

**IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF PSYCHOLOGY**

PH.D. THESIS

**INVESTIGATING THE EFFECTS OF EXECUTIVE
FUNCTIONS AND SOCIAL COGNITION ON THE
RELATIONSHIP BETWEEN AUTISTIC TRAITS AND
MENTAL HEALTH**

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**THESIS SUPERVISOR
PROF. TIMOTHY R. JORDAN**

ISTANBUL, 2024

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RELATIONSHIP BETWEEN AUTISTIC TRAITS AND
MENTAL HEALTH**

by

DİLRUBA SÖNMEZ

**A thesis submitted to the School of Graduate Studies in partial
fulfillment of the requirements for the degree of Doctor of
Philosophy in Clinical Psychology**

**THESIS SUPERVISOR
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ISTANBUL, 2024

THESIS APPROVAL PAGE

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy in Clinical Psychology.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ÖZ

OTİSTİK ÖZELLİKLER VE RUH SAĞLIĞI ARASINDAKİ İLİŞKİDE YÜRÜTÜCÜ İŞLEVLER VE SOSYAL BİLİŞİN ETKİSİNİN İNCELENMESİ

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Bu tezin amacı, ruh sağlığı semptomlarına yönelik yürütücü işlevler ve sosyal bilişi içeren çevrimiçi bir eğitim programı tasarlamak ve bu programın etkilerini incelemektir. Ayrıca, otistik özellikler ile ruh sağlığı semptomları arasındaki ilişkide bu faktörlerin aracılık rolünü araştırmaktır. Bu amaçlar doğrultusunda dört farklı çalışma gerçekleştirilmiştir. İlk çalışmada, çevrimiçi eğitim programının güvenilirliği ve geçerliliğini artırmak amacıyla bir ön çalışma yapılmış, çevrimiçi veri toplama yönteminin kalem-kâğıt yöntemine göre bir fark yaratmadığı bulunmuştur. İkinci çalışmada ise, çevrimiçi programın tasarımına zemin hazırlamak için yürütücü işlevler ve sosyal bilişin rolleri ve ilişkileri araştırılmış, bu iki faktörün otistik özellikler ile ruh sağlığı semptomları ilişkisindeki rolü incelenmiştir. Sonuçlar, duygusal empatinin bir bileşeni olan kişisel sıkıntının, otistik bir özellik olan dikkat değiştirme ile ruh sağlığı semptomları arasında önemli bir aracılık rolü oynadığını ortaya koymuştur. Üçüncü çalışmada, çevrimiçi eğitim programının ruh sağlığı semptomlarını azaltmadaki ve yürütücü işlevler ile sosyal bilişi geliştirmedeki etkinliği pilot bir çalışma ile değerlendirilmiştir. Dördüncü çalışmada ise, altı hafta süren çevrimiçi eğitim programı, katılımcıların rastgele deney ve kontrol gruplarına atanmasıyla test edilmiştir. Sonuç olarak, deney grubundaki ruh sağlığı skorlarında önemli bir düşüş gözlemlenmiştir. Ayrıca, duygusal empati üzerinde de anlamlı iyileşmeler bulunmuştur. Bu bulgular, tasarlanan çevrimiçi müdahalenin ruh sağlığı belirtilerini azaltma potansiyeline sahip olduğunu ve otistik özellikler ile ruh sağlığı arasındaki

etkileşimin dikkate alınması gerektiğini göstermektedir. Çalışma, bazı sınırlamalara rağmen, etkili çevrimiçi müdahale programlarının hem nörotipik hem de nöroçeşitli bireyler için ruh sağlığını destekleyebileceğini vurgulamaktadır.

Anahtar Kelimeler: Çevrimiçi Eğitim, Otistik Özellik, Ruh Sağlığı, Sosyal Biliş, Yürütücü İşlevler.



ABSTRACT

INVESTIGATING THE EFFECTS OF EXECUTIVE FUNCTIONS AND SOCIAL COGNITION ON THE RELATIONSHIP BETWEEN AUTISTIC TRAITS AND MENTAL HEALTH

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The primary objective of the research reported in the current thesis is to design and examine the impact of an online training program that includes executive functions and social cognition targeting mental health symptoms. Additionally, it aims to investigate the mediating role of these factors in the relationship between autistic traits and mental health symptoms. In line with these objectives, four different studies were conducted. In the first study, a preliminary study was carried out to increase the reliability and validity of the online training program, and it was found that the online data collection method did not differ from the pencil-and-paper method. The second study examined the roles and relationships of executive functions and social cognition before designing the online program to understand their impact, particularly in the relationship between autistic traits and mental health symptoms. The results showed that personal distress, a part of affective empathy, plays a significant mediating role between attention switching, an autistic trait, and mental health symptoms. In the third study, the efficacy of the online training program in reducing mental health symptoms and improving executive functions and social cognition was evaluated through a pilot study. In the fourth study, the six-week online training program was tested by randomly assigning participants to either an experimental or control group. As a result, a significant decrease in mental health scores was observed in the experimental group. Additionally, significant improvements in affective empathy were achieved. These

results suggest that the designed online intervention has the potential to reduce mental health symptoms and that the interaction between autistic traits and mental health should be considered. This study, despite some limitations, highlights the importance of designing effective online intervention programs and indicates that such programs could support mental health in both neurotypical and neurodiverse individuals.

Keywords: Autistic Traits, Executive Functions, Mental Health, Online Training, Social Cognition





To my father and mother

for their unwavering love, guidance, and patience

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“Verily Allah will soon give you so amply that you will be well-pleased” (93:5)

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LIST OF SYMBOLS AND ABBREVIATIONS

ACC	Anterior Cingulate Cortex
ADHD	Attention Deficit and Hyperactivity Disorder
ASD	Autism Spectrum Disorder
AQ	Autism Quotient
BAP	Broad Autism Phenotype
BAPQ	Broad Autism Phenotype Questionnaire
CI	Confidence Interval
DASS	Depression Anxiety Stress Scale
dmPFC	Dorsomedial Prefrontal Cortex
dIPFC	Dorsolateral Prefrontal Cortex
DSM	Diagnostic and Statistical Manual of Mental Disorders
EFs	Executive Functions
ERST	Emotional Rule Shifting Task
EQ	Empathy Quotient
F	The Ratio of Variances
GAD	Generalized Anxiety Disorder
ICD	International Classification of Diseases
IFG	Inferior Frontal Gyrus
IPL	Inferior Parietal Lobe
PHQ	Patient Health Questionnaire
SES	Socioeconomic Status
SRS	Social Responsiveness Scale
STEU	Situational Test of Emotional Understanding
STEM	Situational Test of Emotional Management
ToM	Theory of Mind
TPJ	Temporoparietal Junction
MNS	Mirror Neuron System
N	Sample Size
R	Correlation Coefficient
vmPFC	Ventromedial Prefrontal Cortex
US	United States
WCC	Weak Central Coherence

WCST Wisconsin Card Sorting Task
WM Working Memory
WHO World Health Organization



CHAPTER I

GENERAL INTRODUCTION

1.1. Background of the Study

Autism spectrum disorder (ASD) refers to a neurodevelopmental condition that is associated with impairments in social and cognitive functions, repetitive behaviors, and restricted interests (American Psychiatric Association, 2013), while autistic traits refer to a subclinical level of ASD and its symptoms distributed in the general population (Baron-Cohen et al., 2001a). Previous studies have identified people with elevated autistic traits who show susceptibility to other mental health conditions such as anxiety disorders, mood disorders, borderline personality disorder, internet addiction, conduct disorder, substance abuse, and suicidal risk in the general population (Albantakis et al., 2020; Dell’Osso et al., 2019; Dell’Osso et al., 2018; Lundstörn et al., 2011). Although there is no identifiable explanation of susceptibility to other mental health conditions, the presence of social and cognitive impairments, including problems in executive functions and social cognition, might be contributing factors (Eussen et al., 2013; Zelazo, 2020).

Social cognition, which includes cognitive and affective empathy, is crucial for individuals' overall functioning. Many studies have demonstrated that individuals with stronger empathic abilities tend to have better social skills, higher academic success, improved mental health, and enhanced social functioning (Allemand et al., 2015; Baron-Cohen, 2001a;). Cognitive empathy involves understanding and predicting one's and others' emotions, desires, intentions, and beliefs (Shamay-Tsoory, 2011). Affective empathy, also known as emotional empathy, refers to the ability to recognize and experience the emotional reactions of others and respond appropriately to them (Blair, 2005).

Executive functions (EFs) are a collection of neurocognitive skills that help regulate cognitive, behavioral, and emotional processes (Diamond, 2013). These skills play a crucial role in social, cognitive, and psychological development, as well as overall mental and physical well-being, public safety, and success in academic and professional life. They are essential for various aspects of functioning, such as social interactions, self-regulation, problem-solving, emotional regulation, and adaptive reasoning in diverse contexts (Diamond, 2013; Zelazo, 2020). In the literature, three core EF skills (inhibitory control, working memory, and cognitive flexibility) have been empirically validated, and while they are distinct, they also have some common underlying elements (Miyake et al., 2000). To date, many studies have focused on these three core skills - cognitive flexibility, inhibitory control, and working memory (Diamond, 2013).

Previous research indicated that social cognitive skills, cognitive and affective empathy, and EFs, including working memory, inhibitory control, and cognitive flexibility, play important roles in physical and mental health, quality of life, social competence, school and job success, marital harmony, and public safety (Allemand et al., 2015; Diamond, 2013). Nevertheless, although autistic traits increase susceptibility to other mental health conditions, no study so far has focused on examining the relationships among autistic traits, executive functions, and social cognitive skills to design intervention and prevention programs for mental health conditions and quality of life in both general and clinical populations.

In recent years, digital interventions, including online computer-based and smartphone-based interventions, have been started for use in different areas, including mental health problems, executive functions, and social cognitive skills in both clinical and non-clinical populations (Sari et al., 2020; Nahum et al., 2021; Sandgreen, Frederiksen & Bilenberg, 2021). Many studies conducted with clinical and non-clinical populations have reported positive outcomes of online interventions on mental health symptoms, quality of life, executive functions, and social cognitive skills (Beloe & Derakshan, 2019; Macoun et al., 2021; Nahum et al., 2021; Sari et al., 2020). However, it is crucial to conduct more research to determine their effectiveness in both clinical and non-clinical settings due to the limitations of digital interventions (Sandgreen et al., 2021). It is worth noting that a recent systematic review by Akgün

and colleagues (2019) highlighted the lack of research on digital mental health interventions in Türkiye, emphasizing the need for further studies.

1.2. Theoretical Framework

Different theories have attempted to understand and explain ASD, its symptoms, and its outcomes to the individuals. However, due to the various findings and origins of ASD, it is challenging to provide a precise explanation. Multidimensional explanation is needed to provide a better understanding of ASD in the literature (Happé & Ronald, 2008). The three dominant cognitive theories used for examining social cognitive impairments in ASD are Executive Dysfunction, Theory of Mind Deficit, and The Empathizing-Systemizing Theory (The Extreme Male Theory).

1.2.1. Theory of Mind Deficit

Theory of mind (ToM) is defined as inferring one's own and other's mental states to explain and predict actions (Baron-Cohen & Wheelwright, 2004). ToM is generally used interchangeably with cognitive empathy and mentalizing. When it comes to comprehending the mental states of others, ToM abilities are often classified as a component of cognitive empathy. However, there are some distinctions between the two. While ToM centers on comprehending and embracing the perspectives of oneself and others, cognitive empathy additionally considers emotional and social intentions (Canty et al., 2021; Perry & Shamay-Tsoory, 2013). Brothers & Ring (1992) have identified two kinds of ToM functions: cold and hot. Cold ToM pertains to the capability to attribute mental states to others, while hot ToM encompasses the emotional and social aspects of this ability. Wimmer and Perner (1983) invented the first false belief task to measure ToM skills in children and found that 57% of children aged four correctly answered questions, and 3-year-old children did not answer correctly. Then, Baron-Cohen, Leslie, and Frith (1985) proposed the '*ToM deficit hypothesis*' in ASD. The purpose of this hypothesis was to explain the core social communicative impairments in individuals with ASD. Their results indicated that 80% of autistic children did not correctly respond to the ToM task (Sally-Anne Task) compared to a typically developing group and children with Down Syndrome. These results were replicated in other studies (Bos and Stokes, 2018; Stewart et al., 2020;

Zhao et al., 2020). However, Happé (1994) found that some individuals with ASD also passed these tasks which questioned the universality of the deficits across the ASD population as the origin of ASD is shown in the spectrum.

1.2.2. Empathizing-Systemizing Theory and The Extreme Male Brain Theory

Baron-Cohen (2002) developed the ToM deficit hypothesis, and he proposed the Empathizing and Systemizing Theory and used the term ‘empathy’ rather than ToM to explain social communication problems. The empathy term compasses all ToM skills, mentalizing skills, and both aspects of cognitive and affective empathy which involves emotion recognition, emotional contagion, and sympathy. Baron-Cohen argued that individuals with ASD show difficulties and are delayed developing in empathic skills, whereas their systemizing skills are hyper-developed including the drive to analyze or construct systems (e.g., collectible systems, mechanical systems, numerical systems, etc.). The researcher mentions at least six basic systemizing areas: technical systems (e.g., a computer, a musical instrument), natural systems (e.g., weather, a plant), abstract systems (e.g., mathematics), social systems (e.g., legal systems), organizable systems (e.g., collection, library), and motoric systems (e.g., a technique of sports or instrument). It is also called The Extreme Male Brain Theory (Baron-Cohen, 2002) because the researcher relies on different brain types to explain ASD and it provides significant steps toward knowing how biological and genetic factors affect cognition (Greenberg et al., 2018). Five basic brain types are mentioned in this theory. First, individuals are more prone to empathizing which called as “female brain”, the second is who is prone to systemizing called as “male brain”, the third one is the “balanced brain” which shows an equal development of both empathizing and systemizing, the fourth is “extreme male brain” which is hyperdeveloped on systemizing and according to researcher autistic individuals fall on this brain type and the last one is “extreme female brain” which shows hyper development of empathizing skills. However, this theory has become controversial due to considerations raised by psychometric instruments and statistical approaches (Skuse, 2009).

1.2.3. Executive Dysfunction

There have been several theories proposed to explain the social and non-social symptoms of ASD, including the ToM Deficit, E-S Theory, and Extreme Male Brain Theory. However, one of the most influential theories is the Executive Dysfunction Theory, which covers both social and non-social symptoms, such as restricted and repetitive behavior (Hill, 2004; Ozonoff et al., 1991). EFs is an umbrella term that includes planning, cognitive flexibility, attention, working memory, and response inhibition (Hill, 2004). This theory was proposed by observing difficulties in cognitive flexibility, inhibitory control, and working memory in individuals with ASD (Demetriou et al., 2019). According to this theory, deficits in ToM and executive functions are associated with each other, and impairments in frontal lobe function in ASD may result in impairments in both executive functions and emotional behavior (Ozonoff et al., 1991; Pennington & Ozonoff, 1996). Hill (2004) reviewed Executive Dysfunction Theory in ASD by focusing on four main areas, including planning, cognitive flexibility, inhibitory control, and self-monitoring, and executive dysfunction suggests impairment in distinct domains of executive function, supporting a fractionated model of executive function. Although there is heterogeneity in executive function performance in individuals with ASD, recent meta-analyses suggest that social communicative skills, such as empathy and ToM skills, may contribute to these differences in EFs performance, as they are believed to be associated with systems that work together (Demetriou et al., 2019; Demetriou et al., 2018).

1.3. The Statement of Problem and the Objectives of the Current Thesis

As stated above, the underlying reasons for vulnerability to mental health issues are not yet fully understood in elevated autistic traits. Furthermore, even though there is no recent study of the prevalence of mental health problems in Türkiye, according to the recent global report of the World Health Organization (WHO, 2022), mental health problems such as major depressive disorder and anxiety disorders show 27.6% and 25.6% increases, respectively. Additionally, the recent cumulative incidence findings for people up to the age of 30 years with ASD were 54.1% for depression and 50.0% for anxiety disorders (Kirsch et al., 2020). As previously stated above, a similar

susceptibility to mental health problems, including anxiety disorders, mood disorders, conduct disorder, and suicidal risk, has been reported in individuals with elevated autistic traits (Albantakis et al., 2020; Dell’Osso et al., 2019; Dell’Osso et al., 2018). Even mild autistic traits may increase susceptibility to other mental health conditions in neurotypical individuals (Lundstörn et al., 2011).

Research suggests that difficulties in EFs and social cognition could play a role in developing such conditions (Eussen et al., 2012; Zelazo, 2020). These impairments, which affect a person’s ability to plan, organize, and regulate their behavior, as well as their capacity to perceive and interpret social cues, may increase their susceptibility to mental health challenges (Allemand et al., 2015; Diamond, 2013). To develop impactful interventions and prevention programs for individuals with autistic traits and those without autistic traits, it could be beneficial to explore impairments linked to EFs, including inhibition, working memory, cognitive flexibility, and social cognitive abilities, such as cognitive and affective empathy. Using these insights can improve life for those seeking clinical support in clinical conditions and society as a whole. Moreover, as digital interventions become more widespread in addressing mental health issues among both clinical and non-clinical populations, there is a need to conduct further research on their effectiveness (Sandgreen et al., 2021). Importantly, a recent systematic review by Akgün and colleagues (2019) emphasized the scarcity of research on digital mental health interventions in Türkiye and emphasized the need for more studies.

Accordingly, the primary objective of the thesis is to design and test the efficacy of online executive functions and social cognitive training that might help to reduce mental health symptoms in the neurotypical population regarding autistic traits. The second objective is to investigate the mediating roles of EFs (cognitive flexibility, inhibitory control, and working memory) and social cognitive skills (cognitive empathy and affective empathy) on the relationship between autistic traits and mental health symptoms (depression, anxiety, and stress) that would be a significant step to understand their roles for designing intervention and prevention programs.

1.4. Research Questions

Four main research questions will be addressed in the current thesis:

- I.** What are the mediating roles of executive functions (cognitive flexibility, inhibitory control, and working memory) in the association between autistic traits and mental health symptoms (anxiety, depression, and stress)?
- II.** What are the mediating roles of social cognitive skills (cognitive empathy and affective empathy) in the association between autistic traits and mental health symptoms (anxiety, depression, and stress)?
- III.** What is the efficacy of online executive functions and social cognitive skills training in promoting mental health by reducing depression, anxiety, and stress symptoms?
- IV.** What is the efficacy of online executive functions and social cognitive skills training on executive functions (working memory, inhibitory control, and cognitive flexibility) and social cognitive skills (cognitive empathy and affective empathy)?

1.5. Overview of the Following Chapters

The following chapter aims to provide a comprehensive review of the literature on ASD, executive functions, social cognition, and mental health symptoms. In Chapter 3, the first study was conducted to analyze the comparison between online-based and paper-based data collection procedures before using online data collection procedures for the following studies in the current thesis. For this purpose, two main questionnaires, Autism Quotient (AQ) and Depression Anxiety Stress Scale - 21 (DASS-21), were used to compare two data collection procedures, and the introduction, methodology, results, and discussion were presented. With the results from this study, Chapter 4 highlights the importance of understanding the roles of executive functions and social cognition before developing the online training program and emphasizes the need to explore how executive functions and social cognition mediate the relationship between autistic traits and mental health symptoms using the validated online data collection method. In this chapter, the mediator roles of executive functions and social cognition were examined to provide further insights into their

relationships and roles in mental health outcomes, setting the stage for the development of the training program. After investigating the roles and relationships of executive functions and social cognition, Chapter 5 focuses on the development of an online training program. Drawing from the findings of the previous chapters, this chapter reports the design and development of the training program, specifically addressing the practical aspects of combining executive functions and social cognitive skills into a cohesive intervention. The feasibility of the program was tested here, providing valuable insights into its usability and setting the stage for further refinement before moving on to efficacy testing. Building on all the information gathered from the previous chapters, Chapter 6 focuses on testing the efficacy of the combined executive functions and social cognition online training program. The efficacy of the program is tested with a larger sample, evaluating its impact on mental health outcomes. This final chapter assesses whether the program can effectively reduce mental health symptoms in neurotypical individuals, drawing conclusions based on the entire body of work presented in the thesis

CHAPTER II

LITERATURE REVIEW

2.1. Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by difficulties in social interactions and communications, the presence of repetitive behaviors, and restricted/narrow interests (American Psychiatric Association, 2013). The term “autism” derived from the Greek word ‘autos’ which means “self,” and Eugen Bleuler, a Swiss psychiatrist, was the first to use the term “autism” in 1911 to indicate social withdrawal and self-centered thinking in a group of patients with schizophrenia (Frith, 2003). At first, “autism” was used interchangeably with schizophrenia until Kanner (1943) published “Autistic Disturbances of Affective Contact”. In his work, symptoms including extreme autistic aloneness, obsessiveness, intolerance of change, impairments in language ability, and restricted interests were observed in 11 children. In 1944, Hans Asperger, an Austrian psychiatrist, introduced and listed similar features in his work called “autistic psychopathy,” which refers to autistic aloneness, impairments in social interactions and communications and language, restricted interests, and showing average or above average intelligence and in the literature this condition is called “Asperger’s Syndrome” (Frith, 2003). According to diagnostic criteria of the International Classification of Diseases -11 (ICD-11, World Health Organization (WHO), 2019) and Diagnostic and Statistical Manual of Mental Disorders – V (DSM – V, American Psychiatric Association, 2013), ASD is characterized by persistent deficits in social interaction and communication, restricted and narrow behaviors, interests, and activities. As these symptoms and patterns vary from person to person, the intensity and effects of the symptoms can also vary from person to person ranging from mild to extremely severe. High Functioning Autism, Atypical Autism, and Asperger’s Syndrome are often used to indicate individuals with ASD without intellectual disability or language delay in the literature (de Giambattista et al., 2019; Faridi & Khosrowabadi, 2017). However, according to

ICD-11 and DSM-V, all levels are considered under the diagnosis of ASD (American Psychiatric Association, 2013; WHO, 2018).

2.1.1. Prevalence of Autism Spectrum Disorder

The estimated prevalence rates of ASD have shown increased and varied over the past years in studies. In 2018 reports for the United States (US), 1 to 44 children aged eight years have been diagnosed with ASD, and it was found that the rate of boys diagnosed with ASD is 4.2 times higher than girls (Maenner et al., 2021). Whereas, according to reports for the US in 2020, 1 to 36 children aged eight years have been diagnosed with ASD (The overall prevalence is 27.6 per 1.000) and 3.8 times more prevalent in boys compared to girls. (Maenner et al., 2023). According to a global prevalence review by Zeidan and its colleagues (2023), 1 to 100 children across the world are diagnosed with ASD. The median prevalence rate is 65 / 10.000, and the rate of boys diagnosed with ASD is 4.2 times more prevalent than girls. In 2012 reports, the global median prevalence rate was found 62 / 10.000 (Elsabbagh et al., 2012). The differences and changes between rates in the studies could be the result of community awareness, global public health response, progress and development of diagnoses, case identification and definition, and differences in methodology (Fletcher-Watson & Happé, 2019; Zeidan et al., 2023). In Türkiye, although there is no prevalence study for ASD, according to the Ministry of Family Work and Social Services' report (2020), there are 1315 children who were diagnosed with ASD went to both primary public and special education schools, and 474 children who were diagnosed with ASD went to the middle public schools between 2019 and 2020.

2.1.2. Onset and Etiology of Autism Spectrum Disorder

Even though the diagnosis of ASD is commonly made in around 2-3 years because the symptoms have become more apparent with age, studies indicate that brain abnormalities in ASD could be started in the prenatal or neonatal period of life, and the first signs of the symptoms such as joint attention, language problems and social interactions problems (e.g., emotional expressions) may be observed around 12 months. Parents have started to be concerned about their children in the first months

of their age. (Courschesne et al., 2003; Courschesne et al., 2007; Landa & Garrett-Mayer, 2006; Stone et al., 1999).

Over the years, researchers have indicated that the reason for ASD has not been explained with specific factors, and it is more complex beyond this perspective. Both genetic/biological factors and environmental factors are associated with ASD in many studies. (Amaral, 2017; Fletcher-Watson & Happé, 2019). Aside from old popular explanations of the cause of ASD, such as "refrigerator mother," in one of the important twin studies by Folstein and Rutter (1977), the researcher collected data from participants who were at least one child with ASD (11 monozygotic twins and ten dizygotic twins). In their results, 4 of the 11 monozygotic twins were concordant, which means both children were diagnosed with ASD; however, none of the dizygotic twins were. Additionally, while 9 of the 11 monozygotic twins show cognitive abnormalities, 1 of the ten dizygotic twins show cognitive abnormalities. Additionally, in a population-based cohort study (1986 to 2006) in Sweden, the heritability of ASD was found to be approximately 50% (Sandin et al., 2014). According to the review by Sealey et al. (2016), there is no one specific gene that is related to ASD, more than 1000 genes were expected to play a role in ASD. For example, the CNTAP2 gene is associated with core ASD behaviors by affecting language, communication, and working memory (Peñagarikano et al., 2011).

Many studies have argued that even though environmental factors cannot solely explain ASD, they have significant roles in the expression of the genes, in turn, the symptoms of ASD (Foley et al., 2009; Karimi et al., 2017; Wang et al., 2008; Wozniak et al., 2016). In terms of these factors, older maternal and parental age (aged 34 or above) are one of the important prenatal risk factors for ASD (Karimi et al., 2017; Parner et al., 2012). In addition, maternal physical and mental health are also other important prenatal factors such as metabolic syndrome (Ornoy et al., 2015) including diabetes (Gardener et al., 2011), hypertension, obesity (Krakowiak et al., 2012), and parental psychiatric history including schizophrenia, depression, anxiety and personality disorder are other risk factors (Bölte et al., 2008; Daniels et al. 2008; Larsson et al., 2005). Prenatal medication use and low socioeconomic status are also considered risk factors (Durkin et al., 2010; Gardener et al., 2009). Low birth weight,

jaundice, and postnatal infection are also some of the postnatal risk factors for ASD (Karimi et al., 2017).

2.1.3. Social Skills Impairments in Autism Spectrum Disorder

Social skills are a set of skills for facilitating adaptation and coping with the social world (Soto-Icaza et al., 2015). Difficulties in social interaction and communication are core characteristics of ASD (APA, 2013). The social communication process is an integration of different functions such as language, social interactions, and social cognition, including theory of mind, empathic skills, emotion recognition, and regulation processes (Niznikiewicz, 2013). In ASD literature, various studies have been conducted to examine these functions in individuals with ASD. These core social features result in various impacts for individuals with ASD including failure to adapt to social context, language problems, social isolation, difficulties in initiating and maintaining communication, detecting social cues, deficits in joint attention, reduced eye contact, problems in cognitive and affective empathy (Baron-Cohen, 1988; Bellini et al., 2007; Charman, 2003; Gutstein & Whitney, 2002; Kasari & Sterling, 2013; Otero et al., 2015; Senju & Johnson, 2009).

Regarding language, although individuals with ASD show similar patterns of language acquisition with children with Down's Syndrome and typically developing children (TD, Frith, 2003), the main problem is the pragmatics of language, which means the usage of language appropriately in social interaction (Tager-Flusberg, 1999). Additionally, individuals with ASD show a limitation in the expression of needs, intentions, and others' mental states (Tager-Flusberg, 1996, 1997, 1999). In terms of the theory of mind (ToM) and empathic skills that are related to identifying, understanding, and reasoning about one's own and other's mental and emotional states, such as intentions, desires, and emotions (Baron-Cohen & Wheelwright, 2004; Blair, 2005; Canty et al., 2021), many studies have demonstrated that individuals with ASD show impairments in affective empathy and cognitive empathy compared to TD group (Bos & Stokes, 2018; Mazza et al., 2014; Sönmez & Jordan, 2023) and emotion recognition and regulation skills and emotional understanding are also significant functions in social context that individuals with ASD show difficulties and impairments (Blair, 2005; Connor et al., 2020; Losh & Capps, 2006). Additionally,

individuals with ASD show atypical visual attention in social contexts. Participants with ASD showed more visual attention to non-social (e.g., objects) than social objects (e.g., faces, Chita-Tegmark, 2015).

Wing and Gould (1979) examined the quality of social interactions in ASD under four headings: social aloofness (severe impairments and no interaction), passive interaction (no approach to interaction but no resistance towards others' approaches), active but odd interaction (inappropriate social interactions), and lastly appropriate interaction. Differences in the interaction quality of autistic individuals and social impairments can also be associated with different problems in their daily lives. For example, autistic individuals who show inappropriate social interaction may confront loneliness/social isolation, bullying, peer rejection, poor academic performance, and mental health problems, including anxiety and depression (Bellini, 2006; Church et al., 2010; Day et al., 2020; Eussen et al., 2012; Stice & Lavner, 2019).

2.1.4. Cognitive and Neural Basis of Autism Spectrum Disorder

Cognitive and neural features are significant to understanding the core symptoms of ASD, including social communication deficits and repetitive behaviors. Many studies have shown related cognitive functions and brain regions for symptoms of ASD (see Table 2.1. by Amaral et al., 2008; Baron-Cohen, 2002; Hill, 2004). Social cognitive impairments, including perception, theory of mind, and executive functions, are not solely associated with social impairments but also are important skills for cognitive functioning and repetitive/restricted behaviors and interests (Baron-Cohen, 2002; Fong & Iarocci, 2020; Ozonoff et al., 1991). Weak Central Coherence (WCC) theory by Frith (1989) states that autistic individuals show a different cognitive style of perceiving and thinking about in context. They process information by focusing on specific details and smaller distinct parts rather than paying attention to an object as a coherent whole within context. This theory found some support in the literature. For example, individuals with ASD showed superior local processing, but there is no consensus for global processing. Both findings are present in terms of having intact global processing (Mottron et al., 2006; Plaisted et al., 2003) or having impaired global processing (Behrmann et al., 2006).

In terms of executive functions, previous studies have indicated that individuals with ASD show impairments in basic executive functions, including planning, inhibitory control, self-monitoring, and cognitive flexibility (Hill, 2004; Ozsivadjian et al., 2021). Ozonoff and their colleagues (1991) proposed an executive dysfunction theory that focuses on both social and non-social aspects of ASD and indicates that individuals with ASD show difficulties in executive functions that result in social-communicative impairments and repetitive behaviors (Ozonoff et al., 1991). Another social cognitive skill is ToM, which the researchers indicated that autistic individuals have difficulties in understanding and reasoning their own and others' mental states (Baron-Cohen et al., 1985). As in the previous section, this skill is one of the important features of social functioning as well as cognitive functioning (Blair, 2005). Brain imaging studies in individuals with ASD have demonstrated reduced activation in three brain regions (left medial prefrontal cortex, temporal-parietal junction, and the temporal poles) that are associated with ToM skills (Castelli et al., 2002; Happé, 1996).

The mirror neuron system (MNS) is one of the significant neural mechanisms for social cognitive processes (Pfeifer et al., 2008). The premotor cortex, inferior parietal lobe, motor, and somatosensory cortex are indicated to involve MNS mechanisms, which are associated with imitation, joint attention, ongoing coordination, and prediction of one's action, intention, and behaviors (Redcay & Warnell, 2018). MNS is also thought to be an important system for social learning, which is implicit learning to transfer one's experience and knowledge through play, cultural practices, and daily social exchanges, including behaviors in daily life (Vivanti & Rogers, 2014). "Broken mirror neuron theory" for autism proposed that individuals with ASD show atypical activation in MNS regions, but impairments are solely associated with this area these impairments are also associated with the interaction between MNS and other brain regions (Chan & Han, 2020; Friston, 2011; also see Table 2.1). Consistent with atypical activation in MNS, previous studies have indicated that individuals with ASD show difficulties in social learning, including imitation, use of language and play for communication, joint attention, and empathic skills (Chan & Han, 2020; Vivanti & Rogers, 2014).

In addition, previous studies have found that individuals with ASD showed greater gray and white matter and cortical thickness compared to the control group, and these

differences are mainly observed in the anterior areas of the brain rather than the posterior areas (Hazlett et al., 2012; Schumann et al., 2010) and atypical gray matter volume is found to contribute symptomology of ASD including atypical sensory processing and social cognitive impairments (Zhao et al., 2022). Additionally, some studies indicated abnormalities in amygdala and hippocampus size and volume. For example, children with ASD showed a small size amygdala and larger hippocampus compared to the control group (Nordahl et al., 2012; Xu et al., 2020). A recent study found that using oxytocin in the treatment of ASD symptomology showed reduced amygdala activation, in turn, leading to better self-report social functioning and lesser avoidant attachment (Bernaerts et al., 2020). Many studies highlighted that disarranged connections and communication between different brain regions in ASD such as connection between frontal and posterior cerebral structures may also result in symptoms of ASD (Just MA et al., 2012; Sofologi et al., 2020; Wass, 2011).

Table 2.1. Symptoms and Related Brain Regions in ASD

Social Impairments	Communication Deficits	Repetitive Behaviors
<ul style="list-style-type: none"> • Orbitofrontal Cortex • Anterior Cingulate Cortex • Fusiform Gyrus • Superior Temporal Sulcus • Amygdala 	<ul style="list-style-type: none"> • Inferior Frontal Gyrus (Broca's Area) • Superior Temporal Sulcus • Supplemental Motor Area • Basal Ganglia • Substantia Nigra • Thalamus • Pontine Nuclei • Cerebellum 	<ul style="list-style-type: none"> • Orbitofrontal Cortex • Anterior Cingulate Cortex • Basal Ganglia • Thalamus
<i>Mirror Neuron Regions</i>		
<ul style="list-style-type: none"> • Inferior Frontal Gyrus • Posterior Parietal Cortex 		

Source Note: Reproduced from Amaral, D. G., Schumann, C. M., & Nordahl, C. W. (2008). Neuroanatomy of autism. *Trends in Neurosciences*, 31(3), (p. 138), with kind permission of the author.

2.1.5. Autistic Traits

Autistic traits are a term used to describe the presence of ASD symptoms in individuals who may not meet the clinical criteria for an ASD diagnosis. These traits can also be observed in family members of those with autism or in neurotypical individuals and are also referred to as the Broad Autism Phenotype (BAP) in the literature (Baron-Cohen et al., 2001a; Hurley et al., 2007). In his case study, Kanner (1943) observed that parents of children with autism exhibit patterns of ASD symptoms including obsessive or rigid patterns and social difficulties that are below the threshold. As mentioned in the previous section 2.1.1, heritability is one of the important factors and Folstein and Rutter (1977) showed that the rates of diagnosis of ASD in both siblings were mainly observed in monozygotic twins compared to dizygotic twins. The heritability rate ranges from 9% to 33% in the first-degree relatives of ASD and the control group (Wheelwright et al., 2010). Also, the rates of autistic traits in control parents change between 5-9 %, and the rates in undergraduate students are from 18% to 40% (Sasson et al., 2013; Wainer et al., 2013). As Kanner states in 1943, the first-degree relatives of ASD have been reported to the presence of difficulties in pragmatic language, social functioning including quality and of relationships, and rigid, obsessive, perfectionist personality traits (Hurley et al., 2007; Losh et al., 2008). A meta-analysis study by Tick and its colleagues (2016) indicated that heritability is strong in ASD, but the importance of the environmental factors was highlighted. Also, although people with high autistic traits have difficulties and similar patterns in social cognitive functioning, their functionality in daily life is not clinically impaired (Losh et al., 2009).

Several scales have been developed to measure and evaluate autistic traits in neurotypical individuals. These include the Autism Quotient (AQ, Baron-Cohen et al., 2001a), the Broad Autism Phenotype Questionnaire (Hurley et al., 2007, BAPQ), and the Social Responsiveness Scale (SRS, Constantine & Todd, 2005). The BAPQ focuses on three key areas - aloof personality, rigidity, and pragmatic language - that are associated with the core symptoms of ASD, including social impairments, communication deficits, and restricted/repetitive behaviors and interests. The AQ is also a commonly used self-report measure for autistic traits, with various formats available for use in both clinical and non-clinical populations (such as online and in-

paper versions, as noted in studies by Dell’Osso et al., 2019; Galvin et al., 2020; Greenberg et al., 2018; and Shalev et al., 2022). AQ examines autistic traits in five main areas, and these are communication, social skills, attention switching, imagination, and attention to detail (Baron-Cohen et al., 2001a). AQ has the advantage of including both social and non-social aspects of autistic traits compared to other scales such as SRS and shows high discriminant validity to differentiate autistic and non-autistic groups, even though the scale is not a diagnostic instrument (Baron-Cohen et al., 2001a; Hoekstra et al., 2008; Ruzich et al., 2015).

2.1.6. Autistic Traits and Mental Health Problems

Many studies have indicated that comorbid symptoms, lower scores in quality of life, and internalizing and externalizing symptoms were frequently observed in individuals with ASD and elevated autistic traits (Albantakis et al., 2020; Kanne et al., 2009; Mason & Happé, 2022; van Steensel et al., 2013). Lai and colleagues (2019) conducted a meta-analysis and systematic review to determine the prevalence of comorbidity in ASD. Their findings suggest that individuals with ASD are more likely to experience mental health issues compared to the neurotypical individuals. Specifically, the comorbidity rates for mental health problems were found to be 28% for attention-deficit hyperactivity disorder, 20% for anxiety disorder, 13% for sleep disorder, 12% for disruptive, impulse control and conduct disorder, 11% for depression, 9% for obsessive-compulsive disorder, 5% for bipolar disorder, and 4% for schizophrenia. Another systematic review and meta-analysis study by Hollocks et al. (2019) for the prevalence rate for anxiety and depression in ASD demonstrates that the lifetime prevalence rates for any anxiety disorder and depression are 42% and 37%, respectively.

In terms of anxiety in ASD, van Steensel et al. (2011) indicated that the comorbidity rates of anxiety disorders are up to about 40% in children and adolescents with ASD. Wood and Gadow proposed a model in 2010 to explain the possible causes and effects of anxiety-related problems experienced by individuals with ASD. According to their model, people with ASD encounter various stressors related to their condition, such as challenges in social interactions and executive function, being bullied or excluded by peers, sensory difficulties, and discrimination due to their repetitive behavior in

environments like school. These stressors might lead to internalizing issues like depression and anxiety (Acker et al., 2018; Czermainski et al., 2015; Muskett et al., 2019; Wood & Gadow, 2010). For instance, children with ASD or the presence of higher autistic traits show higher rates of depression than neurotypical individuals, specifically with the presence of bullying (Rai et al., 2018). Individuals with ASD may experience anxiety for three potential reasons according to the hypothetical model by Wood and Gadow (2010). One reason could be due to the symptoms of ASD. Another possibility is that anxiety may act as a mediator or moderator, affecting the severity of ASD symptoms. Lastly, anxiety may represent ASD symptoms, as there are overlapping symptoms that can be challenging to differentiate (Wood & Gadow, 2010).

The association between autistic traits and mental health is not limited to autistic individuals. In fact, previous findings have indicated that individuals in the general population who are diagnosed with anxiety disorders or mood disorders show higher autistic traits (Albantakis et al., 2020; Towbin et al., 2005; van Steensel et al., 2013). Additionally, higher autistic traits are associated with early onset of bipolar disorder, higher anxiety disorder, and longer hospital stays (Dell'Osso et al., 2019). Another study showed that individuals with borderline personality disorder are also associated with higher autistic traits (Dell'Osso et al., 2018). In fact, high autistic traits are associated with anxiety and depression symptoms, difficulties in interpersonal relationships and personal adjustment, and lower mental well-being (Kanne et al., 2009; Stimpson et al., 2020), and possible predictors of anxiety, depression, and stress (Fietz et al., 2018). Lundström and colleagues (2011) have found that even lower-level autistic traits increase susceptibility to other mental health problems and are partly influenced by genetic and environmental conditions. Previous studies indicate that anxiety-related problems and depression are observed as the most common mental health problems in individuals with ASD and elevated autistic traits (Kanne et al., 2009; Howlin et al., 2000) and externalizing problems such as behavioral problems including aggression or hyperactivity are shown in the literature (Shea et al., 2018).

There is no single explanation for susceptibility to other mental health conditions, lower quality of life, and internalizing, and externalizing symptoms in ASD and individuals with elevated autistic traits. However, previous studies have suggested that

difficulties in executive functions are associated with internalizing behavior, anxiety, and depression symptoms (Gardiner & Iarocci, 2018; Hollocks et al., 2014; Zimmerman, 2016). Moreover, many studies have shown that difficulties in social cognitive skills in people with ASD and elevated autistic traits including emotion regulation, social problem-solving skills, social and communication difficulties, and empathic skills are also associated with other mental health conditions (Colonnese et al., 2017; Conner et al., 2020; Pickard et al., 2017). For instance, cognitive empathy is negatively associated with social anxiety, panic disorder, and separation anxiety disorder, while affective empathy is positively associated with all anxiety dimensions in inpatient adolescents (Gambin & Sharp, 2018). In a recent study, affective empathy shows a positive association with generalized anxiety disorder and a marginally positive association with social phobia and total anxiety score in adolescents with ASD (Sönmez & Jordan, 2023).

2.2. Social Cognition

One of the core impairments in ASD and significant autistic traits is linked to social cognition. Social cognition refers to an information process in social settings by using cognitive processes such as perception, attention, memory, and action planning (Frith, 2008). Social cognition is an umbrella term including some basic social cognitive skills such as recognition, understanding, and reasoning about own's and others' mental states (e.g., intentions and desires), and emotions to respond and adapt to the social world that calls in the literature as theory of mind or empathic skills (Baron-Cohen et al., 2002; Blair, 2005; Kanske et al., 2015). Empathy is a broad concept that is generally described as the ability to recognize and feel what others are feeling; however, before feeling it, we need to understand our own and others' emotions and mental states (i.e., intentions, desires, thoughts) in terms of prediction of their feelings, actions, thoughts. So, empathy is not solely associated with emotional aspects but also involves cognitive mechanisms (Blair, 2005; Perry & Shamay-Tsoory, 2013). To understand this system, two main theories, simulation theory, and theory-theory, proposed explanations about how and why this system works (Carruthers, 1996; Davies & Stone, 1995). Simulation theory proposes that humans automatically form a simulation of others' motor acts and that humans use mentalizing skills to understand and predict others' mental states, emotions, and actions by these acts (Gallese &

Goldman, 1998). Theory-theory explains this system by developing and using our theories based on our experiences, causal law, the knowledge about the world starting from our early life to understand and empathize with others' mental states (Gopnik & Wellman, 1994).

Many studies have shown that various systems are essential to perform empathic skills, including emotional skills like emotional contagion. This is one of the earliest developing systems and is defined by the ability to influence the emotional and arousal states of others. For example, babies start to cry when they hear another baby crying in their first days of life (Geangu et al., 2010; Singer & Lamm, 2009). One of the main differences between empathy and emotional contagion is the presence of self-other distinction and awareness in empathy but emotional contagion occurs without awareness, and it is kind of the developmental precursor of empathy (Singer & Lamm, 2009). In addition, sympathy is an emotional response that is confused with empathy and involves similar skills but is less directive, such as feeling for someone (Batson, 2009; Singer & Lamm, 2009) and compassion is also one of the popular terms and often used interchangeably with empathy which defined by the motivation to ease someone's distress or pain. Empathy could also include compassion but sometimes is not such as empathic distress which is accepted as part of empathy and may lead to a decrease in the motivation to alleviate others' distress and pain (Davis, 1983; Eisenberg & Fabes, 1990; McCall and Singer, 2013).

As mentioned above, empathy involves both affective and cognitive aspects. In neuroimaging studies, different parts of the brain are involved in these two different aspects of empathy (Kanske et al., 2015). For instance, while MNS system, inferior frontal gyrus (IFG), inferior parietal lobe (IPL), amygdala, insula, and anterior cingulate cortex (ACC) are responsible for affective empathy, ventromedial prefrontal cortex (vmPFC), dorsomedial prefrontal cortex (dmPFC), temporoparietal junction (TPJ), and dorsolateral prefrontal cortex (dlPFC) are shown to be active in cognitive empathic skills (Perry & Shamay-Tsoory, 2013). Whereas affective empathy involves emotional contagion, emotion recognition, and shared pain, and where simulation theory may take place, cognitive empathy involves theory of mind and perspective-taking skills which theory-theory may involve using our knowledge to make inferences

others' mental states and actions (Blair, 2005; Chakrabarti & Baron-Cohen, 2013; Perry & Shamay-Tsoory, 2013; Shamay-Tsoory et al., 2009).

2.2.1. Cognitive Empathy

Cognitive empathy refers to the ability to take the perspective of own and others' mental states including emotions, desires, intentions, and beliefs in terms of predicting their actions (Blair, 2005; Shamay-Tsoory, 2011). Cognitive empathy is generally used interchangeably with theory of mind (ToM) which is also firstly defined by imputing the mental states of own and others by Premack and Woodruff (1978) and mentalizing. In the literature, ToM abilities are seen as a part of cognitive empathy and two of them show some differences. While ToM is associated with understanding and taking perspective own and others, cognitive empathy also involves the emotional and social intentions as well (Canty et al., 2021; Perry & Shamay-Tsoory, 2013). Brothers & Ring (1992) illustrated cold and hot ToM functions. Cold ToM refers to the ability to attribute others' mental states, hot ToM involves emotional and social aspects of this attribution ability. The neuroimaging studies showed that the medial prefrontal cortex, superior temporal sulcus, the temporoparietal junction, and the temporal poles are associated with cold ToM skills while vmPFC and amygdala are associated with hot ToM skills (Frith & Singer, 2008; Shamay-Tsoory et al., 2005; Shamay-Tsoory et al., 2010; Perry & Shamay-Tsoory, 2013). For instance, while the participants used their cold ToM skills, dlPFCs were activated and vmPFCs were suppressed. Whereas vmPFC is active when the participants are engaged in hot ToM tasks and dlPFC is suppressed (Goel & Dolan, 2003). Perry and Shamay-Tsoory (2013) summarized the model of empathy to conclude that cognitive empathy is responsible for higher cognitive functions, hot and cold ToM skills (i.e., affective, and cognitive ToM skills), and self-other distinction.

To measure cognitive empathy, the first 'false belief' test was invented by Wimmer and Perner (1983). The content of the task is similar to the test called Sally-Anne Task by (Baron-Cohen et al., 1985). The children were shown a picture of Sally putting an object in a box and then leaving. While Sally was gone, Anne moved the object to a different location. The question posed is where Sally will look for the object when she returns. In Wimmer and Perner's study, most of the children aged 3 failed and only

57% of the 4-year-old children passed (1983). In addition, Strange Stories (Happé, 1994), and Reading Mind in the Eyes (Baron-Cohen et al., 2001b) are commonly used measurements for cognitive empathy tasks in the literature. Strange Stories (Happé, 1994) is one of the popular tasks for cognitive empathy, there are 24 short stories about social situations including intentions, jokes, and sarcasm. In this task, participants read short stories and interpreted why a character said something that was not meant literally. Each story is accompanied by a picture and two questions to test comprehension ("Was what X said true?") and mental state justification ("Why did X say that?"). The Reading Mind in the Eyes Test consists of 28 black and white eyes pictures to represent complex mental states and participants are asked to choose one of the four options that describe the picture well. This test is widely used in different studies and adapted to different languages including Turkish (Girli, 2014), French (Prevost et al., 2014), Persian (Khorashad et al., 2015), and Japanese (Kunihira et al., 2006). The other behavioral and self-report measures including The Director Task (Dumontheil et al., 2010), and Multifaceted Empathy Test (Dziobek et al., 2008), the Interpersonal Reactivity Index (IRI, Davis, 1983), and the Basic Empathy Scale (Jolliffe & Farrington, 2006) are also commonly conducted to measure both cognitive empathy and affective empathy.

2.2.2. Affective Empathy

Affective empathy (i.e., emotional empathy) is defined by identifying and experiencing the affective reactions of others and responding to them appropriately (Blair, 2005). Affective empathy involves several skills including emotion contagion, emotion recognition, shared pain, and empathic concern and sometimes may result in personal distress (Perry & Shamay-Tsoory, 2013; Zaki, 2017). As the simulation theory proposed, many studies indicated that the MNS system provides support for basic affective empathic skills including emotion contagion, imitation, emotion recognition, and shared pain by using visuomotor neurons (Blair, 2005; Perry & Shamay-Tsoory, 2013). For instance, mimicry in facial expressions is strongly associated with affective empathy rather than cognitive empathy (Drimalla et al., 2019). Chakrabarti et al. (2006) found a positive correlation between the Empathy Quotient (EQ, self-report measurement of empathy) and the IFG area when video clips related to basic emotion were shown to the participants.

Emotional expression can help to transfer the information from one's to another and these expressions are produced automatically and intentionally by the individuals. The findings indicated that each emotional expression shows different implications that may related to several distinct systems (Blair, 2003). The recognition and experiencing of emotions, especially fear, social perception, and behavior, reward systems are associated with the limbic system, particularly the amygdala. Specifically, fear, sadness, and happiness are seen as reinforcers to prepare and perform future actions. For instance, while fear and sadness play roles as aversive conditions to be avoided in future situations and discourage future actions, happiness acts as a reinforcer to increase probability of the future actions (Blair, 2003; Blair, 2005; Perry & Shamay-Tsoory, 2013). Not only MNS system and visuo-motor neurons involved the emotional empathy, but also tactile and smelling processes are associated with their somatosensory mirror system. Experiencing pain and shared pain processes are involved in the activation of ACC and the insula and these activations show a positive correlation with the detection of the pain intensity from others' facial expressions (Decety et al., 2010; Saarela et al., 2007).

To measure affective empathy, Empathy Quotient (Baron-Cohen & Wheelwright, 2004), and IRI (Davis, 1983) are some of the popular empathy scales in the literature. IRI has four subscales to measure different components of empathy compared to EQ. Even though there is no consensus on these distinctions, while personal distress and empathic concern are accepted as components of affective empathy, perspective-taking, and fantasy are components of cognitive empathy (Sindermann et al., 2019). In terms of behavioral measurements, Self-Assessment Manikin (SAM) is used to measure self-reported emotional responses to facial expression images for affective empathy in the literature. The task requires participants to examine each facial expression and rate how they feel it on a valence scale (more negative (1) to more positive (9)) (Güntekin & Basar, 2007; Wai & Tiliopoulos, 2012). The multifaceted Empathy Test (Dziobek et al., 2008) is also a popular behavioral measurement for two components of empathy (cognitive empathy and affective empathy), and the test measures the arousal level of participants for affective empathy after showing a picture and giving related information to participants.

The onset of cognitive empathy and affective empathy are considered separately in the literature because each component of empathy shows different patterns of developmental stages. Previous studies have indicated that affective empathy shows earlier developmental patterns compared to cognitive empathy by using emotion contagion, emotion recognition, and imitation (Dondi et al., 1999; Singer & Lamm, 2009). For instance, even from 12 days to 21 days old infants can imitate the facial expressions of their primary caregivers (Meltzoff & Moore, 1977) and at 10 weeks infants are capable of imitating fear, sadness, and surprise (Haviland & Lewica, 1987). It was shown that the MNS system started the functioning in early months of life (Nyström, 2008). Additionally, previous studies have shown that emotional contagion in infants is observed in the first days of life (Geangu et al., 2010; Singer & Lamm, 2009). At the ages of 18- and 36-months old infants became distressed and responsive to others' sadness (Bandstra et al., 2011) These affective empathic skills including emotion recognition, emotional understanding, empathic concern, and shared pain develop with age (Decety, 2010).

Previous studies with false belief tasks for cognitive empathy have demonstrated that 57 % of children aged 4 years old can pass the first-order false belief tasks compared to 3-year-olds (Wimmer & Perner, 1983). This skill develops by the age and 6 years of children sufficiently perform the false belief tasks compared to 3-4 years children (Wellman & Liu, 2004). As mentioned in section 2.2.1., cognitive empathy is associated with the activation of vmPFC which shows maturation through late adolescence, and the age-related differences in brain activity in terms of cognitive empathy were observed between ages 9 and 16 (Decety, 2010; Moriguchi et al., 2007). According to Dorris and colleagues (2022), children between the ages of 6-7 and 10-12 demonstrated considerable improvement in their cognitive empathic skills. Cognitive empathy reached its highest level between the ages of 19-25 and declined among those aged 65 and above. It is worth noting that females exhibit superior cognitive empathic abilities across all age groups.

2.2.3. Social Cognition and Autistic Traits

Many studies have indicated that individuals with ASD and elevated autistic traits show difficulties in social cognitive skills (Baron-Cohen, 2011; Grove et al., 2014;

Harmsen, 2019; Mazza et al., 2014) that may be associated with the quality of social relationships, and comorbid mental health problems such as anxiety (Eussen et al., 2013; Keifer et al., 2020; Lei & Ventola, 2018; Patriquin, 2019). In 1985, Baron-Cohen and colleagues proposed the “theory of mind deficit hypothesis” and their results showed that 80% of autistic children failed the ToM task (i.e., Sally - Anne Task) compared to children with Down’s Syndrome who have lower verbal and non-verbal IQ scores and only 20% of autistic children passed the task. Happé (1994) also found that autistic children showed lower scores on the ToM task (i.e., Strange Stories) and this study replicated by Girli (2017) that showed Turkish autistic children have lower scores on both Strange Stories and Reading Mind in the Eyes Test compared to TD group. Baron-Cohen (2002) developed this hypothesis and proposed the theory called ‘Empathizing-Systemizing Theory (E-S)’ which stated that individuals with ASD showed deficits in empathizing skills including cognitive and affective empathy and ToM skills and showed better systemizing skills (explained in detail in section 2.6) and some of the research supported his theory by showing impairments in both cognitive and affective empathy tasks (Bos & Stokes, 2018; Grove et al., 2014; Sönmez & Jordan, 2023). However, there is no consensus on affective empathy tasks because many studies indicated that individuals with ASD show intact affective empathic skills (Mazza et al., 2014; Mul et al., 2018; Rueda et al., 2015). For example, Rogers and colleagues (2007) employed IRI on individuals with ASD and found that participants showed lower scores on cognitive empathy subscales (i.e., perspective taking and fantasy) but showed no differences on affective empathy subscales (i.e., personal distress and empathic concern) compared to a control group.

Similarly, several studies indicated that elevated autistic traits may result in social cognitive difficulties including cognitive and affective empathy and ToM skills (Grove et al., 2014; Gökçen et al., 2014). Individuals with elevated autistic traits show lower scores in emotional intelligence trait, empathy quotient (affective and cognitive components), and theory of mind tasks (Reading Mind in the Eyes and The Movie for the Assessment of Social Cognition by Dziobek (2006); Gökçen et al., 2014; Gökçen et al., 2016). In addition, Svedholm-Hakkinen and colleagues (2017) indicated that elevated autistic traits in the general population supported E-S Theory by showing lower scores on empathy and higher scores in systemizing tasks and Shah and colleagues (2019) found that autistic traits are the predictor of atypical cognitive,

affective, and total empathy score in the general population. Grove and colleagues (2014) found that first-degree relatives of autistic individuals also showed milder impairments in similar social cognitive tasks compared to individuals with autism and non-clinical groups. Additionally, a recent study demonstrated that younger and older adults with elevated autistic traits showed difficulties in ToM tasks, even though older age could be a risk factor for lower ToM performance (Stewart et al., 2020). Another study found that higher autistic traits are related to cognitive empathic difficulties but not affective while higher psychopathic traits are related to lower affective empathic tests, not cognitive empathic skills (Lockwood et al., 2013).

Emotion recognition is also an essential part of the social cognitive skills (specifically, in affective empathic skills) for better social functioning (Blair, 2005; Perry & Shamay-Tsoory, 2013). Even though several studies indicated that individuals with ASD showed difficulties in emotion recognition (Fridenson-Hayo et al., 2016; Kuusikko et al., 2009; Rump et al., 2009), there some studies showed that individuals with ASD showed impairments in emotion recognition only for complex emotions such as surprise, not the basic emotions (Jones et al., 2011; Tracy et al., 2011). However, the recent systematic review and a meta-analysis study stated that individuals with ASD showed impairments in all emotion recognition levels (Yeung, 2022) and individuals with ASD showed different strategies for processing emotions compared to the typically developing (TD) group (Leung et al., 2023). In terms of autistic traits, individuals with elevated autistic traits showed higher attention to emotion biases, no attentional biases to fearful faces, and higher response time to reading mental states from eyes which are similar patterns observed in individuals with ASD (Miu et al., 2012). In particular, fathers of autistic children show lower performance on the Reading Mind in The Eyes test than mothers and the control group (Palermo et al., 2006). However, a recent study indicated that intact visual-emotional face processing was observed in individuals with elevated autistic traits (Greene et al., 2020).

Together with emotion recognition, emotion regulation is also another essential concept to continue effective social interaction as well as better mental health outcomes and defined as an automatic or intentional process to modify one's emotional states for adaptive functioning (Mazefsky et al., 2013; Tone & Tully, 2014). Emotion

regulation and empathic skills are associated with social cognitive skills and the findings have indicated that increased emotion regulation strategies are positively associated with cognitive empathic skills while negatively associated with affective empathic skills (Thompson et al., 2022). Individuals with ASD showed difficulties in emotion regulation strategies which may result in temper tantrums, impulsive behaviors, or aggression and it was found that all core symptoms of ASD are associated with difficulties in emotion regulation strategies (Berkovits et al., 2017; Cai et al., 2018). Mazefsky and colleagues (2013) summarized possible contributors of emotion dysregulation in ASD. Function and motivation of emotion and emotional experience are some of the contributors due to less organized and goal-directed emotions, also enhanced negative emotional experience, and reduced positive emotion experience were observed in ASD and individuals with elevated autistic traits (Zhao et al., 2020). Differences in physiological activity and neural circuitry, comorbid psychiatric conditions which are highly common in ASD and individuals with elevated autistic traits (Fietz et al., 2018; Hollocks et al., 2019), difficulties in cognitive skills including attention, cognitive flexibility, and problem-solving skills and differences in perception and information processing are other factors to contribute emotion dysregulation in ASD and individuals with elevated autistic traits (Mazefsky et al., 2013). Findings across individuals with elevated autistic traits do not show consensus. For example, some studies have found that higher autistic traits are associated with emotion dysregulation, lower reappraisal strategies in particular and self-reported emotion dysregulation in the general population (De Groot & Van Strien, 2017; Liu et al., 2017; Zhao et al., 2020) whereas other findings have indicated that higher autistic traits are associated with reappraisal success and intact emotional arousal in electrophysiological findings (De Groot & Van Strien, 2017; Diefenbach et al., 2021).

2.2.4. Social Cognition and Mental Health

Previous research suggests that social cognitive skills are linked to mental health outcomes and treatment success in psychotherapy (Allemand et al., 2015; Fernandes et al., 2018; Gambin & Sharp, 2018). Empathy, in particular, is associated with positive outcomes such as better quality of life, social competence, and prosocial behavior, while lower empathy scores are associated with negative outcomes such as poor peer relationships, bullying, aggression, psychopathy, and violence. (Allemand

et al., 2015; Baron-Cohen, 2001; Blair, 2005; Lovett & Sheffield, 2007). Studies have shown that individuals with social anxiety disorder, major depressive disorder, ASD, schizophrenia, and psychopathy often struggle with empathy (Gambin & Sharp, 2018; Lee et al., 2011; Sönmez & Jordan, 2023; Tibi-Elhanany & Shamay-Tsoory, 2011; Washburn et al., 2016). However, the two main components of empathy, affective and cognitive, have different relationships with mental health conditions (Gambin & Sharp, 2018; Sönmez & Jordan, 2023). For example, Gambin and Sharp (2018) found that cognitive empathy is negatively associated with social anxiety, separation anxiety disorder, and panic disorder, while affective empathy is positively associated with these conditions in inpatient adolescents. Similarly, depression is positively associated with affective empathic components (i.e., higher levels of empathic stress), while it is negatively associated with cognitive empathic skills including perspective-taking, theory of mind, and empathic accuracy (Schreiter et al., 2013). In addition, Yan and colleagues (2021) have conducted a meta-analysis study to examine the relationship between depression and empathy, and their results showed that affective empathy is positively correlated with depression. These differences could be explained by Tone and Tully's model (2014). According to their model (Tone & Tully, 2014), although better affective empathic skills are associated with empathic concern and better social functioning, this skill also may lead to personal distress. Due to self-oriented aversive reactions, affective empathy can be seen as a 'risky strength' together with biological and environmental factors in the model. In this context, emotion regulation is the key concept to regulating personal distress in terms of developing internalizing problems (Gambin & Sharp, 2016; Tone & Tully, 2014).

Along with internalizing problems, neurocognitive conditions such as ASD, schizophrenia, Alzheimer's disease, Parkinson's disease, and dementia are also associated with social cognitive skills (Baron-Cohen, 2011; Blair, 2005; Coundouris et al., 2020; Perry & Shamay-Tsoory, 2013). Schizophrenia is one of the neuropsychiatric disorders characterized by social cognitive impairments including emotional and social perception, ToM skills, and empathic skills (Canty et al., 2021; Nahum et al., 2021; Perry & Shamay-Tsoory, 2013) and developed different social cognitive training in terms of the treatment for schizophrenia (e.g., Nahum et al., 2013; Nahum et al., 2021). A recent study indicated that individuals with early schizophrenia show better performance in cognitive empathy tasks compared with individuals with

chronic schizophrenia (Canty et al., 2021). However, there is no consensus for affective empathy. Some studies have reported intact affective empathy skills (Haker et al., 2013; Michaels et al., 2014) while others found lower scores on affective empathy measures (Lee et al., 2011; Shamay-Tsoory et al., 2007). ASD is another neuropsychiatric condition associated with social cognitive impairments including empathic skills, emotion recognition, and ToM skills (Baron-Cohen, 2011; Sabbagh, 2004) whose treatments of social functioning are also focused on social cognitive skills (e.g., Didehbani et al., 2016; Patriquin, 2019).

2.3. Executive Functions

Executive Functions (EFs) are a set of neurocognitive skills that support the top-down control of cognitive, behavioral, and affective processes and these skills are essential to perform and continue social, cognitive, and psychological development as well as better mental and physical health, public safety, marital harmony, and success in academic and work life (Diamond, 2013; Zelazo, 2020). These skills are necessary for various mechanisms in our lives including complex social functioning, self-regulation, problem-solving, emotion regulation, and deliberate reasoning to adapt and learn in different contexts (Diamond, 2013; Zelazo, 2015). Throughout history, researchers have given a great deal of attention to EFs. The importance of the frontal lobe and its associations with EFs in human development has been worked in the literature and studies have been done with patients with frontal lobe damage (e.g., Phineas Gage, Miyake et al., 2000; Stuss, 1992; Pennington & Ozonoff, 1996). In Phineas Gage's example, after the frontal lobe damage, he showed severe problems such as difficulties in controlling and regulating actions and continuing his daily life (Miyake et al., 2000).

In terms of theoretical frameworks in EFs literature, unitary and multifactorial models have been proposed to explore and provide a better understanding of EFs. Unitary models including Luria (1966), Baddeley and Hitch's central executive hypothesis (1974), and Posner's cognitive attention theory (1982) have been proposed and studied EFs as a unitary construct, and the dysfunctionality in EFs resulted in behavioral dysregulation. Luria (1966) is one of the first examiners of EFs related to frontal lobe damage. In this model, there is a hierarchical nature of brain function, and the frontal lobe damage is at the top of the hierarchy and proposed top-down control process but

states bidirectional influence between this hierarchy as well. In turn, these behavioral outcomes that patients showed result in frontal damage syndrome. Multifactorial models have divided EF into different domains. One of the influential multifactorial models is Miyake's unity in diversity model (Miyake et al., 2000). In this model, three core EF skills, inhibition, working memory, and set-shifting (i.e., cognitive flexibility) are empirically confirmed and these skills can be distinguishable but not completely independent of each other and share some underlying commonality (Miyake et al., 2000) and so far many studies focus on three core skills which are cognitive flexibility, inhibitory control, and working memory in the literature (Diamond, 2013; Zelazo, 2020).

Although the historical perspective mainly relies on frontal lobe damage and dysfunction, other brain regions and networks are also associated with EFs. For example, the previous findings have indicated that dorsolateral PFC, lateral parietal cortex, bilateral insula, lateral and superior mPFC, middle and inferior temporal cortex, posterior cingulate cortex, precuneus, thalamus, amygdala, and limbic system are associated with EFs skills (Niendam et al., 2012; Zelazo et al., 2020). Due to mainly the dominance of PFC, EFs skills are not fully functioning in infancy and childhood; however, EF have started to emerge in the first days of life (Fuster, 2000; Zelazo & Müller, 2002). According to Piaget (1954), the first signs of EF were observed between 8-9 months in the sensorimotor stage and Diamond (2006) states that between 8-12 months detour reaching was also observed in the research findings. During the second year of life, infants develop EFs by grasping. Between ages 3 and 7, improvements in EFs including cognitive flexibility and inhibition were observed and it continues through adolescence and early adulthood periods (Diamond, 2006).

EFs and social cognition are connected mechanisms to facilitate better functioning in human life and making a clear distinction between them is difficult. Even though some researchers accepted them as two distinct mechanisms (Schulte et al., 2022; Wellman et al., 2008), some studies stated that social cognition is part of the EF mechanism (Zelazo, 2020; Zimmerman et al., 2016). Hot and cool EFs terms are preferred according to EFs including social cognitive skills or not (Zelazo & Carlson, 2012). Metcalfe and Mischel (1999) first mentioned "hot-cool systems" and the researchers proposed that hot systems involve affective processes and influence behavior and are

controlled by cool processes; however, the model undermines top-down processes. Rather than focusing on bottom-up processes or undermining top-down processes, Zelazo and Carlson (2012) indicated that the concept of hot EFs implies that contexts that are important for motivation require distinct top-down processes. Cool EFs include working memory, inhibition, planning, and cognitive flexibility mechanisms that are operated in non-affective contexts, while hot EF involves motivational and affective aspects of EFs mechanisms including ToM and empathic processes (Zimmerman, 2016, also see McDonald, 2013). This thesis will explore the distinct but interconnected mechanisms of EFs and social cognition, building upon prior research (Blackmore & Choudhury, 2006; Gökçen, 2015; Gökçen et al., 2016; Ozonoff et al., 1991).

2.3.1. Working Memory

Working memory (WM) is one of the essential EFs that involves holding information in short-term memory and working with it. WM is a critical cognitive function that helps individuals with various skills such as reasoning, organizing, thinking, and considering information (Diamond, 2013). Baddeley and Hitch proposed the ‘central executive hypothesis’ for WM (1974) that WM consists of three subsystems which are the phonological loop, episodic buffer, and visual sketchpad that are responsible for processing and storing temporally visual and verbal information (Baddeley, 2000). The central executive is part of the WM that involves the coordination of the information between the phonological loop and visual sketchpad, and it is a kind of supervisory role that has limited capacity. WM is overlapped with short-term memory, but WM involves not only holding information but also manipulating it and WM is related to the activation of dPFC (Diamond, 2013).

WM plays important roles in different parts of our lives. Increased WM capacity is related to improvements in children’s reasoning ability, also related to academic performance and intelligence, and WM is connected to other EFs skills including inhibitory control and cognitive flexibility and they work in an interconnective way to provide better functioning (Conway et al., 2003; Diamond, 2013; Spencer, 2020). In addition, WM is associated with other everyday functioning including reading, navigating, problem-solving, comprehension, and as well as social functioning

(Beilock & DeCaro, 2007; de Jong, 2006; Friedman & Miyake, 2004; Goldstein et al., 2014; Kane et al., 2004; Garden et al., 2002). Studies indicate that the development of WM starts in the early months (e.g., 9 to 12 months, Bell & Cuevas, 2016) and there is significant development through childhood years and adolescence (Cowan, 2023; Gathercole et al., 2004); however, WM starts to decline older ages as well as other EFs such as inhibitory control. It may happen due to neural system capacity changes over time (Solesio-Jofre et al., 2012; Spencer, 2020).

To measure WM skills, several tasks are developed. Earlier studies generally use memorizing sequence numbers, pictures, and words and these tasks are called as n-back task, the digit span task, and the word span task (Wechsler, 1998, Kirchner, 1958). In the digit span or word span tasks, participants need to memorize the sequences of the digits, words, or sentences and recall them in the experiment. The n-back task by Kirchner (1958) is one of the popular tasks for WM in the literature (Barendse et al., 2018; Han et al., 2022; Yuk et al., 2020). In this task, words or numbers can be used. A sequence of words, letters, or numbers is presented and asked to the participants whether a target stimulus is the same or different from stimuli presented “n” trials ago.

2.3.2. Inhibitory Control

Inhibitory control refers to an ability to control attention, behavior, thoughts, and emotions in a range of different situations (e.g., distractions, impulsive utterances, internal predispositions, and needs; Diamond, 2013). Inhibitory control involves various aspects of daily functioning (Diamond, 2013). First, control of attention (i.e., selective attention) by enabling us to focus on what we want and inhibiting other distractors. Second, cognitive inhibition refers to suppressing, manipulating, and controlling attention for cognitive/mental abilities. Self-control/ regulation are also parts of inhibitory control by controlling, manipulating, and organizing one’s emotions, thoughts, and actions. These skills are not solely distinct from WM capacity because WM capacity is also involved in these processes (Anderson & Levy, 2009; Diamond, 2013). For instance, ignoring distractors while performing other tasks, and ignoring irrelevant information are some examples of inhibitory control skills in daily life (Hasher & Zacks, 1988; Logan, 1994). These skills are associated with effective

social and emotional functioning by controlling impulsive actions (Rhoades et al., 2009; Riggs et al., 2006). Several studies indicated that effortful control over emotions, thoughts, and behaviors is related to better social, emotional, and academic outcomes and negative emotionality is related to lower effortful control, in turn, lower management of attention, emotions, and behavioral responses (Eisenberg & Spinrad, 2004; Rothbart & Bates, 1998). Such inhibitory control is also an important factor for psychological resilience to manage potential interruptions (Spielberg et al., 2015). The cohort study by Moffitt and colleagues (2011) with conducting 1,000 children following them from birth to age 32 found that children between 3 to 11 ages have better inhibitory control skills including waiting their turn, increased inhibit distractors, and higher selective attention and less impulsivity less likely to show risky behaviors, using smokes and drugs and they offer better physical and mental health (e.g., less obesity, low blood pressure). Also, they show better academic achievement and higher income, and they reported higher positive emotionality (e.g., happiness) than those who had lower inhibitory control during these years (Moffitt, 2013).

The activation of PFC is also significantly found in inhibitory control studies (Bunge et al., 2002; Dorston et al., 2002). Dorston and colleagues (2002) specifically indicated that bilateral vPFC, the right parietal lobe, and the right dPFC showed increased activation during the inhibition tasks. The activity of PFC shows increases during early adolescence with maturation and this development in adolescents is associated with improved selective attention abilities and inhibitory control (Anderson et al., 2001; Leon-Carrion et al., 2004). However, although inhibitory control develops during the adolescents' years, impulsivity and risk-taking behavior increase due to the increase of subcortical activation in the nucleus acumens (part of the basal ganglia) and the amygdala (Erns et al., 2005; Steinberg, 2008).

In the assessments of inhibitory control, several tasks were developed. Windows task (Russell et al., 1991) is one of the examples to measure inhibitory control in children (Russell et al., 1991; Yers et al., 2007). In this task, children are given two boxes, one with a reward (e.g., chocolate) and one empty. They are asked to point to the box an opponent should look in and get to keep the other box. The task requires them to resist the desire to point to the reward and instead point to the empty box. The Stroop task is another popular inhibitory task (Jahromi et al., 2013; Stroop, 1935; Xiao et al., 2012).

In this task, participants are expected to read color words printed in congruent or incongruent colors as quickly and accurately as possible. The difference in reading times measures the inhibition of distracting information. The variants of the task are done in computer to use select (e.g., colors, emotions, day/night) rather than reading. Go / No Go Task is also used to measure inhibitory control (Donders, 1969; Happé et al., 2006; Sanderson & Allen, 2013; Xiao et al., 2012). In this task, participants are asked to press the button when they see the go target, not the no-go target. They need to respond quickly and accurately. The go target is shown more often, so they must inhibit the pre-potent pattern established at the start.

2.3.3. Cognitive Flexibility

Cognitive flexibility is another core EFs that is defined by changing a person's perspective spatially and interpersonally, being flexible to changes and demands, and adapting to these stimuli successfully. Cognitive flexibility also involves task switching and set-shifting to be used to measure cognitive flexibility as well (Diamond, 2013). It also refers to the ability to change, manage, and shift attention to better functioning between different tasks (Miyake et al., 2000). According to Dajani and Uddin (2015), several subdomains of EFs work together to better cognitive flexibility and these are salience detection and attention, WM, inhibitory control, and switching. Increased flexibility is associated with better emotional, social, and academic functioning (Hayes et al., 2016; Lin et al., 2013). Bilgin (2017) found that higher cognitive flexibility is associated with a higher level of extroversion, openness to new experiences, higher self-efficacy and mental well-being and more self-controlled and cognitive flexibility is a predictor of life satisfaction, happiness, academic achievement, and school adaptation (Asıçı & İkiç, 2015; Bing, 2011; Çikrikci, 2018; Demirtaş, 2020; Lin et al., 2013; Titz & Karbach, 2014). In addition, higher cognitive flexibility skill is associated with less parent-child conflict and children can come up with alternative solutions to solve conflict (Ahn et al., 2008).

As mentioned in previous sections, EF skills have started to develop from infancy through early adulthood. Rapid changes in EF skills are observed between preschool and adolescence years (Buttelmann & Karbach, 2017; Hughes, 1998). To see the development of cognitive flexibility, task-switching, and set-shifting tasks are

generally applied to children. For instance, while children aged 4 can switch the rules of the task and apply it, 3-year-old children keep the first rule and show difficulties in applying the second rule (Doebel & Zelazo, 2015). Their performance on cognitive flexibility develops with age and they can apply this skill in more complex tasks and reach peak performance around the ages of 21 and 30 (Cepeda et al., 2001; Diamond, 2013). These developmental differences are associated with the maturation of specific brain regions like other EF skills (Diamond, 2013). For example, PFC and parietal regions, basal ganglia are associated with the development of cognitive flexibility (Bunge & Wright, 2007). Frontoparietal regions are highly active during cognitive flexibility tasks including vPFC, dPFC, anterior cingulate and right anterior insula and premotor cortex and inferior and superior parietal cortex, thalamus, occipital cortex show activation as well (Dajani & Uddin, 2015; Kim et al., 2012; Niendam et al., 2012).

To measure cognitive flexibility, the Wisconsin Card Sorting Task (WCST, Grant & Berg, 1948) is one of the popular cognitive flexibility tasks. The participant is asked to sort a deck of 128 cards into four stacks based on the color, shape, or quantity of geometric shapes. The sorting rule changes after every 10 correct matches without the participant knowing. Another popular variant of WCST is the Dimensional Change Card Sort Task (DCCS) specifically developed for children (Zelazo, 2006). In this version, children are asked to sort cards based on dimensions, such as color and shape, but the examiner informs them when the rule has changed. Additionally, the Stroop Test can also be used for cognitive flexibility in the literature (Djamshidian et al., 2011; Moore & Malinowski, 2009; Stroop, 1935).

2.3.4. Executive Functions and Autistic Traits

Many studies have proposed that individuals with ASD show difficulties in core EFs including WM, cognitive flexibility, and inhibitory control, and EFs play an important role in understanding difficulties that are related to ASD (Demetriou et al., 2018; Hill, 2004). Due to the spectrum of ASD, indicating direct causality for difficulties in EFs is difficult because cognitive, emotional, and developmental variability changes across this disorder (Demetriou et al., 2018). Executive Dysfunction hypothesis proposed to explain both social and non-social symptoms of ASD by impairments in EFs (Ozonoff

et al., 1991). Impaired PFC activation and abnormal brain connectivity may contribute to these dysfunctionalities (Aoki et al., 2013; Ozonoff et al., 1991). Even though the results are mixed due to the spectrum, the review study conducted between 1980 and 2012 concluded that autistic individuals show more difficulties and errors in cognitive flexibility tasks compared to healthy controls (Leung & Zakzanis, 2014). In addition, difficulties in inhibitory control and WM are also present in the ASD literature but these difficulties are also changes across the measurements. For instance, autistic individuals show no differences in the Stroop Task compared to control groups but show difficulties in the Go/No Go task (Christ et al., 2007; Langen et al., 2012). These differences may be explained by different age groups in the literature because EFs performance develops with age (Diamond, 2013; Geurts, 2014). In addition, another meta-analysis study for WM in ASD showed that significant WM impairments were found in individuals with ASD compared to the TD group and there are no age-related differences in this domain of EFs (Wang et al., 2017). Happé and colleagues compared groups with ASD, ADHD, and TD in their study (2006). According to their findings, both ADHD and ASD groups show lower scores on EFs compared to the TD group. However, the ADHD group showed lower scores on Go/No Go tasks compared to the ASD and TD group, while the ASD group showed lower scores on cognitive estimates tasks for selection and monitoring of response. By age, the ASD group showed better performance for all EF performance compared to the ADHD group and showed similar functioning with the TD group (Happé et al., 2006). The findings of the meta-analysis by Lai and colleagues (2017) indicate that the most significant impairments were observed in cognitive flexibility, particularly in set switching set-shifting, and WM in individuals with ASD. On the other hand, inhibitory control is not as prominently affected.

Similarly, Gökçen and colleagues (2016) found individuals with elevated autistic traits show similar patterns of EFs difficulties (i.e., inhibitory control and cognitive flexibility). Another study demonstrated that individuals with high autistic traits show lower scores on all EFs tasks including inhibitory control, set-shifting, cognitive flexibility, WM, self-monitoring, planning, and task monitoring (Christ et al., 2010). Hyseni et al. (2019) stated that children with ASD and elevated autistic traits show lower performance on neuropsychological tasks (e.g., attention, memory, and language). A recent study suggests that individuals with subthreshold autistic traits are

at risk of developing cognitive (e.g., EFs skills), and emotional and behavioral difficulties (Shirama et al., 2022). In addition, parents of autistic children showed lower scores on inhibitory control, selective attention, cognitive flexibility, planning, and sustained attention compared to parents of the TD group which supports the BAP studies in the literature (Shalani et al., 2019).

2.3.5. Executive Functions and Mental Health

The review by Zelazo (2020) indicated that many studies show difficulties in EFs are associated with different mental health problems and clinical conditions including learning disabilities, attention-deficit/hyperactivity disorder, conduct disorder, ASD, obsessive-compulsive disorder, depression, and anxiety. As mentioned in previous sections, better EFs skills (i.e., WM, inhibitory control, and cognitive flexibility) are associated with better emotional and social functioning through better self-control and regulation, higher flexibility with resilience to negative experiences, better emotion regulation, higher academic achievement and better school performance, higher mental well-being, and positive emotional outcomes (Diamond, 2013; Eisenberg et al., 2004; Hayes et al., 2016; Lin et al., 2013; Moffitt et al., 2011; Spielberg et al., 2015). Yang and colleagues (2022) conducted a meta-analysis of prospective longitudinal studies for EFs and their relations with internalizing and externalizing problems. According to their results, better EFs skills in childhood are associated with fewer attention-deficit/hyperactivity symptoms, less substance use, and internalizing problems including depression and anxiety. In addition, lower externalizing problems such as less impulsivity, less maladaptive behaviors, and conduct disorder (Yang et al., 2022).

Zelazo (2020) states that EFs could develop by practicing but also be affected by different conditions including stress, socioeconomic status (SES), or trauma. One of the studies on the relationship between stress and EFs indicates that acute stress conditions impair WM and cognitive flexibility (Shields et al., 2016a). However, this could be a bidirectional effect because deficits in EF skills may result in vulnerability to stress dysregulation as well as emotion dysregulation (Williams et al., 2009; Zelazo, 2020). Not only stress, but environmental conditions such as SES, neglect, malnutrition, and exposure to loud noise that may result in higher stress levels could

interrupt the development of EFs skills (Blair & Raver, 2016; Zelazo, 2020). Adverse childhood experiences (ACEs) as well as trauma are other essential conditions that may be considered for the effects on EFs. In a systematic review by Polak and colleagues (2012), patients with post-traumatic stress disorder (PTSD) show lower EFs performance compared to controls, and specifically higher severity of comorbid depressive symptoms in patients with PTSD is related to poorer EFs performance. Another study found that EFs are a mediator factor in the relationship between childhood trauma, and internalizing and externalizing problems (Wei & Lü, 2023). In terms of other clinical conditions, anxiety is negatively associated with EF performance (Shields et al., 2016b). In addition, trait anxiety negatively predicts EF performance in children (Ursache & Raver, 2014). A meta-analysis study by Yang and colleagues stated a significant relationship between rumination, inhibition, and cognitive flexibility which may result in other clinical conditions including depression and anxiety (Yang et al., 2017). ADHD and ASD are also some of the other clinical disorders that are associated with difficulties EFs performance, and several studies have been conducted to examine these relationships in the literature (Barkely, 2011; Craig et al., 2016; Dajani & Uddin, 2015; Pennington & Ozonoff, 2006). In conclusion, EFs are related to both physical and psychological functioning in our lives (Diamond, 2013; Zelazo, 2020).

2.4. Summary

Autistic traits refer to a subclinical level of ASD and the presence of ASD symptoms in family members as well as in the general population (Baron-Cohen et al., 2001a; Hurley et al., 2007). Individuals with ASD and elevated autistic traits show difficulties in social cognitive skills including cognitive and affective empathy. Moreover, the presence of difficulties in EFs including WM, cognitive flexibility, and inhibitory control were reported in the literature as well. As mentioned above sections, social cognitive skills, such as cognitive and affective empathy, and executive functions, including WM, inhibitory control, and cognitive flexibility, are crucial for physical and mental well-being, quality of social relationships, and success in school and work. However, even though autistic traits can increase the likelihood of other mental health issues, no study has yet examined the links between autistic traits, executive functions,

and social cognitive skills, to develop effective intervention and prevention programs for mental health and quality of life in both general and clinical populations.

In the following chapter, the comparison of online-based and paper-based data collection procedures using two main questionnaires, the Autism Quotient (AQ) and the Depression Anxiety Stress Scale 21 (DASS-21), was conducted. The results of this study provided a foundation for the methodological choices in subsequent chapters, confirming the reliability of the online data collection method. Building on these findings, Chapter 4 investigates the mediator roles of executive functions and social cognition in the relationship between autistic traits and mental health symptoms. This investigation aligns with the thesis's main objectives and provides crucial insights that inform the development of the online training program in the next chapter. In Chapter 5, a thorough review of the literature was conducted to guide the design of the online training program, focusing on combining executive functions and social cognitive skills. The training program and its manual are explained in detail, and a pilot study was conducted to test the feasibility of this intervention. Finally, Chapter 6 examines the efficacy of the combined executive functions and social cognition online training program in improving mental health outcomes. The chapter evaluates whether the program effectively reduces mental health symptoms in neurotypical individuals, drawing on the insights gathered from all previous chapters.

CHAPTER III

STUDY 1: THE COMPARISON OF ONLINE-BASED AND PAPER-BASED DATA COLLECTION FOR AUTISM QUOTIENT (AQ) AND DEPRESSION, ANXIETY AND STRESS SCALE 21 (DASS-21)

3.1. Introduction

Online-based data collection in clinical psychology has become more prevalent due to various opportunities such as easier application to the participants, reaching larger, representative, and diverse samples, better efficiency in managing, collecting, and entering data, and reduced costs (Campos et al., 2011; Lahoud et al., 2022; Nelson et al., 2021; Patalay et al., 2016). However, concerns about the validity and reliability of data can occur due to possible problems including the quality of the data and methodological issues (Newman et al., 2021; Rouse, 2019; Smith et al., 2016). Many studies in the mental health field have conducted to see whether online data collection was valid and reliable or not and it was found no difference between the two procedures (Campos et al., 2011; Chetverikov & Upravitelev, 2016; Nelson et al., 2021; Zlomke, 2009). More specifically, the comparison of online and paper-based data collection procedures for social anxiety disorder, agoraphobia, panic, depression, and quality of life was shown to be valid and reliable to use both online and paper-based data collection procedures (Carlbring et al., 2007; Hedman et al., 2010; Naus et al., 2009). Zlomke (2009) has also shown that Depression Anxiety Stress Scale – 21 (DASS – 21) and Penn State Worry Questionnaire (PSWQ), are valid and reliable for online data collection compared to the previous study findings which used paper-based data collection format. On the other hand, Newman and colleagues (2021) stated that online data collection might lead to possible biases including sampling bias and low-quality data. According to previous findings, participants are generally lower income but higher education level, lower average age, lower social engagement, higher mental

health problems, and showing higher percentage of white group in the online data collection study when compared to the general population (Buhrmester et al., 2011; Levay et al., 2016; Newman et al., 2021; Paolacci & Chandler, 2014; Stone et al., 2019; Ophir et al., 2020). Regarding the quality of data, some of the studies stated that inattentiveness and more mistakes caused by distractors can occur in the online-based data collection procedures (Arugete et al., 2019; Buhrmester et al., 2011; Newman et al., 2021).

Studies have shown that the authority of a researcher can significantly influence research outcomes (Breakwell et al., 2012). Milgram's obedience and authority studies from 1963 and 1974 demonstrated how an authoritative figure can affect participants' behavior in experimental settings. Other studies have also confirmed the potential impact of a researcher's authority on participants during experiments (Blass & Schmitt, 2001; Kreimer, 2016; Mayhew & Murphy, 2013). Regarding data collection procedures, past research has revealed that participants are more likely to complete online surveys when asked by an authority figure, such as a department chair, faculty member, or colleague (Trespalacios & Perkins, 2016; Saleh & Bista, 2017). However, no studies have yet compared the potential authority bias between online-based and paper-based data collection procedures regarding research validity and reliability.

The Autism Quotient (AQ) is a tool used to measure the traits associated with the autism spectrum in adults and the measure was developed by Baron-Cohen et al. (2001). The AQ is used to evaluate autistic traits in different groups, including university students (Dell'Osso et al., 2019; Galvin et al., 2020) and clinical samples like individuals with autism spectrum disorder (Shalev et al., 2022). The AQ has five subscales: social skills, communication, attention to detail, attention switching, and imagination. It is widely used and available in different languages (e.g., Turkish by Köse et al., 2010; Dutch by Hoekstra et al., 2008; Japanese by Wakabayashi et al., 2006). Many studies use AQ online, including a study with 14,354 participants (Greenberg et al., 2018) and another with 5570 participants (Shalev et al., 2022). However, no research has compared online-based and paper-based data collection procedures for AQ. A concern has been raised about using online data collection for the mental health scales DASS-21, which is widely used across different countries (Zanon et al., 2021). DASS-21, developed by Lovibond and Lovibond in 1995,

consists of 21 questions with 7 items for each subscale. It is a brief scale that can be used for clinical and non-clinical populations in many countries (Bibi et al., 2020; Zanon et al., 2021). Similar to AQ, DASS-21 is commonly administered through online data collection (Bibi et al., 2020; Wittayapun et al., 2023; Zlomke, 2009). Zlomke (2009) examined the psychometric properties of DASS-21 and showed valid and reliable results. However, the study did not investigate the differences between paper-based and online-based data collection methods in their research. The comparison was only conducted in one condition rather than both conditions (online-based and paper-based) within the same experiment. Additionally, the study did not have a comparison group, rather, the participants in other studies were used as a comparison. A controlled experiment is necessary to compare the effects of online-based and paper-based data collection on both AQ and DASS-21 scores.

To minimize possible biases, it is important to conduct a study to compare online-based and paper-based data collection. This can help increase the validity and reliability of the current thesis. Therefore, before utilizing AQ and DASS-21 in online data collection, the current study was conducted to compare the administration of the data using online-based and paper-based procedures in AQ and DASS-21. In addition to previous studies comparing online-based and paper-based methods, another variable was added (researcher presence) to determine whether the presence of the researcher affects the study. The following two hypotheses were addressed in the study:

- Online-based and paper-based data collection procedures for AQ and DASS-21 show no differences in the current sample.
- The researcher's presence or absence conditions have an impact on online-based and paper-based data collection procedures for AQ and DASS-21 in the current sample.

3.2. Methods

3.2.1. Study Design

The main interest of this research increases the validity and reliability of the current thesis. For this aim, reducing possible confounding variables (i.e., using online data collection) which defined by variables that might have a possible impact on dependent variables in the experiment (Breakwell et al., 2012). Therefore, this study adopted a cross-sectional research design. A cross-sectional design refers to testing a different group of participants that it is interested in at a single point in time. A different group of participants also called a between-participants design which indicates each participant is in only one condition in the experiment (Breakwell et al., 2012). Independent variables are the type of data collection (online-based and paper-based) and the researcher's presence condition (the presence and absence of the researcher). Dependent variables are scores of AQ, DASS-21, and their subscales.

3.2.2. Participants

A power analysis (G*Power) was conducted to determine the number of participants. For this study, 90 participants are needed to reach a medium effect size of .30 with an adequate power of .80 at $\alpha = .05$ (Faul et al., 2009); so, 96 participants (71 female, 25 male) who are fluent in writing and speaking were collected for this study. Participants were pseudo-randomly assigned to four groups equally 48 participants for internet-based (researcher presence or absence) and 48 participants for paper-based (researcher presence or absence) data collection groups. See Table 3.1. for more detailed information for descriptive of the participants in four groups. Inclusion criteria for this study were being aged 18 or above and no record of any psychiatric or physical conditions.

3.2.3. Materials

3.2.3.1. Demographic Information Form

The researchers have formed a demographic form aimed at collecting demographic information. This form gathered basic details such as age, gender, education level, marital status, whether the person has children, and any history of physical or psychiatric disorders.

3.2.3.2. Autism Quotient

Autism Quotient is a self-report quotient to measure autistic traits and developed by Baron-Cohen et al., (2001). Köse and colleagues adapted to the Turkish version of AQ (2010). The scale consists of 50 Likert scale questions (“definitely agree”, “slightly agree”, “slightly disagree”, and “definitely disagree”) and participants get either 1 or 0 according to the questions. For this quotient, the minimum and maximum scores are 0 and 50. In the Turkish adaptation of the AQ, Cronbach’s alpha and test-retest reliability scores for this scale are 0.64, and 0.72, respectively.

3.2.3.3. Depression Anxiety Stress Scale - 21

Depression Anxiety Stress Scale - 21 (DASS - 21) is a self-report scale to examine depression, anxiety, and stress levels for adults and was developed by Lovibond and Lovibond (1995). Sarıçam has adapted the scale to Turkish (2018). This scale consists of three subscales (depression, anxiety, and stress). The total number of items is 21. In the Turkish adaptation of the DASS-21, the Cronbach’s alpha and test-retest reliability scores for these subscales are .87 for depression, .85 for anxiety, and .81 for stress subscales and test-retest reliability are $r = .68$ for depression, $.66$ for anxiety, and $.61$ for stress.

3.2.4. Procedure

Approval from the ethical committee of Ibn Haldun University was obtained for this study (No. E-71395021-100-26164). Each participant accepted to participate in this

study voluntarily. The data was collected by using convenience sampling and under two different conditions: online-based and paper-based. For paper-based conditions, participants filled out the forms in the Cognition and Perception Lab in the presence of research assistants (presence condition) or outside the lab without a researcher (absence condition). It followed the same procedure for online-based data collection. In one case, data was collected via Google Forms without a researcher, and participants received the link through e-mail and social media platforms. In the other online-based condition, the study was conducted on computers in the Cognition and Perception Lab with the presence of research assistants (presence condition).

Table 3.1. Demographic Characteristics

	Paper-based (<i>n</i> = 48)		Online-based (<i>n</i> = 48)	
	Researcher Presence (<i>n</i> = 24)	Researcher Absence (<i>n</i> = 24)	Researcher Presence (<i>n</i> = 24)	Researcher Absence (<i>n</i> = 24)
Age (<i>M</i> (<i>SD</i>))	21.57 (2.04)	25.6 (6.3)	23.46 (2.76)	24.75 (5.00)
Sex (%)				
Male	10 (41.7 %)	6 (25.0 %)	3 (12.5%)	6 (25 %)
Female	14 (58.3 %)	18 (75.0 %)	21 (87.5%)	18 (75%)
Education (%)				
University	23 (95.8 %)	13 (56.5%)	16 (66.7%)	15 (62.5%)
Master/Ph.D	-	10 (43.4%)	8 (33.3%)	9 (37.5%)
Relationship (%)				
Single	22 (91.7%)	17 (70.8%)	17 (70.8%)	15 (62.5%)
Married	1 (4.2%)	4 (16.7%)	2 (8.3%)	7 (29%)
In relationship	1 (4.2%)	3 (12.5%)	5 (20.8%)	2 (8.3%)
Having child (%)				
Yes	-	5 (21.7%)	-	1 (4.2%)
No	24 (100%)	19 (78.2%)	24 (100%)	23 (95.8 %)

Note. Three participants declined to answer education level, but all participants are students in university.

3.2.5. Data Analyses

The data were analyzed through the R statistical computing environment (Version R version 4.1.3; R Core Team, 2022). Two independent variables are present in this study: type of presentation (paper-based vs. online-based), and researcher's presence conditions (presence vs. absence). The dependent variables are AQ and DASS-21 and their subscales' scores of participants. Before further analysis, the required assumptions by groups were checked, and then, using the *stats* package (R Core Team, 2022), 2 x 2 between-subject ANOVAs were conducted that examined the effect of the type of presentations and type of supervision on AQ and DASS-21 and their subscales' scores of participants. Due to multiple comparisons, the *p*-value was set at .01 to reduce Type I errors.

3.3. Results

According to ANOVA tests on the AQ total and DASS-21, non-significant effects of types of presentation for AQ, $F(1, 92) = .62, p = .43, \eta^2 = .01$ and DASS-21, $F(1, 92) = 1.00, p = .31, \eta^2 = .01$ and non-significant effects of the researcher presence condition for AQ, $F(1, 92) = .00, p = .98, \eta^2 = .01$ and DASS-21, $F(1, 92) = .15, p = .69, \eta^2 = .01$ were found. There was no interaction effect between factors for AQ, $F(1, 92) = .16, p = .68, \eta^2 = .01$, and for DASS-21, $F(1, 92) = .05, p = .69, \eta^2 = .01$. According to the univariate ANOVA tests performed on the subscales of the DASS-21 and AQ scales, there was no significant main and interaction effects of researcher presence condition and the type of presentation on the subscales of DASS-21: depression, anxiety, and stress ($ps > .01$) and the subscales of AQ: social skills, attention switching, attention to detail, imagination, and communication ($ps > .01$). Means and standard deviations are presented in Table 3.2.

Table 3.2. Group Comparison

<i>M (SD)</i>	Paper-based group (<i>n</i> = 48)		Online-based group (<i>n</i> = 48)		
	Researcher Presence (<i>n</i> = 24)	Researcher Absence (<i>n</i> = 24)	Researcher Presence (<i>n</i> = 24)	Researcher Absence (<i>n</i> = 24)	<i>p</i>
DASS-21	20.42 (11.36)	21.91 (14.55)	18.50 (10.11)	18.92 (11.57)	<i>p</i> > .01
Depression	7.12 (4.58)	6.87 (4.49)	6.33 (3.71)	6.58 (4.46)	<i>p</i> > .01
Anxiety	6.00 (4.35)	6.45 (6.22)	4.87 (3.85)	4.92 (3.81)	<i>p</i> > .01
Stress	7.79 (3.45)	9.12 (5.34)	7.75 (4.21)	7.46 (4.19)	<i>p</i> > .01
AQ	18.50 (5.00)	18.91 (5.94)	18.08 (6.47)	17.63 (3.21)	<i>p</i> > .01
Social Skills	3.29 (1.97)	3.33 (1.91)	3.04 (1.97)	2.83 (1.34)	<i>p</i> > .01
Attention Switching	5.08 (1.95)	4.16 (1.97)	4.95 (1.75)	4.54 (1.50)	<i>p</i> > .01
Attention to Detail	4.54 (2.25)	5.83 (2.07)	5.38 (2.06)	5.88 (2.11)	<i>p</i> > .01
Communication	2.50 (1.53)	2.37 (1.63)	2.13 (1.90)	1.71 (1.37)	<i>p</i> > .01
Imagination	3.08 (1.76)	3.20 (1.95)	2.58 (1.44)	2.67 (1.05)	<i>p</i> > .01

Note. AQ = Autism Quotient Total Score; DASS-21 = Depression Anxiety Stress Scale Total Score.

3.4. Discussion

The current study investigated the effects of presentation type (online-based and paper-based), and the researcher's presence condition on AQ and its subscales and DASS-21 and its subscales in college students. The results demonstrated that there are no significant effects of the type of presentation and the researcher presence condition on AQ and DASS-21 and their subscales.

The study found that there were no significant differences between online and paper-based administrations of mental health scales. This is consistent with previous research on different mental health questionnaires (Carlbring et al., 2007; Campos et al., 2011; Hedman et al., 2010; Naus et al., 2009). A previous study by Zlomke (2009) has shown that the online-based DASS-21 is valid and reliable compared to the paper-based study by Lovibond and Lovibond (1995). This study extended this result by using both

online-based and paper-based data collection groups and showed that online-based or paper-based data collection for DASS-21 and AQ, and their subscales did not differ in terms of administration and supervision. Therefore, researchers can freely choose online-based data collection for DASS-21 and AQ since it has some advantages including anonymity, reaching larger samples, reducing costs, and eliminating interviewer/experimenter-biased responses. (Eerola et al., 2021; Newman et al., 2021).

In addition, it was found that the researcher's presence or absence did not have a significant impact on the questionnaire scores. This means that the participants were not influenced by the presence of the researcher during the study, despite our initial expectations. Previous research has shown that biases such as authority bias, demand characteristics, and social desirability can affect the validity and reliability of a study (Milgram, 1963; Nicholas & Maner, 2008; Sharpe & Whelton, 2016). Although this study did not confirm the previous findings, our results provide some support for the literature. In a previous study on demand characteristics and social desirability in therapy rating scales, half of the participants completed the questionnaire and rating scales with the observer (their therapist) present. This group showed no significant differences compared to the group that completed the measures without an observer (Reese et al., 2013). It is important to consider the education level of registered university students as a factor when conducting this study. This is because there may be a self-selection bias, despite the use of random assignment to allocate participants into the four groups. All participants in the study were volunteers who willingly accepted the invitation to participate, which may explain the lack of significant differences observed across the groups.

3.4.1. Limitations and Future Studies

There are some possible limitations in the current study. One potential limitation is that all participants are students who are registered in the colleges which may not be representative of the general population. Participants' education level, their familiarity with technology, and self-serving bias could be some possible confounding factors. Future research should use different age ranges and groups to increase the generalizability of the results, and more replications are needed for to same and different mental health questionnaires in the literature. Lastly, the number of female

participants is higher than male participants, and the representativeness of males in paper-based (absence of researcher), and online-based (the researcher presence and absence conditions) groups could be low due to the random assignment. It is important to highlight these differences because previous findings have indicated that the scores of AQ and DASS-21 were shown to differ across sexes (Baron-Cohen et al., 2014; Opanković et al., 2021; Pisula et al., 2013).



CHAPTER IV

STUDY 2: THE MEDIATOR ROLES OF THE EXECUTIVE FUNCTIONS AND SOCIAL COGNITION IN THE RELATIONSHIP BETWEEN AUTISTIC TRAITS AND MENTAL HEALTH

4.1. Introduction

Elevated autistic traits increase the susceptibility to other mental health conditions including depression and anxiety disorders in both general and clinical populations (Albantakis et al., 2020). Ishizuka and colleagues (2022) found that autistic traits (i.e., attention switching, and attention to detail) can be seen as predictors of persistent depression in individuals with newly depressed outpatients. In the study by Towbin and colleagues (2005), the researchers found that 62% of children and adolescents who were diagnosed with anxiety and depression showed evidence of ASD symptoms for at least one measure of ASD symptom severity and autism spectrum traits. According to Lundström and colleagues (2011), even mild symptoms of autism can increase an individual's vulnerability to other mental health problems, which both genetic and environmental factors can influence. Previous studies have shown that people with autism spectrum disorder (ASD) and elevated autistic traits tend to experience anxiety and depression more commonly than other mental health issues (Kanne et al., 2009; Howlin et al., 2000). The susceptibility to mental health conditions cannot be precisely determined in ASD. Still, it is highly probable that social and cognitive impairments, including problems with executive functions and social cognitive skills, could significantly contribute to it (Eussen et al., 2013; Zelazo, 2020).

4.1.1. Social Cognition and Executive Functions as Mediators

Social cognitive skills including cognitive and affective empathy are essential to continue better functioning in our lives and many studies have indicated that better empathic skills are associated with better social competence, academic achievement, better mental well-being, and better social functioning (Allemand et al., 2015; Baron-Cohen, 2001; Blair, 2005). Sönmez and Jordan (2023) found that affective empathy is positively associated with generalized anxiety disorder and showed positive marginal associations with total anxiety score and social phobia in adolescents with ASD while cognitive empathy showed negative associations with separation anxiety disorder. Similarly, in a study conducted by Gambin and Sharp (2018), it was discovered that cognitive empathy has a negative correlation with social anxiety, separation anxiety disorder, and panic disorder in adolescent patients. On the other hand, affective empathy has a positive correlation with these conditions. Lei and Ventola (2018) showed that early ToM skill in participants with ASD is the mediator of the relationship between autistic traits and anxiety symptoms. Additionally, depression is found to be positively associated with affective empathic components, specifically with higher levels of empathic stress. However, it is negatively associated with cognitive empathic skills such as perspective-taking, theory of mind, and empathic accuracy, as noted by Schreiter et al. (2013).

EFs skills are also significantly related to emotional and social functioning including better self-control and regulation, higher academic achievement and better school performance, higher mental well-being, better marital status, and public safety (Diamond, 2013). EFs skills in ASD are predictor for better social competence and emotional regulation (Fong & Iarocci, 2020) and problems in emotion regulation are associated with internalizing and externalizing problems (Cai et al., 2018; Conner et al., 2020; Mazefsky et al., 2013). Hollocks and colleagues (2014) showed that significant relations were found between EFs and anxiety symptoms in individuals with ASD but not depression. The study also did not find significant associations between social cognitive skills and anxiety in ASD (Hollocks et al., 2014). Another study has indicated that impairments in flexibility and metacognition were found in ASD and problems in flexibility are associated with anxiety, while problems in metacognition are positively associated with depression and poor adaptive functioning

(Wallace et al., 2016). However, there is no study to examine together the mediator roles of social cognition and EFs on the relationship between autistic traits and mental health symptoms in the literature. Many studies suggest that understanding these roles could help to provide better treatment and prevention methods (Fong & Iarocci, 2020; Sönmez & Jordan, 2023; Wallace et al., 2016).

The main purpose of this study is to investigate the mediator roles of executive functions (cognitive flexibility, working memory (WM), inhibition) and social cognition (cognitive empathy, affective empathy) in the relationship between autistic traits and mental health to design combined executive functions and social cognition online training program. The following two hypotheses were addressed in this chapter:

- Executive functions (cognitive flexibility, inhibitory control, and working memory) mediate the relationship between autistic traits and mental health symptoms (anxiety, depression, and stress).
- Social cognitive skills (cognitive empathy and affective empathy) mediate the relationship between autistic traits and mental health symptoms (anxiety, depression, and stress).

4.2. Methods

4.2.1. Study Design

In this second study of the thesis, a cross-sectional design was applied to investigate the associations between autistic traits, executive functions, social cognition, and mental health symptoms (depression, anxiety, and stress) in adult participants. A cross-sectional design is defined by testing participants at a single point in time to examine the roles of the variables (Breakwell et al., 2012). For this study, the participants were tested at a single time and examined to investigate the mediating roles of executive functions and social cognitive skills. The mediator is a variable that explains the relationship between related variables (MacKinnon et al., 2007). In this study, the expected mediator variables are executive functions (cognitive flexibility, inhibition, and working memory) and social cognition (cognitive empathy and affective empathy)

in the relationship between autistic traits and mental health (depression, anxiety, and stress).

4.2.2. Participants

A power analysis (G*Power) was conducted to determine the number of participants. For multivariate analyses, 146 participants are needed to reach a medium effect size of .15 (F^2) with an adequate power of .95 at $\alpha = .05$ (Faul et al., 2009). The current study sample consists of 159 participants (141 female, 18 male) between ages 18 and 45 ($M = 27.90$, $SD = 6.48$). Demographic characteristics and descriptive statistics are presented in Table 4.1. Convenience sampling method via advertisement through social media, mail groups, and on campuses was used to collect participants. Inclusion criteria for adult participants are being aged 18 or above, being able to use computers, smartphones, or tablets, reading and speaking Turkish, having no record of any psychiatric disorders, and having no record of any physical and neurological conditions that prevent the use of technological devices. Participants who are under age 18 and have any record of psychiatric and physical conditions that prevent to use of technological devices were excluded from the study.

4.2.3. Materials

4.2.3.1. Self-Report Questionnaires

4.2.3.1.1. Demographic Information Form

Basic information such as age, sex, education level, and psychiatric and physical history of participants for inclusion criteria was obtained from the participants, and it was developed by the researcher.

4.2.3.1.2. Autism Quotient

To measure autistic traits, the Autism Quotient (AQ; Baron-Cohen et al., 2001) was used. AQ for adults is adapted to Turkish culture (Köse et al., 2010). The self-report questionnaire consists of 50 questions rating; “definitely agree”, “slightly agree”,

“slightly disagree”, and “definitely disagree”. In the Turkish adaptation of the AQ for adults, Cronbach’s alpha value for this scale is .64, and test-retest reliability is $r = .72$. The AQ is a widely used assessment tool that measures five subscales: social skills, communication, attention to detail, attention switching, and imagination. It is available in different languages (e.g., Turkish by Köse et al., 2010; Dutch by Hoekstra et al., 2008; Japanese by Wakabayashi et al., 2006).

4.2.3.1.3. Depression Anxiety Stress Scale - 21

Depression Anxiety Stress Scale - 21 (DASS - 21) is a self-report scale to examine depression, anxiety, and stress levels for adults by Lovibond and Lovibond (1995). The Turkish adaptation study for DASS-21 was conducted by Sarıçam (2018). This scale consists of three subscales, one for depression, one for anxiety, and one for stress. The total number of items is 21. For this scale, inter-scale reliability with Cronbach’s Alpha is .87 for depression, .85 for anxiety, and .81 for stress subscales. Test-retest reliability is $r = .68$ for depression, .66 for anxiety, and .61 for stress.

4.2.3.1.4. Interpersonal Reactivity Index

To measure cognitive and affective empathy, the Interpersonal Reactivity Index (IRI) was used. IRI was developed by Davis (1980) and adapted to Turkish culture (Engeler & Yargic, 2007). IRI is a self-report measure that consists of 28 questions. The scale has 4 subscales which are perspective-taking, empathic concern, fantasy, and personal distress. Components of affective empathy are personal distress and empathic concern, while cognitive empathy includes perspective-taking and fantasy (Sindermann et al., 2019). In the Turkish version of the IRI, the internal consistency of four subscales ranged from .60 to .76 and test-retest reliability ranged from .66 to .80 for each subscale.

Table 4.1. Demographic Characteristics and Descriptive Statistics ($n = 159$)

	<i>n</i>	Mean (SD)	Minimum	Maximum
Age	159	27.90 (6.48)	18	45
Sex (%)				
Female	141 (88.7)	-	-	-
Male	18 (11.3)	-	-	-
Education (%)				
Middle School	3 (1.9)	-	-	-
High School	18 (11.3)	-	-	-
Associate degree	19 (11.9)			
Bachelor's degree	83 (52.2)	-	-	-
Master's degree	28 (17.6)	-	-	-
Doctorate degree	8 (5.0)	-	-	-
AQ	159	19.97 (6.07)	6	38
Social Skills	159	3.84 (1.99)	0	9
Attention Switching	159	5.58 (1.86)	1	10
Attention to Detail	159	4.66 (1.90)	0	8
Communication	159	2.99 (2.21)	0	10
Imagination	159	2.90 (1.94)	0	7
DASS-21	159	26.19 (11.56)	6	57
Depression	159	7.28 (4.39)	0	20
Anxiety	159	9.68 (4.07)	1	19
Stress	159	9.23 (4.07)	0	21
The Eyes	159	24.45 (3.94)	8	32
SAM	159	124.28 (18.09)	72	182
IRI	159	70.11 (11.72)	40	95
Perspective Taking	159	17.62 (4.26)	7	28
Fantasy	159	17.76 (4.76)	4	28
Empathic Concern	159	16.48 (3.20)	9	25
Personal Distress	159	18.25 (4.18)	8	28
WM Accuracy	159	131.51 (51.15)	31	398
WM Errors	159	41.04 (26.18)	1	128
IC Accuracy	159	329.68 (82.97)	119	400
IC Errors	159	11.87 (20.36)	0	150
CF Accuracy	159	188.18 (26.89)	87	230
CF Errors	159	26.06 (23.62)	20	45

Note. AQ = Autism Quotient; DASS-21 = Depression Anxiety Stress Subscale-21; SAM = Self Assessment Manikin; IRI = Interpersonal Reactivity Index; WM = Working Memory; IC = Inhibitory Control; CF = Cognitive Flexibility

4.2.3.2. Performance Tasks

To assess executive functions such as cognitive flexibility, WM, and inhibitory control, as well as social cognition, including cognitive empathy and affective empathy, the following performance tasks were administered. Based on previous studies (Ajilci & Nejati, 2017; Gökçen et al., 2016; Fernandez-Prieto et al., 2021; Groves et al., 2022; Johnston et al., 2019), the errors and accuracy were recorded for each task to ensure standardized measurements. Before scoring begins, each task starts with a non-scored trial to ensure participants understand the task. The only exception was for self-assessment manikin for affective empathy and detailed information was mentioned.

4.2.3.2.1. Wisconsin Card Sorting Task

Wisconsin Card Sorting Task (WCST) is a performance task to measure cognitive flexibility (Berg, 1948). The cards were displayed on the screen. It consists of 100 cards in total. There are two blocks in total 200 cards were shown to participants. The sorting rule changes every 10 cards, meaning there are 20 stages, requiring participants to adjust their strategies. Participants were expected to learn from the feedback and adapt the rules during the task by trial and error. Participants are required to match the color, number, and shape of the cards to the corresponding rule and response. Accuracy and errors were measured.

4.2.3.2.2. N Back Task

Working memory was measured by *N* Back Task (Kirchner, 1958). There are different versions including three different conditions (i.e., one back, two back, and three back). A sequence of stimuli was presented one by one, and participants needed to decide whether the presented stimuli were the same as the stimuli that were displayed *N* trials ago. In this study, the $n = 2$ rule was applied, and participants were required to respond whether the letter was 2 trials ago or not. The total stimulus sequence consists of 15 letters. Each stimulus is presented for 500 milliseconds. Participants can answer within 3 seconds. A new letter is presented every 1300 milliseconds. The letters A, B, C, D,

E, H, I, K, L, M, O, P, R, S and T are used. There are 8 blocks of 50 trials each. Accuracy and false errors were measured.

4.2.3.2.3. Go / No Go Task

Go / No Go Task was used to measure inhibition. The task requires participants to respond as quickly and accurately as to the presented target stimulus ("go" trials) but avoid responding to non-target stimulus ("no go" trials). Only the text "go" or "not go" appears. When the "go" sign is seen, a reaction must be made within 1000 milliseconds. When you see "not go", participants should not press the button. Response speed 1000 milliseconds in go/no go trials. There are 12 blocks of 50 trials each. Commission errors (i.e., incorrectly responding to no-go trials) and accuracy were measured.

4.2.3.2.4. The Eyes Test

The Eyes Test is a performance task for emotion recognition which is widely regarded as an indicator of cognitive empathy. In this test, participants were presented with a series of 37 black-and-white images of human eyes. For each image, participants were asked to choose which of 4 words best describes what the person in the image is feeling or thinking. It was adapted for Turkish by Girli (2014). The Cronbach alpha internal consistency coefficient for this test is greater than .70. High scores indicated high cognitive empathy scores.

4.2.3.2.5. Self-Assessment Manikin

Self-Assessment Manikin was used to measure self-reported emotional responses to facial expression images for affective empathy. Karolinska Directed Emotional Faces (KDEF, Conley et al., 2018; Lundqvist et al., 1998) were used to express facial emotions. In total, 30 images (15 male, 15 female) were chosen randomly and seven emotional expressions including happiness, neutral, anger, fear, and disgust were depicted. The task requires participants to examine each facial expression and rate how they feel it on a valence scale (more negative (1) to more positive (9)). The tasks were

adapted from Wai and Tiliopoulos (2012). Valence scores for each emotion were obtained by summing responses for all images.

4.2.4. Procedure

Approval from the ethical committee of Ibn Haldun University was obtained for this study (No. E-71395021-050.06.04-34359). Each participant accepted to participate in this study voluntarily. The data were collected through an online website designed by the researcher (www.mindzone.com.tr). The link was sent either through e-mail or social media platforms (WhatsApp, Instagram, Twitter, LinkedIn, and Facebook) via advertisement. After participants had logged in to the website, the self-report questionnaires and performance tasks were completed. All tasks took 30 mins approximately. All data is kept on the database confidentially.

4.2.5. Data Analysis

SPSS 25.0 package and PROCESS Macro 4.2. for SPSS (Hayes, 2022) were used to analyze the data. Firstly, preliminary analyses including descriptive statistics analysis were conducted, see demographic characteristics of participants in Table 4.1. The skewness and kurtosis of data are between -1 and +1 and it is acceptable to use parametric tests according to Hair and colleagues (2013). Before using mediation analysis, the relationships between variables were examined by conducting Pearson correlation, controlling age and sex due to the possible effects of mental health, social cognition, and EFs, following previous studies (Connor et al., 2020; Donaldson et al., 2022; Mason & Happe, 2022). The findings are presented in Table 4.2 and Table 4.3. Lastly, according to the results of Pearson correlation analyses, four subscales of autistic traits (attention switching, attention to detail, communication, and imagination) and, only one EF which is WM, and social cognitive skills (self-report cognitive empathy and affective empathy) on mental health symptoms were examined through the mediation analyses by the PROCESS Macro package 4.2., Model 4 using bootstrapped estimation with 5000 samples (Hayes, 2022). Attention switching, attention to detail, communication, and imagination subscales of autistic traits entered the model as independent variables, mental health symptoms (DASS-21 total score, anxiety, and depression subscale) as dependent variables, and Self-report empathy

subscales (i.e., personal distress, perspective-taking, and fantasy) and WM errors as the mediator factors. However, only significant findings were observed between attention switching and mental health symptoms (DASS-21 total score, anxiety, and stress) with the mediating role of personal distress. Direct effects, indirect effects, and total effects of the mediation models were reported in the Results section.

4.3. Results

4.3.1. Correlation Analysis

To investigate the relationships between autistic traits, social cognition (cognitive empathy and affective empathy), executive functions (working memory, inhibitory control, and cognitive flexibility), and mental health symptoms, Pearson correlation analysis was conducted controlling age and sex. According to our findings, as expected, the AQ and its subscales, along with the DASS-21 and its subscales, exhibit a significant correlation within their respective measures ($p < .001$). The total AQ score is positively correlated with the DASS-21 total score ($r(159) = .31, p < .001$), stress subscale ($r(159) = .30, p < .001$), anxiety subscale, ($r(159) = .33, p < .001$), and depression subscale, ($r(159) = .23, p < .01$). In terms of subscales of AQ, social skills subscale was only correlated with stress subscale ($r(159) = .17, p < .05$). Attention switching shows positive significant correlation with the DASS-21 total score ($r(159) = .21, p < .01$), stress subscale ($r(159) = .22, p < .01$), anxiety subscale, ($r(159) = .25, p < .01$). Communication was also significantly positively correlated with the DASS-21 total score ($r(159) = .19, p < .05$), stress subscale ($r(159) = .20, p < .05$), anxiety subscale, ($r(159) = .17, p < .05$), and was marginally correlated with depression subscale, ($r(159) = .16, p = .053$).

In terms of the performance test for social cognition, only the Eyes test accuracy was significantly negatively correlated with the imagination subscale, ($r(159) = -.20, p < .05$), while the self-report empathy measure, IRI total score, was positively correlated with the DASS-21 total score ($r(159) = .17, p < .05$), stress subscale ($r(159) = .16, p < .05$), and was marginally correlated with depression subscale, ($r(159) = .15, p = .055$). A negative correlation with imagination was found ($r(159) = -.22, p < .01$). A relationship was found between autistic traits and empathy in attention switching with

personal distress, ($r(159) = .20, p < .05$), and with the imagination, ($r(159) = -.18, p < .05$). Specifically, personal distress subscale is positively correlated with the attention switching ($r(159) = .20, p < .05$), DASS-21 total score ($r(159) = .29, p < .001$), stress subscale ($r(159) = .30, p < .001$), anxiety subscale, ($r(159) = .25, p < .001$), and depression subscale, ($r(159) = .26, p < .001$). Perspective-taking was also negatively correlated with attention to detail ($r(159) = -.16, p < .05$), and communication, ($r(159) = -.21, p < .01$). Marginal negative association with social skills were found, ($r(159) = -.15, p = .053$). Fantasy is negatively associated with communication, ($r(159) = -.17, p < .05$), and imagination ($r(159) = -.24, p < .01$). Detailed information was presented in Table 4.2.

Regarding executive functions, the WM errors score was positively correlated with the attention to detail subscale of AQ, ($r(159) = .17, p < .05$), and a marginally positive association between the WM accuracy and the attention to detail subscale was observed ($r(159) = .15, p = .053$). Besides, positive correlations were present in the relationship between WM errors and DASS-21 ($r(159) = .17, p < .05$), and inhibitory control errors and DASS-21, ($r(159) = .21, p < .01$). WM errors were also positively correlated with anxiety, ($r(159) = .18, p < .05$). Inhibitory control errors were also positively correlated with anxiety ($r(159) = .24, p < .01$), and depression ($r(159) = .20, p < .01$). Interestingly, there is no other significant relationship between executive functions, autistic traits, and mental health symptoms in the current study ($p > .05$). Detailed information is presented in Table 4.3. Lastly, regarding the correlation between social cognition and EFs, only significant correlations were found between the Eyes test (accuracy) and WM errors ($r(159) = -.30, p < .001$) and between the Eyes test (accuracy) and inhibitory control errors ($r(159) = -.51, p < .001$).

4.3.2. Mediation Analyses

Three mediation analyses were conducted based on significant correlation results which were reported in the previous section. First mediation analysis was conducted to examine the mediating effect of self-report affective empathy on attention switching and DASS-21, age and sex as covariates. The total effect of the model was found to be significant, $F(3, 155) = 5.01, b = 1.36, SE = .48, 95\% \text{ CI } [.41, 2.30], R^2 = .08, p < .01$. It was found that there was a statistically significant direct effect, $F(4, 154) = 6.75, \beta$

= .17, $b = 1.05$, $SE = .47$, 95 % CI [.11, 1.99], $R^2 = .15$, $p < .001$. Age and sex were non-significant after affective empathy entered the model ($p > .05$). A statistically significant indirect effect was also found, $b = .31$, $SE = .15$, 95 % CI [.07, .66], when tested using bootstrapped estimation with 5000 samples (Hayes, 2022). These results suggest that personal distress partially mediated the relationship between attention switching and DASS-21. See Figure 4.1. Mediation Model 1. (* = $p < .05$, ** = $p < .01$, *** = $p < .001$).

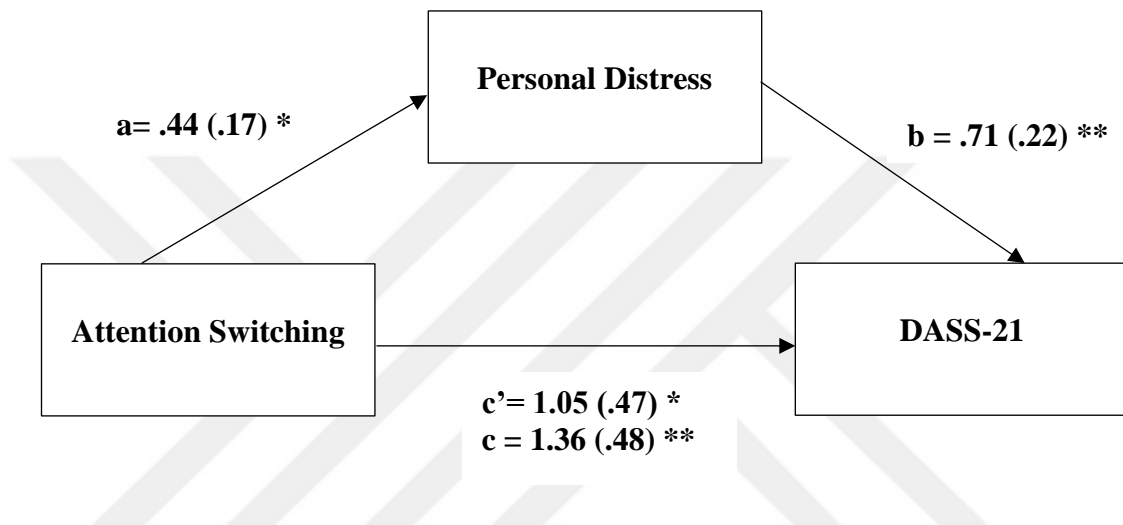


Figure 4.1. Mediation Model 1

A second mediation analysis was conducted to examine the mediating effect of self-report affective empathy on attention switching and anxiety subscale. The total effect of the model was found to be significant, $F(3, 155) = 6.30$, $b = .52$, $SE = .17$, 95 % CI [.19, .84], $R^2 = .11$, $p < .001$. It was found that there was a statistically significant direct effect, $F(4, 154) = 6.63$, $b = .43$, $\beta = .19$, $SE = .17$, 95 % CI [.10, .76], $R^2 = .15$, $p < .001$. Age and sex were non-significant after affective empathy entered the model ($p > .05$). A statistically significant indirect effect was also found, $b = .09$, $SE = .05$, 95 % CI [.01, .20], when tested using bootstrapped estimation with 5000 samples (Hayes, 2022). These results suggest that personal distress positively partially mediated the relationship between attention switching and anxiety subscale. See Figure 4.2. Mediation Model 2 (* = $p < .05$, ** = $p < .01$).

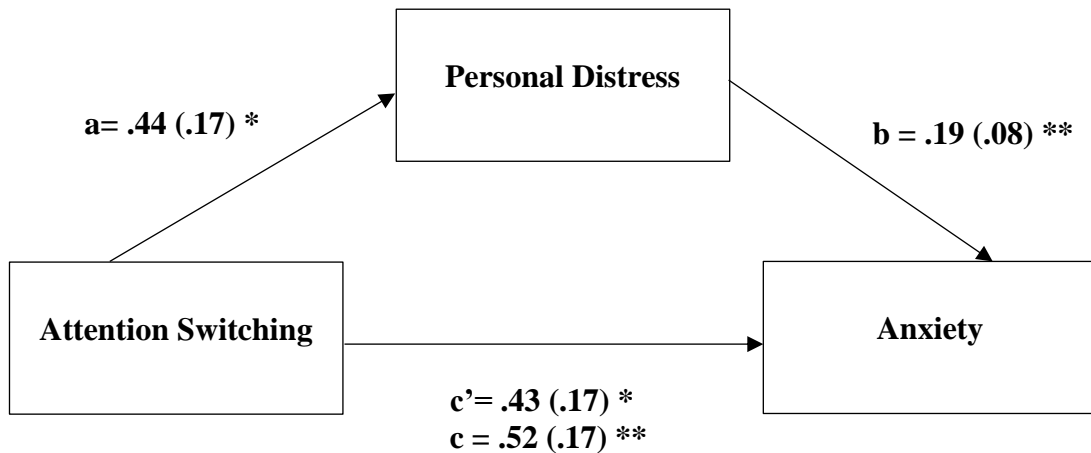


Figure 4.2. Mediation Model 2

A third mediation analysis was conducted to examine the mediating effect of self-report affective empathy on attention switching and stress subscale. The total effect of the model was found to be significant, $F(3, 155) = 4.14$, $b = .51$, $SE = .17$, 95 % CI [.17, .84], $R^2 = .07$, $p < .01$. It was found that there was a statistically significant direct effect, $F(4, 154) = 6.19$, $b = .40$, $\beta = .19$, $SE = .17$, 95 % CI [.06, .73], $R^2 = .14$, $p < .001$. Age and sex were non-significant after affective empathy entered the model ($p > .05$). A statistically significant indirect effect was found, $b = .11$, $SE = .05$, 95 % CI [.03, .23], when tested using bootstrapped estimation with 5000 samples (Hayes, 2022). These results suggest that personal distress positively partially mediated the relationship between attention switching and stress subscale. See Figure 4.3. Mediation Model 3 (* = $p < .05$, ** = $p < .01$).

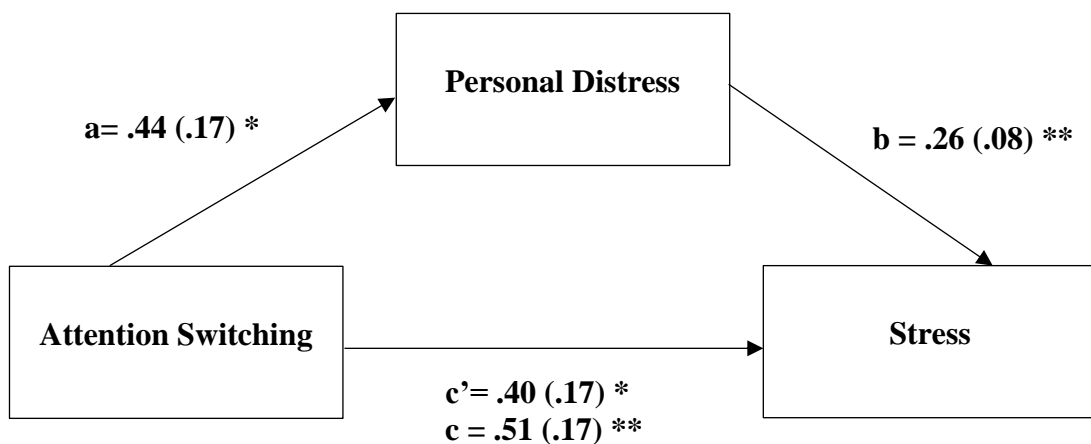


Figure 4.3. Mediation Model 3

4.3.3. Exploratory Analyses

Even though the lack of correlation among autistic traits, EFs, social cognition, and mental health was observed in the mediation analyses, further analysis was conducted to explore how the interrelationship among mental health, EFs, and social cognition works. This is important for the further chapter which designed a combined EFs and social cognition training program for mental health symptoms. According to the significant relationship between WM errors and the Eyes test, and between inhibitory control and the Eyes test, the mediation analyses were conducted to explore direct effect, indirect effect, and total effects for predicting mental health symptoms. However, the only significant model was found among WM errors, DASS-21, anxiety, and the Eyes test. The eyes entered the model as a mediator, as the literature suggests interconnections between EFs and social cognition, and most of the behavioral measures support the direction: of “EFs → Cognitive Empathy”, even though the exact relationship is still elusive (Wade et al., 2018).

In terms of DASS-21, the total effect of the model was found to be significant, $F(3, 155) = 3.76$, $b = .07$, $SE = .03$, 95 % CI [.00, .14], $R^2 = .07$, $p < .05$. It was found that there was no statistically significant direct effect, $F(4, 154) = 5.24$, $b = .05$, $SE = .04$, $\beta = .11$, 95 % CI [-.02, .12], $R^2 = .10$, $p > .05$. Sex was non-significant after affective empathy entered the model ($p > .05$); however, age was significant ($b = -.36$, $SE = .14$, 95 % CI [-.63, -.09], $p < .01$). A statistically significant indirect effect was found, $b = .02$, $SE = .01$, 95 % CI [.00, .05], when tested using bootstrapped estimation with 5000 samples (Hayes, 2022). These results suggest that the Eyes test positively fully mediated the relationship between WM errors and DASS-21. See Figure 4.4. Mediation Model 4 (* = $p < .05$, ** = $p < .01$).

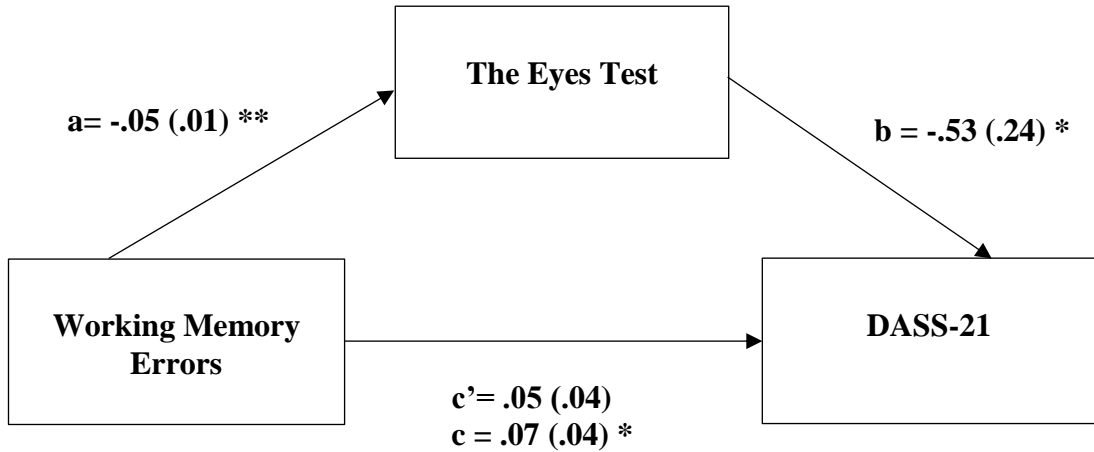


Figure 4.4. Mediation Model 4

In terms of anxiety, the total effect of the model was found to be significant, $F(3, 155) = 4.62$, $b = .03$, $SE = .01$, 95 % CI [.00, .05], $R^2 = .08$, $p < .01$. It was found that there was no statistically significant direct effect, $F(4, 154) = 5.24$, $b = .02$, $SE = .01$, $\beta = .11$, 95 % CI [-.01, .04], $R^2 = .12$, $p > .05$. Sex was non-significant after affective empathy entered the model ($p > .05$); however, age was significant ($b = -.14$, $SE = .05$, 95 % CI [-.23, -.05], $p < .01$). A statistically significant indirect effect was found, $b = .01$, $SE = .01$, 95 % CI [.00, .02], when tested using bootstrapped estimation with 5000 samples (Hayes, 2022). These results suggest that the Eyes test positively fully mediated the relationship between WM errors and anxiety subscale. See Figure 4.5. Mediation Model 5 (* = $p < .05$, ** = $p < .01$).

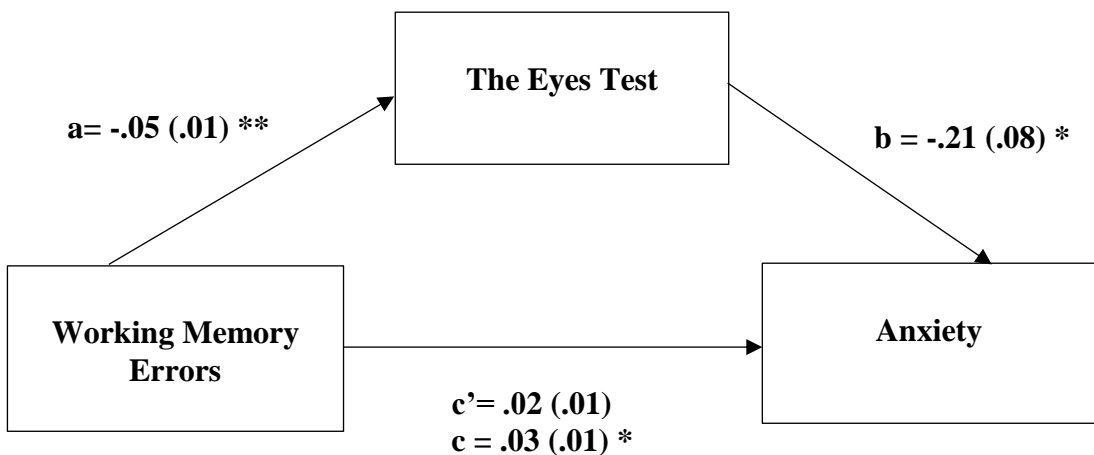


Figure 4.5. Mediation Model 5

Table 4.2. Correlations among Autistic Traits, Social Cognition, Mental Health Symptoms ($n = 159$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. AQ	-																
2. Social Skills	.75***	-															
3. Attention Switching	.58***	.27***	-														
4. Attention to Detail	.30***	.10	.04	-													
5. Communication	.73***	.47***	.22**	-.11	-												
6. Imagination	.66***	.37***	.18*	.03	.45***	-											
7. DASS-21	.31***	.14	.21**	.13	.19*	.09	-										
8. Stress	.30***	.17*	.22**	.14	.20*	.09	.93***	-									
9. Anxiety	.33***	.12	.25**	.14	.17*	.11	.94***	.82***	-								
10. Depression	.23**	.08	.12	.11	.16 ^a	.04	.92***	.77***	.80***	-							
11. IRI	-.08	-.08	.06	.12	-.10	-.22**	.17*	.16*	.15	.15 ^b	-						
12. Perspective Taking	-.13	-.15 ^a	-.02	.16*	-.21**	-.15	.03	.01	.05	.03	.73***	-					
13. Fantasy	-.14	-.11	.00	.08	-.17*	-.24**	.06	.06	.11	.05	.80***	.49***	-				
14. Empathic Concern	.03	.02	-.03	.05	.07	-.02	.10	.10	.09	.11	.60***	.23**	.33***	-			
15. Personal Distress	.06	.04	.20*	.04	.08	-.18*	.29***	.30***	.25***	.26***	.69***	.29***	.36***	.32***	-		
16. SAM	-.02	-.03	-.01	-.01	-.02	-.02	-.06	-.03	-.08	-.04	-.06	-.01	-.10	-.06	-.00	-	
17. The Eyes	-.07	.01	.10	-.14	.01	-.20*	-.22**	-.17*	-.24**	-.20*	-.09	-.03	-.07	-.16*	-.01	-.07	-

Note. AQ= Autism Quotient Total Score; DASS-21 = Depression Anxiety Stress Scale – 21 Total Score; IRI= Interpersonal Reactivity Index Total Score; SAM = Self-Assessment Manikin.

*** $p < .001$ ** $p < .01$; * $p < .05$; a=.053; b=.055

Table 4.3. Correlations among Autistic Traits, Executive Functions, Mental Health Symptoms ($n = 159$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. AQ	-															
2. Social Skills	.75***	-														
3. Attention Switching	.58***	.31***	-													
4. Attention to Detail	.30***	.07	.06	-												
5. Communication	.73***	.49***	.29***	-.12	-											
6. Imagination	.66***	.40***	.16*	-.03	.48***	-										
7. DASS-21	.31***	.18*	.22**	.18*	.20*	.16*	-									
8. Stress	.30***	.17*	.23**	.20*	.18*	.13	.92***	-								
9. Anxiety	.33***	.20*	.24**	.14	.20**	.23**	.93***	.79***	-							
10. Depression	.23**	.13	.14	.17*	.16*	.10	.93***	.76***	.69***	-						
11. WM Accuracy	.04	.03	-.06	.15 ^a	-.06	.09	-.13	-.10	-.13	-.12	-					
12. WM Errors	.07	.01	-.05	.17*	.05	.03	.17*	.16 ^b	.18*	.13	.15	-				
13. IN Accuracy	.04	-.01	.02	.12	-.01	.00	-.01	.01	.00	-.02	.65***	.54***	-			
14. IN Errors	.10	.07	-.06	.08	.05	.14	.21**	.14	.24**	.20*	-.03	.49***	-.06	-		
15. CF Accuracy	.12	.05	.06	.09	.03	.11	.03	.02	.05	.00	.52***	.36***	.80***	-.04	-	
16. CF Errors	-.10	-.03	-.09	-.05	-.03	-.10	-.03	-.03	-.06	-.00	-.51**	-.51***	-.85***	-.17*	-.87***	-

Note. AQ= Autism Quotient Total Score; DASS-21 = Depression Anxiety Stress Scale – 21 Total Score; WM Accuracy = Working Memory Accuracy; IN Accuracy = Inhibitory Control Accuracy; CF Accuracy = Cognitive Flexibility Accuracy; *** $p < .001$ ** $p < .01$; * $p < .05$; a = .068; b = .052

4.4. Discussion

The primary aim of this study was to explore whether executive functions including cognitive flexibility, working memory, and inhibition, and social cognition including cognitive empathy and affective empathy mediate the relationship between autistic traits and mental health. This chapter addressed two hypotheses:

4.4.1. H1: Executive Functions (Cognitive Flexibility, Inhibitory Control, and Working Memory) Mediate the Relationship between Autistic Traits and Mental Health Symptoms (Anxiety, Depression, and Stress)

Contrary to our initial hypothesis, we discovered a positive relationship solely between attention to detail and WM. Interestingly, our findings unveiled no other significant correlations between EFs and the majority of autistic traits. These results align with the argument proposed by Happé and colleagues (2006) that autism should be viewed not as a singular category, but rather as distinct dimensions studied independently due to potential variations in effects and causal factors. Notably, dimensions of autism may vary depending on the questionnaires employed and the diverse samples under study. For instance, within the Autism Quotient (AQ), although five subscales exist, some studies propose a three-factor model (e.g., BAPQ, Hurley et al., 2007; AQ – Turkish Adaptation, Köse et al., 2010). Each dimension could be associated with different facets of ASD leading to disparities in subscales (Happé et al., 2006; Stimpson et al., 2021). For instance, Ishizuka and colleagues (2022) found that only attention to detail and attention switching are predictors of depression. Furthermore, Hoekstra and colleagues (2008) have suggested a two-factor model comprising social skills (including social skills, communication, imagination, and attention switching) and attention to detail. Thus, exploring various dimensions of autistic traits can provide nuanced insights and aid in tailoring appropriate intervention and prevention strategies.

In our current study, we discovered that only attention to detail is significantly linked to WM, a finding consistent with existing literature documenting WM challenges in individuals with ASD and those exhibiting elevated autistic traits (Demetriou et al., 2018; Gökçen et al., 2016; Hyseni et al., 2019; Shirima et al., 2022). Various

dimensions of autistic traits may manifest as strengths or challenges in an individual's life. For instance, while attention to detail and attention switching may enhance performance on visual WM tasks by focusing on minute details, they might not necessarily contribute to semantic WM tasks, such as n-back tasks involving letters, as observed in our study, or digit span tasks devoid of visual cues (Grinter et al., 2009; Muth et al., 2014; Nicholls & Stewart, 2023; Richmond et al., 2013; Uddin, 2022). In our investigation, it was noted a negative association between attention to detail and WM performance, alongside a positive correlation between both attention to detail and WM and symptoms of mental health disorders. This seemingly paradoxical relationship may lend support to the Attentional Control Theory proposed by Eysenck et al. (2007), which posits that anxiety could disrupt the top-down cognitive control system, consequently amplifying bottom-up processing and impairing EFs, particularly WM performance. Previous research has indicated a positive impact of WM training on anxiety, depression, and stress traits (Beloe & Derakshan, 2018; Sari et al., 2016), suggesting that WM training could potentially improve the association between autistic traits and symptoms of mental health disorders in both neurotypical and neurodiverse populations.

Furthermore, it was found a negative relationship between the Eyes test and WM errors, and the Eyes test and inhibitory control (errors). These findings also confirmed the previous studies which stated that EFs and social cognition work together for better functionality (Demetriou et al., 2019; Demetriou et al., 2018). Wade and colleagues (2018) have also highlighted the interconnection between EFs and social cognition and direction is still elusive. According to our exploratory analysis among EFs, mental health, and the Eyes test, it was found the Eyes mediate the relationship between WM errors and DASS-21 and the relationship between WM errors and anxiety subscale and supported the previous studies on the direction of WM errors to the Eyes test (Wade et al., 2018) and anxiety also explained by their interconnection. This study has also confirmed that EFs involved emotions called hot EFs including cognitive empathic processes are seen as the central functions for anxiety disorders and also show relations with cold EFs (Salehinejad et al., 2021). Therefore, the importance of combined tasks in the assessment and intervention program could be highlighted; however, more research is needed to extend these findings.

However, there could be some possible explanations for the non-significant relationship between EFs, autistic traits, and mental health symptoms. One possible explanation could be that our sample only included non-clinical participants, while previous studies had focused on clinical samples, such as individuals with ASD and ADHD. Besides, similar findings were observed in previous studies that found no significant relationship between autistic traits in non-clinical samples and the EFs tasks. (Kunihira et al., 2006; Landry & Al-Taei, 2015; Maes et al., 2013). Therefore, it is possible that even though elevated autistic traits may be observed in non-clinical participants, it is not sufficient to conclude that there is a deficiency in EFs tasks in general.

Another possible explanation could be the observed differences between self-report and performance tasks by measuring EFs in the literature. Recent studies have found that self-report measures of EFs such as BRIEF (Giola et al., 2002), are more effective in highlighting the relationship between clinical symptoms and EFs, compared to performance-based EFs in both clinical and non-clinical populations (Buchanan, 2016; Dube et al., 2022; Mason et al., 2021). It was claimed that even though self-report measures could include social desirability and informant bias, they reflect real-world behaviors in daily lives that are possible reasons to relate to clinical symptoms and functioning of individuals (Snyder et al., 2021; van Aken et al., 2023). Therefore, multiple measuring was suggested to test EFs in terms of mental health in the literature that may be taken into account for future studies as well.

An alternative explanation for the non-significant correlation between mental health symptoms and EF tasks may be the absence of emotional involvement in EF tasks. Previous literature suggests that EF tasks primarily focus on cognitive tasks and do not take into account real-world tasks that involve emotional contexts (Petersen & Welsh, 2014; Smitherman et al., 2007; Zelazo, 2010). Many studies indicate that hot EFs involve information processes related to reward, emotion, and motivation, whereas cool EFs include cognitive functions that are operated in non-affective contexts (Salehijened et al., 2021; Zelazo & Carlson, 2012). Furthermore, hot EFs are more closely associated with social skills, emotion regulation skills, and mood disorders (Bernabei et al., 2018; Tsermenstseli & Poland, 2016). De Vries and Geurts (2012) have found that children with ASD do not show ecologically valid set-shifting tasks

but rather show difficulty in emotional tasks. Thus, autistic traits and mental health symptoms, such as depression, anxiety, and stress, are more closely linked to emotional regulation skills and socio-communication deficits. Although the study measures both cognitive and affective empathy tasks for social cognition, it only focuses on measuring cool EFs and not hot EFs as suggested by previous researchers. It could be interesting to involve both cool and hot EFs in future studies to measure the relationship between autistic traits and mental health.

4.4.2. H2: Social Cognitive Skills (Cognitive Empathy and Affective Empathy) Mediate the Relationship between Autistic Traits and Mental Health Symptoms (Anxiety, Depression, and Stress)

In the current study, the self-report affective empathy component (personal distress) was found as the only mediator in the relationship between certain autistic traits (i.e., attention switching) and mental health symptoms (total DASS-21 score, anxiety, and stress). These findings partially confirmed our hypothesis. A positive relationship was found between personal distress and attention switching and a negative relationship was shown between personal distress and imagination. Besides, self-report personal distress was also positively related to mental health symptoms (anxiety, depression, and stress). Similar to previous findings in EFs, this analysis also confirmed the argument of Happé and colleagues (2006) by supporting the different findings of autism dimensions. Moreover, the current findings were also consistent with the previous findings by showing positive associations among affective empathy, mental health symptoms, and autistic traits (Gambin & Sharp, 2018; Sönmez & Jordan, 2023; Tone & Tully, 2014). According to Tone & Tully (2014), affective empathy can be considered a "risky strength" that may increase internalizing problems such as anxiety, depression, and stress if effective emotion regulation skills are not in place. This current study supports this argument by showing the mediation role of affective empathy and it is suggested that utilizing adaptive and effective emotion regulation strategies could be helpful in both preventing and intervening in emotional dysregulation, as well as effectively utilizing affective empathic skills, as previous studies have highlighted the importance of emotion regulation in ASD (Cai et al., 2018; Conner et al., 2020). A negative association between the imagination subscale and personal distress may explained by the participants' higher Eyes test performance.

The model by Nahal et al. (2021) proposed that an optimal level of imagination may ease effective social attention and imagination, in turn, the enhancement of the Eyes may serve as a protective factor for personal distress may be another explanation of the results in the current study. In addition, a lack of effective imagination skills could be related to difficulties in imagining the aversive experiences and feelings of others which may result in the lack of personal distress. The recent study by Gregory and colleagues (2024) also supports this explanation by showing that episodic simulation of events (imagination) increases empathic concern, personal distress, and helping intentions.

Moreover, this investigation revealed that a heightened score in perspective-taking correlates with decreased levels of some of the autistic traits, consistent with prior research (Bos & Stokes, 2018; Mazza et al., 2014). However, a positive association between attention to detail and perspective-taking was observed in the current study. As mentioned before, attention switching and attention to detail may serve as a strength in some tasks for individuals. For instance, Nahal and colleagues (2021) found that higher attention to detail and attention switching increased the Eyes test performance in the study. Intriguingly, self-reported perspective-taking and fantasy, facets of cognitive empathy, show no link with symptoms of mental health. One potential interpretation might be that people often perceive and interpret symptoms of mental health, such as anxiety, stress, and depression, primarily as emotional experiences rather than cognitive ones when assessing themselves through self-report measures because conversely, the Eyes test, a cognitive empathy performance assessment, exhibits a significant correlation with mental health symptoms, aligning with existing literature indicating a negative relationship between cognitive empathy and mental health symptoms (Gambin & Sharp, 2018; Hezel & McNally, 2014). It was found that only the Eyes test and imagination had a significant negative relationship in terms of performance tasks. This is in line with previous studies, which claimed that a negative correlation existed between autistic traits and the Eyes test (Gökçen et al., 2014; Hezel & McNally, 2014; Mazza et al., 2014).

The current study did not find any relationship between performance tasks including the self-assessment manikin and the Eyes test, and self-report tasks for social cognition similar to literature findings. Previous research on emotional tasks and empathy

showed inconsistent results between self-report empathy and performance tasks for empathy (Grainger et al., 2022; Melchers et al., 2015; Sunahara et al., 2022). Performance tasks mainly focused on 'state' empathy and emotional tasks, while self-report measures generally focused on 'trait' and 'perceived skills' empathy by asking questions about possible scenarios and situations related to empathic skills (Grainger et al., 2022). This variability may lead to lower validity and reliability scores for different studies such as those by Higgings et al. (2024), Hollocks et al. (2014), and Johnston et al. (2008). The Eyes test's psychometric properties show some inconsistencies in research studies, leading to inconsistencies in both clinical and non-clinical samples (Higgings et al., 2024; Hollocks et al., 2014; Johnston et al., 2008). Therefore, the results should be evaluated with caution before drawing any conclusions. Therefore, using both self-report and performance tasks can help to identify differences in study samples, as in this study.

4.4.3. Limitations and Future Directions

This study may have some potential limitations that need to be considered. Firstly, it could be beneficial to include self-report measures of EFs such as the BRIEF in addition to performance tasks, as this approach may provide a more comprehensive understanding of EF skills in daily life situations. Recent studies have suggested that integrating self-report EF measures alongside performance tasks could enhance the translation of EF skills into real-world scenarios (Snyder et al., 2021; van Aken et al., 2023). In Turkish version of BRIEF for adults is currently not available, however, future studies can also focus on self-report measures of EF adaptation for their studies. Furthermore, it would be valuable to explore the roles of both 'cool' (cognitive) and 'hot' (affective) EFs with mental health, as the literature on these variables is currently limited (Petersen & Welsh, 2014; Smitherman et al., 2007; Zelazo, 2010). Besides, although measurements for the performance tests (e.g., accuracy and errors) were chosen based on previous studies (Ajilci & Nejati, 2017; Gökçen et al., 2016; Fernandez-Prieto et al., 2021; Groves et al., 2022; Johnston et al., 2019), reaction times (RTs) of the answers could also give more detail information and future studies should consider it.

Moreover, despite our efforts to recruit participants through social media and mail groups, the study predominantly consisted of female participants compared to males. Although we controlled for sex as a covariate to mitigate potential effects, future studies may benefit from employing diverse sampling methods to ensure a more balanced representation of sex. Additionally, while our study examined autistic traits, it is important to note that the findings may not be generalizable to clinical populations, such as individuals diagnosed with ASD. Therefore, future research should aim to replicate these findings in both clinical and non-clinical samples to enhance the generalizability of the results across populations.



CHAPTER V

DESIGNING EXECUTIVE FUNCTIONS AND SOCIAL COGNITION ONLINE TRAINING: THE PILOT STUDY

5.1. Introduction

Psychological interventions are defined by employing different techniques to change desired outcomes including social cognitive skills, behaviors, emotions, or beliefs in individuals (Hodges et al., 2011). Designing proper intervention could be seen as a complex issue due to challenges in reporting may result in difficulties in replication, interpretation, or clear manuals to implementation; however, using the steps based on the previous literature can help to avoid these complexities and challenges (van Agteren et al., 2021). The traditional pipeline model was developed in biomedical research and now it has been used in behavioral interventions in psychology as well. The word ‘pipeline’ refers to a conceptualized pathway to design intervention based on the scientific research area and community that will be used (Gitlin & Czaja, 2015). The traditional pipeline was applied from biomedical research to behavioral intervention and the steps of the traditional pipeline were presented in Figure 5.1 (Medical Research Council, 2000).



Figure 5.1. Traditional Pipeline

In Phase I, identifying problems and variables, theoretical framework, and methodology including materials that can be used in pretest and posttest options are included in the first step of the designing intervention program (Gitlin & Czaja, 2015). In Phase II, feasibility is another important step in designing the intervention including designing the training manual, considering validity (see details in 5.2.2), and conducting the pilot study (Gitlin & Czaja, 2015). Phase III consists of investigating the efficacy of the intervention program. This phase includes fully testing the intervention to different groups including experimental and control groups on expected outcomes. The main concern of this phase is to examine the effect of intervention on the participants and to provide continuity for the internal validity of the research. In Phase IV, the replication of the intervention, reliability of the findings, and generalizability are important features to take into consideration (Gitlin & Czaja, 2015).

As the current thesis has been included in three distinct phases: Phase I (Chapter 1, Chapter 2, Chapter 3, Chapter 4), Phase II (Chapter 5), and Phase III (Chapter 6), each phase is systematically built upon the findings and insights from the preceding phase. One of the main objectives of the thesis was to design an online training program that combines social cognition and EFs to address mental health challenges. This approach aimed to integrate the understanding of social cognition and EFs to develop a comprehensive intervention that can effectively support mental well-being. Accordingly, to follow the requirements of Phase II, this chapter consists of designing a training manual, methodology issues, and pilot testing for the online combined EFs and social cognition training. The efficacy of the intervention program using experimental and control groups will be tested in the next chapter to fulfill the requirements of Phase III.

5.1.1. Development Stage

5.1.1.1. Phase I: Discovery

In the current thesis, Phase I including the general literature review, theoretical framework, and variables are defined and presented in the previous chapters. As stated in the previous chapters, it has been observed that autistic traits could potentially

heighten the likelihood of experiencing mental health challenges (Albantakis et.al., 2020; Dell’Osso et.al., 2019; Dell’Osso et. al., 2018; Lundstörn et. al., 2011). Nevertheless, there hasn't been any research conducted to investigate the connections and interventions between these traits, executive functions, and social cognitive abilities. This chapter attempts to develop an online intervention that targets combined EFs and social cognition for mental health. In Phase II, feasibility is another important step in designing the intervention including designing the training manual, considering validity (see details in 5.2.2), and conducting the pilot study (Gitlin & Czaja, 2015).

5.1.1.2. Phase II: Feasibility

5.1.1.2.1. Literature Review for Intervention

Online assessments of executive functions such as WM, cognitive flexibility, and inhibitory control, as well as social cognitive skills (cognitive and affective empathy), are commonly used for both clinical and non-clinical populations. To evaluate these functions and skills, performance tasks and questionnaires can be used in the previous studies (Berardi et al., 2021; Couette et al., 2020; Sandgreen et al., 2021), and the assessment tools for five main areas in the current thesis were reviewed and presented in Table 5.1. However, only performance tasks are included in the task-based training program, along with their references and examples from the literature because the training included performance tasks rather than self-report measures. Previous studies have extended these tools with different versions, including both social cognition and executive functions.

In addition to the assessment tasks, interventions designed for EFs, and social cognition studies were reviewed for this current thesis. In terms of intervention for EFs, previous studies that designed interventions are based on different assessment tasks (see Table 5.1.) for each intervention area, including WM training, cognitive flexibility training, and inhibitory control training (Beloe & Derakshan, 2019; Chen et al., 2022; de Vries et al., 2015; de Vries et al., 2018; Hadwin & Richards, 2016; Macoun et al., 2021; Prins et al., 2013; Roughan & Hadwin, 2011; Sandgreen et al., 2021; Sari et al., 2016; Varanda & Fernandes, 2017).

In terms of social cognition training, there is no consensus on the content of the training. However, some of the contents are presented including gaze, emotion and face recognition and matching tasks, maintenance, and management of emotions, understanding and taking own and others' perspectives, and cognitive distortions (Ibrahim et al., 2021; Sacks et al., 2013; Sandgreen et al., 2021; Schoeneman Patel et al., 2022; Nahum et al., 2021; van der Stouwe et al., 2018).

Even though previous studies have indicated that EFs and social cognition are both essential and work together for better functionality (Demetriou et al., 2019; Demetriou et al., 2018), there is no online training program including both combined and non-combined EFs and social cognitive skills. As our previous study (Chapter 4) showed that the performance tasks of cognitive empathy and WM (errors), and cognitive empathy and inhibitory control (errors) have a negative correlation with each other, designing a combination of EFs and social cognitive skills might be worth combining and examining together. Therefore, the main purpose of this section is to fulfill the requirement of Phase II and design the online training manual based on the literature review above. In the following sections, designing the training manual, consideration of validity, and the results of the pilot study to test training were present.

Table 5.1. The Assessment Tools of Executive Functions and Social Cognition

Main Areas	Performance-based Assessment Tools	Example of Studies in the Literature (Listed alphabetically)
Working Memory	<ul style="list-style-type: none"> • N-Back Task • Digit Span Task • Picture Span Task • Verbal Span Task • Spatial Memory • Emotional N-Back Task 	Beloe & Derakshan (2019). Barendse et al. (2018). Han et al. (2022). Kirchner (1958). Sari et al. (2016), Sari et al. (2020). Yuk et al. (2020). Wechsler (1998). Yeung & Chan (2020). Zhang et al. (2021). Zhang & Robb (2021)

Table 5.1. (cont.)

Main Areas	Performance-based Assessment Tools	Example of Studies in the Literature (Listed alphabetically)
Cognitive Flexibility	<ul style="list-style-type: none"> • Wisconsin Card Sorting Task (WCST) • Dimensional Change Card Sort Task (DCCS) • Task Switching Task • The Stroop Task • Gender-Emotion Switching Task • Emotional Rule Shift Task 	<p>de Vries & Geurts (2012). Djamshidian et al. (2011). Grant & Berg (1948). Gökçen et al. (2014). Hollocks et al. (2021). Moore & Malinowski (2009). Rogers & Monsell (1995). Stroop (1935). Yeung & Chan (2020), Zelazo (2006).</p>
Inhibitory Control	<ul style="list-style-type: none"> • Window Task • The Stroop Task • Go/No Go Task (including different variants with emotions, pictures, and colors) • Stop Signal Task • Emotional Stop Signal Task • Anti-Saccade Task • Flanker Task 	<p>Donders, (1969). Eriksen & Eriksen, (1974). Hallett, (1978). Happé et al. (2006). Jahromi et al. (2013). Loeffler et al. (2019). Logan & Cowan (1984). Russell et al. (1991). Sanderson & Allen, (2013). Sari et al. (2016). Schulz et al. (2007). Stroop, (1935). Xiao et al. (2012). Waring et al. (2019). Yeung & Chan (2020).</p>
Cognitive Empathy	<ul style="list-style-type: none"> • False Belief Task / Sally-Anne Task • Strange Stories • Reading Mind in the Eyes • Director Task • Movie for the Assessment of Social Cognition (MASC) • Multifaceted Empathy Test (MET) • The Situational Test of Emotional Understanding (STEU) • The Situational Test of Emotional Management (STEM) 	<p>Baron-Cohen et al. (1985). Baron-Cohen et al. (2001b). Dumontheil et al. (2010). Dziobek et al. (2008). Dziobek et al. (2006). Happé (1994). MacCann & Roberts (2008). Sönmez & Jordan (2020). Tatar & Cansız (2022). Wimmer & Perner, (1983).</p>

Table 5.1. (cont.)

Main Areas	Performance-based Assessment Tools	Example of Studies in the Literature (Listed alphabetically)
Affective Empathy	<ul style="list-style-type: none"> • Self-Assessment Manikin for Affective Empathy • Emotion Recognition Task • Movie for the Assessment of Social Cognition (MASC) • Multifaceted Empathy Test (MET) • The Situational Test of Emotional Understanding (STEU) • The Situational Test of Emotional Management (STEM) 	<p>Dziobek et al. (2008). Dziobek et al. (2006). Güntekin & Basar (2007). Lockwood et al. (2013). MacCann & Roberts (2008). Wai & Tiliopoulos (2012). Yeung & Chan (2020).</p>

5.1.2. Designing Executive Functions and Social Cognition Online Training

The online training program is named *MindZone* and features a combination of social cognitive and executive function skills derived from a literature review, depicted in Table 5.1. *MindZone* is accessible through the training website on various devices such as computers, tablets, or smartphones (www.mindzone.com.tr). The program comprises tasks aligned with five intervention areas: WM, cognitive flexibility, inhibitory control, cognitive empathy, and affective empathy, as outlined in detail in Table 5.2. During the initial week, participants will engage in non-combined training tasks based on the literature review to ease their adaptation to the platform. Subsequently, combined executive function and social cognitive tasks will be introduced. Some tasks are modeled after those found in the literature, while others are

based on similar tasks (see Table 5.2). Validity concerns are addressed in the section 5.1.2.1.

Participants are provided with a brief introduction to each task before they begin, and they receive feedback on their progress and scores upon completion. The literature lacks consensus on the duration of the training, so the average training time of 6 weeks, totaling 5 hours, was used (Sandgreen et al., 2021). Participants are expected to dedicate 50 minutes of play per week to meet the training requirement. The training program was developed using the Karolinska Directed Emotional Faces (KDEF) and Racially Diverse Affective Response (RADIATE) Emotional Face Stimulus Set (Conley et al., 2018; Lundqvist et al., 1998). A preview of the website can be found in Image 5.1 and Image 5.2.





Image 5.1. Preview of the MindZone Main Page

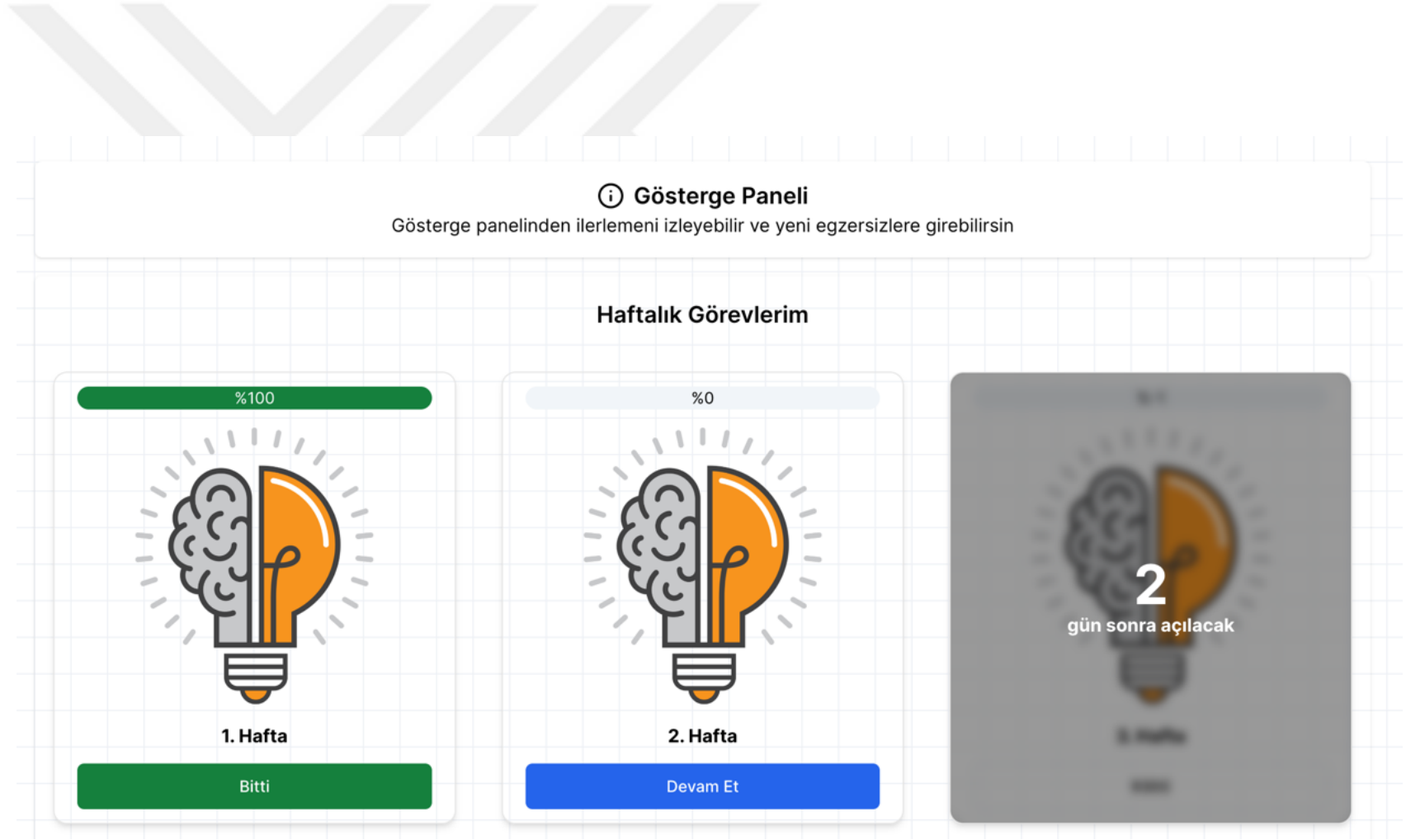


Image 5.2. Preview of the Dashboard

Table 5.2. MindZone Manual

Training Areas	Content (Each block lasts 10 minutes)
Week 1	
Working Memory	Digit Span Task: During the first week for the working memory, participants exercise Digit Span Task which is commonly used in research (Wechsler, 1998; Kirchner, 1958). First, participants received a brief explanation of the task, followed by a 'start' button displayed in the middle of the screen. Upon receiving the command to touch the screen, participants begin the exercise. In this task, participants repeated the numbers displayed on the screen, with the sequence of numbers gradually increasing up to a total of nine.
Cognitive Flexibility	Task Switching Task: Participants practice the Task Switching Task developed by Rogers and Monsell in 1995. The task consists of consonant and vowel letters, as well as odd and even numbers. Initially, brief information was, followed by 'start' button appearing at the center of the screen to prompt the participant to touch the screen and begin the exercise. Before the task begins, a trial game was played, and an informational message was displayed to familiarize participants with the task.
Inhibitory Control	The Stroop Task: It was administered in the first week, and it has been utilized by numerous studies in the literature (Jahromi et al., 2013; Stroop, 1935; Xiao et al., 2012). This task requires participants to read colored words that are printed in either congruent or incongruent colors as quickly and accurately as possible. The colors are presented in written form, and the individual must respond with either the color of the written word or the color that is written.
Cognitive Empathy	Director Task: Participants in a task are shown a series of shelves with objects on them. They receive instructions from a "Director" who can only see some of the objects. The task requires participants to correctly interpret the instructions and move only the objects that the Director can see. This task tests the participant's ability to use the perspective of the Director to correctly complete the task (Dumontheil et al., 2010).
Affective Empathy	Face Perception and Matching: The task requires participants to recognize faces from various angles and match them with the target answer. Each face is displayed for 2000 milliseconds (ms), followed by four options. Participants must choose the correct option that matches the target picture. Once they have responded, they received feedback indicating whether their response was true or false. Designed by the researcher based on the literature.

Table 5.2. (cont.)

Training Areas	Content (Each block lasts 10 minutes)
Week 2	
Working Memory	Memory Span for Faces: The objective of the task is to match identical faces on the cards. The target face image was displayed on the screen for 5000 ms. Then, 4 choices appear, and the person was asked to match the same face. This task combined social cognition and EFs and designed by the researcher based on the literature review.
Cognitive Flexibility	Emotional Rule Shift Task: Similar to the Emotional Rule Shift Task (ERST, Gökçen et al., 2014), emotions were expressed through opening and closing the mouth. The training used a total of 192 color images of 96 male and 96 female faces, which varied in valence (positive and negative emotion) and expressiveness/activation (strong and weak). Each image was two-dimensional and differed in two aspects, strong-positive, strong-negative, weak-positive, and weak-negative, capturing their powerful expressions (such as happiness, calm, anger, sadness, fear, and disgust). The target picture was shown for 2000ms and was then followed by a 400ms fixation point.
Inhibitory Control	Emotional Stop Signal Task: This is a modified version of the original stop signal task developed by Logan and Cowan in 1984 (Waring et al., 2019). In this task, individuals are presented with positive and negative pictures and are required to press for positive pictures and stop for negative pictures. Each facial expression type, Fear, Anger, Disgust, Neutral, and Happy, serves as both target and non-target. The task consists of “Go” and “No-Go” trials with 35 targets and 13 non-targets per block. The target and non-target pictures were shown for 500 ms, followed by a pause of 1000 ms. The target picture may be repeated, or it continues in random order like the non-target image.
Cognitive Empathy	Understanding Mind and Emotion: A total of 32 short stories were created in Turkish to evaluate cognitive empathy skills similar to the Situational Test of Emotional Understanding (STEU; MacCann & Roberts, 2008). Each story was accompanied by four emotional response options, and incorrect answers were followed by feedback, including the correct answer and an explanation for it. The purpose of the test was to help individuals improve their cognitive empathy skills by presenting them with possible scenarios.
Affective Empathy	Face and Emotion Matching: An activity has been planned to help people match emotions with facial expressions. This exercise is designed to allow participants to identify emotions from different angles on the same face and to match the emotions of different people by using pictures of emotions from various facial angles. Designed by the researcher based on the literature review.

Table 5.2. (cont.)

Training Areas	Content (Each block lasts 10 minutes)
Week 3	
Working Memory	Memory Span for Facial Emotions: The objective of the game is to match identical facial emotions on the cards. The target face image was displayed on the screen for 5000 ms. Then, 4 choices appear, and the person was asked to match the same emotion. Unlike the previous week, the participants attempt to match the emotions with their corresponding faces. Designed by the researcher based on the literature.
Cognitive Flexibility	Gender-Emotion Switching Task: The task involves matching either by gender or by emotion. A total of 96 color images for 6 emotions (happiness, calm, anger, disgust, fear, sadness) and 48 male and 48 female face for positive and negative emotions were selected. Each trial includes two factors: valence (positive and negative emotion) and gender. The target picture was displayed for 2000ms. While the task initially involved two rules, a third rule was added later, which involves the expression of emotions (strong/weak), similar to the ERST study (de Vries & Geurts, 2012; Gökçen et al., 2014).
Inhibitory Control	Emotional Face Stroop Task: In a study conducted by Loeffler et al. (2019), a total of 60 pictures were chosen. These included 30 happy, 10 fearful, 10 angry, and 10 sad pictures, with 30 being positive and 30 being negative. The faces were centered on the nose, with no obstruction of the eyes or mouth area. Participants were required to indicate their facial expressions as quickly and accurately as possible by pressing the key, without paying attention to the labels. Each face was presented for one second, followed by a 2-second interval. Responses were possible until the next trial began, with a 400 ms fixation cross used to prepare participants for the next face.
Cognitive Empathy	Emotional Management: In the Understanding Mind and Emotion section of Week 2, participants were presented with different scenarios similar to the Situational Test of Emotional Management (STEM, MacCann & Roberts, 2008). They were asked to choose the most appropriate response in terms of their emotional management and regulation skills.
Affective Empathy	Affective Response Management: For the upcoming test, participants were presented with 30 different stories, similar to the STEU test (MacCann & Roberts, 2008). In the first 16 questions, participants were shown pictures depicting emotions and asked to identify which emotion is being portrayed.

Table 5.2. (cont.)

Training Areas	Content (Each block lasts 10 minutes)
Week 4	
Working Memory	Emotional-N-back Task: The experiment conducted by Augusti and colleagues. in 2014 included equal numbers of pictures depicting male (18) and female (18) actors. Each emotional expression such as sad, neutral, happy, disgusted, angry, and fearful, was depicted during the 36-picture presentation. The duration of each picture was 5000 ms
Cognitive Flexibility	Gender/Emotion/Expression Switching Task: Week 4 was similar to Week 3, with 4 cards like ERST (Gökçen et al., 2014), each with faces on them. The rule was either matching by gender or matching by emotion. The gender rule from the previous week was added, making a total of 3 rules to change. For this task, a total of 192 color images of male (96) and female (96) faces were selected. Each trial consists of valence (positive or negative emotion), sex (male, female), and emotional expression (strong or weak).
Inhibitory Control	Emotional Go/No Go Task: In a study by Schulz et al. (2007), 48 pictures were chosen from the same database. Each facial expression type (Happy, Calm, Anger, Fear, and Disgust) served as both target and nontarget between blocks for six blocks of Target/Nontarget pairs. Positive emotions (Happy and Calm faces) were associated with "Go" responses, while negative emotions (Anger, Fear, and Disgust) were associated with "No-Go" responses. Each target photo was displayed for 500 ms, followed by a 1000 ms break, after which the next image (either target or non-target) was displayed in a random order. There were 35 targets and 13 nontargets per block.
Cognitive Empathy	Cognitive Distortions: Introducing to cognitive distortions and asked to reflect on how frequently they experience them. Examples were provided to help examine the reality of each thought, determining whether they are true or not. Cognitive distortions are defined as biased or inaccurate ways of thinking, according to Gibbs and Potters (1992) and Barriga et al. (2001). They are also referred to as "thinking errors" (Yochelson & Samenow, 1976) and are categorized into four main types: self-centered, blaming others, minimizing, mislabeling, and assuming the worst. Barriga et al. (2008) found that cognitive distortions are negatively associated with cognitive and affective empathy and can impact a person's social functioning (Burns, 1989). It was used for both empathy skills as well (van der Stouwe et al., 2018). Designed by the researcher based on the literature review.
Affective Empathy	Affective Response: A set of 30 short stories, similar to the Situational Emotional Understanding Test (STEU; MacCann & Roberts, 2008), was presented in Turkish. Each story was displayed for 5000 ms and the exercise aimed to explore the emotional response one might exhibit when facing a particular situation, as well as the emotional response regulation expected from others.

Table 5.2. (cont.)

Training Areas	Content (Each block lasts 10 minutes)
Weeks 5 & Week 6	
Working Memory	All tasks for each week were presented in a mixed order.
Cognitive Flexibility	
Inhibitory Control	
Cognitive Empathy	
Affective Empathy	

5.1.2.1. Validity

The concept of validity is generally measured by assessing the variables that it is intended to measure. When discussing the validity of a study, we refer to the internal validity which measures the extent to which we can attribute a cause-and-effect relationship to the intervention itself, and not to other factors that may influence the study's results (Breakwell et al., 2012). In this thesis, it was taken several considerations to reduce the impact of confounding variables and increase internal validity.

Some of the possible confounding variables that are considered by the researcher and the supervisor are (1) the data collection procedure, (2) type of supervision (i.e., the presence or absence of the researcher in data collection), (3) practice effect, (4) order effect, (5) valid and reliable tasks based on the literature, and (6) peer review. To address these variables, firstly, we conducted a study to determine whether online data collection or the presence of the researcher could lead to confounding variables in Chapter 3. The results showed that neither factor had a significant impact on the study's outcomes.

The practice effect is defined as improving outcomes due to repeated exposure to the tasks and it is another possible confounding factor that we addressed by using different tasks in the training compared to the main performance tasks in the pretest and posttest conditions. We also used the counter-balancing technique to reduce the order effect, which refers to the potential changes in the participants due to the order of tasks in the experiment (Breakwell et al., 2012; Duff et al., 2007). Furthermore, we chose valid and reliable tasks based on a literature review and previous studies, as outlined in section 5.1.3 to increase the reliability and validity of the intervention program. Lastly, we utilized peer review to ensure the content and methodology of the intervention program were evaluated by experts in the field (Merriam, 2009). This intervention program underwent peer review by the supervisor, dissertation committee members, and a neuropsychologist who completed a degree in neuropsychology contributing to the study's internal validity.

5.2. Study 3: The Pilot Study

According to the requirements of Phase II, the importance of the pilot study has been highlighted (Medical Research Council, 2000). Rather than the test hypothesis, according to Leon and colleagues (2011), the main goal of the pilot study should be to test whether the designed intervention works for further studies. Therefore, the main purpose of the pilot study is to test the feasibility of the designed combined online training program (MindZone) in the current sample.

5.2.1. Participants

First, 24 participants were recruited for the current pilot study. However, only 18 participants completed the study's pretest and posttest. Therefore, the current study sample consists of 18 participants (11 female, 7 male) between ages 22 and 40 ($M = 28.39$, $SD = 4.08$). The participants were randomly and equally assigned to experimental and control groups (waiting list). Demographic characteristics and descriptive statistics are presented in Table 5.1. Convenience sampling method via advertisement through social media, mail groups, and on campuses was used to collect participants. Inclusion criteria for adult participants are being aged 18 or above, being able to use computers, smartphones, or tablets, reading and speaking Turkish, having no record of any psychiatric disorders, and having no record of any physical and neurological conditions that prevent the use of technological devices. Participants who are under age 18 and have any record of psychiatric and physical conditions that prevent to use of technological devices were excluded from the study.

5.2.2. Materials

5.2.2.1. Self-Report Questionnaires

5.2.2.1.1. Demographic Information Form

Basic information such as age, gender, education level (e.g., undergraduate, postgraduate), and the history of physical and psychiatric disorders for inclusion criteria were collected from the participants as developed by the researcher.

5.2.2.1.2. Autism Quotient

To measure autistic traits, the Autism Quotient (AQ; Baron-Cohen et al., 2001) was conducted. AQ for adults is adapted to Turkish culture Köse and colleagues (2010). The self-report questionnaire consists of 50 questions using a Likert-scale rating; “definitely agree”, “slightly agree”, “slightly disagree”, and “definitely disagree”. In the Turkish adaptation of the AQ for adults, Cronbach’s alpha value for this scale is .64, and test-retest reliability is $r = .72$. The AQ is a widely used assessment tool that

measures five subscales: social skills, communication, attention to detail, attention switching, and imagination.

5.2.2.1.3. Depression Anxiety Stress Scale - 21

Depression Anxiety Stress Scale - 21 (DASS - 21) is a self-report scale to examine depression, anxiety, and stress levels for adults by Lovibond and Lovibond (1995). The Turkish adaptation study for DASS-21 was conducted by Sarıçam (2018). This scale consists of three subscales, one for depression, one for anxiety, and one for stress. The total number of items is 21. For this scale, inter-scale reliability with Cronbach's Alpha is .87 for depression, .85 for anxiety, and .81 for stress subscales. Test-retest reliability is $r = .68$ for depression, .66 for anxiety, and .61 for stress.

5.2.2.1.4. Interpersonal Reactivity Index

To measure cognitive and affective empathy, the Interpersonal Reactivity Index (IRI) was used. IRI was developed by Davis (1980) and adapted to Turkish culture (Engeler & Yargic, 2007). IRI is a self-report measure that consists of 28 questions. The scale has 4 subscales which are perspective-taking, empathic concern, fantasy, and personal distress. In the Turkish version of the IRI, the internal consistency of four subscales ranged from .60 to .76 and test-retest reliability ranged from .66 to .80 for each subscale.

5.2.2.2. Performance Tasks

To evaluate executive functions such as cognitive flexibility, WM, and inhibitory control, as well as social cognition including cognitive empathy and affective empathy, it was administered the following performance tasks To ensure standardized measurement, it was recorded the errors for each task based on previous intervention studies (Chooi & Logie, 2020; de Vries et al., 2015; Macoun et al., 2021; Maraver et al., 2016). Each task begins with a non-scored trial to ensure that participants understand the task before scoring begins. The only exceptions are for the self-assessment manikin for affective empathy and the Eyes Test for which detailed information was provided.

5.2.2.2.1. Wisconsin Card Sorting Task

Wisconsin Card Sorting Task (WCST) is a performance task to measure cognitive flexibility (Berg, 1948). The cards were displayed on the screen. The task consists of 200 cards in two blocks, and the sorting rule changes every 10 cards. Participants were expected to learn from the feedback and adapt the rules during the task by trial and error. The participant is expected to match the cards according to their color, number, and shape. Participants only receive feedback on whether a card's sorting is correct. Feedback helps participants understand and adjust the current sorting rule. After each selection, they receive feedback on the accuracy of the selection. Error rates were measured.

5.2.2.2.2. N Back Task

Working memory was measured via the *N* Back Task (Kirchner, 1958) with three different conditions (i.e., one back, two back, and three back). A sequence of stimuli was presented one by one, and participants needed to decide whether the presented stimuli were the same as the stimuli that were displayed *N* trials ago. The complete stimulus sequence comprises 15 letters. Every stimulus appears for half a second (500 milliseconds). Participants are allowed to react within three seconds (1300 milliseconds). A new letter is displayed every three seconds (1300 milliseconds). The letters A, B, C, D, E, H, I, K, L, M, O, P, R, S, and T are used in the sequence. There are eight blocks, with each block containing 50 trials. False errors were measured.

5.2.2.2.3. Go / No Go Task

Go / No Go Task was used to measure inhibition. The task requires participants to respond as quickly and accurately as to the presented target stimulus ("go" trials) but avoid responding to non-target stimulus ("no go" trials). Response speed 1000 milliseconds in go/no-go trials. Only the text "go" or "no go" appears. When the "go" sign is seen, a reaction must be made within 1000 milliseconds. There are 12 blocks of 50 trials each. Commission errors (i.e., incorrectly responding to no-go trials) were measured.

5.2.2.2.4. The Eyes Test

The Eyes Test is a performance task for emotion recognition which is widely regarded as an indicator of cognitive empathy. In this test, participants were presented with a series of 28 black-and-white photographs of human eyes. For each photograph, participants were asked to choose which of 4 words best describes what the person in the photograph is feeling or thinking. The task was adapted for Turkish by Girli (2014). The Cronbach alpha internal consistency coefficient for this test is greater than .70. Accuracy was measured. Higher scores indicated better cognitive empathy.

5.2.2.2.5. Self-Assessment Manikin

Self-Assessment Manikin (SAM) was used to measure self-reported emotional responses to facial expression images for affective empathy. Karolinska Directed Emotional Faces (KDEF, Conley et al., 2018; Lundqvist et al., 1998) were used to express facial emotions. In total, 30 images (15 male, 15 female) were chosen and seven emotional expressions including happiness, neutral, anger, fear, and disgust were depicted. The task requires participants to examine each facial expression and rate how they feel it on a valence scale (more negative (1) to more positive (9)). The tasks were adapted from Wai and Tiliopoulos (2012). Valence scores for each emotion were obtained by summing responses for all images.

5.2.3. Procedure

Approval from the ethical committee of Ibn Haldun University was obtained for this study (No. E-71395021-050.06.04-34359) and the protocol ID of clinical trials was obtained (NCT06213194). Each participant accepted to participate in this study voluntarily. The data were collected through an online website designed by the researcher. The link was sent either through e-mail or social media platforms (WhatsApp, Instagram, Twitter, LinkedIn, and Facebook) via advertisement. After participants logged in on the website, the pretest, consisting of the self-report questionnaires and performance tasks, was completed. All tasks took 25 mins approximately. All data is kept on the database confidentially. The post-test was collected at the end of the 6th week. Besides, the research team checked whether each

participant completed the requirement each week or not, and if they had not, reminder messages and phone calls were used to increase the continuity of the training. Money gift cards were used as incentives to reduce the drop-out rate for the study. After the completion of the study, the control group (on the waiting list) was planned to access the online training program following ethical guidelines.

5.2.4. Data Analysis

SPSS 25.0 package was used to analyze the data. Firstly, preliminary analyses including descriptive statistics analysis were conducted, see the demographic characteristics of participants in Tables 5.3 and 5.4. The data's skewness and kurtosis fall within an acceptable range (-1.5 to +1.5) for the application of parametric tests, as specified by Tabachnick and Fidell (2013). In the experimental study, 2 x 2 mixed design repeated measure ANOVA was conducted to examine the group (experimental and control group) and the effects of time (pretest and posttest). Independent variables are time and group, dependent variables are autistic traits, mental health symptoms, EFs, and social cognitive tasks.

5.2.5. Results

5.2.5.1. Demographic and Descriptive Statistics

The mean, standard deviations, minimum and maximum scores for AQ and its subscales, DASS-21 and its subscales, IRI and its subscales, WM false errors, inhibitory control commission errors and cognitive flexibility perseverative errors, The Eyes test and Self-Assessment Manikin (SAM) for affective empathy were presented in Table 5.4.

Table 5.3. Demographic Characteristics ($n = 18$)

	Experimental Group				Control Group			
	<i>n</i>	Mean (SD)	Min	Max	<i>n</i>	Mean (SD)	Min	Max
Age	9	27.67 (2.69)	23	32	9	29.11 (5.18)	22	40
Sex (%)								
Female	6	(66.7)			5	(55.6)		
Male	3	(33.3)			4	(44.4)		
Education (%)								
Middle School	0	-			2	(22.2)		
High School	2	(22.2)			1	(11.1)		
Associate degree	1	(11.1)			0	-		
Bachelor's degree	4	(44.4)			2	(22.2)		
Master's degree	1	(11.1)			4	(44.4)		
Doctorate degree	1	(11.1)			0	-		

Note. SD = Standard Deviation; Min = Minimum; Max = Maximum

5.2.5.2. The Results of the Pilot Training

The significant main effects of time were found in DASS-21, with $F(1, 16) = 6.93$, $p < .05$, $\eta^2 = .30$, and its anxiety, $F(1, 16) = 8.85$, $p < .01$, $\eta^2 = .36$, and depression subscales, $F(1, 16) = 5.03$, $p < .05$, $\eta^2 = .24$. In addition, the significant main effects were found in inhibitory control errors ($F(1, 16) = 9.99$, $p < .05$, $\eta^2 = .27$), and the errors score of cognitive flexibility, $F(1, 16) = 43.28$, $p < .001$, $\eta^2 = .73$. The only interaction effect between time and group were found in self-assessment manikin for affective empathy, $F(1, 16) = 5.01$, $p < .05$, $\eta^2 = .24$. See 5.5. Group comparison for descriptive results for both groups.

Table 5.4. Descriptive Statistics ($n = 18$)

	Experimental Group				Control Group			
	<i>n</i>	Mean (SD)	Min	Max	<i>n</i>	Mean (SD)	Min	Max
AQ	9	20.22 (6.08)	23	32	9	18.33 (5.94)	12	28
Social Skills	9	3.56 (2.19)	0	7	9	2.78 (1.72)	1	6
Attention Switching	9	4.56 (2.60)	1	9	9	5.11 (1.34)	3	7
Attention to Detail	9	5.11 (2.37)	1	8	9	5.00 (1.41)	3	8
Communication	9	3.22 (2.73)	1	8	9	2.44 (2.07)	0	6
Imagination	9	3.78 (2.39)	1	7	9	3.00 (2.00)	1	6
DASS-21	9	26.89 (6.90)	14	35	9	23.33 (13.28)	12	50
Depression	9	7.89 (3.37)	4	15	9	5.67 (5.12)	2	15
Anxiety	9	10.56 (3.74)	5	17	9	9.22 (4.35)	5	18
Stress	9	8.44 (2.01)	5	12	9	8.44 (4.00)	5	17
The Eyes	9	19.56 (7.50)	7	28	9	22.22 (5.78)	8	28
SAM	9	142.00 (21.99)	107	178	9	118.11 (14.72)	100	141
IRI	9	76.89 (30.06)	41	112	9	73.33 (13.35)	55	92
Perspective Taking	9	17.89 (5.71)	10	28	9	19.00 (2.50)	15	23
Fantasy	9	19.89 (9.62)	7	28	9	19.67 (6.27)	12	28
Empathic Concern	9	19.11 (9.96)	9	28	9	17.67 (5.05)	13	28
Personal Distress	9	19.00 (5.87)	12	27	9	17.00 (5.10)	11	25
WM Errors	9	80.00 (43.84)	28	168	9	67.67 (36.23)	21	123
IC Errors	9	30.11 (42.07)	4	129	9	22.67 (31.65)	0	100
CF Errors	9	25.22 (26.16)	20	41	9	24.22 (22.35)	21	38

Note. Min = Minimum; Max = Maximum; AQ = Autism Quotient; DASS-21 = Depression Anxiety Stress Subscale-21; SAM = Self-Assessment Manikin; IRI = Interpersonal Reactivity Index; WM = Working Memory; IC = Inhibitory Control; CF = Cognitive Flexibility

Table 5.5. Group Comparison ($n = 18$)

	Experimental Group			Control Group			<i>p</i>
	<i>n</i>	Pretest Mean (SD)	Posttest Mean (SD)	<i>n</i>	Pretest Mean (SD)	Posttest Mean (SD)	
DASS-21	9	26.89 (6.90)	21.11 (11.69)	9	23.33 (13.28)	23.33(13. 28)	$p > .05$
Depression	9	7.89 (3.37)	5.56 (3.13)	9	5.67 (5.12)	3.56 (1.81)	$p > .05$
Anxiety	9	10.56 (3.74)	8.00 (4.47)	9	9.22 (4.35)	7.00 (4.18)	$p > .05$
Stress	9	8.44 (2.01)	7.67 (4.69)	9	8.44 (4.00)	7.11 (3.75)	$p > .05$
The Eyes	9	19.56 (7.50)	20.78 (6.83)	9	22.22 (5.78)	24.33 (5.67)	$p > .05$
SAM	9	142.00 (21.99)	124.44 (20.74)	9	118.11 (14.72)	130.00 (13.99)	$p < .05$
IRI	9	76.89 (30.06)	67.67 (27.30)	9	73.33 (13.35)	64.33 (10.26)	$p > .05$
Perspective Taking	9	17.89 (5.71)	15.56 (8.03)	9	19.00 (2.50)	19.11 (3.72)	$p > .05$
Fantasy	9	19.89 (9.62)	18.67 (8.06)	9	19.67 (6.27)	16.67 (5.12)	$p > .05$
Empathic Concern	9	19.11 (9.96)	16.67 (7.12)	9	17.67 (5.05)	15.22 (1.98)	$p > .05$
Personal Distress	9	19.00 (5.87)	16.78 (8.64)	9	17.00 (5.10)	13.33 (3.39)	$p > .05$
WM Errors	9	80.00 (43.84)	16.67 (29.71)	9	67.67 (36.23)	55.67 (121.74)	$p > .05$
IC Errors	9	30.11 (42.07)	3.11(2.97)	9	22.67 (31.65)	6.33 (6.91)	$p > .05$
CF Errors	9	25.22 (26.16)	59.00 (36.81)	9	24.22 (22.35)	76.22 (43.20)	$p > .05$

Note. AQ = Autism Quotient; DASS-21 = Depression Anxiety Stress Subscale-21; SAM = Self-Assessment Manikin; IRI = Interpersonal Reactivity Index; WM = Working Memory; IC = Inhibitory Control; CF = Cognitive Flexibility, *p* value: statistical significance

5.2.6. Discussion

This pilot study aimed to evaluate the feasibility of an online training program that integrates both EFs and social cognition. While the program is still in its early stages, it represents an important first step in combining EFs and social cognition in designing an online training program targeting mental health symptoms regarding autistic traits. Participants provided valuable feedback on the usability of the website, particularly with errors they encountered, and these were addressed throughout the process,

improving the training experience. These adjustments were aimed at creating a more user-friendly interface, a crucial element in maintaining participant engagement. Furthermore, we incorporated stages where participants received feedback on their progress, a strategy designed to enhance motivation and adherence throughout the training. Such usability issues are common in the early stages of online intervention development and have been frequently highlighted in the literature (Donkin et al., 2011; Eysenbach, 2005). Technical difficulties, misunderstandings regarding task instructions, and problems with maintaining participant engagement are often stated as barriers to successful online training (Mohr et al., 2013). Providing feedback on progress is particularly important in online interventions, as it fosters a sense of achievement and supports adherence (Oinas-Kukkonen & Harjumaa, 2009). The difficulties it confronted, such as participants encountering errors in the tasks and providing feedback to refine the system, are common in the development of online cognitive training programs. Previous studies have shown that early-stage online platforms often struggle with engaging users consistently, particularly in cognitive or skill-based interventions (Andersson et al., 2008). In our case, resolving these issues involved iterative adjustments based on feedback, a necessary process when implementing novel interventions (Oinas-Kukkonen & Harjumaa, 2009).

The statistical analysis revealed significant main effects of time on measures such as DASS-21 total scores, and anxiety and depression subscales. Additionally, time effects were found in cognitive outcomes such as inhibitory control errors and cognitive flexibility. However, it is important to note that these effects reflect changes over time across both groups (experimental and control) rather than an effect specifically attributable to the training program. Therefore, while these findings suggest some changes in mental health and cognitive outcomes, it is premature to conclude that these changes are due to the training itself. Moreover, the small sample size ($n = 18$) further limits the conclusions that can be drawn from this study. The observed effects, though statistically significant, must be interpreted with caution. The primary aim of this pilot was not to establish the efficacy of the training but rather to assess its feasibility and provide initial insights into potential areas for further refinement. As such, this study provides an important stepping stone toward future research with larger samples and more rigorous designs, where the efficacy of the training program can be properly evaluated.

In the following study, addressing these usability issues from the outset with a focus on simplification of tasks and user-friendly interface designs could potentially enhance participant retention and training outcomes. Additionally, providing ongoing feedback on progress during training may help maintain motivation and ensure adherence. Larger sample sizes and control for extraneous variables such as user experience with technology should also be considered to more definitively assess the efficacy of online cognitive training programs.

5.3. Summary

The main purposes of this chapter are to design combined EFs and social cognitive training and to conduct the pilot study to test the training. This section presents the requirements for phase II after outlining the stages of the intervention program. The literature was reviewed to design the intervention program, and a study manual was created considering the validity of the intervention program. The manual was developed on a website platform with added visuals. Next, the results of a pilot study involving 18 participants are presented. According to the pilot study, there are no effects of group, but time has a significant effect on mental health symptoms in both experimental and control groups. However, it is important to note that a small number of participants is not enough to draw any conclusions. Therefore, in the following chapter, according to the requirements of Phase III, the intervention program will be implemented and tested on more participants, including both experimental and control groups.

CHAPTER VI

STUDY 4: INVESTIGATING THE EFFICACY OF EXECUTIVE FUNCTIONS AND SOCIAL COGNITION TRAINING ON MENTAL HEALTH SYMPTOMS

6.1. Introduction

Nowadays, digital interventions have become more popular day by day to use in different areas including mental health problems, executive functions including working memory (WM), cognitive flexibility and inhibitory control, and social cognitive skills in both clinical and non-clinical populations (Sandgreen et al., 2021). In terms of non-clinical populations, the studies have indicated that executive function training could be effective for both the enhancement of cognitive functions as well as mental health conditions (Beloe & Derakshan, 2020; Sari, et al., 2020). For example, Beloe and Derakshan (2020) have reported that adaptive WM training decreases anxiety and depression symptoms in adolescents and the effects of training lasted for a month. Another study by Roughan and Hadwin (2011) showed that WM training reduces school-related difficulties and associated mental health problems in adolescents. Another study conducted smartphone compassion training for Swedish university students, which resulted in improved self-compassion and emotional awareness compared to the wait-list group (Andersson et al., 2021). Bendtsen and colleagues (2020) developed a mobile health intervention program to promote the mental health of university students. In their randomized control trial (RCT) study, participants showed improvement in positive mental health and reduced depression and anxiety symptoms compared to a control group. Olfers and Band (2018) applied game-based training to improve flexibility and attention and measured in Electroencephalographic (EGG) activity. Their results showed that flexibility and attention show increased performance in healthy young adults compared to the control

group. In addition, response selection was improved due to flexibility training. This was indicated by a larger N2 amplitude compared to the control group. Additionally, conflict monitoring was more efficient, as shown by reduced Nc/CRN and larger Pe amplitude (Olfers & Band, 2018). Although studies in Türkiye included both social cognitive training and mental health, which are rare, Sari and colleagues (2020) observed reduced trait anxiety and test anxiety in university students after WM training.

Ben-Zion et al. (2018) have found that cognitive flexibility is a significant predictor of post-traumatic stress disorder (PTSD) and have suggested neurocognitive skills intervention could be an important prevention. Roepke and colleagues (2015) conducted an RCT to examine the effects of smartphone training for depression and depression scores of participants declined after the training compared to the control group. Similarly, the digital intervention of cognitive behavioral therapy (iCBT) was also shown to be effective in anxiety and depression compared to the control group after 8 weeks of training (Richards et al., 2020). Similarly, smartphone-based CBT was also found to be effective for depression compared to the control group (Lukas et al., 2021). Previous research shows the effectiveness of computer-based social cognitive training in schizophrenia by focusing on emotion recognition, social perception, social discrimination, and theory of mind (Sacks et al., 2013). In other studies, computer-based social cognitive training shows the efficacy of social cognition and social functioning in schizophrenia (Nahum et al., 2021) and the same training program was also effective for ASD and healthy older adults (Nahum et al., 2013). In another study, a randomized control trial (RCT) conducted with ASD participants found an overall improvement in WM, cognitive flexibility, social behavior, ADHD behavior, and quality of life, and the authors suggested a need for further research into the usefulness of cognitive interventions (de Vries et al., 2015). A recent study has shown that game-based cognitive training in school-aged children with ASD provides an improvement in attention, WM, emotion regulation, flexibility, social skills, and communication (Macoun et al., 2021). Moreover, computer-based social cognitive training in adolescents and adults with ASD increases amygdala and fusiform area activation which are associated with facial affect response skills (Bölte et al., 2015). Virtual Reality Social Cognition Training for Autism by Didehbani and colleagues (2016) designed for 5 weeks including emotion recognition, social

understanding, and empathy skills shows improvements in emotion recognition, ToM skills, and executive functions. Another digital intervention called the MindChip for socio-emotional skills in autism showed improvements in cognitive empathy and affective empathy skills. A significant difference in self-efficacy, autistic traits, and mental health outcomes was found within the analysis; however, there are no significant differences in self-efficacy, autistic traits, and mental health outcomes between experimental and control groups (Tang et al., 2021). The recent meta-analysis study for digital intervention in ASD by Sandgreen and colleagues (2021) summarized that digital interventions are mostly designed in computer-based format and targeted to social skills. It was found .32 effect size according to Cohen's *d*, which is a positive but small effect. However, due to the limitation of digital intervention, more studies are needed to see whether these interventions are effective in both clinical and non-clinical populations (Sandgreen et al., 2021) and specifically, there is limited research in Türkiye for digital mental health intervention to suggest conducting different studies in the recent systematic review by Akgün et al. (2019).

Accordingly, the primary aim of the current study is to test the efficacy of the online training program on mental health (DASS-21 and its subscales) regarding autistic traits. The secondary aim of the current study is to test the efficacy of the online training program on executive functions (working memory, inhibitory control, and cognitive flexibility), and social cognitive skills (cognitive empathy and affective empathy).

The following two hypotheses were addressed in the current study:

- Online training on executive functions and social cognitive skills will promote mental health by reducing DASS-21 and its subscales scores in the current sample.
- Online training on executive functions and social cognitive skills will promote executive functions (working memory, inhibitory control, and cognitive flexibility) and social cognitive skills (cognitive empathy and affective empathy) in the current sample.

6.2. Methods

6.2.1. Study Design

The present study adopted a multifactorial design including pretest and posttest conditions to test the efficacy of combined EFs and social cognition online training via computers, tablets, or smartphones for mental health symptoms (depression, anxiety, and stress) in the experimental and control groups. Multifactorial design also called mixed design refers to including both within-participant design (testing the same participants over time) and between-participant design (comparing different groups, Breakwell et al., 2012). The independent variable for this study is online training while the dependent variables are mental health scores (depression, anxiety, and stress symptoms), executive functions (cognitive flexibility, inhibition, and working memory), and social cognition (cognitive empathy and affective empathy). According to our previous findings (Chapter 4), autistic traits are included in this study as covariates, which are defined by characteristics that might affect the study's outcome (Cambridge University Press, n.d.).

6.2.2. Participants

A power analysis (G*Power) was conducted to determine the number of participants needed to achieve this goal. For repeated measures analyses, 44 participants are required in order to reach a medium effect size of .25 with an adequate power of .80 at $\alpha = .05$ (Faul et al., 2009) to determine interaction effects of between and within participants' factors. Convenience sampling via advertisement through social media, mail groups, and on campuses was used to collect participants. Initially, 178 adult participants were recruited for this study to reach adequate power for multivariate analysis. Participants randomly and equally were assigned to the experimental group (89 participants) and control group (89 participants) to see whether the combined training program was effective for the general population. 33 participants for the experimental group and 48 participants for the control group completed the posttest. However, after checking outliers and normality analysis, 31 participants for the experimental group (28 female, 3 male), and 34 participants for the control group (29 female, 5 male) were included in the further analyses. Please see the figure 6.1. the

flow of participants through each stage of the study. The details of the participants were presented the Table 6.1. Demographic Characteristics. To reduce drop-out, incentives such as drawing for money/prizes were used. Inclusion criteria for adult participants are being aged 18 or above, being able to use computers, smartphones, or tablets, being native Turkish citizens, having no record of any psychiatric disorders, and having no record of any physical and neurological conditions that prevent to use of technological devices. Participants who are under the age of 18 and have any record of psychiatric and physical conditions that prevent to use of technological devices were excluded from the study.

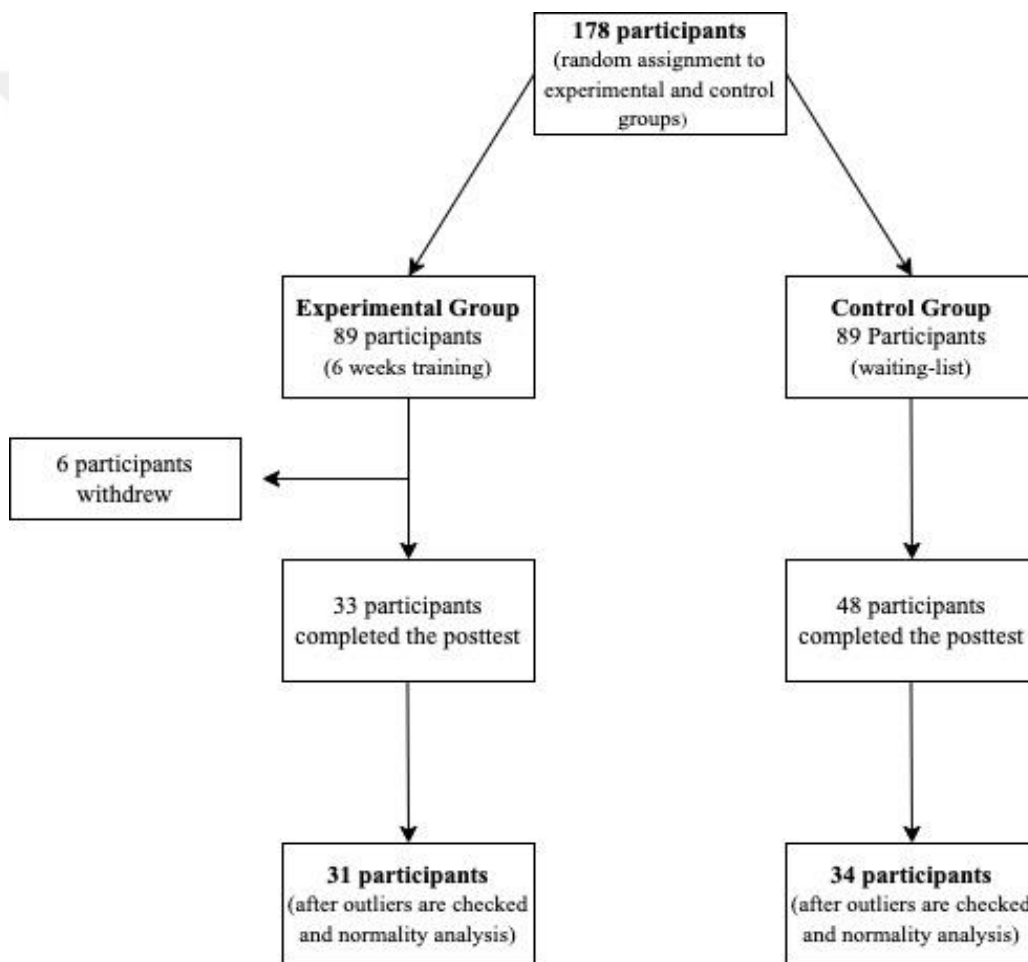


Figure 6.1. The Flow of Participants

6.2.3. Materials

6.2.3.1. Self-Report Questionnaires

6.2.3.1.1. Demographic Information Form

Basic information such as age, gender, education level (i.e., undergraduate, postgraduate), and income was obtained from the participants, and it was developed by the researcher.

Table 6.1. Demographic Characteristics ($n = 65$)

	Experimental Group				Control Group			
	<i>n</i>	Mean (<i>SD</i>)	Min	Max	<i>n</i>	Mean (<i>SD</i>)	Min	Max
Age	31	27.58 (5.95)	18	40	34	27.24 (6.13)	18	45
Sex (%)								
Female	28	(90.3)			29	(85.3)		
Male	3	(9.7)			5	(14.7)		
Education (%)								
Middle School	0	-			1	(2.9)		
High School	1	(3.2)			2	(5.9)		
Associate degree	4	(12.9)			4	(11.8)		
Bachelor's degree	23	(74.2)			21	(61.8)		
Master's degree	2	(6.5)			5	(14.7)		
Doctorate degree	1	(3.2)			1	(2.9)		
AQ	31	20.23 (5.34)			34	20.85 (5.71)		
Social Skills	31	3.97 (2.09)			34	4.18 (1.97)		
Attention Switching	31	5.94 (1.90)			34	5.85 (1.67)		
Attention to Detail	31	5.19 (1.76)			34	5.85 (1.67)		
Communication	31	2.45 (1.77)			34	3.44 (2.26)		
Imagination	31	2.68 (2.00)			34	2.85 (1.86)		

Note. AQ = Autism Quotient; SD = Standard Deviation; Min = Minimum; Max = Maximum

6.3.2.1.2. Autism Quotient

To measure autistic traits, the Autism Quotient (AQ; Baron-Cohen et al., 2001) was used. AQ for adults is adapted to Turkish culture by Köse and colleagues (2010). The self-report questionnaire consists of 50 questions using a Likert-scale rating; “definitely agree”, “slightly agree”, “slightly disagree”, and “definitely disagree”. In the Turkish adaptation of the AQ for adults, Cronbach’s alpha value for this scale is .64, and test-retest reliability is $r = .72$. The AQ is a widely used assessment tool that measures five subscales: social skills, communication, attention to detail, attention switching, and imagination. It is available in different languages (e.g., Turkish by Köse et al., 2010; Dutch by Hoekstra et al., 2008; Japanese by Wakabayashi et al., 2006).

6.3.2.1.3. Depression Anxiety Stress Scale - 21

Depression Anxiety Stress Scale - 21 (DASS - 21) is a self-report scale to examine depression, anxiety, and stress levels for adults by Lovibond and Lovibond (1995). The Turkish adaptation study for DASS-21 was conducted by Sarıçam (2018). This scale consists of three subscales, one for depression, one for anxiety, and one for stress. The total number of items is 21. For this scale, inter-scale reliability with Cronbach’s Alpha is .87 for depression, .85 for anxiety, and .81 for stress subscales. Test-retest reliability is $r = .68$ for depression, .66 for anxiety, and .61 for stress.

6.3.2.1.4. Interpersonal Reactivity Index

To measure cognitive and affective empathy, the Interpersonal Reactivity Index (IRI) was used. IRI was developed by Davis (1980) and adapted to Turkish culture by Engeler and Yargic (2007). IRI is a self-report measure that consists of 28 questions. The scale has 4 subscales which are perspective-taking, empathic concern, fantasy, and personal distress. Components of affective empathy are personal distress and empathic concern, while cognitive empathy includes perspective-taking and fantasy (Sindermann et al., 2019). In the Turkish version of the IRI, the internal consistency of four subscales ranges from .60 to .76, and test-retest reliability ranges from .66 to .80 for each subscale.

6.3.2.2. Performance Tasks

It was administered the following performance tasks to evaluate executive functions such as cognitive flexibility, WM, and inhibitory control, as well as social cognition including cognitive empathy and affective empathy. To ensure standardized measurement, we recorded the errors for each task based on previous intervention studies (Chooi & Logie, 2020; de Vries et al., 2015; Macoun et al., 2021; Maraver et al., 2016). Each task begins with a non-scored trial to ensure that participants understand the task before scoring begins. The only exceptions are for the self-assessment manikin for affective empathy, and the Eyes Test for which detailed information was provided.

6.3.2.2.1. Wisconsin Card Sorting Task

The Wisconsin Card Sorting Task (WCST) is a cognitive flexibility performance task that was first developed by Berg in 1948. During the task, 200 cards in two blocks are displayed on the screen and the sorting rule changes after every 10 cards. Participants are expected to learn from feedback and adapt the rules during the task by trial and error. They need to match the cards according to their color, number, and shape. The task measures the error rates of the participants. Participants receive feedback only on the accuracy of their sorting, which helps them understand and adjust the current sorting rule. Feedback is given after each card selection.

6.3.2.2.2. N Back Task

Working memory was evaluated through the N Back Task (Kirchner, 1958) in three different conditions - one back, two back, and three back. In this study, the $n = 2$ rule was applied. A sequence of stimuli was displayed one by one, and participants had to decide if the presented stimuli were the same as the stimuli that appeared in N trials earlier. The complete stimulus sequence consists of 15 letters and each stimulus was displayed for 500 milliseconds. Participants had three seconds to react (3000 milliseconds) and a new letter appeared every three seconds (3000 milliseconds). The letters A, B, C, D, E, H, I, K, L, M, O, P, R, S, and T were used in the sequence. There were eight blocks, with each block containing 50 trials. False errors were measured.

6.3.2.2.3. Go / No Go Task

Go / No Go Task was used to measure inhibition. The task requires participants to respond as quickly and accurately as to the presented target stimulus (“go” trials) but avoid responding to non-target stimulus (“no go” trials). Participants need to respond in 2000 milliseconds when the “go” sign is presented and avoid responding when “no-go” is presented. There are 12 blocks of 50 trials each. Commission errors (i.e., incorrectly responding to no-go trials) were measured.

6.3.2.2.4. The Eyes Test

The Eyes Test is a performance task for emotion recognition which is widely regarded as an indicator of cognitive empathy. In this test, participants were presented with a series of 28 black-and-white photographs of human eyes. For each photograph, participants were asked to choose which of 4 words best describes what the person in the photograph is feeling or thinking. The version used was adapted for Turkish by Girli (2014). The Cronbach alpha internal consistency coefficient for this test is greater than .70. Accuracy of the test was measured.

6.3.2.2.5. Self-Assessment Manikin

Self-Assessment Manikin was carried out to measure self-reported emotional responses to facial expression images for affective empathy. Karolinska Directed Emotional Faces (KDEF, Conley et al., 2018; Lundqvist et al., 1998) were used to express facial emotions. In total, 30 images (15 male, 15 female) were chosen and seven emotional expressions including happiness, neutral, anger, fear, and disgust were depicted. The task requires participants to examine each facial expression and rate how they feel it on a valence scale (more negative (1) to more positive (9)). The tasks were adapted from Wai and Tiliopoulos (2012). Valence scores for each emotion were obtained by summing responses for all images.

6.3.3. Procedure

Approval from the ethical committee of Ibn Haldun University was obtained for this study (No. E-71395021-050.06.04-34359) and the protocol ID of clinical trials was obtained (NCT06213194). The participants for the study were recruited using convenience sampling through advertisements on social media, mail groups, and campuses. Once recruited, all participants completed pretest questionnaires and tasks before assigning them to the groups and undergoing training on the *MindZone* training website (www.mindzone.com.tr). 31 participants for the experimental group (28 female, 3 male), and 34 participants for the control group (29 female, 5 male) were included for the study. The experimental group underwent an online 6-week training period through the website developed by the researcher (www.mindzone.com.tr), while the control group was placed on a waiting list. Posttests were collected at the end of the 6th week from both experimental and control groups. Additionally, the researcher and research assistant checked each participant's progress weekly, sent reminder messages, and made phone calls to improve training continuity if participants had not completed the requirements. Details about training are presented in Table 5.2. *MindZone* Manual (see Chapter 5). After the completion of the research studies, the control group (on the waiting list) is scheduled to access the online training program in accordance with ethical guidelines.

6.3.4. Data Analysis

The data from the current study was analyzed using the SPSS 25.0 package. Initial analyses were performed to determine if the data showed a normal distribution. Before conducting parametric tests, the Shapiro-Wilk test, box plots, and skewness and kurtosis scores were used to check for normal distribution. The self-report questionnaires' data was found to be normally distributed according to the Shapiro-Wilk test ($p > .05$). As for the performance tasks, the skewness and kurtosis of the data fell within an acceptable range for applying parametric tests, as specified by Hair and colleagues (2010). Covariate analyses were conducted to account for the effects of autistic traits in the intervention model. Before including covariates in the analyses, correlation analyses and tests for homogeneity of regression slopes were performed according to the assumptions of covariance (Field, 2013). The results showed that only

communication and attention-switching had significant correlations with dependent variables ($p < .05$) and met the assumptions for being used as covariates for mental health symptoms (Field, 2013). Regarding EFs and social cognitive skills, communication, attention to detail and imagination entered as covariates in the model ($p < .05$); however, only communication met the assumptions for homogeneity of regression slopes for EFs and social cognitive skills (Field, 2013). All correlation tables for these assumptions were presented in Appendix C, D, and E. Moreover, t-test analysis was carried out to see whether the pretests of dependent variables and AQ and its subscales for experimental and control groups differ. Due to more than 15 variables; a conservative p -value was set ($p = .01$). The results showed no significant differences in all pretest scores and AQ (all $ps > .01$).

In the experimental study, 2 x 2 mixed design repeated measure ANOVAs were conducted to examine the group (experimental and control group) and the effects of time (pretest and posttest) on mental health (DASS-21 and its subscales), as well as executive functions (working memory, inhibitory control, and cognitive flexibility), and social cognitive skills (cognitive empathy and affective empathy). In terms of performance tasks, to ensure standardized measurement, errors were used in the analyses for each EF task based on previous intervention studies (Chooi & Logie, 2020; de Vries et al., 2015; Macoun et al., 2021; Maraver et al., 2016). While accuracy was used for cognitive empathy and summing scores of images in affective empathy entered as dependent variables.

6.4. Results

6.4.1. Mixed Design Repeated Measure ANOVA for Mental Health Symptoms

2 x 2 mixed design repeated measure ANOVA was conducted to investigate the effects of time and group on mental health symptoms (DASS-21 and its subscale). The main effects of time were not significant for DASS-21, anxiety, depression, and stress when attention switching, and communication were entered as covariates ($p > .05$). The interaction between time and attention switching were not significant ($p > .05$). However, the interaction between time and communication were significant, for DASS-21 with $F(1, 61) = 7.91, p < .01, \eta_p^2 = .12$, anxiety ($F(1, 61) = 6.18, p < .05$,

$\eta_p^2 = .09$), depression ($F(1, 61) = 7.79, p < .01, \eta_p^2 = .10$), and stress ($F(1, 61) = 4.80, p < .05, \eta_p^2 = .07$). The interaction between time and group was significant for DASS-21, ($F(1, 61) = 4.82, p < .05, \eta_p^2 = .07$), and marginally significant for anxiety ($F(1, 61) = 3.82, p = .055, \eta_p^2 = .06$), but not significant depression and stress ($p > .05$). The main effect for group and communication were not significant for all mental health scores ($p > .05$). However, the main effect of attention switching was significant for DASS-21 with $F(1, 61) = 6.31, p < .05, \eta_p^2 = .09$, anxiety ($F(1, 61) = 6.29, p < .05, \eta_p^2 = .09$), depression ($F(1, 61) = 5.09, p < .05, \eta_p^2 = .08$), and stress ($F(1, 61) = 5.11, p < .05, \eta_p^2 = .08$). Refer to Table 6.2 for descriptive statistics and Table 6.3 for the results of the mixed design repeated measures ANOVAs.

6.4.2. Mixed Design Repeated Measure ANOVA for Executive Functions and Social Cognition

2 x 2 mixed design repeated measure ANOVA was conducted to investigate the effects of time and group on EFs (working memory, inhibitory control, and cognitive flexibility) and social cognitive skills (cognitive empathy and affective empathy). The main effect of time was significant for WM error ($F(1, 62) = 5.92, p < .05, \eta_p^2 = .09$), cognitive flexibility errors, ($F(1, 62) = 13.62, p < .001, \eta_p^2 = .18$) and empathic concern ($F(1, 62) = 12.75, p < .001, \eta_p^2 = .17$) when communication were entered as covariate. Besides, the main effect of time was significant for personal distress without communication, ($F(1, 63) = 25.50, p < .001, \eta_p^2 = .29$). The interaction between time and communication was not significant for all dependent variables, ($p > .05$). The interaction between time and group only significant for cognitive flexibility errors ($F(1, 62) = 4.56, p < .05, \eta_p^2 = .07$). The main effect was group only significant for affective empathy, ($F(1, 62) = 9.23, p < .01, \eta_p^2 = .13$) and communication marginally affects personal distress ($F(1, 62) = 3.83, p = .055, \eta_p^2 = .06$). See Table 6.2. for descriptive statistics and Table 6.3. for the results of mixed design repeated measure ANOVAs.

Table 6.2. Descriptive Statistics ($n = 65$)

	Experimental Group			Control Group			<i>p</i>
	<i>n</i>	Pretest Mean (SD)	Posttest Mean (SD)	<i>n</i>	Pretest Mean (SD)	Posttest Mean (SD)	
DASS-21	31	26.90 (10.47)	19.97 (8.25)	34	27.47 (10.90)	24.18 (11.99)	<i>p</i> >.05
Depression	31	9.87(3.72)	7.65 (2.57)	34	10.24 (4.02)	9.15 (4.13)	<i>p</i> >.05
Anxiety	31	9.42 (3.70)	6.74 (2.94)	34	9.44 (3.94)	8.03 (4.20)	<i>p</i> >.05
Stress	31	7.61 (3.98)	5.58 (3.56)	34	7.79 (4.05)	6.32 (3.98)	<i>p</i> >.05
The Eyes	31	24.45 (3.88)	25.39 (4.29)	34	25.65 (3.27)	26.59 (3.44)	<i>p</i> >.05
SAM	31	130.16 (20.43)	126.16 (12.90)	34	119.35 (16.88)	117.38 (16.61)	<i>p</i> <.05
IRI	31	75.65 (13.25)	74.61 (11.34)	34	72.00 (11.34)	73.79 (15.75)	<i>p</i> >.05
Perspective Taking	31	18.71 (4.35)	18.35 (3.80)	34	17.88 (4.61)	18.26 (4.91)	<i>p</i> >.05
Fantasy	31	19.48 (5.13)	19.52 (5.07)	34	18.71 (5.81)	18.32 (5.57)	<i>p</i> >.05
Empathic Concern	31	18.00 (3.90)	21.81 (3.95)	34	16.62 (3.03)	21.21 (4.33)	<i>p</i> >.05
Personal Distress	31	19.45 (4.67)	14.94 (4.65)	34	18.79 (5.19)	16.00 (5.29)	<i>p</i> >.05
WM Errors	31	20.65(9.19)	13.13 (8.59)	34	15.09 (11.94)	10.50 (7.55)	<i>p</i> >.05
IC Errors	31	5.48 (6.59)	4.48 (3.37)	34	3.24 (5.18)	3.85 (3.21)	<i>p</i> >.05
CF Errors	31	21.35 (10.93)	41.61 (20.02)	34	21.97 (3.94)	37.24 (14.91)	<i>p</i> >.05

Note. DASS-21 = Depression Anxiety Stress Subscale-21; SAM = Self-Assessment Manikin; IRI = Interpersonal Reactivity Index; WM = Working Memory; IC = Inhibitory Control; CF = Cognitive Flexibility, *p* value: statistical significance; *SD* = Standard Deviation

Table 6.3. The Results of Mixed Design Repeated Measure ANOVAs ($n = 65$)

	Main Effect						Interaction		
	Time			Group			Time x Group		
	<i>F</i>	η_p^2	<i>p</i>	<i>F</i>	η_p^2	<i>p</i>	<i>F</i>	η_p^2	<i>p</i>
DASS-21	1.14	.01	$p > .05$	.56	.01	$p > .05$	4.82	.07	$p < .05$
Depression	.01	.00	$p > .05$	.89	.02	$p > .05$	3.82	.06	$p = .062$
Anxiety	.98	.02	$p > .05$	.26	.02	$p > .05$	3.61	.06	$p = .055$
Stress	1.62	.04	$p > .05$	.40	.01	$p > .05$	3.30	.05	$p = .072$
The Eyes	.01	.00	$p > .05$	1.39	.02	$p > .05$	.06	.00	$p > .05$
SAM	.02	.00	$p > .05$	9.23	.13	$p < .05$	.30	.01	$p > .05$
IRI	.52	.48	$p > .05$	1.00	.02	$p > .05$	.74	.01	$p > .05$
Perspective Taking	.05	.00	$p > .05$	.29	.01	$p > .05$	.20	.00	$p > .05$
Fantasy	.21	.00	$p > .05$	.82	.01	$p > .05$	.01	.00	$p > .05$
Empathic Concern	12.75	.17	$p < .001$	2.34	.04	$p > .05$	.34	.01	$p > .05$
Personal Distress	2.68	.04	$p > .05$	.07	.00	$p > .05$	2.32	.04	$p > .05$
WM Errors	5.92	.09	$p < .05$	2.72	.04	$p > .05$	.76	.01	$p > .05$
IC Errors	.90	.01	$p > .05$	2.62	.04	$p > .05$	.52	.01	$p > .05$
CF Errors	13.67	.18	$p < .001$	.78	.01	$p > .05$	4.56	.07	$p < .05$

Note. DASS-21 = Depression Anxiety Stress Subscale-21; SAM = Self-Assessment Manikin; IRI = Interpersonal Reactivity Index; WM = Working Memory; IC = Inhibitory Control; CF = Cognitive Flexibility.

6.5. Discussion

The main goal of this study was to assess the efficacy of an online training program on mental health using the DASS-21 and its subscales. Additionally, the study aimed to evaluate the impact of the online training program on executive functions (including working memory, inhibitory control, and cognitive flexibility) as well as social cognitive skills (such as cognitive empathy and affective empathy). This study

represents a significant advancement as it is the first to conduct combined online EFs and social cognitive skills training to address mental health symptoms associated with autistic traits. Two hypotheses were tested accordingly.

6.5.1. H1: Online Training on Executive Functions and Social Cognitive Skills will Promote Mental Health by Reducing DASS-21 and Its Subscales Scores in the Current Sample

The current findings did not support our initial hypothesis regarding the significant effect of the group. However, it was found that the main effect of time was only significant when not considering covariates, communication, and attention switching. The results align with our previous findings in Chapter 4 and with Happé and colleagues' (2006) suggestion that autism should be viewed as distinct dimensions, studied independently to consider potential variations in effects and causal factors. Moreover, it was found that time and communication have a significant interaction with mental health symptoms. This interaction with communication traits might suggest nuanced effects that covariates might mask. Ishizuka and colleagues (2022) propose that communication might have state-dependent characteristics, and our results seem to support this view by demonstrating the modifying effects of communication on mental health symptoms over time, which might influence how participants' psychological states evolve over the training period. The interaction between time and communication traits further suggests that improvements in mental health outcomes may be influenced by how participants perceive their communication skills. Building on this, Stimpson and colleagues (2021) revealed that participants' social autistic trait, like aloofness, is a significant negative predictor for mental well-being. Similarly, Rai and colleagues (2018) found that social autistic trait is a core predictor of depression in their sample. This suggests that improving communication abilities could be a beneficial component of mental health interventions targeting mental health symptoms.

The impact of attention-switching on mental health symptoms is significant, demonstrating a strong influence on various psychological outcomes. This finding aligns with previous research and studies that have shown attention-switching to be a significant predictor of mental health issues such as depression, anxiety, worry,

dispositional mindfulness, and repetitive negative thinking (Freeth et al., 2013; Ishizuka et al., 2022; Zappulla et al., 2023). The significant effect of attention-switching on these variables suggests the importance of tailoring interventions to individual cognitive traits. Personalized approaches that take into account non-social autistic traits such as attention-switching could improve the effectiveness of mental health treatments, along with considering social autistic traits like communication. Similar to earlier findings (Chapter 4), training WM and attention to improving attention-switching skills may offer alternative options for intervention and prevention (Bailey & Wells, 2024; Beloe & Derakshan, 2020; Sari, et al., 2020). These current findings might highlight the importance of this combined online training program which both cognitive and social skills need to be considered to develop the intervention.

The study's findings partly confirmed the first hypothesis by showing a significant interaction between time and group on DASS-21, and marginal significance on the anxiety subscale ($p = .055$). This is in line with previous literature on conducting online cognitive training for mental health problems (Beloe & Derakshan, 2020; Sari et al., 2020). However, the current study extends this by adding social cognitive skills to reduce mental health symptoms. Which, this is the first study to apply combined online EFs and social cognitive skills training regarding the effects of autistic traits in the neurotypical population. The lack of a main effect indicates that the online training program did not have a consistent effect across all participants. However, the interaction with time suggests differential effectiveness over time. Specifically, the experimental group showed a notable reduction in DASS scores (from 26.90 to 19.97), suggesting that the training program was efficacious in significantly reducing mental health symptoms in the experimental group. The control group also showed a reduction in DASS scores (from 27.47 to 24.18), but the reduction was smaller compared to the experimental group. The larger decrease in the experimental group's DASS scores compared to the control group might indicate that the online training program had a more substantial effect on reducing mental health symptoms. Even though statistically are not significant, similar marginal patterns are presented in all subscales (anxiety, depression, and stress; see Table 6.3.). The MindZone appears to be efficacious in significantly reducing DASS-21 scores over time compared to the control group. This differential reduction highlights the combined EFs and social cognition training

potential benefit in alleviating symptoms of depression, anxiety, and stress. Further analysis and replication with larger samples could examine these findings and provide more insight into MindZone's efficacy.

However, several potential explanations for the lack of a main effect of group and time need to be considered. In terms of mental health symptoms, the study recruited participants from the neurotypical population, excluding those with psychiatric conditions. This exclusion may have reduced the overall effect sizes and significance of the intervention. The neurotypical population might exhibit less severe symptoms compared to clinical populations, making it challenging to detect significant changes and possibly explain the less statistically significant results. Nevertheless, reducing mental health symptoms in the neurotypical population may suggest the effectiveness of combined online training programs, although further research is needed to support this conclusion. Furthermore, it is important to consider individual differences such as autistic traits as a significant factor in the lack of a main effect of group and time. These current findings support previous research indicating that autistic traits in the neurotypical population can impact mental health and intervention programs (Rosbrook & Whittingham, 2010; Stimpson et al., 2021). The findings of the current study show that attention-switching plays a key role in mental health outcomes, as indicated by its significant main effect across all dependent variables. Individuals with better attention-switching abilities may handle stress, anxiety, and depressive symptoms better, regardless of any intervention, but future studies should consider examining autistic traits in this context to replicate these findings in both neurotypical and neurodiverse populations to increase the robustness of the results. Because this is the first study to apply combined EFs and social cognitive training on neurotypical populations regarding the effects of autistic traits. Additionally, the significant interaction between time and communication traits suggests that changes in mental health scores over time are influenced by individuals' communication abilities. Those with better communication skills may experience more significant improvements or less decline over time, but still is unclear. These possible explanations for autistic traits on mental health need to be examined in the future study.

Another possible explanation is the timing of the data collection period. In this study, pretest data started to be collected at the end of April, and posttest data were collected

between the last week of June and the first week of July. Seasonal variations can affect mental health scores, with summer months typically showing lower levels of depression and anxiety (Lukmanji et al., 2020; Zerón-Ruggerio et al., 2022). Increased outdoor activities and the absence of homework and exams for students during this time could explain this pattern. In the current study, participants were mostly bachelor's degree students, so the impact of finals week on their mental health cannot be discounted, especially considering previous research showing the effect of increased workloads and exams on students' mental health (Wang et al., 2017). Soreni and colleagues (2020) noted a decrease in online searches for mental health problems during the summer, which aligns with the observed pattern of mental health symptoms. Therefore, the time of data collection might need to be considered in terms of intervention studies, specifically in non-clinical populations.

6.5.2. H2: Online Training in Executive Functions and Social Cognitive Skills will Promote Executive Functions (Working Memory, Inhibitory Control, and Cognitive Flexibility) and Social Cognitive Skills (Cognitive Empathy and Affective Empathy) in the Current Sample

The research findings revealed that there was a significant main effect of time on working memory (WM) errors, cognitive flexibility errors, and empathic concern. The group exhibited a notable impact solely on affective empathy when accounting for communication. Notably, an interaction between time and group was observed in the domain of cognitive flexibility.

The main effect of time on WM errors appeared to imply a significant change in WM performance across the study. Specifically, the experimental group demonstrated a marked decline in WM error scores (from 20.65 to 13.13), while the control group also exhibited a slight reduction (from 15.09 to 10.50) compared to the experimental group. However, it was not possible to definitively attribute these changes to the training program. Besides, there were no significant effects of training on inhibitory control tasks as well. One of the possible explanations could be a ceiling effect, where participants were already performing at a high level, thus constraining the potential for further improvement (Brehmer et al., 2012; Karbach & Verhaeghen, 2014). As neurotypical participants were included in the current study, the ceiling effect might

have an impact on the results. The means scores of errors in experimental and control groups are 20 and 15 which are similar to previous findings with non-clinical populations compared to clinical populations (e.g., schizophrenia, depression, and anxiety) reported by Moran (2016), Snyder (2013) and Conklin and colleagues (2000). Furthermore, improvements in cognitive tasks from the training program may not have been effectively transferred to the assessment tasks, indicative of the near vs. far transfer phenomenon, well-documented in cognitive training literature (de Vries et al., 2015; Sala & Gobet, 2017; Simons et al., 2016). A previous study with ASD by Vries and colleagues (2015) found no significant effect on far transfer tasks for both WM and inhibitory control tasks compared to increased scores on near transfer tasks. Future studies with larger sample sizes are needed to confirm the effect size, and it is important to consider the ceiling effect when assessing the efficacious of the training program.

The significant main effect of time for cognitive flexibility errors suggests that participants' cognitive flexibility also underwent significant changes during the study period. Interestingly, both groups showed increased error scores in the posttest. Specifically, the experimental group showed more errors than the control group. This was an unexpected result of the current study. One of the possible explanations for these results could be the fatigue affecting error rates over time. Previous findings showed that fatigue in neurotypical participants has an impact on their cognitive flexibility tasks (Plukaard et al., 2015). As previously stated the posttest score started to obtain the last week of June which is the end of the school term in Türkiye and most of the participants reported in bachelor's degree. Hence, the timing of data collection might have an impact on the fatigue for cognitive flexibility scores. Specifically, regarding the experimental group, the fatigue of the training and posttest conditions might also result in fatigue for the cognitive flexibility task. Moreover, similar to WM, the cognitive flexibility tasks used in the training may not have effectively transferred to the assessment tasks, leading to increased errors. This lack of transfer is a common issue in cognitive training research (de Vries et al., 2015; Sala & Gobet, 2017; Simons et al., 2016). The training program generally involved combined EFs and social cognitive tasks which might also not have transferred to the effects on solely EF tasks. The near and far transfer effect should be taken into account in future studies and needs for further research.

The current study found significant results for measures of affective empathy, but not for cognitive empathy, in both time and group comparisons. Specifically, there was a significant increase in empathic concern over time, and communication skills showed a small impact on personal distress, although not sufficient to be significant. This could suggest that communication skills might benefit personal distress more noticeably with a larger sample or longer training. In the experimental group, empathic concern significantly increased over the study period, but it is unclear if this change is due to the training. This uncertainty is due to the lack of interaction between time and group, and the absence of a main effect of the group. However, the experimental group showed a significant difference from the control group in affective empathy levels. They had lower scores when rating faces with different emotions.

Overall, there was a slight reduction in SAM for affective empathy and an increase in self-reported empathic concern, suggesting that affective empathy can be developed in beneficial ways. This aligns with Tone and Tully's (2014) argument that affective empathy could be a 'risky strength' without emotion regulation. The current results show no sharp changes, but a slight decrease in the feeling towards images that depicted emotions and an increase in self-reported empathic concern may indicate to regulate their emotions effectively. This could be supported by lower DASS-21 scores after the training, especially in the experimental group. The literature stated that personal distress is negatively associated with mental health symptoms but higher empathic concern might be associated with better emotion regulation (Huang et al., 2020). Besides, similar findings in the literature show that while affective empathy improves with intervention, cognitive empathy does not (Castillo et al., 2013; Martinago et al., 2021). Possible explanations could be differences in the developmental process between affective empathy and cognitive empathy. Affective empathy develops earlier and faster (Dimberg et al., 2000; Neumann & Strack, 2000), while cognitive empathy develops more slowly and deliberately (Martinago et al., 2021). Therefore, a six-week training period may not be enough to improve cognitive empathy. Besides, as cognitive empathy tasks need more mentalizing and cognitive processes (Martinago et al., 2021; Perry & Shamay-Tsoory, 2013), fatigue could be an important factor in implementing the training program and data collection and the efficacy of the training program.

6.5.3. Limitations and Future Studies

The current study has several limitations that should be acknowledged. Firstly, a notable limitation is the high drop-out rate. Out of the 89 participants in the experimental group who completed the pretest, only 33 completed the posttest, indicating a 65% drop-out rate. This is consistent with findings from previous studies, which have reported high drop-out rates in online studies, ranging from 50% to 89% (Melville et al., 2010). A recent systematic review and meta-analysis also demonstrated that dropout rates in digital interventions varied from 40% to 53% (Meyerowitz-Katz et al., 2020). Despite implementing incentives and reminders such as messages and phone calls, the attrition rate reflects similar patterns observed in previous studies. Conducting qualitative studies involving thematic analyses with participants could help identify important themes to reduce drop-out rates as done for online education programs (Greenland & Moore, 2021). Also, due to the high attrition rate, follow-up results could not be obtained from the participants; hence, including follow-up studies should provide detailed information about the efficacy of the training program for future research to consider. Besides, although random assignment methods were used to allocate participants into experimental and control groups, convenience sampling was used rather than random sampling methods. Future studies should consider conducting randomized control trials (RCTs) to test the effectiveness of the training which is seen as a gold standard in clinical studies (Barker et al., 2016).

Even though we conducted an exploratory analysis in Chapter 4 to observe the relationship between EFs and social cognition in terms of mental health symptoms, we could not state that the positive outcomes are solely related to EFs or social cognition because of the combined training program. However, demonstrating the roles of working memory and cognitive empathy on anxiety might provide some understanding that is needed for further investigation. Moreover, Previous studies have indicated that self-report measures of EFs alongside performance tasks could improve the understanding of how EF skills apply to real-world situations (de Vries et al., 2015; van Aken et al., 2023). It would be beneficial to include self-report measures such as the BRIEF in addition to performance tasks, as this approach may offer a more comprehensive understanding of EF skills in daily life, potentially revealing different effects of training programs. Additionally, it would be valuable to explore the roles of

both 'cool' (cognitive) and 'hot' (affective) EFs in mental health, as the existing literature on these variables is limited (Petersen & Welsh, 2014; Smitherman et al., 2007; Zelazo, 2010). Since MindZone targets combined EFs and social cognitive skills, including 'hot' EFs in pretest and posttest conditions might demonstrate extended effects of the training program. This attempt might also provide the see near/far transfer effect for EFs tasks. Future studies should incorporate both 'cool' and 'hot' EFs tasks in testing conditions to yield comprehensive results. Furthermore, although performance test measurements (i.e., errors) were selected based on previous studies (Ajilci & Nejati, 2017; Gökçen et al., 2016; Fernandez-Prieto et al., 2021; Macoun et al., 2021; Maraver et al., 2016), consideration of reaction times (RTs) for the responses could provide more detailed information, which should be taken into account in future studies.

Furthermore, the study was conducted with neurotypical participants, and the findings cannot be generalized to neurodiverse samples. Future studies should replicate these findings for neurodiverse populations including ASD to provide a more comprehensive understanding in terms of autistic traits and mental health. Moreover, despite efforts to recruit participants through social media and mail groups, the study predominantly consisted of female participants compared to males. Even though previous studies have indicated that affective disorders, including anxiety and depression, are more commonly seen in females compared to males (Altemus et al., 2014), and that males are less likely to seek help regarding mental health problems in Türkiye (Güney et al., 2024), future studies should use diverse sampling methods to ensure balanced representation of sex.

CHAPTER VII

GENERAL DISCUSSION

The present chapter will feature a summary of the findings from Study One to Study Four. The discussion will be concise, thoroughly summarizing all findings and their relevance to the research questions. Additionally, the clinical implications, suggestions for future studies, and general limitations will be presented.

7.1. Summary of Findings

The primary aim of the current thesis was to develop an online training program targeting EFs and social cognitive skills to mitigate the susceptibility of mental health symptoms in neurotypical individuals regarding autistic traits. The secondary aim of the current thesis was to explore the influence of executive functions (EFs) and social cognitive skills on the correlation between autistic traits and mental health symptoms for the development of intervention and prevention programs. This was the first study to examine mediating roles of EFs (cognitive flexibility, inhibitory control, and working memory) and social cognitive skills (cognitive empathy and affective empathy) simultaneously in neurotypical individuals regarding autistic traits and was the first study to design a combined online EFs and social cognitive skills training program in Türkiye. Accordingly, four studies have been conducted to examine and test these objectives of the current thesis.

In Chapter 3, the first study was a cross-sectional study that aimed to examine the effects of data collection procedures (online-based and paper-based) and types of supervision (presence and absence of the researcher during data collection) on the self-report questionnaires Autism Quotient (AQ) and Depression, Anxiety, Stress Scale – 21 (DASS-21), as well as their subscales, which are the main two questionnaires in the current thesis. This study sought to reduce possible biases in the following studies, all of which were planned to be conducted via an online platform, and also aimed to

consider the type of supervision effect. This was the first study to be conducted for both AQ and DASS-21 using a between-subject design. The study involved 96 participants (71 female and 25 male). They were divided into four groups: online-based with supervision, online-based without supervision, paper-based with supervision, and paper-based without supervision. A 2 x 2 between-subject ANOVA was used to compare these groups. The results indicated that there were no significant differences across the groups in terms of AQ and its subscales, as well as DASS-21 and its subscales. In conclusion, the data collection procedure (online-based and paper-based) and type of supervision showed no effects on AQ, DASS-21, and their subscales. This study was an initial step in assessing the validity and reliability of conducting online data collection and training procedures.

In the second study (Chapter 4), a cross-sectional study was conducted to explore the mediating roles of EFs such as cognitive flexibility, inhibitory control, and WM, as well as social cognitive skills including cognitive empathy and affective empathy, in the link between autistic traits and mental health symptoms. The purpose was to investigate how heightened autistic traits may increase the susceptibility to other mental health conditions in both clinical and non-clinical populations. The study aimed to extend existing literature findings by examining the potential mediating roles of EFs and social cognitive skills. A total of 159 participants took part in the study, consisting of 141 females and 18 males. The research involved conducting Pearson correlation analyses and mediation analyses to assess the relationships between variables and the mediating roles of EFs and social cognitive skills. The results revealed that only personal distress (a component of affective empathy) served as the mediating factor in the connection between attention switching (a subscale of AQ) and mental health symptoms measured by DASS-21 and its subscales. Furthermore, the study found a negative relationship between WM and attention to detail (a subscale of AQ), as well as a negative link between higher perspective-taking skills and autistic traits, which supported existing literature. Furthermore, significant relationships between cognitive empathy and WM, and cognitive empathy and inhibitory control were found. Besides, the exploratory analysis showed that the Eyes test for cognitive empathy mediates the relationship between WM and DASS-21 and the relationship between WM and anxiety. This is important for further research to design a combined EFs and social cognitive skills training program. However, the study did not identify any relationships

between other EFs, autistic traits, and mental health symptoms. Importantly, this study is the first of its kind to investigate the mediating roles of both EFs and social cognitive skills in the relationship between autistic traits and mental health symptoms in neurotypical individuals.

In Chapter 5, Study Three serves as a pilot study to assess the feasibility of an online training program that combines executive functions and social cognitive skills. This chapter follows the traditional pipeline model, applying Phase I for discovery and Phase II for feasibility. Phase I involved exploring research questions, establishing a theoretical framework, conducting a general literature review, and defining variables, as detailed in Chapter 1 and Chapter 2. Phase II encompassed creating a manual and testing the pilot program to determine its feasibility for further research. As per the requirements, existing assessment tools and training programs were reviewed to design a new manual for a combined executive functions and social cognitive skills training program, drawing from the literature review. In the pilot study, 24 participants were initially recruited, but only 18 (9 in the experimental group and 9 in the control group) completed the training program and the post-test. A 2 x 2 mixed design repeated measure ANOVA was used to analyze the impact of the training (pretest and posttest) on both the experimental and control groups. The results indicated a significant effect of time for both groups, but no significant effect of group was observed in the pilot study. These findings suggest that participants in both groups experienced reduced mental health symptoms. However, it is important to note that the sample size of 18 may not be sufficient to draw definitive conclusions. The primary aim of this study was to test the feasibility of the online training program, and it was determined that the program is now ready to be evaluated for effectiveness with a larger number of participants in future studies.

In Chapter 6, the main aim of Study Four is to test the efficacy of the online training program on mental health (DASS-21 and its subscales). The secondary objective is to test the training program's efficacy on EFs (working memory, inhibitory control, and cognitive flexibility) and social cognitive skills (cognitive empathy and affective empathy) for the requirements of Phase III. 178 neurotypical participants who completed the pretest were randomly and equally assigned to the experimental group (89 participants) and control group (89 participants). 33 participants in the

experimental group completed six weeks of online combined EFs and social cognitive training programs, while 48 participants in the control group completed the posttest at the end of the six weeks. After checking outliers and normality analysis, 31 participants from the experimental group and 34 participants from the control group were included in the analysis. A 2 x 2 mixed design ANOVA was conducted, with time and group as independent variables, and mental health symptoms, EFs, and social cognitive skills as dependent variables. Communication and attention-switching were entered as covariates. The results showed a significant time and group interaction for DASS-21 and a marginal interaction for the anxiety subscale. Communication and attention-switching impacted mental health symptoms and the training program. Interestingly, increased errors in the cognitive flexibility task were observed in both groups. Additionally, a significant reduction in WM errors was observed, but the main effect of the group was not significant for EFs and social cognitive skills except for affective empathy. Significant differences in affective empathy scores in both self-report and performance tasks were found, while no changes in cognitive empathy and inhibitory control scores were observed. In summary, the main objective of the thesis was tested by showing that participants in the experimental group showed significant reductions in DASS-21 scores compared to the control group. However, although significant changes were observed in WM, affective empathy, and cognitive flexibility, the results were not sufficient to conclude that these changes were due to the training.

7.2. Relations of Findings to the Research Questions

7.2.1. Research Question 1: What are the Mediating Roles of Executive Functions (Cognitive Inhibitory Control, and Working Memory) in the Association between Autistic Traits and Mental Health Symptoms (Anxiety, Depression, and Stress)?

In Chapter 4, the results from Study Two showed that there are no mediating roles of the EFs (cognitive flexibility, inhibitory control, and working memory) in the current sample. However, important relationships were found that might help to provide a baseline for further research to extend these findings. A negative relationship between WM and attention to detail (a subscale of AQ) supports existing literature which states

that reduced WM scores are observed in individuals with elevated autistic traits (Demetriou et al., 2018; Gökçen et al., 2016; Shirima et al., 2022). Additionally, a positive relationship was found between WM errors and mental health symptoms (depression, anxiety, and stress), as well as between attention to detail and mental health symptoms in the current sample. Therefore, despite no mediating roles being observed in the current study, significant relationships might provide a starting point for future studies. Specifically, WM performance, mental health symptoms, and autistic traits are related to each other, which might support the Attentional Control Theory by Eysenck (2007), which proposes that anxiety might disrupt the EFs system, so autistic traits might increase this susceptibility for this disruption. Furthermore, significant relationships were found between WM and cognitive empathy, inhibitory control, and cognitive empathy. This aligns with existing literature showing that executive functions and social cognition work together for better functionality (Demetriou et al., 2019; Demetriou et al., 2018). Furthermore, the Eyes test mediates the relationship between WM and DASS-21 and the relationship between WM and anxiety, in turn, the importance of interconnections of EFs and social cognition in terms of mental health was highlighted. This study is a significant step in designing a combined program for EFs and social cognitive skills training. It did not find any correlations between other EFs, autistic traits, and mental health symptoms. Importantly, this is the first study to explore the mediating roles of EFs and social cognitive skills in the relationship between autistic traits and mental health symptoms in neurotypical individuals. Clinical implications and future research will be discussed in the following section.

7.2.2. Research Question 2: What are the Mediating Roles of Social Cognitive Skills (Cognitive Empathy and Affective Empathy) in the Association between Autistic Traits and Mental Health Symptoms (Anxiety, Depression, and Stress)?

Study Two (Chapter 4) showed that only personal distress (one aspect of affective empathy) plays a role as a mediator in the relationship between attention switching (one aspect of autistic traits) and mental health symptoms (depression, anxiety, and stress). The current findings are consistent with previous research, showing that there are positive links between affective empathy, mental health symptoms, and autistic

traits such as attention switching (Gambin & Sharp, 2018; Sönmez & Jordan, 2023; Tone & Tully, 2014). This finding supports the argument of Tone & Tully (2014) which proposed that affective empathy can be considered a "risky strength" that could result in internalizing problems such as anxiety, depression, and stress if effective emotion regulation skills are not in place. This will be extended further in the clinical implications section. Even though the mediator role of cognitive empathy was not observed in the current study, the findings of the current study found that a higher perspective-taking score is associated with lower scores of autistic traits which is in line with previous studies (Bos & Stokes, 2018; Mazza et al., 2014). Besides, cognitive empathy (the Eyes test) shows a negative association with mental health symptoms. Similar to EFs, significant relationships across autistic traits, social cognitive skills, and mental health symptoms might be a starting point for further research to extend this knowledge.

7.2.3. Research Question 3: What is the Efficacy of Online Executive Functions and Social Cognitive Skills Training in Promoting Mental Health by Reducing Depression, Anxiety, and Stress Symptoms?

Study Four (Chapter 6) identified a significant interaction between time and group on DASS-21, as well as a marginal interaction on anxiety while investigating the efficacy of the online training program. This is the first attempt to examine combined online EFs and social cognition training regarding the effects of autistic traits in the neurotypical population in Türkiye. These findings confirmed the previous studies (Beloe & Derakshan, 2020; Sari et al., 2020). Furthermore, the current study extended the previous findings by using social cognitive skills to alleviate mental health symptoms. The fact that this effect is observed in an interaction suggests that the decrease in DASS-21 scores in the experimental group over time is more substantial than any changes observed in the control group. This might indicate that the intervention was beneficial in reducing symptoms of depression, anxiety, and stress. While not definitive, this marginal interaction for anxiety implies that the online training may have some impact on reducing anxiety levels in the experimental group, but further research with a larger sample size or more additional measures might be needed to confirm these findings. It was observed no significant main effects of time and group on the DASS-21 and its subscales scores, which indicates that there might

be no significant changes over time or consistent differences between the experimental and control groups. However, the significant time x group interaction reveals a more nuanced effect of our intervention. Specifically, this interaction suggests that the changes in mental health outcomes, as measured by the DASS-21, varied depending on whether participants were in the experimental or control group. While the control group showed little change, the experimental group experienced a notable improvement, particularly throughout the study. This finding highlights the importance of considering the dynamic nature of the training's effects, which are not captured by examining time or group independently.

7.2.4. Research Question 4: What is the Efficacy of Online Executive Functions and Social Cognitive Skills Training on Executive Functions (Working Memory, Inhibitory Control, and Cognitive Flexibility) and Social Cognitive Skills (Cognitive Empathy and Affective Empathy)?

Study Four (Chapter 6) revealed that there was a significant main effect of time on WM errors, cognitive flexibility errors, and empathic concern. The significant time effect indicates that participants' WM errors decreased over the study period, with both the experimental and control groups showing a decrease. However, a decrease in the experimental group was more apparent. This finding suggests that time combined with the natural learning process or repeated testing, led to improved WM performance for the experimental and control groups, although it is unclear whether the online training program directly results in this improvement. Interestingly, a significant interaction between time and group was observed in cognitive flexibility. The significant time effect and interaction suggest that the effect of time on cognitive flexibility errors differed between the experimental and control groups, with the experimental group showing a greater increase in errors, which could indicate challenges with the online training program for this cognitive domain. The increase in cognitive flexibility errors, especially in the experimental group, might suggest that the online training program might need revisions and some considerations. There could be possible explanations such as too challenging tasks might result in fatigue, not appropriately designed to see both near and far transfer effect, and data collection timing (de Vries et al., 2015; Plukaard et al., 2015; Sala & Gobet, 2017; Simons et al., 2016; Zerón-Rugério et al.,

2022). All of these explanations indicate a need for careful monitoring of processes in such programs.

The group variable (experimental vs. control) showed a notable impact solely on affective empathy, particularly when communication was accounted for as a covariate. This may imply that the online training may have influenced how participants in the experimental group responded emotionally, compared to the control group. The increase in empathic concern over time suggests that participants became more empathetic as the study progressed. The lack of significant findings for cognitive empathy indicates that the intervention may have been more effective in influencing affective empathy rather than cognitive understanding of others' emotions. The impact of communication on personal distress suggests that communication skills may have a potential, but small, effect on reducing personal distress, which could be more noticeable with a larger sample size or a longer intervention period. The study highlights that online interventions might be particularly effective in influencing affective aspects of empathy, such as empathic concern and performance tasks for affective empathy. This suggests that such programs could be useful in therapeutic settings where improving affective empathy is a goal. Overall, while the intervention appears to have had some beneficial effects on affective empathy, the increase in cognitive flexibility errors and the lack of strong effects on other cognitive measures suggest that the intervention's design and implementation may need consideration.

7.2.5. Overall Findings

The findings of this thesis offer an understanding of how EFs and social cognitive skills interact with autistic traits and mental health outcomes. Although the mediating roles of EFs were not found to be significant in the relationship between autistic traits and mental health symptoms, key relationships were observed between WM, inhibitory control, cognitive empathy, and mental health symptoms. In Chapter 4, a mediation model was presented in which cognitive empathy fully explained the relationship between WM and DASS-21, and the relationship between WM and anxiety in our sample. These results align with previous literature suggesting that EFs contribute to the core features of ASD, such as difficulties in the theory of mind, social cognition, and social impairment (Demetrious et al., 2018; de Vries & Geurts, 2015),

which might be related to mental health symptoms. On the other hand, relationships were found among attention to detail (one aspect of autistic traits), WM errors, and mental health symptoms, such as anxiety, further supporting the notion that anxiety may disrupt cognitive functions, consistent with Eysenck's Attentional Control Theory (2007). This might also suggest that autistic traits might increase susceptibility to difficulties in cognitive processes due to mental health symptoms, reinforcing the need for targeted cognitive interventions. However, further research is needed to investigate the relationships and directions among mental health symptoms, attentional processes (related to attention to detail and attention switching subscale of AQ), cognitive empathy, and working memory to determine whether cognitive empathy or EFs is the key element in this process in terms of autistic traits.

Social cognition, particularly affective empathy, was shown to play a significant mediating role between attention-switching and mental health symptoms. This finding is consistent with the argument that affective empathy, while beneficial in some contexts, may also act as a "risky strength" in individuals lacking effective emotion regulation skills (Tone & Tully, 2014; Nair et al., 2024). This aligns with the view that empathy is not uniformly protective but can also lead to heightened stress and anxiety in emotionally taxing situations (Dziobek et al., 2008; Tone & Tully, 2014). The relationship between personal distress, attention switching, and mental health outcomes (Ishizuka et al., 2022; Tone & Tully, 2014) might reinforce the idea that interventions aiming to enhance both emotional regulation and attentional process may be particularly effective for individuals with higher autistic traits. Future research should further explore how enhancing emotion regulation strategies might mitigate these effects, building on current findings. Building on these findings, the impact of the intervention on empathy, particularly affective empathy, was notable. The increase in empathic concern over time suggests that the training successfully enhanced participants' emotional responsiveness. However, the lack of significant changes in cognitive empathy highlights the potential need for longer or more targeted interventions to fully develop this skill set. Given the complexity of empathy as a multi-dimensional construct, future interventions may need to differentiate between affective and cognitive empathy training to achieve more comprehensive improvements.

Furthermore, the combined EFs and social cognition training program revealed several key points in terms of efficacy. Although there were no significant main effects of the group on DASS-21, the significant time and group interaction suggest that the online training had a measurable impact on reducing mental health symptoms, particularly in the experimental group. This finding aligns with recent studies on the effectiveness of online cognitive training for mental health (Beloe & Derakshan, 2020; Nahum et al., 2021; Olfers & Band, 2018; Sari et al., 2020). While the marginal effects observed for anxiety suggest that the training had a limited immediate effect, it might also indicate the potential for more substantial impacts with extended training periods or larger sample sizes. Overall, the findings of this thesis suggest that the combined online training program shows promise in improving certain aspects of mental health and empathy, particularly affective empathy. However, the mixed results regarding cognitive flexibility and cognitive empathy indicate that further refinement of the training program is necessary. Future studies should aim to extend the duration of the intervention, increase the sample size, and consider the role of individual differences in participants' cognitive and emotional responses to the training. Additionally, the results highlight the importance of integrating emotion regulation strategies within cognitive training to ensure a holistic approach to improving mental health outcomes.

7.3. Clinical Implications and Future Studies

The first clinical implication highlighted by the research reported in the current thesis is the importance of disseminating online mental health programs in Türkiye. Previous studies have demonstrated the significant efficacy of online intervention programs for both neurotypical and neurodiverse populations (Andersson et al., 2021; Beloe & Derakshan, 2020; Richards et al., 2020; Sandgreen et al., 2021; Sari et al., 2020). However, these programs' development and efficacy testing in Türkiye remains insufficient to provide comprehensive insights. This study is the first to integrate EFs and social cognition within an online training program (MindZone) to evaluate its efficacy on mental health symptoms, specifically autistic traits, in a neurotypical population. Therefore, further replication of MindZone is necessary to assess its validity and reliability across different populations. Building on the current findings, the limitations and potential explanations should be carefully considered for future investigations in diverse samples. As a Phase IV requirement, additional replications

are essential to develop a valid and reliable psychological intervention program and test the effectiveness of the program.

The second key point is that the second study (Chapter 4) supports the viewpoint of Tone and Tully (2014), indicating that affective empathy can be seen as a "risky strength." The current findings highlighted the importance of using adaptive and effective emotion regulation strategies to prevent and address emotional dysregulation while effectively utilizing empathic skills. Previous studies have shown that maladaptive emotion regulation strategies such as rumination are linked to both internalizing and externalizing problems and children, adolescents, and young adults are the most vulnerable age groups that could benefit from adopting adaptive emotion regulation techniques to improve mental well-being (Helland et al., 2022; Moltrecht et al., 2021). Specifically, setting treatment goals and providing psychoeducation about acceptance have a positive impact on emotion regulation in adolescents (Helland et al., 2022) and similar findings supported by Wisman and colleagues (2023). Therefore, future studies should investigate the effects of emotion regulation on the relationship between autistic traits and mental health symptoms, to extend the current findings and to integrate these techniques into different intervention programs such as *MindZone* that could help reduce mental health issues. Specifically, Study Four in Chapter 6 showed an increase in empathic concern scores, a slight decrease in SAM for affective empathy, and a decrease in DASS-21 scores, which might suggest that the *MindZone* program might alleviate the mental health symptoms by developing better affective empathic skills, including emotion regulation. However, these findings need replications and including an emotion regulation questionnaire might also give more comprehensive information regarding the development of adaptive emotion regulation strategies.

The significant relationship between WM, autistic traits, and mental health problems in the current study is consistent with previous studies indicating that WM training can have a positive impact on mental health issues (Beloe & Derakshan, 2020; Sari et al., 2016). This might suggest that such training could improve the relationship between autistic traits and mental health symptoms in both clinical and non-clinical settings. Future studies may consider applying WM training regarding autistic traits. Besides, the mediating role of the Eyes test in the relationship between WM and DASS-21 and

the relationship between WM and anxiety may highlight the training program involved in emotions has an impact on alleviating mental health symptoms. Future studies should examine hot WM training tasks on mental health to confirm these findings. Additionally, since the literature supports a close relationship between WM and attention (Oberauer, 2019), attention training techniques (ATT) may also be an effective way to address mental health problems. Recent research on ATT has shown promising results in alleviating mental health symptoms (Bailey & Wells, 2024; Knowles et al., 2016; Vogel et al., 2016), which might also with potential implications for individuals with autistic traits and mental health symptoms that future studies could explore for further findings.

Another essential clinical implication is to carefully consider the data collection procedure in the current thesis. With the widespread use of online data collection, it is important to be aware of potential limitations and methodological issues. Questionnaires are commonly employed in clinical settings to gather valuable clinical information. To ensure the reliability and validity of clinical data, it is crucial to address potential factors that may influence these data and to mitigate any limitations (Barker et al., 2015). A review study (Heesacker et al., 2020) suggests that digital technologies for psychological assessment and psychotherapy can help overcome challenges such as cost and time-saving, easier access, and faster data collection and analysis. There are several examples of online survey guidelines (McCord et al., 2020) that demonstrate how online assessment procedures can serve as valuable sources of information. Despite the common use of DASS-21 and AQ in clinical settings, no study has explored possible confounding factors, including data collection procedures and the effects of authority in Turkey. The findings of the current study suggest that DASS-21 and AQ are valid for assessing anxiety, depression, and stress symptoms in both online and paper formats, with no effects of supervision.

7.4. General Limitations

In each study of the current thesis, the potential limitations were presented, and future directions were highlighted. However, overall summary of some potential limitations that should be taken into account below.

As stated in Chapter 6, the high dropout rate is one of the possible limitations of the current thesis. Of the 89 participants in the experimental group who began the study, only 33 completed the posttest, reflecting a 65% dropout rate. This is similar to a recent systematic review and meta-analysis found that dropout rates in digital interventions typically range from 40% to 53% (Meyerowitz-Katz et al., 2020). Despite the implementation of incentives and reminders, such as messages and phone calls, the attrition rate in this study echoes patterns observed in similar research. Furthermore, although random assignment was used to place participants into experimental and control groups, convenience sampling was employed instead of random sampling methods. To establish the effectiveness of the training, future research should prioritize conducting randomized controlled trials (RCTs), which are considered the gold standard in clinical research (Barker et al., 2016).

In both Chapter 4 and Chapter 6, EF tasks were used and the lack of self-report measures could be seen as another potential limitation because self-report measures such as BRIEF could enhance the understanding of how EF skills manifest in real-world contexts (de Vries et al., 2015; van Aken et al., 2023). Moreover, it would be advantageous to explore both 'cool' (cognitive) and 'hot' (affective) EFs in mental health, as the current literature on these dimensions remains limited (Petersen & Welsh, 2014; Smitherman et al., 2007; Zelazo, 2010). Given that the MindZone program targets both EF and social cognition, incorporating 'hot' EF measures in pretest and posttest conditions may reveal extended impacts of the intervention. This could also shed light on the near/far transfer effects for EF tasks.

The current thesis was conducted with neurotypical participants; hence, the findings cannot be generalized to neurodiverse populations. Besides, the neurotypical population may display less pronounced symptoms than clinical populations, which can make detecting significant changes more difficult and potentially explain the less statistically significant findings. Therefore, replications of the current findings are needed. Furthermore, despite efforts to recruit participants through social media and mailing lists, the study sample was predominantly female. Previous research indicates that mental disorders show different patterns in terms of sex (Altemus et al., 2014; Baron-Cohen et al., 2014; Opanković et al., 2021; Pisula et al., 2013) and that males in Türkiye are less likely to seek help for mental health issues (Güney et al., 2024),

future studies should employ more diverse sampling strategies to ensure a balanced sex representation.

7.5. Conclusion

The primary objective of the research reported in the current thesis is to design and investigate EFs and social cognition online training program for mental health and examine the mediating roles of EFs and social cognition in the the relationship between autistic traits and mental health symptoms. The initial studies confirmed that online data collection is as reliable as paper-based methods, allowing for consistent data gathering across studies. Moreover, the research revealed that personal distress, a component of affective empathy, is a key mediator between attention switching (an autistic trait) and mental health outcomes, as measured by the DASS-21. This finding highlights the importance of targeting specific autistic traits in interventions to improve mental health. The online training program was designed and tested for its efficacy in enhancing EFs and social cognitive skills. Although no significant group differences were found overall, the training led to significant improvements in WM and affective empathy. The experimental group also showed a significant reduction in DASS-21 scores. Autistic traits including attention-switching and communication have an impact on mental health, social cognition, and EFs in the targeting of the online training program. While the findings were mixed, the findings suggest that online interventions have the potential to improve mental health symptoms. In conclusion, the research contributes to our understanding of how EFs and social cognition interact with autistic traits to influence mental health and offers insights into developing effective online intervention programs. Despite some challenges, the findings provide a foundation for improving such programs to better support mental health in individuals with autistic traits.

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APPENDICES

APPENDIX A

Evrak Tarih ve Sayısı: 23.05.2023-26164



T.C.
İBN HALDUN ÜNİVERSİTESİ
Sosyal ve Beşeri Bilimler Bilimsel Araştırma ve Yayın Etiği
Kurulu Başkanlığı

Sayı : E-71395021-100-26164
Konu : Etik Kurulu Kararı - Dilruba Sönmez

23.05.2023

İLGİLİ MAKAMA

Kurulumuza başvuran Dilruba SÖNMEZ'in "Online vs. In-Paper: Comparison of Online and In-Paper Data Collection of Autism Quotient and Depression, Anxiety and Stress Scale" isimli projesi; amaç, araştırma türü, veri toplama araçları, süreç ve işlemler, veri analizleri dikkate alınmak suretiyle 18.05.2023 tarihinde değerlendirilerek 2023/03-11 karar numarası ile etik açıdan uygun bulunmuştur.

Bilgilerinizi arz/rica ederim.

Prof. Dr. Alev ERKİLET
Başkan

APPENDIX B

Evrak Tarih ve Sayısı: 13.12.2023-34359



T.C.
İBN HALDUN ÜNİVERSİTESİ
Sosyal ve Beşeri Bilimler Bilimsel Araştırma ve Yayın Etiği
Kurulu Başkanlığı

Sayı : E-71395021-050.06.04-34359
Konu : Etik Kurulu Kararı - Dilruba
SÖNMEZ

13.12.2023

İLGİLİ MAKAMA

Kurulumuza başvuran Dilruba SÖNMEZ'in, "Investigating The Effects Of Executive Functions And Social Cognition On The Relationship Between Autistic Traits And Mental Health" isimli projesi; amaç, araştırma türü, veri toplama araçları, süreç ve işlemler, veri analizleri dikkate alınmak suretiyle 15.09.2023 tarihinde değerlendirilerek 2023/07-03 karar numarası ile etik açıdan uygun bulunmuştur.

Bilgilerinizi arz/rica ederim.

Prof. Dr. Alev ERKİLET
Başkan

APPENDIX C

Table C.1. Correlations among Pretest Scores of Autism Quotient and Its Subscales, Executive Functions, and Social Cognitive Skills

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. AQ	-	.73***	.63***	.13	.67***	.60***	-.21	-.41*	-.07	-.20	.03	.08	-.17	.09	-.24	.09	.08	.13	-.10
2. Social Skills	.62***	-	.27	-.07	.57***	.22	-.15	-.44*	.03	-.23	.14	.33	.07	.26	-.11	.14	-.05	.13	.05
3. ATS	.61***	.39*	-	-.13	.40*	.22	-.12	-.19	-.01	-.16	-.02	-.20	-.15	-.05	-.13	-.08	.03	.27	-.10
4. Attention to Detail	.26	-.06	-.01	-	-.31	-.07	-.10	.04	-.15	-.11	-.08	.20	-.08	.06	-.10	.02	.11	-.24	-.03
5. Communication	.69***	.21	.23	-.04	-	.25	.05	-.30	.20	.01	.19	.04	-.12	.06	-.11	.03	.06	.38*	.01
6.Imagination	.75***	.31	.29	-.02	.62***	-	-.25	-.24	-.27	-.07	-.14	-.14	-.22	-.08	-.21	.14	.08	-.17	-.21
7.IRI	.13	.11	.24	.03	.22	-.17	-	.68***	.83***	.61***	.79***	.05	-.08	-.06	-.06	-.08	-.01	.16	.16
8. PT	.12	.00	.23	-.09	.18	-.08	.78***	-	.43*	.28	.30	-.03	.06	-.11	.14	-.12	.03	.24	.06
9. Fantasy	-.03	.15	.16	.08	-.02	-.26	.81***	.52**	-	.27	.61**	.07	-.11	-.04	-.02	-.12	-.07	.26	.09
10. EC	.13	.02	.12	-.02	.10	.08	.48**	.19	.21	-	.33	-.12	-.28	-.21	-.21	-.01	.12	-.30	.33
11. Personal Distress	.20	.10	.20	-.06	.38*	-.13	.79***	.49**	.45**	.29	-	.21	.08	.16	-.10	.02	-.09	.21	.01
12. WM - A	-.05	-.17	.05	.34*	.08	-.06	.11	.27	-.05	-.24	.26	-	.29	.79**	-.03	.58**	-.54**	.07	.17
13. WM - E	-.15	-.25	.01	.00	-.11	-.43*	.04	.06	-.16	.00	.24	.49**	-	.60**	.60**	.23	-.58**	.02	-.30
14. IN - A	-.12	-.20	.04	.23	.01	-.22	.10	.20	-.09	-.22	.31	.93***	.73**	-	.08	.76***	-.85***	-.06	.09
15. IN - E	-.01	-.19	.09	-.03	-.03	-.12	.07	.19	-.19	.11	.17	.31	.38*	.29	-	-.15	-.25	.06	-.33
16. CF - A	.11	-.02	.19	.12	.18	.00	.08	.08	-.10	-.12	.32	.86***	.53**	.84***	.44**	-	-.76***	-.13	.03
17. CF - E	.01	.08	-.19	.20	-.09	.10	-.09	-.06	.08	.09	-.33	-.86***	-.56**	-.86***	-.34*	-.94***	-	.13	-.04
18. AE	.02	.01	-.01	-.26	-.21	.10	-.28	-.24	-.38*	.26	-.26	-.11	.09	-.09	-.07	-.11	.05	-	-.22
19. CE	0.08	.02	.28	.26	.18	.03	-.07	-.09	-.11	-.10	.08	-.08	-.06	-.02	-.10	-.05	.06	-.17	-

Note. Correlations for experimental group are presented above the diagonal. for control group is below the diagonal. AQ = Autism Quotient; ATS = Attention Switching; IRI = Interpersonal Reactivity Index; PT = Perspective Taking; EC = Empathic Concern; WM = Working Memory; IN = Inhibitory Control; CF = Cognitive Flexibility AE = Affective Empathy; CE = Cognitive Empathy; A = Accuracy; E = Errors; *** $p < .001$ ** $p < .01$; * $p < .05$. All scores were obtained in pretest condition.

APPENDIX D

Table D.1. Correlations among Autism Quotient and Its Subscales, Posttest Scores of Executive Functions and Social Cognitive Skills

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. AQ	-	.73***	.63***	.13	.69***	.60***	.02	-.19	.19	.00	.33	-.35	-.25	.31	.26	-.02	.29	.32	.08
2. Social Skills	.62***	-	.27	-.07	.57***	.022	-.04	-.16	.06	.06	.27	-.29	-.22	.27	.12	-.29	.24	.16	.13
3. Attention Switching	.61***	.39*	-	-.13	.40*	.22	-.05	-.05	.20	-.02	.07	-.08	.04	.25	.29	.03	.25	.43*	.04
4. Attention to Detail	.26	-.06	-.01	-	-.31	-.07	.29	-.26	.11	-.34	.25	-.25	-.17	.09	-.22	-.11	-.18	-.06	-.21
5. Communication	.69***	.21	.23	-.04	-	.25	-.10	.05	.19	.21	.10	-.11	-.26	.20	.32	.21	.31	.18	.10
6. Imagination	.75***	.31	.29	-.02	.62***	-	-.03	-.11	-.01	.08	.22	-.23	-.09	.05	.23	.13	.17	.17	.12
7. WM - A	-.26	-.03	-.23	.52**	-.44**	-.03	-	-.28	.31	-.42*	.36*	-.34	.13	.39*	-.19	-.02	.07	-.30	-.27
8. WM - E	-.04	-.17	-.04	-.03	-.24	-.18	-.14	-	-.04	.06	-.71***	.69**	.08	.10	.16	.19	-.08	.10	.24
9. IN - A	-.13	-.15	.15	.47**	-.12	-.17	-.10	.11	-	-.53**	.33	-.34	.04	.36*	-.12	.08	-.25	-.11	.00
10. IN - E	.31	.21	-.11	-.16	.06	.24	-.07	.46**	-.25	-	-.05	.04	-.06	-.39*	-.07	-.05	.05	-.13	-.08
11. CF - A	.14	.08	-.07	.26	.26	.29	.11	-.11	.04	.19	-	-.99***	-.17	.10	-.20	-.20	.04	-.27	-.14
12. CF - E	-.03	-.01	-.28	.38*	.05	-.18	-.27	.34	-.12	.33	-.20	-	.17	-.10	.20	.19	-.04	.27	.15
13. AE	.00	-.15	-.29	-.32	.00	.02	.07	.47**	-.22	.24	.01	.37*	-	.14	-.20	-.15	-.17	-.15	-.05
14. CE	.09	.09	.15	.32	.29	.06	-.04	-.11	.03	-.39*	.04	-.04	-.19	-	.07	-.17	.01	.14	.18
15. IRI	-.06	.02	.34*	-.02	-.11	-.44**	-.31	.14	.13	-.24	-.17	.15	-.18	.22	-	.50**	.71**	.77***	.60***
16. PT	-.11	.07	.09	.17	-.07	-.40*	-.18	.02	-.05	-.10	-.03	.29	-.23	.21	.81***	-	.21	.16	.04
17. Fantasy	-.19	-.08	.20	.11	-.27	-.54**	-.23	.20	.02	-.30	-.43*	.17	-.15	.14	.87***	.70**	-	.45*	.09
18. EC	-.03	.06	.23	-.10	-.07	-.40*	-.40*	.15	.20	-.12	-.06	.21	-.22	.23	.89***	.74**	.70**	-	.40*
19. PD	.15	.03	.52**	.09	.08	-.03	-.18	.08	.26	-.21	.01	-.18	.02	.12	.59**	.13	.29	.40*	-

Note. Correlations for experimental group are presented above the diagonal. for control group is below the diagonal. AQ = Autism Quotient; IRI = Interpersonal Reactivity Index; PT = Perspective Taking; EC = Empathic Concern; PD = Personal Distress; AE = Affective Empathy; CE = Cognitive Empathy; WM = Working Memory; IN = Inhibitory Control; CF = Cognitive Flexibility; A = Accuracy; E = Errors. *** $p < .001$ ** $p < .01$; * $p < .05$. All scores were obtained in posttest condition.

APPENDIX E

Table E.1. Correlations among Autism Quotient and Its Subscales, Pretest and Posttest Scores of Mental Health Symptoms

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. AQ	-	.73***	.63**	.13	.67***	.60***	.27	.37*	.14	.23	.01	.04	-.01	.00
2. Social Skills	.62***	-	.27	-.07	.57***	.22	.23	.34	.09	.22	.03	-.08	.07	.09
3. Attention Switching	.61**	.39*	-	-.13	.40*	.22	.32	.29	.26	.31	.37*	.29	.29	.38*
4. Attention to Detail	.26	-.06	-.01	-	-.31	-.07	-.19	-.21	-.11	-.21	-.22	-.07	-.15	-.35
5. Communication	.69***	.21	.23	-.04	-	.25	.45**	.53**	.34	.39*	.15	.13	.13	.15
6.Imagination	.75***	.31	.29	-.02	.62**	-	-.05	.08	-.15	-.06	-.28	-.12	-.37*	-.28
7. Pre-DASS-21	.26	-.01	.29	.05	.36*	.09	-	.91***	.91***	.92***	.27	.13	.33	.29
8. Pre -Anxiety	.28	.03	.31	-.02	.30	.14	.93***	-	.78***	.79***	.30	.19	.37*	.26
9. Pre-Depression	.28	.03	.36*	.02	.37*	.06	.91***	.78***	-	.73***	.21	.12	.27	.19
10. Pre-Stress	.15	-.09	.12	.03	.32	.05	.92***	.79***	.78***	-	.24	.06	.26	.33
11.Post-DASS-21	.13	.04	.35*	.11	.08	-.13	.27	.30	.66***	.64***	-	.90***	.92***	.91***
12. Post-Anxiety	.18	.07	.37*	.09	.09	-.08	.13	.19	.62***	.62***	.96***	-	.81***	.68***
13. Post-Depression	.02	-.04	.26	-.02	.01	-.24	.33	.37*	.63***	.59***	.95***	.89***	-	.74***
14. Post-Stress	.17	.09	.37*	.05	.12	-.05	.29	.26	.64***	.60***	.94***	.86***	.83***	-

Note. Correlations for experimental group are presented above the diagonal. for control group is below the diagonal. AQ = Autism Quotient; DASS-21 = Depression Anxiety Stress Scale 21. *** $p < .001$ ** $p < .01$; * $p < .05$.

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