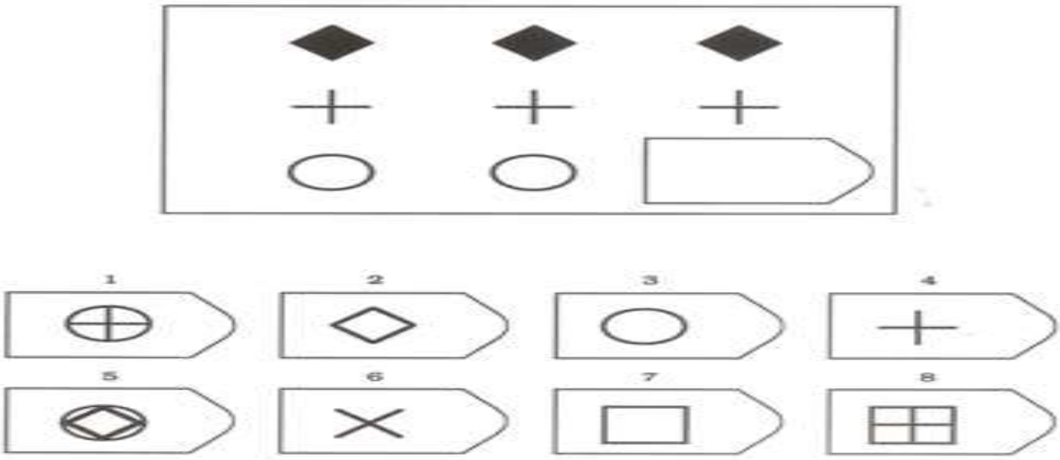


Appendix -IV

Indian Scale for Assessment of Autism (ISAA)

Parent Interview Questions

Domain –I- Social Relationship and Reciprocity

1. Has poor eye contact

- Does the child look at you when you call him/her?
- While asking something does he/she looks at you?
- Call the child and check if he /she look at you, you can also ask the parent to call the child and check his/her eye contact.
- Does the child get fussy when forced to look at people?
- If the child maintains eye contact, check the frequency and duration.

2. Lacks social smile

- Does the child smiles in response to familiar people (Grandparents, relatives/friends)?
- Does the child smile when someone greets him/her?
- Does he smile when father/mother returns home in the evening?
- Does he/she greet others by smiling?

3. Remains Aloof

- Does the child prefer to be alone rather in a group? If yes check the duration and frequency.

- Does the child likes playing with a group of children ?If yes check the frequency and duration
- Does the child wantsparents presence while playing or doing any activity?
- Doe the child feels comfortable being in a group?
- If he /she engaged in group activity how he /she reacts?(Does he/she gets irritated or fussy)
- Does he/she ignore the presence of family members?

4. Does not reach out to others

- Does he/she like being with family members?(Parents, siblings, grandparents)
- Does he/she like playing with his/her siblings/friends?
- Does he/she likes going out with family members?
- Does he/she runs and hugs parents/grandparents/close relatives when they return after a break?
- Is he/she attached to only one family member and ignores others presence?

5. Unable to relate to people

- Does he/she recognizes parents/siblings and other family members.
- Does the child can reach out to his/her parents when in a group?
- Can the child stay away for few days without parent’s presence? If yes check the frequency and duration.

- Does the child clings to parents in a new environment like shopping mall/hospital.

- Does the child have any friend whom he/she likes to play?

6. Unable to respond to social /environmental cues

- How the child behaves when taken to relatives place, family function/friends birthday party?

- How he/she reacts if some family member is happy/sad/angry?

- Does the child behave in his/her usual way by ignoring the social situations?

- Does the child understand the expected behavior in particular situation (when the child is taken to school/ temple).

7. Engages in solitary repetitive play activities

- Does the child prefer playing same game again and again for long duration? (Like playing with crayons/cars/ beads/ strings).

- If the child's play is interrupted how he/she reacts?

- If undisturbed how long he/she continues the same activity?

- Does he/she have any fixated interests? (Like playing by keeping the cars in a line or stacking things).

- When interrupted how the child reacts?

8. Unable to take turns in social interaction

- Does he/she wait for his/her turn in social interaction?

- Can the child wait until the other person finishes his or her conversation?
- Can the child play by taking turns in a game? (Check by asking the child to throw a ball)
- Check frequency and duration.
- Does the child respond to the questions? (Does he/she say - yes/no, or nods head/ speaks in sentences).

9. Does not maintain peer relationships

- Does the child have friends?
- Does he know the names of his/her friends?
- Does he/she prefer playing with any particular child?
- Does he express the wish to play with his/her friends?
- Does he like attending his/her friend's birthday parties?
- Does he share his experiences with his/her friends?
- Does he/she feel close to any particular child?

<u>Domain- II- Emotional Responsiveness</u>

10. Shows inappropriate emotional response

- Does the child cry/laugh inappropriately?(Not matching to the situation)
- Does the child laugh/cry/gets angry without any reason.
- While playing or eating food suddenly does he starts crying or laughing?

11. Shows Exaggerated emotions

- Does the child cry/ laugh/ for long duration.
- Sometimes does he/she behave in an aggressive manner throughout the day?
- If yes check the frequency and duration.

12. Engages in self-stimulating emotions

- Does the child laugh/cry on his /her own?
- If yes check how frequently and for how long he/she laughs/cries.
- Does he/she get aggressive without any reason?
- If he/she gets into any mood is it difficult to change his/her mood?

13. Lacks fear of danger

- Does the child have the fear of falling?
- Does the child know that he/she is not supposed to touch hot things?
- Is he/she alert while walking on road?
- Does the parent need to be alert always to protect the child from dangers?
- Did he/she ever get hurt?

14. Excited or agitated for no apparent reason

- Does the child get excited without any particular reason? If yes check the frequency and duration.(Makes loud noises, jumps, runs)
- How the child reacts if tried to divert him/her.

- Is the child manageable when he gets excited or agitated?

<u>Domain-III-Speech-Language and Communication</u>

15. Acquired speech and lost it

- Does the child lose his/her speech during early years?
- Check is it words, phrases or sentences?
- Check the present level of speech compared to previous years.

16. Has difficulty in using non-verbal language or gestures to communicate

- Check how he/she communicates his / her needs?
- Can the child use gestures (Like pointing) to communicate his/her needs? (Like hunger, thirst, sleep).
- Does the child indicate his/her needs vaguely?
- Does the child say hi and bye nonverbally?
- Can the child understand the nonverbal gestures of others(come, wait, go)
- Check the frequency and duration.

17. Engages in stereotyped and repetitive use of language

- Does the child repeat the same word or sentence repeatedly out of context? If yes check the frequency and duration.
- Does he/she repeat Phrases said by others .(In Television)
- Does the child repeat the same question again and again(Like if the family planed to go out in the evening, does he/she ask when are we going out repeatedly).

- Check for excessive questioning/preoccupation with certain topics of interest.

18. Engages in echolalic speech

- Does he/she repeat the question asked by others instead of answering? (Do you like biscuit?)
- Does the child repeat the phrases, words or parts of words?
- If yes check the frequency and duration?

19. Produces infantile squeals/unusual noises

- Does the child make any peculiar noises?(animal like sounds, high pitched noises)
- Check the frequency/duration and the situations when he/she makes the noises.

20. Unable to Initiate or sustain conversation with others

- Does the child interact on his/her own with others?
- Does the child ask questions?
- Can the child sustain conversation with others(family members, teachers, friends)
- If yes, check the frequency and duration.
- Does he/she respond mostly by nodding his/her head or by saying yes or no?

21. Uses Jargon or meaningless words

- Does he/she use words or phrases which are meaningless?

- Check with parent what type of sounds he/she makes.
- If yes, check the frequency and duration.

22. Uses pronoun reversals

- Does the child say “You want water instead of “I want water”/ Ajay wants water”?
- Does the child have difficulty in using pronouns? (I, me, you, this)

23. Unable to grasp pragmatics of communication (real meaning)

- Does the child understand the real meaning of communication?
- Can the child understand other person’s intentions?
- For Example:
- Break the silence.(Means to talk and not breaking)

Domain-IV- Behaviour Patterns

24. Engages in stereotyped and repetitive motor mannerisms

- Does he/she engage in repetitive behaviors like hand flapping, head nodding, finger wiggling and body rocking?
- If yes, check the frequency and duration.
- Sometimes check if the child uses any objects while engaging in repetitive activities (spinning objects).

25. Shows attachment to inanimate objects

- Does the child plays with strings, threads/ wires?

- Does the child want to keep any object/toy with him/herself throughout the day?
- If parent tries to take it away how he/she reacts.

26. Shows Hyperactivity/Restlessness

- Can the child sit at one place?
- Does he/she move around the house/ classroom?
- Does he frequently get up from the seat?
- Does he/she run around?
- Is it difficult to put him/her to sleep?
- Check the frequency and duration.

27. Exhibits Aggressive Behaviour

- Does the child get angry frequently?
- Does the child shout and scream?
- Is it difficult to control him/her when he/she gets aggressive?
- Check the frequency and duration.

28. Throws temper tantrums

- How the child reacts when his/her demands are not met?
- Does he/she cry/scream/roll on the floor?
- If yes, check the frequency/ duration Intensity.

29. Engages in self InjuriousBehaviour

- Does the child bites/hits self?
- Does the child bangs his/her head?
- If yes check frequency/ duration/Intensity.

30. Insists on sameness

- Does the child insists to follow the same routine every day(brushing, bathing, play time, music time)
- Do he/ she insist on taking same route every day while going to school?
- Does he/she like to wearthe same dress or use same container/spoon?
- Does he/she like to retain the objects with him/her during bed time?
- Does he/she get fussy when there is any change in the routine?

Domain- V- Sensory Aspects

31. Unusually sensitive to sensory stimuli

- Does the child closes his/her ears for certain noises?(Like cooker whistle, mixer noise)
- Does he/she responds by showing startle response to minor sounds/ or ignores loud sounds?
- Does he/she prefer dim light or bright light?
- Check the frequency and reactions of the child.

32. Stares into space for long periods of time

- Does the child look into space?
- If yes, check the situation, frequency and duration.

33. Has difficulty in tracking objects

- Can the child track the moving object?(moving car/bus)
- Check the behavior by asking the child to track a moving toy car.

34. Has unusual vision

- Does the child pick tiny objects from the floor?(Very small beads, threads)
- Does the child focus on insignificant part of a toy or getsfascinated with light?
- How frequently he/she does?

35. Insensitive to pain

- Does he/she feel pain when he/she gets hurt?
- Does he/she cry after getting hurt?
- Does he/she ignore mild pain/injury?
- Does he/she indicate where he/she got hurt?

36. Responds to objects/people unusually by smelling, touching, or tasting

- Does the child put everything in his/her mouth?(Inedible objects-toys, pens, pencils, crayons)
- Does the child likes smellingthings?(Dresses, hair, people)
- Does the child touches/hugs other people?

- Does he/she express dislike when someone tries to touch him/her?
- Doe the child like to eat food of only particular taste?
- Check frequency.

Domain-VI-Cognitive Component

37. Inconsistent attention and concentration

- Does the child pay attention to the given task?
- Can he/she finish the given task?
- Does he/she get distracted easily?
- Does he/she shift his/her attention from one task to the other?

38. Shows delay in responding

- Does the child respond to the questions immediately?
- Do we need to repeat the question or instruction to get the response from the child?
- Does he/she ignore the questions?
- Check the behavior by asking questions.

39. Has unusual memory of some kind

- Does the child remember well phone numbers /routes/mathematics?
- Find out if parents feel that he/she has good memory and in which aspects.

40. Has “Savant Ability”

- Does the child possess any extraordinary ability in drawing, painting/ music?
- Check for any superior ability in the child.

Appendix -V

WISC-IV -Digit Span

3. Digit Span

Start
Ages 6–16:
Forwards: Item 1
Backwards: Sample, then Item 1

Discontinue
Forwards: After scores of 0 on both trials of an item
Backwards: After scores of 0 on both trials of an item

Score
Score 0 or 1 point for each trial
DSF & DSB
Total Raw Score for DS Forwards and Backwards, respectively
LDSF & LDSB
Number of digits recalled on last trial scored 1 point for DS Forwards and Backwards, respectively

Forwards

Trial	Response	Trial Score	Item Score
6–16 1. 2-9		0 1	0 1 2
4-6		0 1	
2. 3-8-6		0 1	0 1 2
6-1-2		0 1	
3. 3-4-1-7		0 1	0 1 2
6-1-5-8		0 1	
4. 8-4-2-3-9		0 1	0 1 2
5-2-1-8-6		0 1	
5. 3-8-9-1-7-4		0 1	0 1 2
7-9-6-4-8-3		0 1	
6. 5-1-7-4-2-3-8		0 1	0 1 2
9-8-5-2-1-6-3		0 1	
7. 1-8-4-5-9-7-6-3		0 1	0 1 2
2-9-7-6-3-1-5-4		0 1	
8. 5-3-8-7-1-2-4-6-9		0 1	0 1 2
4-2-6-9-1-7-8-3-5		0 1	

Backwards

Trial	Response	Trial Score	Item Score
6–16 S. 8-2			
5-6			
1. 2-1		0 1	0 1 2
1-3		0 1	
2. 3-5		0 1	0 1 2
6-4		0 1	
3. 5-7-4		0 1	0 1 2
2-5-9		0 1	
4. 7-2-9-6		0 1	0 1 2
8-4-9-3		0 1	
5. 4-1-3-5-7		0 1	0 1 2
9-7-8-5-2		0 1	
6. 1-6-5-2-9-8		0 1	0 1 2
3-6-7-1-9-4		0 1	
7. 8-5-9-2-3-4-6		0 1	0 1 2
4-5-7-9-2-8-1		0 1	
8. 6-9-1-7-3-2-5-8		0 1	0 1 2
3-1-7-9-5-4-8-2		0 1	

LDSF Max = 9 — Digit Span Forwards (DSF) Total Raw Score (Maximum = 16)

LDSB Max = 8 — Digit Span Backwards (DSB) Total Raw Score (Maximum = 16)

Total Raw Score (Maximum = 32)

5

Appendix -VI

WISC-IV Letter Number Sequencing

7. Letter–Number Sequencing

Start
Ages 6–7: Qualifying Items, Sample Item, then Item 1
Ages 8–16: Sample Item, then Item 1

Discontinue
If child is unable to respond correctly to either Qualifying Item or after scores of 0 on all three trials of an item.

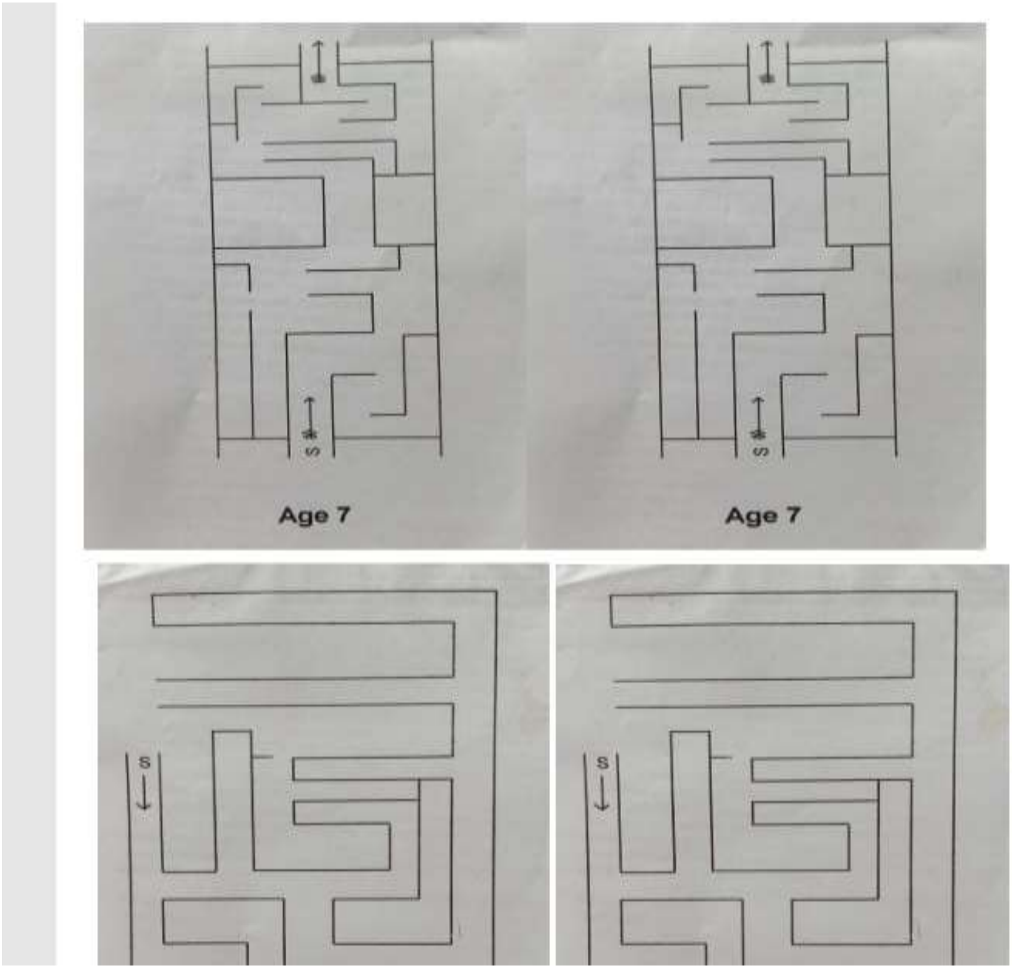
Score
Score 0 or 1 point for each trial

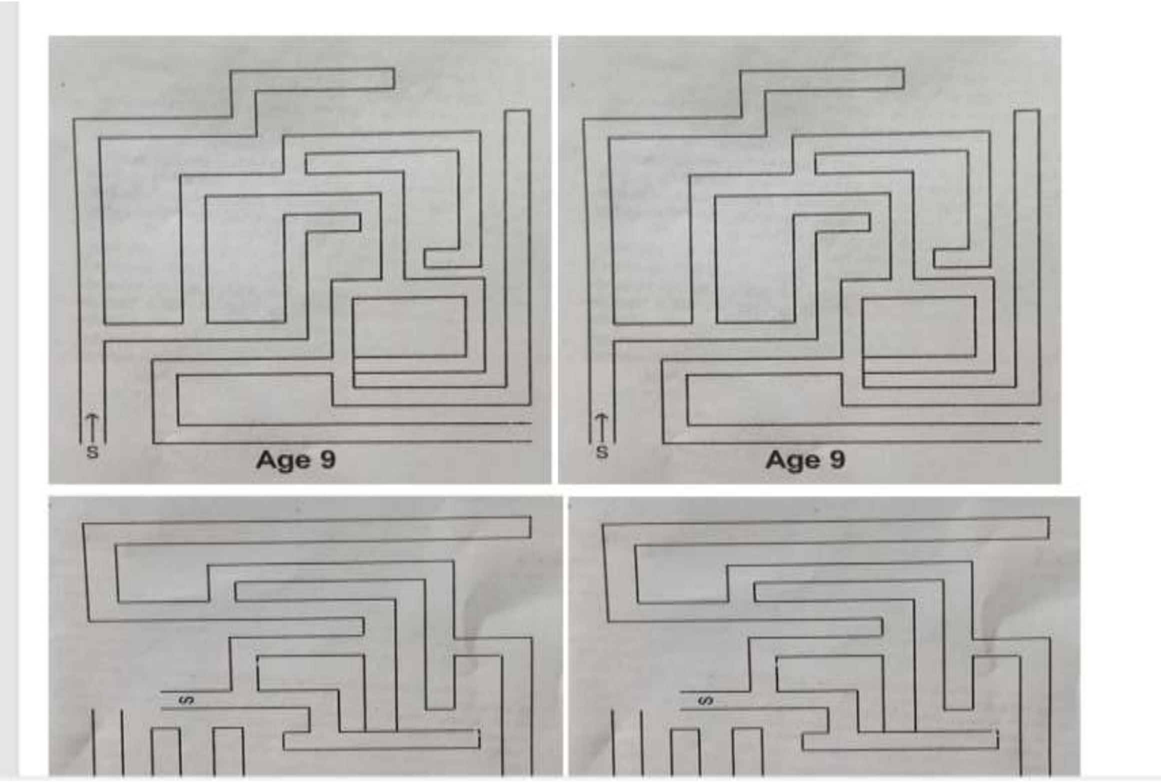
Qualifying Item	Correct Response	Correct
6–7 Counting	Child counts to three.	Y N
Alphabet	Child recites alphabet to the letter C.	Y N

Item	Trial		Correct Responses		Verbatim Response	Trial Score	Item Score
8–16 S.	1.	A - 2	2 - A	A - 2			
	2.	B - 3	3 - B	B - 3			
1.	1.	A - 3	3 - A	A - 3		0 1	0 1 2 3
		If the child responds A-3, immediately correct the child as instructed in the manual.					
	2.	B - 1	1 - B	B - 1		0 1	
	3.	2 - C	2 - C	C - 2		0 1	
2.	1.	C - 4	4 - C	C - 4		0 1	0 1 2 3
	2.	5 - E	5 - E	E - 5		0 1	
	3.	D - 3	3 - D	D - 3		0 1	
3.	1.	B - 1 - 2	1 - 2 - B	B - 1 - 2		0 1	0 1 2 3
	2.	1 - 3 - C	1 - 3 - C	C - 1 - 3		0 1	
	3.	2 - A - 3	2 - 3 - A	A - 2 - 3		0 1	
4.	1.	D - 2 - 9	2 - 9 - D	D - 2 - 9		0 1	0 1 2 3
	2.	R - 5 - B	5 - B - R	B - R - 5		0 1	
		If the child responds 5–R–B or R–B–5, say, Remember to say the letters in order.					
	3.	H - 9 - K	9 - H - K	H - K - 9		0 1	
5.	1.	3 - E - 2	2 - 3 - E	E - 2 - 3		0 1	0 1 2 3
		If the child responds 3–2–E or E–3–2, say, Remember to say the numbers in order.					
	2.	9 - J - 4	4 - 9 - J	J - 4 - 9		0 1	
	3.	B - 5 - F	5 - B - F	B - F - 5		0 1	
6.	1.	1 - C - 3 - J	1 - 3 - C - J	C - J - 1 - 3		0 1	0 1 2 3
	2.	5 - A - 2 - B	2 - 5 - A - B	A - B - 2 - 5		0 1	
	3.	D - 8 - M - 1	1 - 8 - D - M	D - M - 1 - 8		0 1	
7.	1.	1 - B - 3 - G - 7	1 - 3 - 7 - B - G	B - G - 1 - 3 - 7		0 1	0 1 2 3
	2.	9 - V - 1 - T - 7	1 - 7 - 9 - T - V	T - V - 1 - 7 - 9		0 1	
	3.	P - 3 - J - 1 - M	1 - 3 - J - M - P	J - M - P - 1 - 3		0 1	
8.	1.	1 - D - 4 - E - 9 - G	1 - 4 - 9 - D - E - G	D - E - G - 1 - 4 - 9		0 1	0 1 2 3
	2.	H - 3 - B - 4 - F - 8	3 - 4 - 8 - B - F - H	B - F - H - 3 - 4 - 8		0 1	
	3.	7 - Q - 6 - M - 3 - Z	3 - 6 - 7 - M - Q - Z	M - Q - Z - 3 - 6 - 7		0 1	
9.	1.	S - 3 - K - 4 - Y - 1 - G	1 - 3 - 4 - G - K - S - Y	G - K - S - Y - 1 - 3 - 4		0 1	0 1 2 3
	2.	7 - S - 9 - K - 1 - T - 6	1 - 6 - 7 - 9 - K - S - T	K - S - T - 1 - 6 - 7 - 9		0 1	
	3.	L - 2 - J - 6 - Q - 3 - G	2 - 3 - 6 - G - J - L - Q	G - J - L - Q - 2 - 3 - 6		0 1	
10.	1.	4 - B - 8 - R - 1 - M - 7 - H	1 - 4 - 7 - 8 - B - H - M - R	B - H - M - R - 1 - 4 - 7 - 8		0 1	0 1 2 3
	2.	J - 2 - U - 8 - A - 5 - C - 4	2 - 4 - 5 - 8 - A - C - J - U	A - C - J - U - 2 - 4 - 5 - 8		0 1	
	3.	6 - L - 1 - Z - 5 - H - 2 - W	1 - 2 - 5 - 6 - H - L - W - Z	H - L - W - Z - 1 - 2 - 5 - 6		0 1	

Appendix -VII

Porteus Maze Test

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Age 9
S
Age 9
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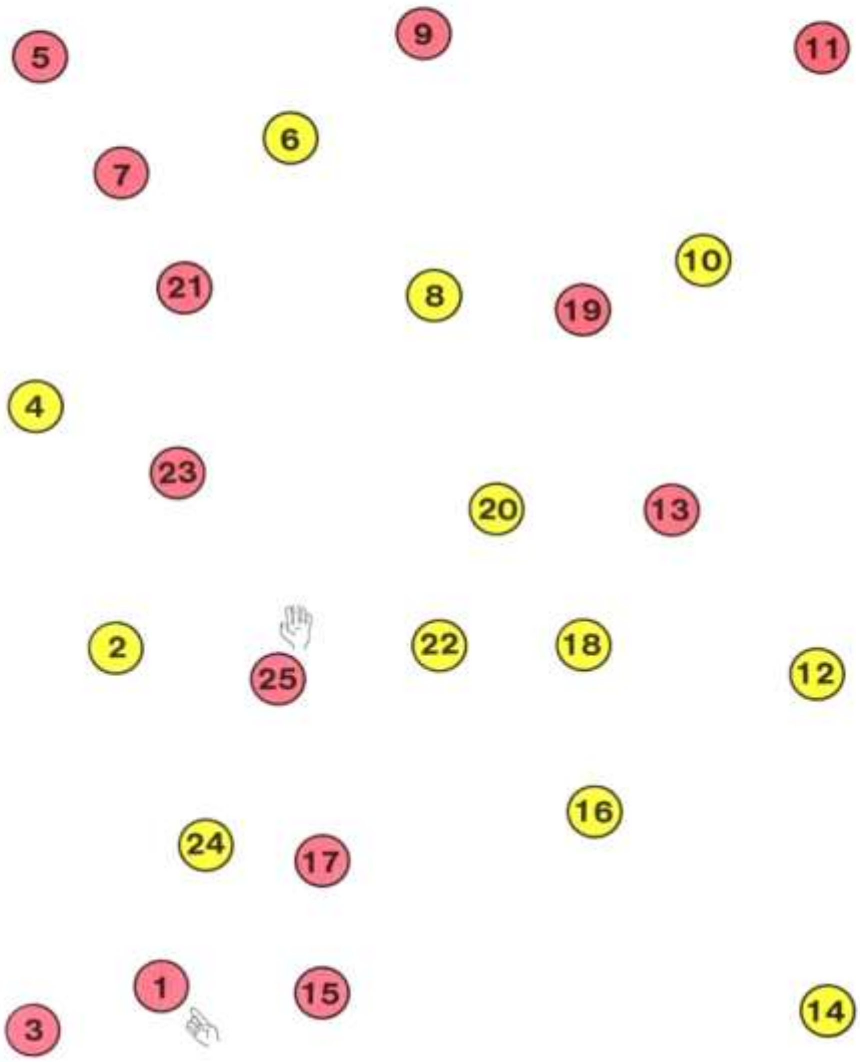
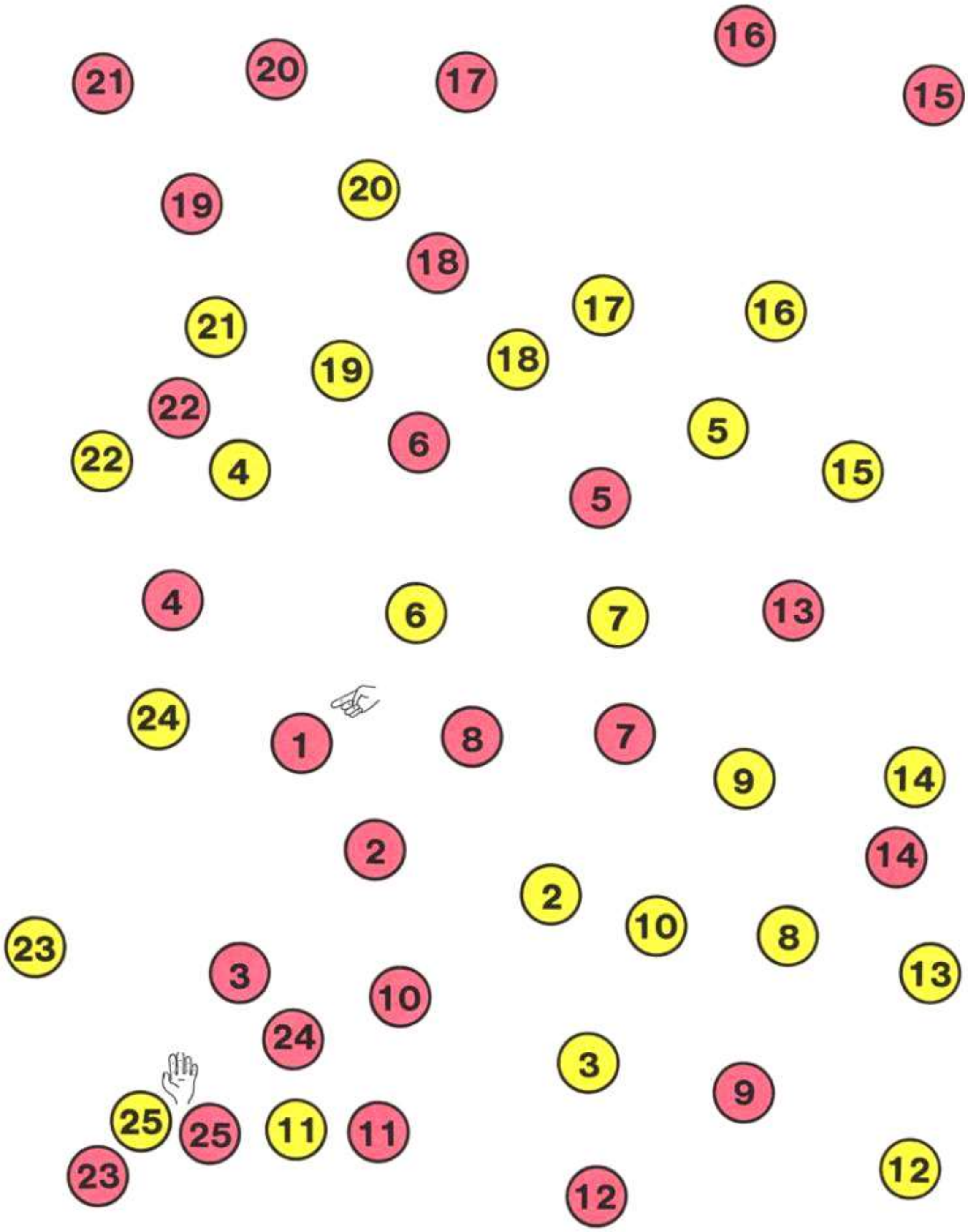
Appendix -VIII

Color Trail Test-Part A

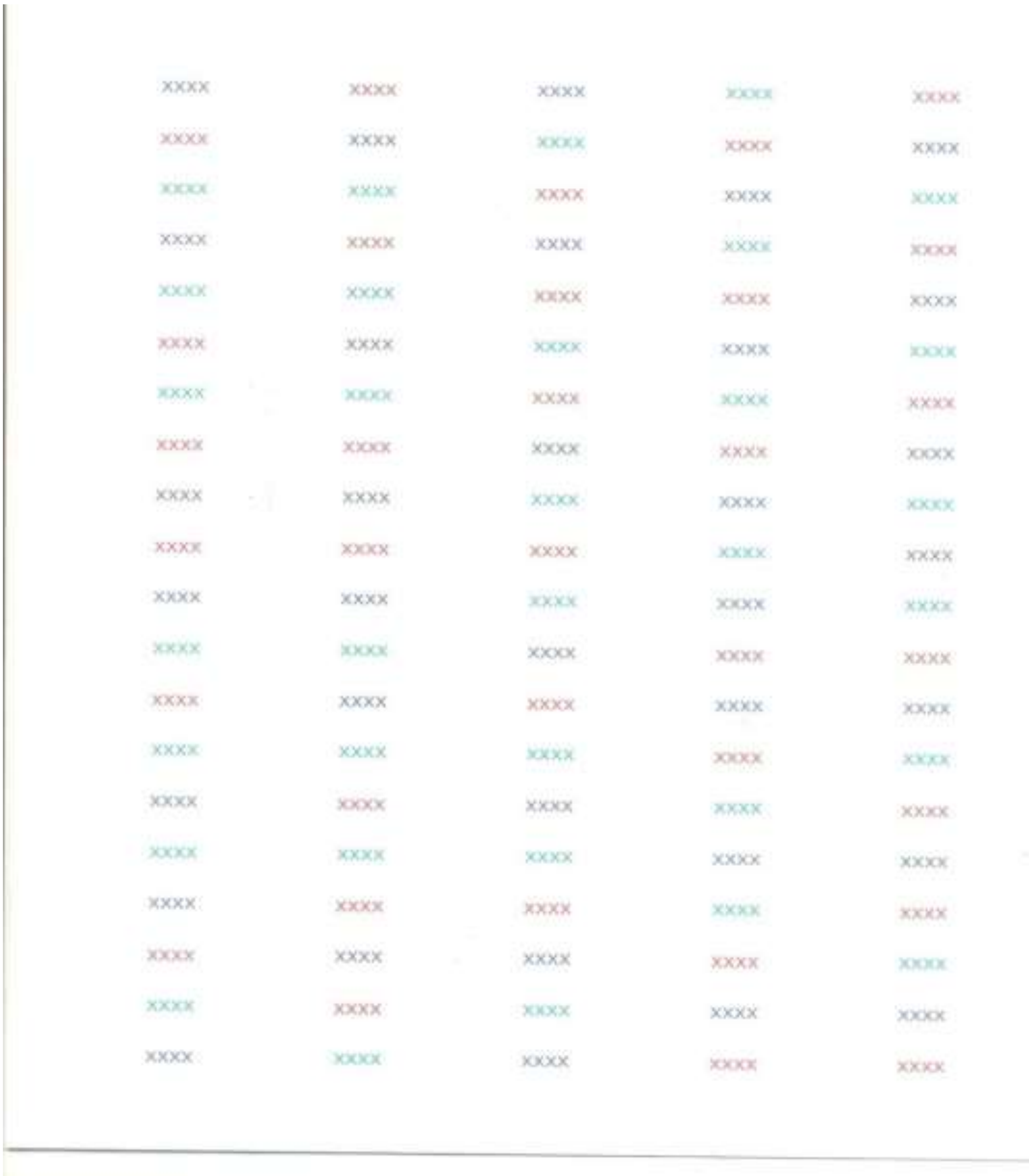


Color Trail Test-Part B



Appendix -IX

Stroop Test for Inhibition



RED	BLUE	GREEN	RED	BLUE
GREEN	GREEN	RED	BLUE	GREEN
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GREEN	BLUE	RED	RED	BLUE
RED	RED	GREEN	BLUE	GREEN
BLUE	GREEN	BLUE	GREEN	RED
RED	BLUE	GREEN	BLUE	GREEN
BLUE	GREEN	RED	GREEN	RED
GREEN	RED	BLUE	RED	BLUE
BLUE	GREEN	GREEN	BLUE	GREEN
GREEN	RED	BLUE	RED	RED
RED	BLUE	RED	GREEN	BLUE
GREEN	RED	BLUE	RED	GREEN
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	GREEN	BLUE	BLUE
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	BLUE	RED	GREEN
GREEN	RED	GREEN	BLUE	BLUE
RED	BLUE	RED	GREEN	RED
GREEN	RED	GREEN	BLUE	GREEN

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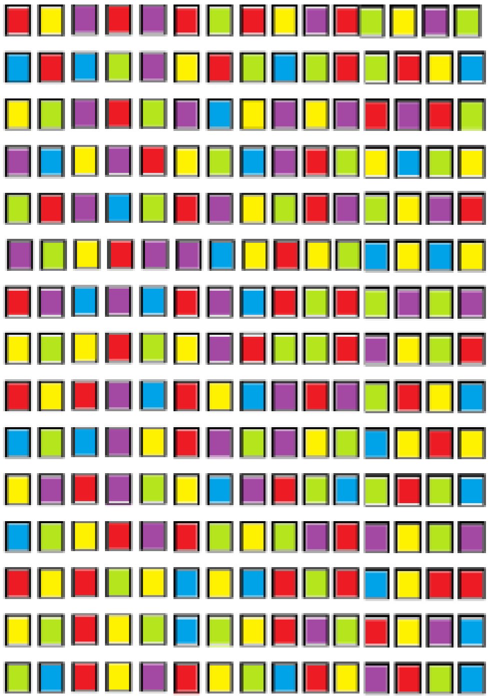
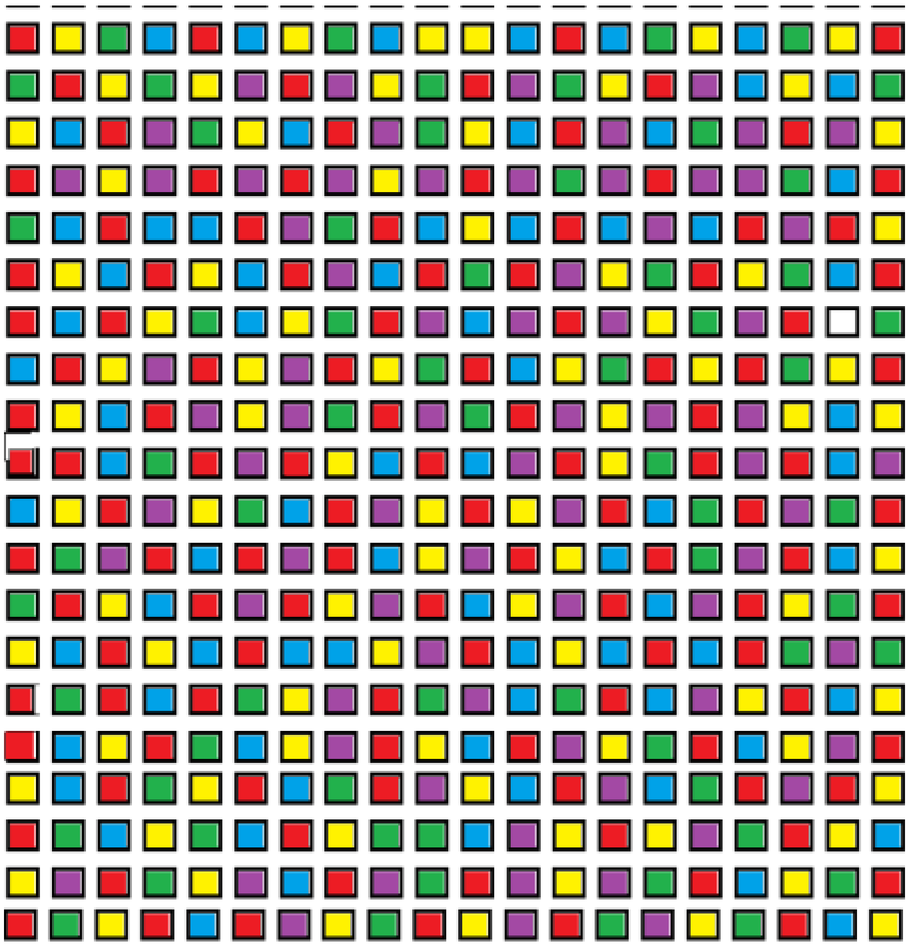
GREEN	RED	BLUE	RED	BLUE
BLUE	GREEN	GREEN	BLUE	GREEN
GREEN	RED	BLUE	RED	RED
RED	BLUE	RED	GREEN	BLUE
GREEN	RED	BLUE	RED	GREEN
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	GREEN	BLUE	BLUE
BLUE	BLUE	RED	GREEN	RED
RED	GREEN	BLUE	RED	GREEN
GREEN	RED	GREEN	BLUE	BLUE
RED	BLUE	RED	GREEN	RED
GREEN	RED	GREEN	BLUE	GREEN

Appendix-X

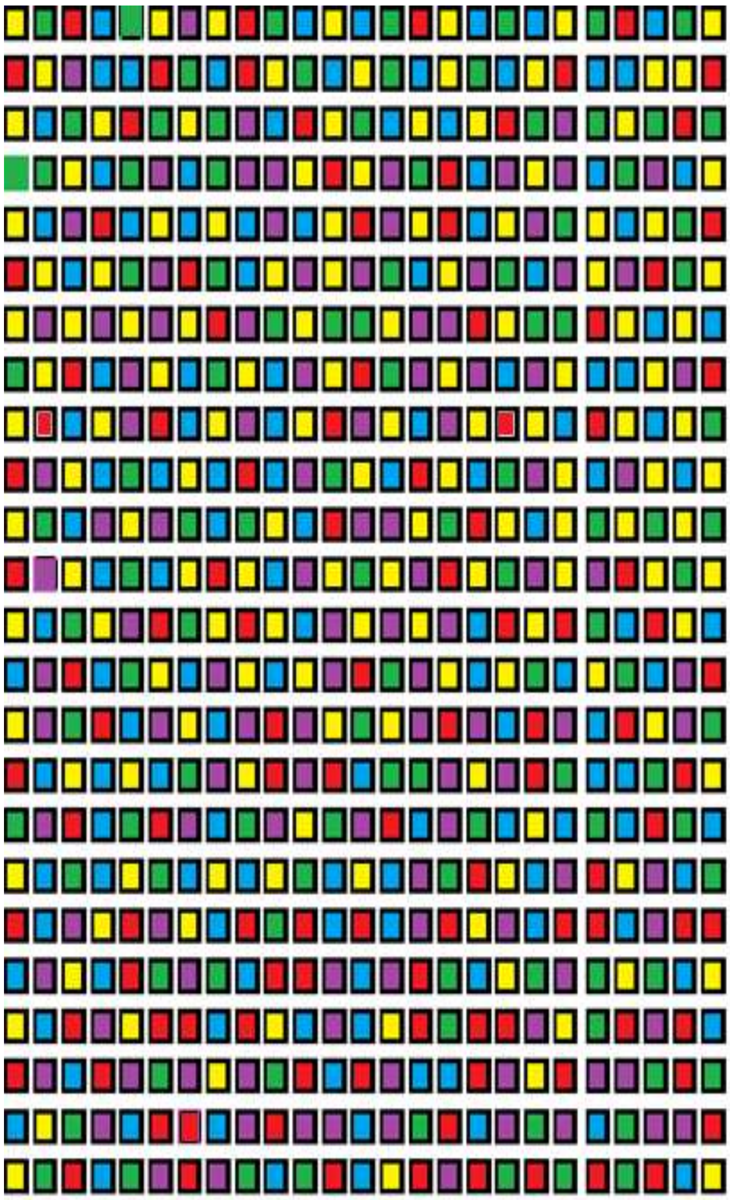
Level-I



Level 2



Level 3



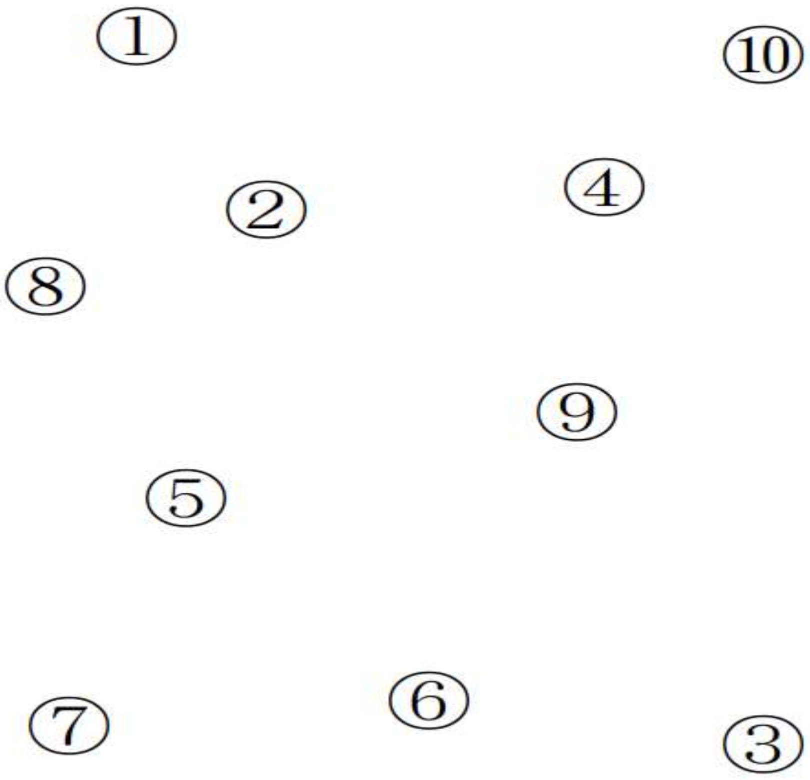
Appendix -XI

Tasks for Attention-Numbers Joining

Level 1

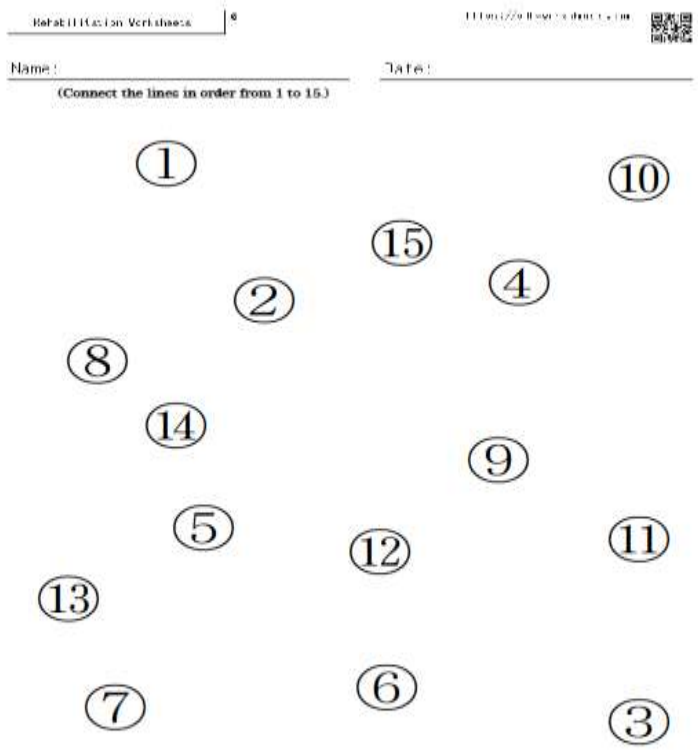
Name: Date:

(Connect the lines in order from 1 to 10.)



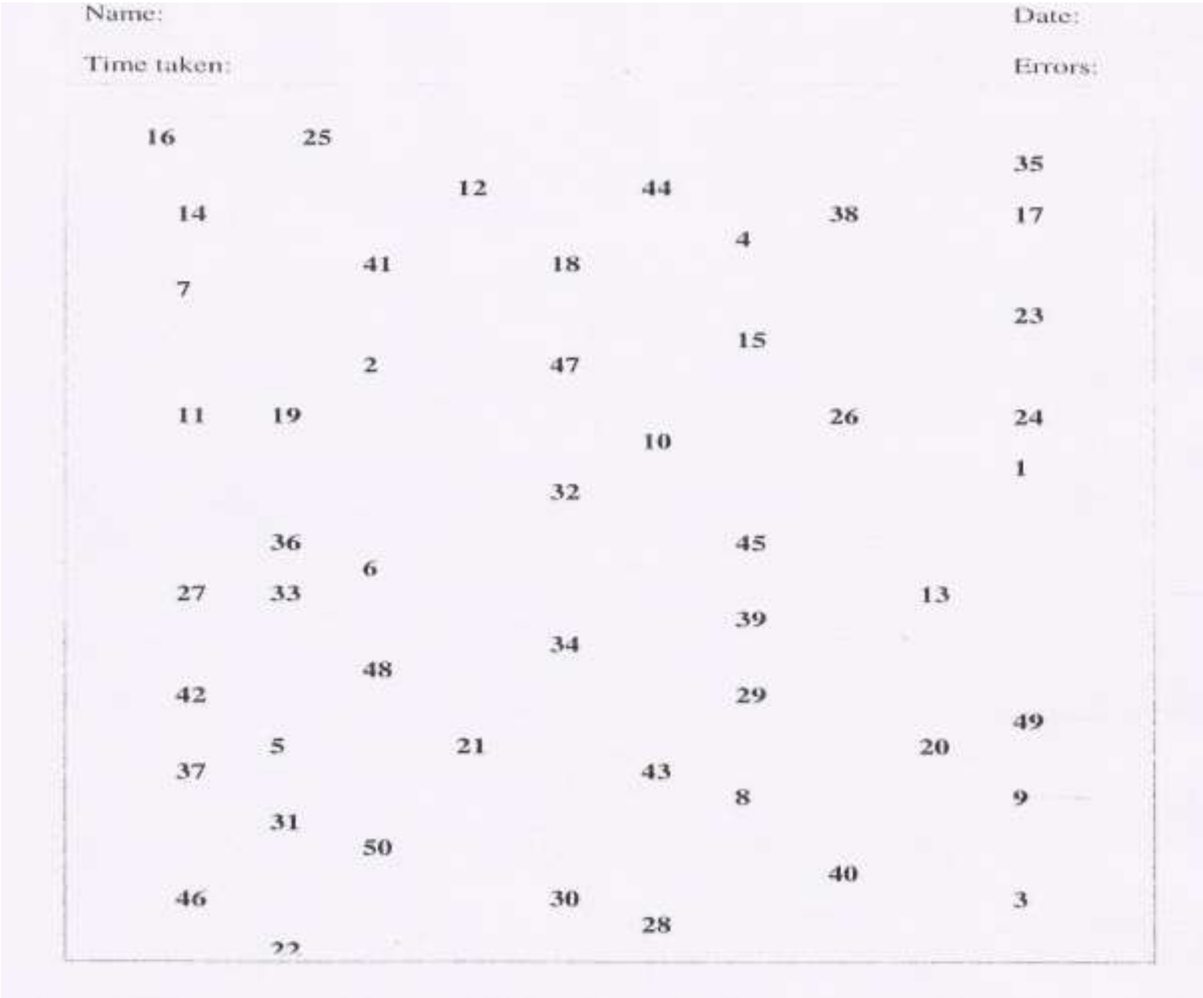
Tasks for Attention-Numbers Joining

Level 2



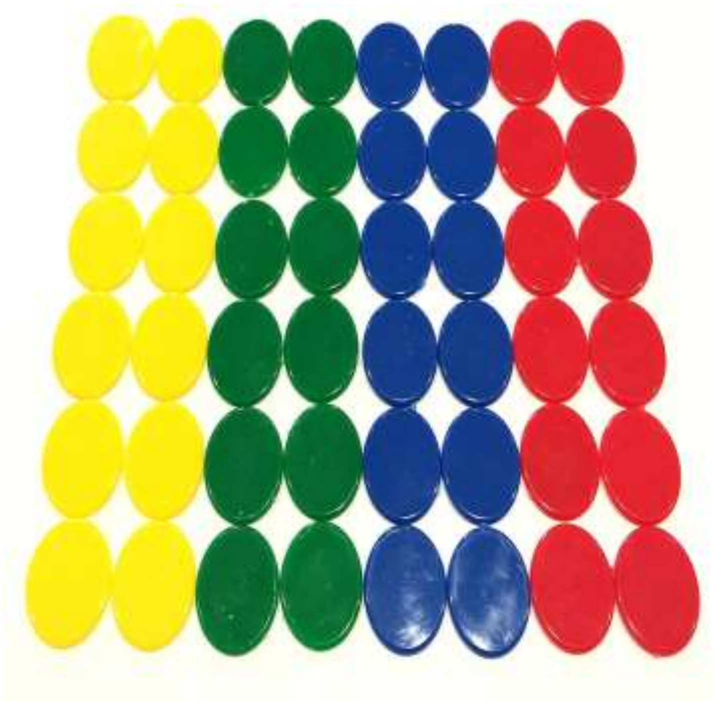
Tasks for Attention-Numbers Joining

Level 3



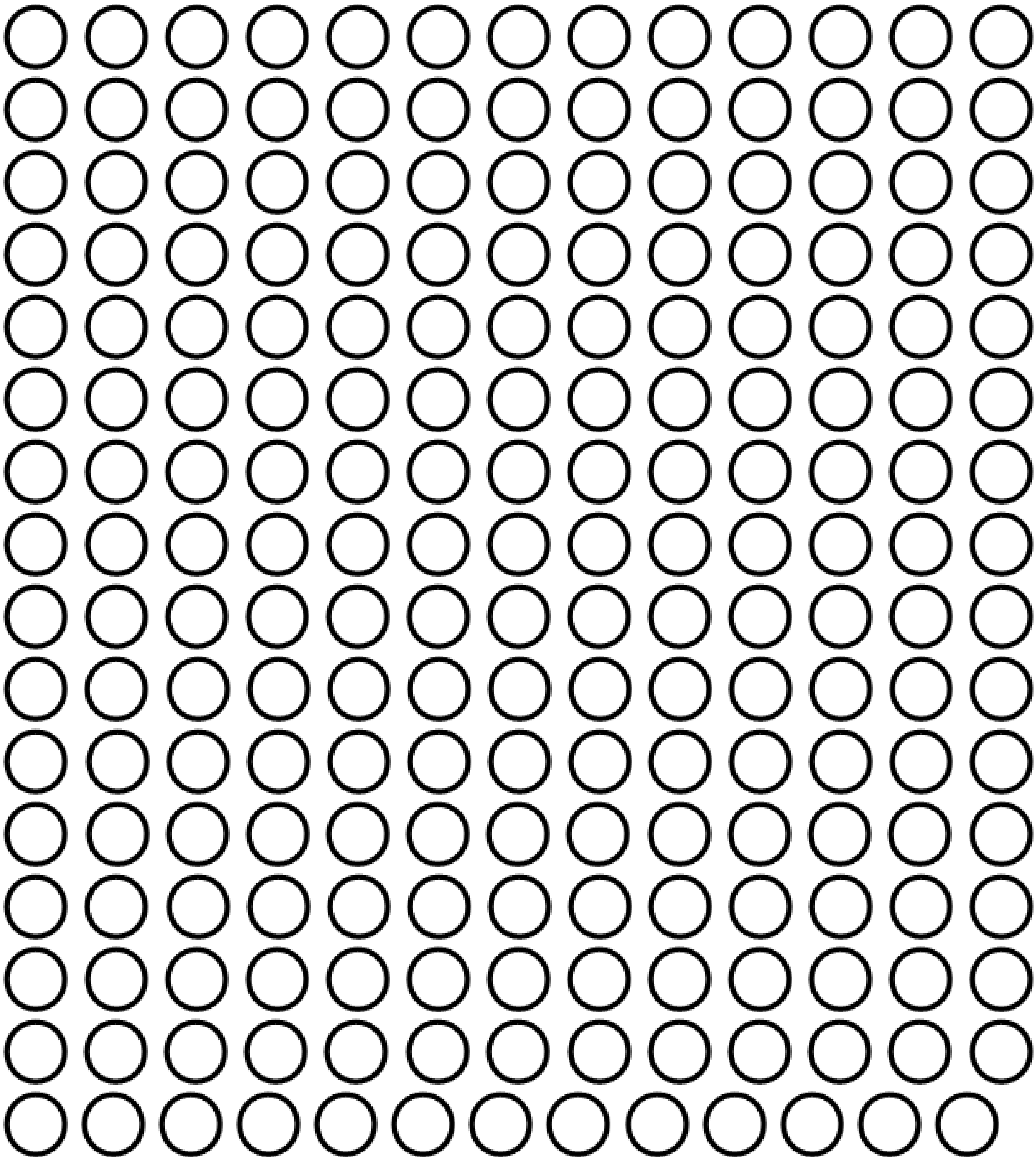
Appendix-XII

Memorizing Sequence of Tokens



Appendix -XIIII

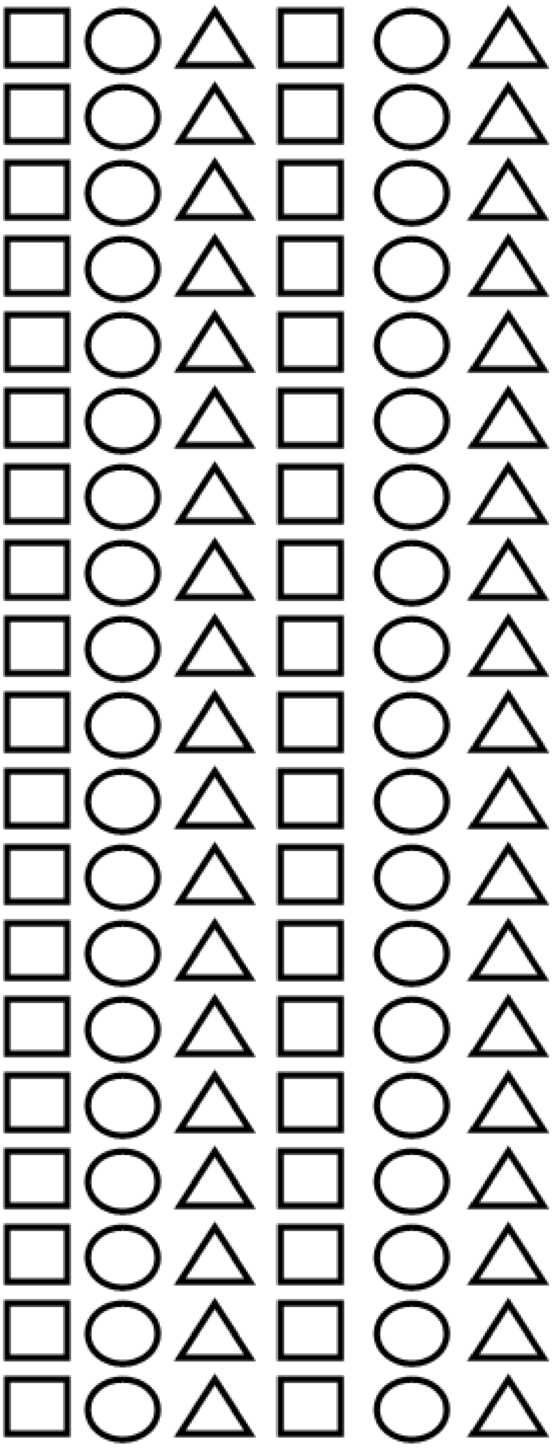
Level 1-Task for Inhibition



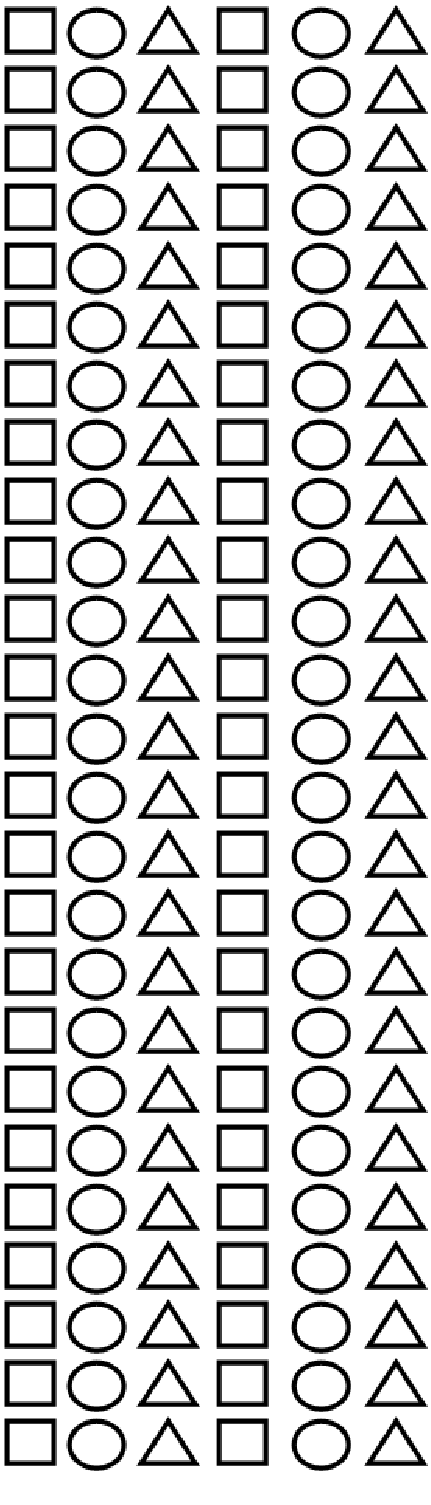
No. of Errors:

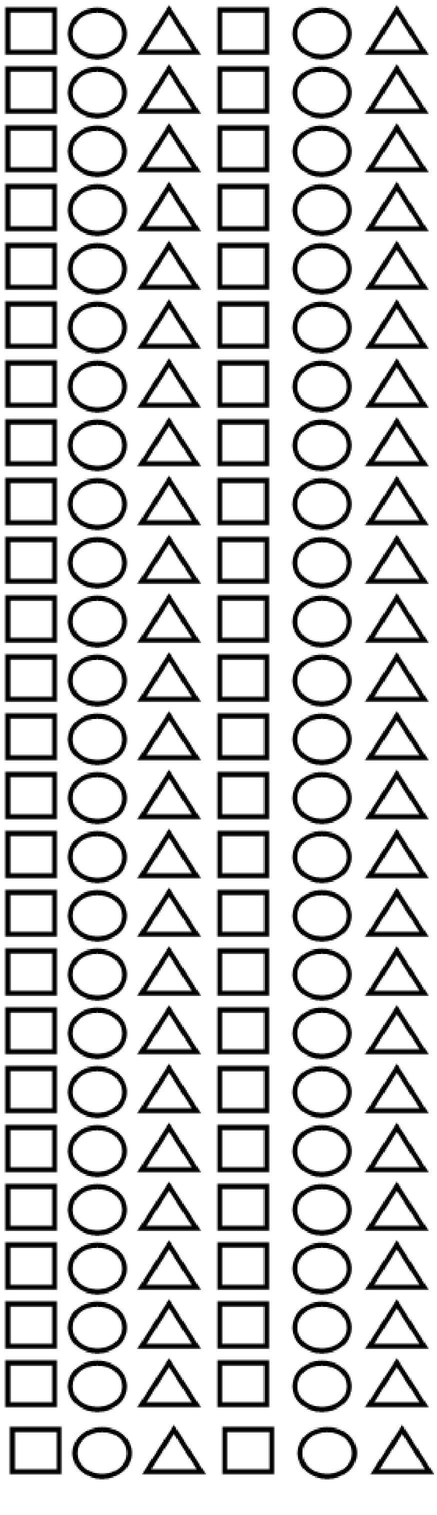
Time Taken

Level-2



Level-3

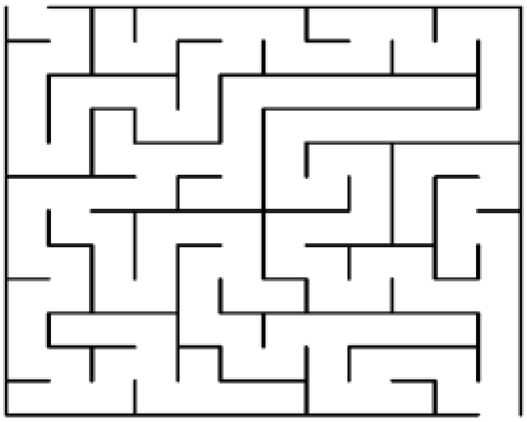




Appendix -XIV

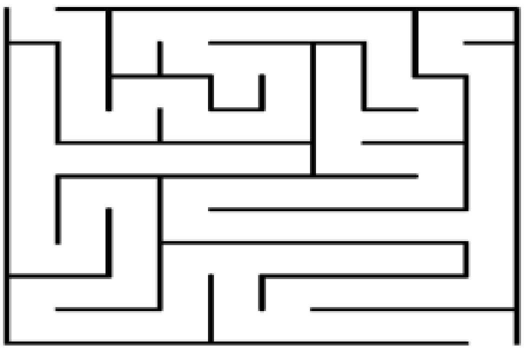
Tasks for Planning-Mazes

Maze Puzzle



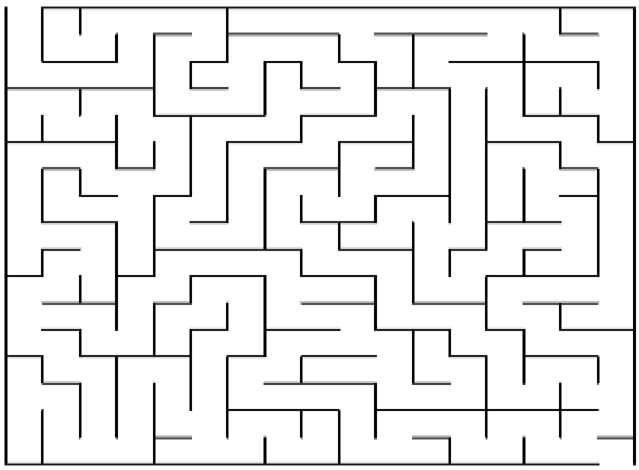
Generated by: mazesforfun.com

Maze Puzzle



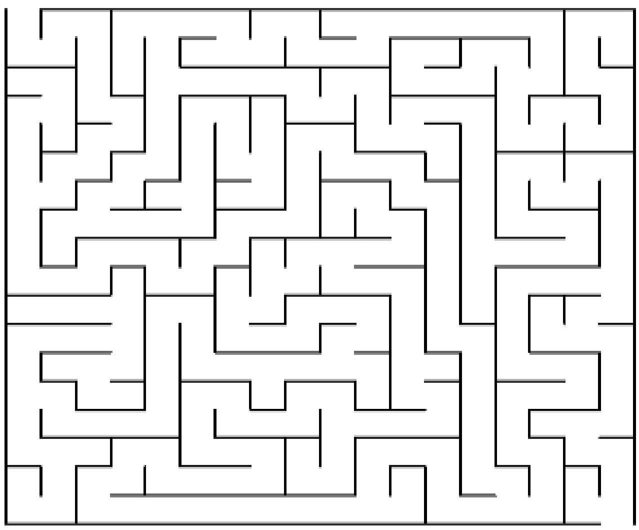
Generated by: mazesforfun.com

Maze Puzzle



Generated by: mazesforfun.com

Maze Puzzle



Generated by: mazesforfun.com

Appendix-XV

Human Ethics Committee
MIZORAM UNIVERSITY
A Central University
(Accredited by NAAC with "A Grade")
Aizawl - 796 004, Mizoram, India

No. MZU/ HEC/ 2023/013

Dated: 04.07.2023

To
P Kalaivani
Department of Clinical Psychology
Mizoram University
Aizawl, Mizoram

The Human Ethics Committee in its meeting held on 04.07.2023 has reviewed and discussed your application to conduct the project entitled; "**Effect of Cognitive Training On Executive Functions Among Children With Autism Spectrum Disorder**".

The following documents were reviewed:

a. Proposal for Ethics Committee and trial protocol (including protocol amendments)/ project.
b. Participant/ Patient Information Sheet and Informed Consent Form (including updates if any) in, English and/ or vernacular language.
c. Current CV of investigator(s).
d. Insurance Policy/Compensation for participation and for serious adverse events occurring during the study participation, if any.
e. DCGI/DBT/BARC/Hospital/ Centre approval letter/submission letter, if any.

Decision of Committee: **Approved**

Member Secretary
Institutional Human Ethics Committee
MZU

Chairman
Institutional Human Ethics Committee
MZU
(DR. JOHN ZOHMINGTHANGA)
MBBS, MD (Path)
Dy Medical Superintendent
Civil Hospital, Aizawl : Mizoram
Regn. No. MCI-6514

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- Published Paper on : Working Memory Among Children with Autism Spectrum Disorder" in Indian Journal of Clinical Psychology, Vol. 51 Jan-June 2024, No. 1-2, 90-95, Copyright, 2024, Indian Association of Clinical Psychologists (ISSN 0303-2582)

- Published Paper on " Mediating role of Acceptance on Parental Stress and Coping among Parents having Children with Autism Spectrum Disorder"., Volume 6, Issue 2, July-December, 2024, ISSN: 2582-1393 (Online) UGC Care List Journal
- Presented Paper on "To study the facilitators and inhibitors of Coping among families having persons with multiple disabilities" in International Conference of Indian Academy of Applied Psychology on 29th January 2022.
- Presented paper on "Working Memory among Children with Autism Spectrum Disorder" in International Conference on Emerging Trends in Psychological Interventions (Health and Allied Sciences): Future Prospects and Challenges on 16th November 2023.

ATTENDED CONFERENCE AND SEMINARS

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- Online Mode on 24th January 2025 organized by NIEPMD.

PARTICULARS OF THE CANDIDATE

NAME OF THE CANDIDATE	: **P. KALAIVANI**
DEGREE	: Doctor of Philosophy
DEPARTMENT	: Clinical Psychology
TITLE OF THESIS	: Effect of Cognitive Training on Executive Functions among Children with Autism Spectrum Disorder
DATE OF ADMISSION	: 14.08.2021

APPROVAL OF RESEARCH PROPOSAL

1. DRC : 30.03.2022
2. BOARD OF STUDIES : 27.05.2022
3. SCHOOL BOARD : 05.07.2022

MZU REGISTRATION NO : 2200624

Ph.D. REGISTRATION NO & DATE: MZU/Ph.D./2025 of 14.08.2021

EXTENSION (IF ANY) : NIL

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INTRODUCTION

Autism spectrum Disorder (ASD) is a lifelong heterogeneous neurodevelopmental condition which includes social and communication impairments and restricted stereotypical patterns of behavior and interests (American Psychiatric Association, 1994). Although the etiological factors of ASD are unknown, the biological factors have been proved to be one of the major contributors, namely the brain pathology. The deficits in executive functions, which is associated with prefrontal cortex is necessary for controlling and regulating behavior and it influences the functional outcomes related to social awareness and adaptive behavior. Executive Functions (EF) is an umbrella term which includes extended group of interacting cognitive processes that are crucial in proper engagement of complex, novel or goal-oriented behaviors that can include physical, emotional and cognitive self-control (Jones et al., 2018). The higher order functions like inhibition, working memory, fluency, planning and flexibility processed in the frontal lobe are major executive functions.

Cognitive Impairment in Executive Functions

People with ASD have dysfunctions with almost all executive functions. People with ASD especially have deficits in cognitive flexibility (Christ et al., 2007), deficits in task initiation (Bramham et al. 2009; Lewis and Boucher 1991; Turner 1999), and working memory (Goldberg et al. 2005; Verte´ et al. 2006). The studies have also found correlation between lack of fluency and stereotypical/repetitive behavior, which is found in ASD (Bishop & Norbury, 2005). It has also been confirmed that repetitive patterns are firmly associated with lack of inhibition (Jones et al., 2018). Language impairment and central deficiencies in ASD, i.e. social impairment and repetitive behavior are also found to be associated with executive function deficiencies (Filipeet al., 2018). Inflexibility in applying social rules and shifting social behaviours or conversational topics could lead to social deficits (Geurts, Corbett, & Solomon, 2009) and lack of generativity could limit one’s ability to generate ideas relevant to the context in conversation with others, resulting in communication impairment (Bishop&Norbury, 2005). Inflexibility in shifting attention could also result in stereotyped behaviour (Mosconi et al., 2009). Several authors have suggested that deficient in EF may also cause some of the social problems in ASD. It has also been suggested that language impairment and central deficiencies in ASD, i.e. social impairment and repetitive behavior also closely associated with executive function deficiencies (Rajendran& Mitchell, 2007). The combination of specific EF impairments in people with ASD has been linked to behavioral characteristics (Kenworthy et al, 2009) and lack of flexibility is observed as one of the main problems of individuals with ASD (Panerai et al., 2014). There is correlation between lack of fluency and stereotypical/repetitive behavior in ASD (F. Golshan, et al., 2019). Language impairment and central deficiencies in ASD like social impairment and repetitive behavior are also tightly associated with executive function deficiencies (Jones et al., 2018).

Cognitive Interventions for Autism Spectrum Disorder

Given the negative impact of executive deficits on the daily functioning of the individuals with Autism Spectrum Disorder, especially concerning autonomy, it is important to target executive functioning directly through evidence-based interventions. It has been well documented that cognitive interventions could have effect on their behaviours and symptomatology. The cognitive interventions focused on cognitive set shifting improved their behavioural flexibilities and repetitive behaviours (Saniee et al., 2019).

Cognitive training exercises have been used in several studies to improve children's performance with repeated practice on executive tasks (Kerns, K.A., 2017). In recent years, a great deal of attention has been paid to improve the executive processes to accelerate the development, stopping or slowing declines, and or to address deficits. Many methods have been explored and it has been noted that "cognitive training" which includes variety of interventions is more effective in improving their behaviours and symptomatology. There are various cognitive training methods available, including downloadable tools, logical games, pencil-and-paper exercises and virtual reality simulations. The computer based applications have been proved to be effective in cognitive training because of the friendly mode of applicability. But there is a tendency for the children with ASD to have increased learning through computer based technology interventions and generalization process in natural settings could be limited especially for children with ASD and henceforth application of noncomputerized programs would be more appropriate for the better outcomes.

METHODS & PROCEDURES

Need for the Study

As the relationship between the executive functions and symptoms of ASD has been well documented, planning interventions is much needed with increasing prevalence of ASD. Many studies have well documented the effect of cognitive interventions in improving the symptoms of ASD, especially their social skills and adaptive behaviors and decreasing their problem behavior. Hence cognitive interventions focusing on executive functions would be a more feasible approach for children with ASD to improve their socio-adaptive behaviors. Moreover, cognitive training studies in individuals with ASD are very limited in Indian settings and hence studying the implication of neurocognitive interventions which is increasingly gaining importance would be more helpful and appropriate to help the children with ASD and with this understanding, present study has been planned by the researcher.

Statement of the Problem

Considering the challenges in people with Autism and role of executive functions in symptoms of Autism, the present study finds out whether cognitive training on executive functions would impact the symptoms of children with Autism.

Aim

The present study aimed to investigate the effect of cognitive training on Executive Functions among children with Autism.

Objectives of the Study

- To assess the executive functions of children with Autism.
- To examine the effect of cognitive training on executive functions of children with autism.
- To examine the effect of cognitive training on symptoms of Autism.

Hypotheses

1. There will be significant impairment in executive functions in children with Autism.
2. Cognitive training will significantly improve the executive functions (attention and cognitive flexibility, working memory, inhibition, and planning ability) in children with Autism.
3. Cognitive training will significantly reduce the symptoms of Autism.

The study participants were selected from National Institute for Empowerment of Persons with Multiple Disabilities (NIEPMD), Chennai, Tamil Nadu, India. The present study was carried out on 40 adolescents, aged between 12 to 16 years both male and female already diagnosed with Autism Spectrum Disorder (ASD) by the qualified mental health professional either Clinical Psychologist or Psychiatrist. The participants were selected who are attending Out Patient Services from NIEPMD. The participants were selected based on the inclusion and exclusion criteria. After the procedure was clearly explained and informed consent was obtained, they were alternatively assigned to two equal groups, namely, Intervention group and Control group.

Inclusion criteria for participants

- Adolescents diagnosed with Autism as per ICD-11.
- Having mild symptoms severity as per Indian Scale for Assessment of Autism.
- Adolescents of both male and female gender aged between 12 to 16 years.
- Adolescents obtaining below average, average, and above average intellectual functioning in SPM.
- Adolescents who can comprehend and speak Tamil or English language.

Exclusion Criteria for participants

- Adolescents having moderate to severe level of Autism symptoms as per Indian Scale for Assessment of Autism.
- Adolescents falling in the category of ‘intellectual impairment’ in SPM.
- Adolescents having any other comorbid neurological disorders/ psychiatric disorders.
- Adolescents with any major medical disorder.
- Adolescents having any other co-morbid physical disability.
- Adolescents n who are already attending any mode of cognitive interventions.

Design of the study

Quasi Experimental Pre Post Research Design

Psychological Tools: The following tools were used in this study:

1. Socio-demographic sheet

A specially designed data sheet was used to collect information on various socio-demographic and clinical variables like age of the child, gender, education, socioeconomic status, parent’s age, type of family, history of any other medical illness, history of any other psychological disorders, and details of any other therapies undertaking.

2. Standard Progressive Matrices (SPM) (Raven, 1938)

SPM was originally developed in mid 1930’s by Raven and it was revised and standardized in Ipswich in 1938. It was designed for use in homes, schools, and workplaces as well as in laboratories. The correlations between item difficulties for different ethnic groups ranged from .97 to .99 in British standardization. Majority of the split-half internal consistency coefficients in the literature exceeded .90. SPM was designed to cover the widest possible range of mental ability and to be equally useful with all persons of all ages, education, nationality or physical condition. Calvert and Waterfall reported retest reliabilities from .83 to .93. The tool was used to assess the intellectual capacity of children with autism since it is easy to administer and it is a nonverbal test.

3. Indian Scale for Assessment of Autism (ISAA) (Ministry of Social Justice and Empowerment, 2008)

This tool was used to assess the severity of autism. As there was no Indian scale to diagnose or measure autism, the National Institute for Mentally Handicapped (NIMH) developed the Indian Scale for Assessment of Autism (ISAA) for diagnosing and measuring the severity of autism in 2009. This scale was based on CARS and has 40 items divided under six domains – social relationship and reciprocity; emotional responsiveness; speech, language and communication; behavior patterns; sensory aspects and cognitive component. The items are rated from 1 to 5, increasing score indicating increasing severity of the problem. A score of <70 indicates no autism, 70-106 (mild autism), 107-153 (moderate autism), and >153 (severe autism). It takes about 15 to 20 minutes for administration of ISAA. The ISAA was devised with the aim of quantifying the severity of autistic symptoms so as to enable measurement of associated disability. ISAA had a sensitivity 93.3, specificity of 97.4, positive and negative likelihood ratios 85.7 and 98.7 and positive and negative predictive values of 35.5 and 0.08, respectively. Reliability was good with validity in sub-optimal range. (r low, in 4/6 domains).

4. Tests for focused attention and cognitive flexibility

Color Trail Test (D'Elia et al., 1996) was developed by WHO and it is test which is free from language and cultural barriers. It has been used to assess focused attention and cognitive flexibility. It also measures cognitive tracking. It has two parts Part A and Part B. The Part A contains circles in two colors namely yellow and pink. The subject is required to serially connect the numbers from 1 to 25 which is randomly placed irrespective of the colors. In Part B, the numbers from 1 to 25 has to be serially connected between two colors yellow and pink. Time taken to complete the task for both trails and errors of both omissions and commissions were recorded. The test contains test-retest reliability of color trails test is reported as .64 for Trail A and .78 for Trail B.

5. Tests for Response inhibition

The Stroop Color-Word Test (Stroop, 1935) - "The Stroop effect" was first described in 1935 by John Ridley Stroop (Stroop, J. R. (1935). Response inhibition measures the perceptual set which can be shifted to conjoin demands by suppressing habitual response in favour of unusual one. The brain area involved in response inhibition is prefrontal cortex. The Stroop test contains color names "Blue", "Green", "Red", and "Yellow" printed in a paper. The subject is asked to read the stimuli column-wise as fast as possible. The time taken to read all the columns is noted down. Then, the subject will be asked to name the color in which the color is printed instead of reading the colors, where the subject is required to inhibit the response. The time taken to name all the colors is noted down. The reading time was subtracted from the naming time to get the Stroop score to assess their performance.

6. Working Memory

Wechsler Intelligence Scale for Children (WISC-IV) constructed by Wechsler. D. (2003) is a test used for assessing cognitive functions in children aged 6–16 years. It is a test used to measure academic potential test in children. WISC-IV consists of 15 subtests, of which 10 are core subtests. It consists of four indices namely Verbal comprehension index, Perceptual Reasoning Index, Working Memory Index and Processing Speed Index. WMI consists of verbal Working Memory tasks (Digit Span and Letter-Number Sequencing) and it was used to measure working memory. Working memory is one of the cognitive domains under executive function and it is an ability to hold information and perform tasks with it. It is essential for comprehension, learning, and reasoning ability. In the Digit span task, the subject is required to repeat the digits in forward and backward given. It consists of two trails and if both the trails are failed, the task is discontinued. It contains the other task, Letter Number Sequencing, in which the subject is given series of numbers and alphabets in random order and the subject is required to sequence both the letter and numbers in order. This requires holding information and manipulating to produce the current sequence of numbers and alphabets given. The total number of correct responses given is considered for scoring.

7. Planning

Porteus Maze Test (Porteus, 1965) –This test used in Malins Intelligence Scale for Children (MISIC) developed by Dr. Arthur J. Malin (1949) which is the subtest of performance scale was administered to assess the planning ability of the child. Porteus Maze test is a measure of planning ability and foresight. The test requires the subject to trace through the maze and reach the end point. The test has 10 mazes of which two were for ages 5 years to 9 years old , four copies for 12 years and 14 years as well as the adult maze. The children version consists of 12 different mazes in which the difficulty increases for each age level from 3 years to 12 years, 14 years, and for adult maze. The child is allowed two trails from 5 years to 9 years of age and four trails for 12 years, 14 years old and for the adult maze. The test is discontinued when the child makes errors on all trails and also if fails in three successive ages. This is not a timed test and the child is required to trace the maze from the starting point to the goal without entering the blinding and not lifting the hand. At each of these mazes completed, success in the first trial gets an addition of one year while success in the second year, addition of half year is credited to the basal age of 4 years.

Cognitive training Module

1. For attention

a. Color cancellation (**Hegde S., 2012**)-For the training purpose, A4 sheet with different colored squares were provided and the participants were asked to strike out all the squares of any two colors within the time limit. The complexity of the task was increased by adding the number of colored squares. It comprises three levels in which the complexity increases with increasing number of squares and number of colors.

b. Number connection (**Hegde S., 2012)-**The task involves serially connecting numbers randomly placed on sheet. The difficulty was achieved by increasing the total numbers to be connected. It has three levels in which the complexity increases by increasing the numbers to be serially connected.

2. Inhibition

a. Design Coloring (Hegde S., 2012)-The task involved coloring a design using color pencils. The evenness in pressure on the strokes and strokes not crossing the borderline of the design were emphasized. The participants were asked to color within the different shapes given in the A4 sheet. The task involves three levels and the complexity was increased by increasing the number and types of shapes.

b. Go-No Go task- The Go/No-Go task requires an individual to withhold a response entirely as opposed to generating an alternate response (Drewe, 1975). The child has to clap the hands when red color is presented and not to clap the hands when blue color is presented. To increase the complexity which has three levels, the number of target colors directing behavior and sequence were increased.

3. **Working Memory**

a. Memorizing pictures were presented from a board/card, identifying on a second board the pictures that were not present in the first board **(Folia PhoniatrLogop., 2017).** It consists of three levels and to increase the complexity, the number of pictures and intruders were increased.

b. Memorizing sequences of colored tokens **(Folia PhoniatrLogop., 2017).** To increase the complexity which has three levels, the number of colored tokens were increased.

4. Planning

Maze completion task (Hegde S.,2012)-Mazes of different complex levels would be used for planning ability (Porteus,1995). Beginning with the start point, the child has to trace the way in the maze without tracing into a blind alley. Different complex level of mazes was used for cognitive training. The complexity of the task would be increased gradually.

Details of the cognitive training Module implemented are as follows:

Cognitive functions	**Activity**	**No of sessions**
Attention	**Color cancellation** • Level 1 (3 sessions) • Level 2(3 sessions) • Level 3(3 sessions) **Numbers joining** • Level 1(3 sessions) • Level 2(3 sessions) • Level 3(3 sessions)	18 sessions
Inhibition	**Coloring within shapes** • Level 1 (3 sessions) • Level 2(3 sessions) • Level 3(3 sessions) **Go-No Go task** • Level 1 (2 sessions) • Level 2 (2 sessions) • Level 3 (2 sessions)	15 sessions
	Memorizing pictures from board a. Level 1 (2 sessions) b. Level 2 (2 sessions)	

Working Memory	c. Level 3 (2 sessions) **Memorizing sequence of colored tokens** a. Level 1 (2 sessions) b. Level 2 (2 sessions) c. Level 3 (2 sessions)	12 sessions
Planning	**Maze activity**	15 sessions
Total Number of sessions		**60 sessions**

Procedure

The study was conducted initially in pilot phase and consecutively, the main phase was conducted.

Pilot phase

A small pilot study was conducted to see the feasibility and applicability of the training module. Five samples diagnosed with Autism by a licensed Clinical Psychologist were selected for the study fulfilling the inclusion and exclusion criteria were selected for cognitive training and totally 20 sessions were carried out for the period of two months. The Rapid naming sequence of colors module was changed to Go-No-Go Task for inhibition as it was found that the task which is nonverbal would be more feasible for the children with Autism. After completion of the sessions, post assessment of the executive functions and symptoms severity of Autism were assessed and the results were found out to be significantly effective.

Main phase

Samples were selected from National Institute for Empowerment of Persons with Multiple Disabilities, Chennai who are attending services at outpatient department. Children already diagnosed with Autism by licensed Clinical Psychologist aged 12 years to 16 years old were assessed with Indian Scale for

Assessment of Autism (ISAA) to assess the symptoms severity of autism and Standard Progressive Matrices (SPM) was used to assess the level of intellectual functioning. Children obtaining below average, average, and above average level of intellectual functioning in SPM and children having mild level of autism in ISAA alone were included in the study. Henceforth, about 40 adolescents, both males and females fulfilling the inclusion criteria were randomly assigned by systematic sampling i.e., first sample was included in the intervention group and consecutively, the second sample was included in the control group. Informed consent from the parents and assent from the child was obtained after explaining the details of the study and nature of the interventions. Neuropsychological Assessments such as Color Trail Test, Stroop Test, WISC-IV Letter Number Sequencing, digit span for working memory, and Porteus Maze Test were administered to assess the baseline functioning of the executive functions of all the children before the interventions. After evaluating the baseline functioning of the executive functions and symptoms level of Autism on each domain, the training module was administered for the children who are included in the intervention group. The intervention was given for the period of six months which comprises two sessions per week. About 60 sessions were given for the children included in the intervention group.

Typical Session

The session was initiated after rapport building with the child and acquiring adequate cooperativeness from the child. The children were given the tasks and their baseline performance was noted, basically the time taken to complete the task and number of errors committed during the task. Each session was carried out for 45 minutes. The complexity of the task was only increased after continued improvement in performance of the task in means of number of errors and time taken reduces for consecutively two sessions. The session was ended with appreciation from the therapist for their efforts. Secondary reinforcements like giving them tokens were also used for children depending upon the children's cooperativeness level. The cognitive interventions were carried out as planned for the period of six months. Post assessment of the executive functions and symptoms of Autism was assessed after the intervention period for both the groups. For the participants in the intervention group, debriefing was conducted about the results and feedback was collected from the participants and further follow up sessions were planned on weekly once basis for the participants who needed further interventions. The participants in the waitlist group would be given similar interventions for the period of two months which were implemented in the intervention group.

RESULTS & DISCUSSION

This chapter presents the results of the study examining the effect of cognitive training on executive functions among children with Autism Spectrum Disorder (ASD). The purpose of this chapter is to report the findings derived from the data analysis in relation to the research objectives and hypotheses formulated in the previous chapters.

1) Sample Characteristics:

Table 1.1: ***Comparison between the participants of Intervention Group and Control Group based on Age:***

Group / Variable	Intervention Group (N=20)		Control Group (N=20)		Mann-Whitney U Test Mean Rank		U	Z
	M	SD	M	SD	Intervention Group	Control Group		
Age (Years)	12.55	2.06	12.10	2.15	21.98	19.03	229.50	0.429

Note. NS= Not Significant

Table 1.1 shows that the Mean Age is 12.10 ± 2.15 for the participants of Intervention group and is 12.55 ± 2.06 for the participants of Control group. The Table further indicates that both compared groups do not differ significantly on 'Age'.

Table 1.2: ***Comparison between participants of Intervention and Control Group based on Gender.***

Group		Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
Variable		Frequency/ Percentage	Frequency/ Percentage	
Gender	Male	17(85)	18 (90)	0.63
	Female	3(15)	2(10)	

The data in Table 1.2 exhibits comparison in terms of Gender and level of intellectual functioning between participants of Intervention and Control Group. The data presented in the table depicts that in terms of Gender, 85% of the participants were male and 15% were female in Intervention group as compared to 90% male and 10% female participants in the control group. The data shows that both the compared groups did not significantly differ in means of 'Gender'.

Table 1.3: ***Comparison between the participants of Intervention and Control Group based on Level of Intellectual Functioning.***

Group	Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
Variable	Frequency/ Percentage	Frequency/ Percentage	

Level of Intellectual Functioning	Above Average	0 (0)	1 (5)	0.484
	Average	13 (65)	11 (55)	
	Below Average	7 (35)	8 (40)	

The data in Table 1.3 exhibits comparison in terms of level of intellectual functioning between participants of Intervention and Control Group. The data presented in the table depicts that 65% of the participants in the intervention group were having average level of intellectual functioning and 35% were having below average level intellectual functioning. However, in the control group,55% of the participants had average level of intellectual functioning and only 40% of them had below average and 5% were having above average level of intellectual functioning. The data shows that both the compared groups did not significantly differ in means of 'Level of intellectual Functioning'.

Table-1.4: ***Comparison between participants of Intervention and Control Group based on***

Group		Intervention Group (N=20)	Control Group (N=20)	Chi-Square Test
Family Type		Frequency/ Percentage	Frequency/ Percentage	
	Nuclear	14 (70)	16 (80)	0.465
	Joint	6(30)	4 (20)	

The data in Table 1.4 exhibits comparison in terms of types of family between participants of Intervention and Control Group. The data presented in the table depicts that 70% of the participants in the intervention group belonged to nuclear family type and 30% of them belonged to joint family type. However, in the control group, 80% of the participants belonged to Nuclear family type and 20% of the participants belonged to Joint Family type. The data shows that both the compared groups did not significantly differ in means of "Family type".

2) Baseline Comparison between Participants of Intervention and Control Group on ISAA Domains and Executive Functions.

Table 2.1: Baseline Comparison between Intervention and Control Group Participants on Various Domains of ISAA.

ISAA Domains	Intervention Group		Control Group		Mann-Whitney U Test				
	Pre-Test		Pre-Test		Mean Rank		U	Z	*p* Value
	Mean	SD	Mean	SD	Intervention Group	Control Group			
Social relationship & Reciprocity	22.80	4.41	21.20	3.38	22.53	18.48	240.5	1.099	.277
Emotional Responsiveness	11.85	2.11	9.70	2.18	25.88	15.13	307.50	2.933	.003**
Speech Language & Communication	17.90	3.55	17.45	4.10	21.35	19.65	217.00	0.462	.659
Behavior Patterns	13.10	1.92	12.35	3.70	21.05	19.95	211.00	0.299	.779
Sensory aspects	8.80	1.91	9.25	1.48	17.98	23.03	149.50	-1.400	.174

Cognitive Component	9.40	2.19	8.40	2.21	22.43	18.58	116.50	1.056	.301

Note **p value significant at 0.01 level

Table 2.1 presents the comparison of baseline ISAA domain scores between the intervention and control groups using the Mann–Whitney U test. The results indicate that the two groups did not differ significantly on most ISAA domains, including Social Relationship & Reciprocity (*z*= 1.099, *p* = .277), Speech, Language & Communication (z=0.462, *p* =.659), Behavior Patterns (*z*=0.299, *p*= .779), Sensory Aspects (*z*=–1.400, *p*= .174), and Cognitive Component (*z*= 1.056, *p*= .301). But, there was significant difference noted between Intervention Group and Control Group in the domain of Emotional Responsiveness (*z*= 2.933, *p*=.003) respectively.

Table 2.2: Baseline Comparison between Intervention and Control Group Participants based on Executive Functions.

Executive Functions	Intervention Group Pre-Test		Control Group Pre-Test		Mann-Whitney U Test				
					Mean Rank		U	Z	*p* value
	Mean	SD	Mean	SD	Intervention Group	Control Group			
DS	2.95	2.28	2.55	1.67	21.03	19.98	189.50	0.293	.779
LNS	8.15	5.82	6.50	7.19	22.20	18.80	166.00	0.941	.369
CTT-A	113.85	48.58	128.55	74.13	19.70	21.30	184.00	-0.433	.678

CTT-B	182.10	64.68	200.45	88.32	18.85	22.15	167.000	-0.893	.383
Stroop-W	54.05	20.28	47.50	23.66	21.33	19.68	216.500	0.447	.659
Stroop-C	43.15	23.51	36.95	18.02	22.00	19.00	230.000	0.812	.429
Stroop-CW	35.65	51.37	20.30	11.55	23.70	17.30	264.000	1.734	.086
Maze	6.70	1.53	6.80	1.96	20.35	20.65	197.000	-0.082	.947

Table 2.2 shows that mean of DS as 2.55 ±1.67 and 2.95 ±2.28 on DS, LNS as 6.50 ±7.19 and 8.15 ±5.82, CTT-A as128.55 ±74.13 and 113.85 ±48.58, CTT-B as 200.45 ±88.32 and 182.10 ±64.68, Stroop-W as 47.50 ±23.66 and 54.05±20.28, Stroop-C as 36.95 ±18.02 and 43.15±23.51, Stroop CW as 20.30 ±11.55 and 35.65 ±51.37, and Maze as 6.80 ±1.96 and 6.70±1.53 for the participants of 'Control' and 'Intervention group, respectively. The mean scores of both groups reveal that all cognitive domains under executive functions are impaired. Overall, the presented data exhibits no significant difference between both the groups in their levels of Digit Span (z= 0.293, p= .779), Letter–Number Sequencing (z= 0.941, p= .369), Color Trail Test–A (z= -0.433, p= .678), Color Trail Test–B (z=–0.893, p=.383), Stroop Word (z=0.447, p= .659), Stroop Color (z= 0.812, p=.429), Stroop Color–Word (z=1.734, p = .086), and Maze Test (z= 0.082, p= .947). The deficits were found in all the cognitive domains under executive functions among the participants belonging to both the Intervention and Control group.

3) Pre-Post Comparison on ISAA Domains and Executive Functions

Table 3.1: Within Group (Pre-Post Training) comparison on ISAA domains of the Intervention Group

ISAA DOMAINS	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z-score	*p*-value
Social Relationship & Reciprocity	22.80	4.41	20.82	3.48	3.937	.001**
Emotional Responsiveness	11.85	2.11	10.55	2.14	3.095	.002*
Speech & Communication	17.90	3.55	17.50	3.43	2.138	.033*
Behavior Patterns	13.10	1.92	10.30	1.78	3.966	<.001***
Sensory Aspects	8.80	1.91	8.65	1.79	0.775	.439
Cognitive Component	9.40	2.19	7.15	2.41	4.029	<.001***
Total ISAA Score	84.10	7.68	74.0	5.75	3.933	<.001***

Note. *** p value significant at .001 level ** p value significant at .01 level* p value significant at .05 level
05 level

Table 3.1 results shows Pre-Post training of intervention group on ISAA domains which exhibits mean of 22.80±4.41 and 20.82±3.48 on Social Relationship and Reciprocity, 11.85±2.11 and 10.55±2.14 on Emotional Responsiveness, 17.90±3.55and 17.50±3.43 on Speech- Language &Communication, 13.10±1.92 and 10.30 ± 1.78 on Behavior Patterns, 8.80±1.91 and 8.65 ±1.79 on sensory aspects, 9.40±2.19 and 7.15±2.41 on cognitive component, 84.10±7.68 and 74.0±5.75 on Total ISAA score. The results of the Wilcoxon Signed-Ranks Test further indicates significant improvements following the intervention in domains of Social

Relationship & Reciprocity (z=3.937, p=.001), Emotional Responsiveness (z= 3.095, p=.002) Speech & Communication (z= 2.138, p =.033), Behavior Patterns (z=3.966, p<.001), Cognitive Component (z=4.029, p<.001), and Total ISAA Score (z=3.935, p<.001). But, there was no significant difference was observed in the Sensory Aspects domain (z= 0.775, p = .439).

Table 3.2: Within Group (Pre-Post Training) Comparison on Executive Domains of the Intervention Group

Executive Functions	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z-score	*p value*
DS	2.95	2.28	5.80	1.40	-3.847	<.001***
LNS	8.15	5.82	10.25	4.91	-3.364	.001**
CTT-A	113.85	48.58	97.10	40.21	-3.921	<.001***
CTT-B	182.10	64.68	155.05	55.99	-3.920	<.001***
Stroop-W	54.05	20.28	50.30	16.84	2.868	.004**
Stroop-C	43.15	23.51	39.60	20.46	-2.958	.003**
Stroop- CW	35.65	51.37	30.20	45.18	-3.948	<.001***
Maze	6.70	1.53	8.20	1.77	-3.197	.001**

Note *** p value significant at .001 level ** p value significant at .01 level ** p value significant at .05 level

Table 3.2 presents the results of the Wilcoxon Signed-Ranks Test comparing baseline and post-intervention executive function scores in the intervention group. Significant improvements were observed across all executive function measures following the intervention. Specifically, participants showed higher post-test scores on Digit Span (z= –3.847, p<.001), Letter–Number Sequencing (z=–3.364, p=.001), and Maze Test (z=–3.197, p=.001). Similarly, significant reductions in completion time were found for Color Trail Test–A (*z*= –3.921, *p*<.001) and Color Trail Test–B (*z*= –3.920, *p*<.001), as well as improved performance on Stroop Word (*z*=–2.868, *p* =.004), Stroop Color (*z*=–2.958, *p*=.003), and Stroop Color–Word (*z*=–3.948, *p*<.001).These findings indicate significant post-intervention gains in attention, working memory, cognitive flexibility, and inhibitory control among the participants.

Table 3.3: Within Group (Pre-Post Training) comparison on ISAA Domains of the Control Group

ISAA DOMAINS	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z-score	*p* value
Social Relationship & Reciprocity	21.20	3.38	21.00	3.12	-1.875	.061
Emotional Responsiveness	9.70	2.18	9.80	2.75	0.390	.697
Speech Language & Communication	17.45	4.10	17.35	3.95	-0.447	.655
Behavior Patterns	12.35	3.70	12.80	3.35	1.617	.106
Sensory Aspects	9.25	1.48	9.55	1.54	1.500	.134
Cognitive Component	8.40	2.21	8.80	2.09	1.496	.135
Total ISAA Score	78.30	7.41	80.0	7.14	2.624	<.01**

Note: **p value significant at .01 level

Table 3.3 shows Pre-Post comparison of control group on ISAA domains, which exhibits mean of 21.20±3.38 and 21.00±3.12 on Social Relationship and

Reciprocity, 9.70±2.18 and 9.80±2.75 on Emotional Responsiveness, 17.45±4.10 and 17.35± 3.95 on speech- language & communication, 12.35±3.70 and 12.80± 3.35 on behavior patterns, 9.25 ±1.48 and 9.55±1.54 on sensory aspects, 8.40±2.21 and 8.80± 2.09 on cognitive component, 78.30 ± 7.41 and 80.0±7.14 on total ISAA score. The results showed difference in the domain of Total ISAA Score (z=2.624, p<.01) after the intervention which indeed has increased post intervention indicating there is no improvement in the Autism symptoms. There was no statistically significant difference in other domains including Social Relationship & Reciprocity (z=-1.875, p=.061), Emotional Responsiveness & Reciprocity (z=0.390, p=.697), Speech, Language & Communication (z=-0.447, p=.655), Behavior Patterns (z=1.617, p=.106), Sensory Aspects (z=–1.500, p=.134), and Cognitive Component (z=1.496, p=.135) among the participants of the control group.

Table 3.4: Within Group (Pre-Post Training) comparison on Executive Domains of the Control Group

Executive Functions	Baseline Assessment		Post Assessment		Wilcoxon Signed-Ranks Test	
	Mean	SD	Mean	SD	Z-score	*p*-value
DS	2.55	1.67	2.35	1.42	-0.816	.415
LNS	6.50	7.19	6.35	6.77	-0.485	.628
CTT-A	128.55	74.13	126.95	77.51	-0.618	.537
CTT-B	200.45	88.32	204.70	92.54	1.740	.082

Stroop-W	47.50	23.66	47.26	23.19	-3.001	<.01 **
Stroop-C	36.95	18.02	36.00	18.01	-1.327	.185
Stroop-CW	20.30	11.55	19.20	11.16	-1.932	.053
Maze	6.80	1.96	6.45	2.04	-1.294	.196

Note. ** p value significant at 0.01 level

Table 3.4 results shows Pre-Post training comparison of control group on executive functions which exhibits mean of 2.55 ± 1.67and 2.35± 1.42 on DS 6.50 ±7.19 and 6.35± 6.77 on LNS, 128.55±74.13 and 126.95± 77.51 on CTT-A, 200.45±88.32 and 204.70± 92.54 on CTT-B, 47.50±23.66 and 47.26±23.19 on Stroop-W,36.95±18.02 and 36.000±18.01 on Stroop-C,20.30±11.55 and 19.20±11.16 on Stroop-CW, 6.80 ±1.96 and 6.45± 2.04 on Maze. Overall, the data exhibits no significant difference between baseline assessment and post assessment of DS (z =-0.816, p=.415), LNS, (z=-0.485, p=.628), CTT-A (z =-0.618, p=.537), CTT-B, (z =1.740, p=.082), Stroop-C (z =-1.327, p=.185), Stroop-CW (z=-1.932, p=.053), and Maze (z =-1.294, p=.196) among the participants of the control group. There is significant difference in Stroop-W (z =-3.001 at p<.01 level) which indicates indeed there is decrease in scores indicating mild decrease in performance on Stroop-W during post assessment.

Table 4.1: Between Group Comparison (Post Training) of Intervention and Control Group on ISAA Domains

ISAA Domains	Intervention Group		Control Group		Mann-Whitney U Test				
	Post-Test		Post-Test		Mean Rank		U	Z	***p* value**
	Mean	SD	Mean	SD	Intervention Group	Control Group			
Social relationship & Reciprocity	20.82	3.65	21.00	3.12	14.78	26.23	85.50	-3.11	.002**
Emotional Responsiveness	10.55	2.14	9.80	2.75	22.58	18.43	158.50	1.133	.257
Speech Language & Communication	17.50	3.43	17.35	3.95	20.93	20.08	191.50	0.231	.817
Behavior Patterns	10.30	1.78	12.80	3.35	16.05	24.95	111.00	-2.428	.015*
Sensory aspects	8.65	1.79	9.55	1.54	17.53	23.48	140.50	-1.634	.102

Cognitive Component	8.80	2.09	8.80	2.09	16.33	24.68	116.50	-2.281	.023*
Total ISAA Score	74.0	7.40	79.25	7.14	15.30	25.70	96	-2.829	.005**

Note:, **p value significant at .01 level, *p value significant at .05 level

Table 4.1 shows post training comparison of various domains of ISAA and Total Score between Intervention and Control Group participants. Significant differences were observed in Social Relationship & Reciprocity (z =-3.11, p=.002), Behavior Patterns (z=-2.428, p=.015), Cognitive Component (z=-2.281, p=.023), and Total ISAA Score (z=-2.829, p=.005), indicating improvement in symptoms of these domains compared to the pre-assessment. But, there was no significant difference noted in Emotional Responsiveness (z=1.133,p=.257), Speech, Language & Communication (z=-0.231, p=.817) and Sensory Aspects (z=-1.634, p=.102) indicating that these domains did not have improvement post training.

Table 4.2: Post Training Comparison between Participants of Intervention Group and Control Group on Executive Functions.

Executive Functions	Intervention Group Post-Test		Control Group Post-Test		Mann-Whitney U Test				
					Mean Rank		U	Z	p value
	Mean	SD	Mean	SD	Intervention Group	Control Group			
DS	5.80	1.40	2.35	1.42	29.65	11.35	17.00	4.995	.001***
LNS	10.25	4.91	6.35	6.77	24.30	16.70	124.00	2.070	.038*
CTT-A	97.10	40.21	126.95	77.51	18.55	22.45	161.000	-1.055	.291
CTT-B	155.0	55.99	204.70	92.5	16.75	24.25	125.00	-2.029	.042*

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STROOP- W	50.30	16.84	47.26	23.19	20.18	19.82	186.500	0.098	.922
STROOP-C	39.60	20.46	36.00	18.01	21.08	19.93	188.500	0.311	.755
STROOP-CW	30.20	45.18	19.20	11.16	22.10	18.90	168.000	0.867	.386
MAZE	8.20	1.77	6.45	2.04	25.25	15.75	105.00	2.602	.009**

Note. *** p value significant at .001; ** p value significant at .01 level; *p value significant at .05 level

Table 4.2 shows the post training comparison between Intervention and Control Group on executive functions. The data indicates a mean of 5.80±1.40 on DS, 10.25±4.91 on LNS, 97.10±40.21on CTT-A, 155.05 ± 55.99 on CTT-B, 50.30±16.84on STROOP-W, 39.60±20.46 on STROOP-C, 30.20±45.18 on STROOP-CW, and 8.20±1.77on MAZE for participants of the Intervention group and 2.35±1.42 on DS, 6.35±6.77on LNS, 126.95±77.51on CTT-A, 204.70 ± 92.54 on CTT-B, 47.26 ±23.19 on STROOP- W, 36.00 ±18.01on STROOP-C, 19.20 ±11.16 on STROOP-CW, and 6.45 ± 2.04 on MAZE for participants of the control group. Results further reveals significant difference between both compared groups on DS (z=4.995 at p<.001 level), LNS (z=2.070 at p.=.038 level), CTT-B (z=-2.029 at p=.042) and maze (z=-2.602 at p=.009), but no difference was noted in other domains such as CTT-A (z=-1.055, p=.291), STROOP-W (z=0.098,p=. 922), STROOP-C (z=0.311, p=.755) and STROOP-CW (z=-0.867, p=.386).

Discussion related to Methodology

Sample

The sample of the study included children aged between 12 and 16 years, both male and female, who were pre-diagnosed with Autism. In this study, the number of samples included more boys than girls. The research has well proven that the prevalence of ASD is higher in boys than in girls. Most epidemiological studies have demonstrated that the general ratio of boys and girls is 4:1. Research has proven that biological and genetic factors play a role, making boys more susceptible to autism than females. Females have a higher threshold than males (Werling & Geschwind, 2013). The previous research done by Werling (2013) also stated that the prevalence of autism is higher in males when compared to females, especially in individuals with intact intellectual functioning. A female protective theory also states that females have a higher threshold, and the symptoms in females are also underdiagnosed due to the manifestation of subtle symptoms than in males, contributing to lower prevalence. Hence, the current study also included more boys than girls.

Both males and females were included in the study because literature evidence indicates no significant differences in executive functions between them. A study done by Demetriou et al. (2018) concluded that executive dysfunction in ASD is relatively stable across development with no evidence for fractionation by sex or other moderators. This suggests that males and females with ASD generally show similar EF profiles, and therefore, including both genders in the interventions would not impact the results. The effect of cognitive training did not show a significant difference in many studies, and it has been proven effective in both males and females. The survey, which did brain imaging studies, has identified subtle differences in brain connectivity and adaptive behaviors, but they may not consistently affect the efficacy of cognitive training (D'Aiello et al., 2023). Hence, the difference in the number of male and female samples would not affect the study's outcome, as previous findings justify.

In this study, although both nuclear and joint family types were included, there was a greater prevalence of atomic family types. This is because the current study was conducted in an urban area where the nuclear family type is prevalent. Hence, a larger number of children from atomic families could be attributed to this factor. Parents were psycho-educated about their involvement and the significance of the cognitive training before the session started. Therefore, the impact of the family type on the outcome of cognitive training would be very meager in this current study.

The current study involved children in the adolescent period because executive functions are somewhat well-formed during this stage. Although rapid development occurs during the preschool years, it is at a rudimentary stage during early childhood. Adolescence is marked by the maturation of more complex executive functions such as abstract reasoning, planning ability, and inhibition, unlike children below 12 years. Therefore, considering the age group from 12 years and above is more reasonable. The previous research evidence has proved that attention skills and working memory mature more across adolescence (Crone & Dahl, 2012). Another study by Steinbeis and Crone (2016) has also supported the current research, reiterating that cognitive flexibility in adolescents for decision-making when accomplishing novel tasks was found to increase. Moreover, the EF difficulties, such as flexibility, inhibition, and planning, are interwoven with autism features, and it is challenging to delineate them into distinct domains and differentiate them from symptoms of ASD and EF difficulties. Especially in young children with ASD, capturing EF deficits may be still more difficult. The psychological assessments of EF functions would be more difficult for young children to comprehend and execute compared to older children. Considering all the demands and restrictions, the children aged 12 years and above were included in the study.

In terms of intellectual functioning, the children whose intellectual level was dull (below) average and above, were only included in the study because the children with intellectual impairment would have impairments in other cognitive functions as well, and there would be a high discrepancy in performance on executive functions when compared with children having average intellectual functioning. Moreover, cognitive training among children with autism who have any intellectual disability may not be feasible, as they would have difficulty comprehending and executing the task, which would be one of the significant limitations in carrying out the study. The outcome results of children with intellectual disability will have more discrepancies with children having average intellectual functioning because of the baseline differences in their executive functions. The study by Benyakorn et al. (2018) found that while executive cognitive training for children with autism spectrum disorder was beneficial, they required additional accommodations, such as extended weeks beyond the training period and longer task durations. Hence, the current study excluded children with intellectual disability. According to the survey done by Memisevic & Sinanovic (2014), the children with ID had significant deficits in EF. The meta-analysis study done by Spaniol & Danielsson (2022) also concluded that problems in executive functions are more common in individuals with intellectual disability than in standard age-matched controls. Hence, all these studies justify the need for excluding the children with intellectual impairment in the current study.

Regarding the severity of symptoms, children with a Mild level of symptom severity on ISAA were only included in the present study. Research done by Petrolo et al. (2025) proposed that children with severe ASD have more impairment in executive functions, particularly in inhibitory control, compared to flexibility. This suggests that as autism symptom severity increases, deficits in basic self-regulation, like impulse control, become more pronounced. Another study done by Valeri et al. (2020) also observed that children with severe Autism showed greater impairments in inhibitory control and further suggested there is a potential association between inhibitory control and the severity of autism symptoms. There are many feasibility challenges while adopting cognitive training in children with severe symptoms of autism, such as having more difficulty in attention, comprehension, and following instructions independently. The cooperation and motivation issues during the cognitive training among children with severe autism symptoms have also been reported in the study, which would be another challenge if including the children with severe symptoms of autism. The translation observed during cognitive training to improvements in real-world situations, such as daily living, social interaction, or adaptive functioning, might be limited due to pronounced communication and behavioral difficulties. Hence, this study included only children with mild autism, considering the limitations and practicality issues during the intervention period.

Tools Used

In the present study, tests with proven efficacy have been used to assess the executive functions of the participants. For assessment of executive functions, the color trail-making test was used to evaluate focused attention and cognitive flexibility. The digit span and letter-number sequencing were used to assess working memory. The Stroop test was used for inhibition, and the maze test was used for planning. All these tests were nonverbal in nature, and it is more feasible for children with Autism and can be administered to children who do not have literacy in English, and the time required to complete the test is also significantly less,. The test used by Pastor-Cerezuela et al. (2016) accounted for the fact that language proficiency in semantic fluency tasks might influence the test's performance in children with autism. These tests can be used with nonverbal instructions, further supporting its use among children with Autism. Moreover, the normative and validation data of the test also include children with neuropsychological disorders, enriching the appropriateness of using this test in children with ASD to distinguish the altered neuropsychological functioning among children with autism. The ISAA scale was used to assess the severity of symptoms, which is a standardized tool for Indian Children. Hence, all the tools used for assessment were applicable for children with autism, as supported by previous studies.

Procedure

After selecting the samples, the cognitive intervention module was chosen based on previous research, particularly that by Hegde S. (2012), which has demonstrated its efficacy in improving executive function through tasks. The participants were divided into an intervention group, which received the cognitive interventions, and a control group, which did not. The interventions were planned twice a weekfor 6 months. A six-month period aligns with the timeframe and is sufficient to provide both short-term improvements and medium-term consolidation during this period of intervention. A six-month period allows monitoring both immediate gains and maintenance of changes, providing more substantial evidence for intervention effectiveness compared to shorter trials. This has been documented in a study by Hajri (2019), which found that using noncomputerized interventions, one session per week for six months, showed significant positive effects on neurocognition and clinical symptoms. Hence, the cognitive intervention planned for about six months was imparted considering its effectiveness in previous literature.

The protocols used for attention involved coloring the given colors and gradually increasing the number of colors. This task is nonverbal, and using colors would be more attractive and engaging for children. This task involves visual scanning, sustained attention, and concentration, and it must be completed within a time frame. For children, bright and distinct colors are more engaging. This task involved canceling bright colors like red, blue, green, yellow, and purple, which would help the children sustain motivation and compliance. Especially for children with autism, using language components like numbers or letters can be a more demanding task. The other task involves serially connecting randomly placed numbers. This task is especially suitable because the rule-based nature of joining numbers aligns well with children with autism, as they prefer more structured and routine tasks. It also enhances visual scanning and spatial organization, which is more commonly difficult for them. The task does not require any language ability to comprehend or execute. It is a more child-friendly and structured task that enhances their attention and other cognitive functions.

For inhibition, coloring within shapes was used, which involves hand-eye coordination, sustained focus, and self-regulation. It supports rule following and strengthens the fine motor skills as well. Avoiding crossing boundaries also helps to improve selective attention. The children are allowed to use colors of their choice, which helps them express themselves while adhering to rules and structure. The working memory task involves the child remembering the sequence of colored tokens. This task involves more visual processing than verbal processing, as most children with autism have stronger visual skills, which helps to leverage and utilize that strength. It needs the ability to hold and manipulate information, which is crucial for adaptive functioning and learning ability. The non-verbal, color-based nature of this task is again more feasible for children with autism. Memorizing pictures from the board is also a nonverbal task and would be effective, similar to the previous task, which focuses on working memory.

The inhibition tasks involved the Go-No-Task, where the child had to execute a motor task while withholding the natural response. This task is more activity-based, involves motor activity, and does not involve any language component to comprehend. This task is more suitable for children with varying levels of language ability. This helps to improve their impulse control and self-monitoring, which is essential for social behaviors and daily adaptive behaviors. The maze test is used to improve planning ability, which is a nonverbal task involving visual processing, a strength in children with autism. It enhances perseverance to complete the task and requires cognitive flexibility to adjust strategies when encountering obstacles or dead ends, thereby strengthening adaptive problem-solving skills. The task is friendlier because it is more engaging for children with autism. Hence, all the tasks planned in the cognitive training module are more feasible and effective for children with autism.

Statistical Analysis

The data collected were statistically analyzed using SPSS 20. Descriptive analysis was done, and the normality of the sample was found using the Kolmogorov-Smirnov Test. This test is more appropriate when the sample size is small. It provides a clear idea and objective criteria for assessing whether parametric assumptions are met. It is simple to compute and widely implemented in statistical software. The tests revealed that the distribution of the samples was not normally distributed, and hence, nonparametric tests were used for further assessment. The significant difference between the two groups based on socio-demographic characteristics such as age was tested using the Mann-Whitney U Test, as this test is used when the population is not normally distributed. Other categorical variables, such as gender, family type, and level of intellectual functioning, were tested using the Chi-Square test, which is more appropriate to determine whether there is a significant difference between the two variables. If the data is nominal, the chi-square test is a more appropriate test used to analyze frequency distributions. The significant difference between the baseline and post-training assessments of the intervention and control groups was assessed using the Mann-Whitney U Test. The Mann-Whitney test is the appropriate test for comparing differences between two independent groups when the assumptions of parametric tests are not met, and tests such as the t-test cannot be used. This test focuses more on the median or rank order rather than the mean, making it more suitable when the data is not normally distributed. It can be used with ordinal data and is hence more applicable in clinical and psychological research. The pre- and post-training comparison of the intervention and control groups was assessed using the Wilcoxon Signed-Rank Test, which is more appropriate when a paired t-test cannot be used and the assumption of normality is not met. Moreover, it is also more useful when the sample size is small, skewed, and has ordinal measurements. Hence, all the tests used for statistical analysis were found to be more appropriate, and the results obtained are more reliable.

Discussion related to Results

At Baseline Level - on ISAA Domains and Executive Functions

The existing literature has strongly revealed that children with Autism have impairment in executive functions, which has been described in various prspectives, including genetic abnormality, theory of mind, and biological perspectives, over time. The biological perspective is gaining importance, and various studies have explored the biological abnormalities related to ASD with neuroimaging studies. It has been described that abnormalities were observed in cortical volume and thickness in both frontal and other cortical brain regions (Demetriou, DeMayo, & Guastella, 2019). In alignment with this, a meta-analysis study by Demetriou et al. (2018), which included 235 studies, attempted to identify the cognitive profile of executive functions, confirming executive dysfunction in children with ASD. They are linked to difficulties in social cognition, adaptive functioning, and goal-oriented behavior, and it also states that it can exacerbate core ASD symptoms such as rigidity, repetitive behaviors, and challenges with daily living skills (Petrolo et al, 2025).The study done by Valeri et al. (2020) observed that children diagnosed with severe ASD showed greater impairments in inhibitory control compared to flexibility, and it also suggested a potential association between impairments in inhibitory control and the severity of autism symptoms.

In the current study, the results revealed that the total average ISAA score of both the control group and the intervention group had mild levels of autism symptoms. They had deficits in all the domains, which included social relationships and reciprocity, emotional responsiveness, speech, language and communication, behavior patterns, sensory aspects, and cognitive components. The executive functions of both groups were found to have deficits, which include Digit Span, Letter Number Sequencing, Color Trails Test, Stroop Test, and Maze Test. The previous study done by Homack& Riccio (2004)found that children with ASD or ADHD often have worse performance in Stroop interference scores than normal children. These findings support our current study findings, which also showed significant impairment in the above domains. In a study conducted by Ghosh, Samajdar, and Halder (2020), the Maze Test was administered to assess executive functioning in children with Autism, and the findings indicated significant impairment in executive functioning and social skills. In the current study, it was found that working memory was impaired in both groups, as assessed using Digit Span and Letter Number Sequencing. This aligns with the previous study by Mayes & Calhoun (2008), which used the Digit Span and Letter Number Sequencing of the WISC-IV to measure WM in high-functioning autism, indicating impairment in WM. The impairment observed cannot be attributed to the verbal nature of the study, as the study conducted by Rabiee et al. (2018) aimed to examine working memory through nonverbal tasks. This study revealed that nonverbal working memory was impaired among participants with high-functioning ASD. This result clearly emphasizes that persons with Autism have deficits in working memory, and it does not depend upon the nature of the test used. In a study by Rabiee et al. (2020), it was found that there is impairment in working memory, and there is a relationship between working memory tasks and social interaction and stereotyped behaviors. Hence, a considerable number of studies have reported working memory deficits among children with Autism and their relationship to Autism symptoms, as well, which is also reported in the current study.

***Pre-post Comparison -on ISAA Domains and Executive Functions*:**

Considering the impairment in executive functions and its relationship to autism symptoms in various studies, the importance of training executive functions is also recommended in many studies. In a study conducted by Maurya and Faijullah Khan (2022), it was demonstrated that Cognitive training programs can lead to significant improvements in executive functioning, understanding of cognitive mental states, and central coherence in children with ASD. These cognitive gains often translate into better social skills, such as increased social communication and more appropriate social interactions. In light of this, many studies have attempted to study the effect of executive functions in children with Autism and have proved its effectiveness. A study done by Petrolo et al. (2025) highlighted the importance of early interventions targeting EF domains in children to improve social, emotional, and adaptive functioning of individuals with ASD. The baseline and post-training comparison of ISAA symptoms and executive functions in the control group, who did not undergo cognitive training, did not show any significant differences in ISAA symptoms or cognitive domains. There was a mild increase in the ISAA score, but the symptoms of Autism such as emotional responsiveness, speech-language and communication, behavior patterns, sensory aspects, and cognitive component did not differ from baseline to post-assessment among children in the control group. This clearly indicates that the children who did not undergo cognitive training did not experience any improvement in their symptoms or executive functions. Indeed, there was a mild decrease in the Stroop-Word score, indicating a decline in performance during the post-assessment among the participants of the control group. This clearly proves that even though the children were attending other therapies, such as speech and occupational therapy, it did not impact their cognitive functions, particularly the executive functions, which demonstrate the efficacy of cognitive training.

The results of comparison between baseline and post-training of the intervention group have revealed that there is a significant reduction in ISAA symptoms, such as social relationships and reciprocity, emotional responsiveness, speech, language and communication, behavior patterns, and cognitive component, and total ISAA score post-training, which is in alignment with the previous studies. There was improvement in all the ISAA symptoms except the sensory aspects. This might explain why the sensory issues of Autism, such as sensitivity to sensory stimuli, insensitivity to pain, unusual vision, and responding to objects and people by smelling, touching, or tasting, are more related to biological factors. There is very scarce evidence supporting the effectiveness of cognitive training on sensory issues as well. Interventions specifically targeting sensory issues, such as sensory integration therapy, have only demonstrated effectiveness in improving sensory processing and related skills in children with autism (Weitlauf et al., 2017). The executive functions have been effective not only in improving EFs but also in reducing autism symptoms in children and young people with ASD, as found in another important study done by Pasqualotto et al. (2021). In a study done by Kenworthy et al. (2014), it was noted that executive functions training has positive effects and improves the social skills of children with ASD. In another study by Sun et al. (2017), stimulation of executive functions demonstrated improvements in communication, interactivity, and social-cognitive performance. This is also aligned with the current study, which has shown effectiveness in improving social and communication areas. The cognitive training module showed notable gains in executive functioning, understanding cognitive mental states, and central coherence, all of which are linked to behavioral regulation in children with ASD, according to a study by Maurya and Faijullah Khan (2022). In this study, the behavior pattern among the intervention group has also demonstrated significant improvement compared to the control group. This finding aligns with the literature, as most studies have reported improvements in behavior patterns, such as regulating behaviors in Autism, after cognitive training.

At Post-Training Level - on ISAA Domains and Executive Functions:

The comparison between the intervention and the control group, post-training, revealed a significant difference in Social Relationship & Reciprocity, Behavior patterns, Cognitive components, and as well as total ISAA score.

However, there is no difference in symptoms such as Emotional Responsiveness, Speech Language & Communication and Sensory aspects. These results partially support the hypothesis that there will be significant improvement in the ISAA symptoms. The results revealed a significant improvement in social responsiveness, which aligns with previous findings by Sun et al. (2017) and Miyajima et al. (2016). Both studies demonstrated that cognitive training programs targeting executive functions led to notable enhancements in social cognition and social functioning among individuals with Autism Spectrum Disorder (ASD). Our observed improvements in social relationship and reciprocity are consistent with Nejati et al.'s 2024 study as well which concluded that cognitive-level training can produce functionally relevant social gain.

There is improvement in the cognitive component post training when compared between the two groups. The training module adopted mostly involves color cancellation, joining random numbers, coloring designs, rapid naming, memorizing a sequence of colored tokens, and a maze targeting multiple cognitive domains of executive functions, it primarily focuses on attention and concentration. Hence, this could be the attributing factor for significant improvement in the cognitive component domain, which involves attention and concentration in ISAA. There was marked improvement in children's level of attention and concentration, which was reflected in their academic skills as well. Spaniol et al. (2018) also report in their study that attention training is considered a feasible and practical approach in children with ASD. The results of the study also revealed significant improvements in behavioral patterns, such as hyperactivity, aggressive behavior, temper tantrums, and self-injurious behavior. Most of the cognitive training programs in other research have shown marked improvement in the behavioral problems and attention, which is the primary problem for most children with Autism. In the meta-analysis study by Pasqualotto et al. (2021), the review highlighted that improvements in executive attention and related EF domains can indirectly lead to better behavioral regulation and reduce behavioral problems. Enhanced executive skills help children with ASD cope more effectively with daily demands, which can reduce the frequency and severity of behavior problems. In a meta-analysis study done by

Pasqualotto et al. (2021), the results revealed that most of the interventions were effective in enhancing executive functions and reducing symptoms in children with ASD which supports overall improvement in the Autism symptoms in the current study. At the same time, other symptoms, such as emotional responsiveness, speech, language, and communication, which involve improving expressive skills like initiating conversations with others, avoiding stereotyped and repetitive language, and avoiding meaningless words did not show significant improvement. The finding may be explained by the nature of cognitive interventions, which primarily target higher-order cognitive processes such as attention, working memory, and cognitive flexibility, rather than the affective components of social functioning. Emotional responsiveness, which involves spontaneous affective expression, empathy, and recognition of others' emotions, is mediated by deeper socio-emotional and neurobiological mechanisms that are less amenable to short-term cognitive practice (Hill, 2004; South & McMahon, 2007). The sensory patterns did not show a significant difference between the pre and post-training of the intervention group. It can be understood that the sensory behavior of Autism children with autism is primarily biological in nature. Many studies support the idea that an imbalance between excitatory and inhibitory signaling in the brain contributes to sensory processing differences in ASD. This is often linked to dysfunction in the gamma-aminobutyric acid system, which is crucial for regulating neural activity. Reduced GABA levels have been observed in the sensorimotor cortex of children with ASD, correlating with altered tactile sensitivity and detection thresholds (Balasco et al., 2020). Neuroimaging studies indicate that individuals with autism may have increased local brain activity but impaired long-range connectivity. This can affect how sensory information is processed and integrated across different brain regions (Marco et al., 2011). Hence, improvement in these symptoms might require a longer duration of interventions to become significant.

The comparison of pre- and post-training assessments of executive functions in the intervention group showed significant differences in DS, LNS, CTT-B, and maze. However, there is no difference in other domains such as CTT-A, STROOP-W, STROOP-C,and STROOP-CW. There is a significant improvement in assessments that focus on attention, working memory, and planning ability. However, there was no significant improvement in assessments that focus on inhibition. Research has shown that, on the classic Stroop test, participants with autism do not have impairment in comparison to typically developing participants, suggesting that inhibition as measured by the Stroop may not be a core area of deficit for many children with autism. As a result, cognitive training aimed at executive functions may not yield measurable improvements on the Stroop test for this group. The lower reading comprehension in children with ASD may mask any potential gains from cognitive training, and they further say that post-training improvements may not be detectable or relevant in this population. There is significant improvement in other cognitive domains, which has been well described in several studies. In the study done by Pasqualotto et al. (2021), the Trail Making Test (TMT) is recognized as a sensitive measure of cognitive flexibility and executive function. Post-intervention assessments using the TMT consistently showed that children with ASD can achieve faster completion times after cognitive training, reflecting improvements in their ability to shift attention, process information, and manage complex sequencing tasks. In another study conducted by Hajri, M. (2019), the results indicated significant improvement in working memory, as assessed with Digit Span and Letter Number Sequencing. In another study by Miyajima, M. (2016), there was a marked improvement in working memory, which led to better performance in digit sequencing. There was marked improvement in Maze performance, indicating better planning ability in children with ASD after cognitive training. The other researchers have also demonstrated similar effects on planning ability and cognitive flexibility, as assessed in the Maze test. In a study done by Maurya & Khan (2022), the cognitive training showed significant improvement in cognitive flexibility and planning ability in children with Autism.

Testing the Hypotheses

Hypothesis 1- "There is significant impairment in executive functions among children with Autism."

Status: Accepted

Hypothesis 2- "Cognitive training had significant effect on executive functions (attention and cognitive flexibility, working memory, inhibitory control, and planning ability) of children with Autism"

Status: Accepted

Hypothesis 3 – "There is significant reduction in symptoms of Autism"

Status: Accepted

Summary

The study aimed to investigate the executive functions among children with Autism and the effect of cognitive training on executive functions and Autism Symptoms. The study involved children aged 12 to 16 years having a Mild level of Autism and intact intellectual functioning. To conduct this study, the participants were divided into two groups. One group received twice-a-week cognitive training sessions for about six months, while the other group served as a control, with no cognitive training sessions provided to them. The assessment related to executive functions was conducted at both baseline and post-training levels, with the baseline assessments revealing that executive functions were impaired. Subsequently, the planned intervention module, which focused on attention and cognitive flexibility, working memory, inhibition, and planning ability, was administered for six months on a two-session-per-week basis. After the intervention was completed, the post-assessment of the executive functions and ISAA symptoms revealed improvement in most of the ISAA symptoms except the sensory pattern. The Stroop test did not show improvement during the post-assessment indicating no significant improvement in inhibitory control. Further, the comparison between the control group and intervention group on ISAA symptoms revealed significant difference in social relationship, reciprocity, behavior pattern, cognitive component domains, and ISAA symptoms. The comparison between the control group and the intervention group on executive functions reveals significant improvement, except for the inhibition task. These results indicate that there is a high need to incorporate the cognitive training methods with other formal and traditional approaches of treating children with ASD. Overall, the study findings could be summarized as:

1. The children with Autism had significant impairment in executive functions in the areas of focused attention, cognitive flexibility, working memory, inhibition, and planning ability.
2. The participants of the intervention group exhibit significant improvement after cognitive training sessions, in domains of focused attention and cognitive flexibility, working memory, and planning ability.
3. The group that received six months of cognitive training exhibits significant improvement in ISAA symptoms in terms of social relationship and reciprocity, emotional responsiveness, speech and communication skills, behavior pattern, cognitive component, and total ISAA score.
4. The comparison between the intervention group and control group on ISAA symptoms after the cognitive training showed that there is a significant difference in social relationship and reciprocity, behavior patterns, cognitive components, and total ISAA score.
5. The comparison between the intervention group and control group on executive functions showed that there is a significant difference in focused attention and cognitive flexibility, working memory, and planning ability.

Conclusion of the Study

The study concluded that there is significant impairment in executive functions and demonstrated the effectiveness of cognitive training, showing significant improvement in the performance of executive functions and Autism symptoms. These findings align with the growing body of research indicating that targeted cognitive training interventions can significantly enhance executive functions in children with ASD. Improvements were observed in key domains such as attention, working memory, cognitive flexibility, inhibition, and planning ability. These areas are often impaired in this population and contribute to challenges in daily living and social skills.

The evidence suggests that cognitive training leads to measurable gains in executive functioning and also in the improvement of Autism symptoms. There was a significant improvement noted in the social relationship & reciprocity, behavioral patterns, cognitive abilities, and overall symptoms of children with Autism who underwent cognitive training. The pre- and post-comparison of the intervention group revealed significant improvement in ISAA symptoms, except for the sensory patterns, highlighting the importance of its effectiveness. The effectiveness of cognitive training should have general applicability in improving the socio-adaptive skills of children with Autism, as clearly demonstrated by the findings of the current study. Nevertheless, the benefits of these interventions may diminish once the training ceases, highlighting the need for sustained or repeated training to maintain improvements. In conclusion, cognitive training represents a promising avenue for supporting executive function development in children with ASD, with the potential to enhance their adaptive skills and quality of life. Future research should focus on optimizing intervention strategies, exploring long-term effects, and ensuring the ecological validity of training programs to maximize real-world benefits for children with autism.

Clinical Implications

The current study demonstrated the effectiveness of cognitive training, particularly in improving executive functions and reducing symptoms of Autism, especially behavior problems and cognitive components like attention and concentration. These findings were noted to show generalization in other settings, including improvement in their adaptive and academic skills. This study helps to gain insight into the importance of adopting cognitive-based interventions along with other traditional behavioral methods for treating children with Autism. As the neuropsychological implication is gaining its importance and this study supports the previous literature, it further directs to explore more about including other individualized and developmentally appropriate cognitive intervention modules as well.

Limitations of the Study

- The methodological challenges include a small sample size, and hence a large number of samples is warranted for more reliability.

- Even though the qualitative feedback as reported by the parents/guardians, showed improvement in many of their socio-adaptive skills, some of the variables did not show statistical significance, which might be due to the limited sample size.
- The age group of the children included in the study ranged from 12 years to 16 years old, which does not include a diverse age group, and hence, the general applicability of the current findings to all persons with Autism should still be explored.
- Long-term sustainability of improvements is not yet well established. The intervention protocol included in the study might not be promising enough to see long-term effects underscoring the need for further rigorous research.
- The characteristics of the samples, such as autism severity and baseline abilities, can vary, and this might affect the effectiveness of protocols.

Future Directions

- The study can be done as a longitudinal study to determine its long-term effectiveness.
- A larger number of samples to be included to prove the effectiveness of the study, as the current study's sample size is small.
- The study can include children of diverse populations, such as age, gender, etc.
- Children with only a mild level of Autism and intact intellectual functioning were only included in the study. Exploring the effectiveness in children with other severities of Autism can be considered for future studies.
- The therapy module can include other interventions to improve the executive functions, and computer-based interventions can also be considered for further studies, as they would be more feasible for children with ASD.