T.R.
USKUDAR UNIVERSITY
INSTITUTE OF HEALTH SCIENCE

DEPARTMENT OF NEUROSCIENCE
NEUROSCIENCE MSc (Eng) PROGRAM

MSc THESIS

EXAMINING THE RELATIONSHIP BETWEEN ATTENTION SKILLS AND EMPATHY IN CHILDREN DIAGNOSED WITH ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

ŞEYMA SOYAL

Thesis Advisor
Prof. Dr. Barış METİN

ISTANBUL – 2025

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ABSTRACT

The aim of this study is to examine the relationship between attention skills and empathy levels in children diagnosed with ADHD. The universe of the study consists of 53 children, 27 of whom were diagnosed with ADHD and 26 were healthy controls, between the ages of 7-12. Reading the Mind in the Eyes Test (RMET) and the computer-based Go/No-Go test were applied to the participants of the study. The Turgay Disruptive Behavior Disorders Screening Scale (T-DSM-IV-S) and the Socio-Demographic Information Form were collected from the parents of the participants. The analysis of the research data was conducted using the IBM SPSS 30.0 program. Before the data analyses of the research, reliability analyses were conducted for the scales. After the reliability of the scales were examined, t-test and Mann-Whitney U Test for independent samples, one-way analysis of variance (ANOVA) and Kruskal-Wallis analysis, Spearman and Pearson correlation analysis and regression analysis were used.

As a result of the research, it was observed that children diagnosed with ADHD made significantly more omission errors compared to the control group and showed weakness in attention skills. A negative relationship was found between the number of inattention symptoms in the scale and cognitive empathy (RMET) correct scores. In addition, a negative relationship was found between average reaction time (ms) and omission errors and cognitive empathy skills. It was also determined by regression analysis that omission errors significantly predicted cognitive empathy levels. Among the demographic factors, gender and mother's education level were found to have a significant impact on the omission error; age was found to have a significant effect on the average reaction time. In addition, being an only child had a significant impact on the commission error.

These findings support the fact that attention deficits in children diagnosed with ADHD negatively affect empathy skills and indicate that cognitive and social-emotional factors should be considered together in the evaluation of children diagnosed with ADHD.

Keywords: *ADHD, Empathy, Sustained Attention, Go/No-Go, Children*

ÖZET

Bu çalışmanın gayesi DEHB tanısı almış çocuklarda dikkat yetenekleri ve empati düzeyleri arasındaki ilişkinin incelenmesidir. Araştırmanın evrenini, 7-12 yaş aralığında kız ve erkek olmak üzere 27'si DEHB tanılı, 26'sı da sağlıklı kontrol grubu olmak üzere toplam 53 çocuk oluşturmaktadır. Araştırmanın katılımcılarına Reading in the Mind Test (RMET) ve bilgisayar tabanlı Go/No-Go testi uygulanmıştır. Katılımcıların ebeveynlerinden ise Turgay Yıkıcı Davranış Bozuklukları Tarama Ölçeği (T-DSM-IV-S) ve Sosyo-Demografik Bilgi Formu toplanmıştır. Araştırma verilerinin analizi IBM SPSS 30.0 programı ile yapılmıştır. Araştırmanın veri analizleri öncesinde ölçeklere yönelik doğrulayıcı güvenirlik analizleri yapılmıştır. Ölçeklerin güvenirlikleri görüldükten sonra bağımsız örneklemler için t-testi ve Mann-Whitney U testi, tek yönlü varyans (ANOVA) ve Kruskal-Wallis analizi, Spearman ve Pearson Korelasyon analizi ve regresyon analizine başvurulmuştur.

Araştırma sonucunda, DEHB tanısı almış çocukların kontrol grubuna kıyasla anlamlı düzeyde daha fazla omission hatası yaptığı ve dikkat becerilerinde de zayıflık gösterdikleri gözlemlenmiştir. Ölçekte yer alan dikkat eksikliği semptom sayısı ile bilişsel empati doğruluk puanları arasında negatif yönde bir ilişki saptanmıştır. Buna ek olarak, ortalama tepki süresi (ms) ve omission hataları ile bilişsel empati becerileri arasında da negatif yönde bir ilişki olduğu görülmüştür. Dikkat hatalarının (Omission error) bilişsel empati düzeylerini anlamlı şekilde yordadığı regresyon analizi ile de tespit edilmiştir. Demografik faktörlerden cinsiyet faktörü ve annenin eğitim durumu faktörünün omission error üzerinde; yaş faktörünün ise ortalama tepki süresi (ms) üzerinde anlamlı bir etkisi olduğu gözlemlenmiştir. Ek olarak tek çocuk olma durumunun ise commission error üzerinde anlamlı bir etkisi olduğu bulunmuştur.

Bu bulgular, DEHB tanısı almış çocuklarda dikkat yetersizliklerinin empati becerilerini olumsuz etkilediğini desteklemekte olup, bu çocukların değerlendirilmesinde bilişsel ve sosyal-duygusal faktörlerin birlikte göz önünde bulundurulması gerektiğine işaret etmektedir.

Anahtar Kelimeler: *DEHB, Empati, Sürekli Dikkat, Go/No-Go Görevi, Çocuklar*

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ŞEYMA SOYAL

FORM OF DECLARATION

I declare that I have obtained all information and documents in this study in accordance with academic rules, presented all visual, auditory, and written information and results in accordance with scientific ethics, have not manipulated any data used, cited sources appropriately according to scientific norms, confirm that my thesis is original and produced by myself, and written according to the Graduate School of Health Sciences Thesis Writing Guide of Üsküdar University.

20/05/2025

Şeyma SOYAL

TABLE OF CONTENTS

LIST OF TABLES

FIGURES

ICONS AND ABBREVIATIONS

ACad: Anterior Cingulate Rostral-Ventral

ACC: Anterior Cingulate Cortex

ACcd: Anterior Cingulate Dorsal

ADHD: Attention-Deficit/Hyperactivity Disorder

ADHD-C: ADHD, Combined Type

ADHD-HI: ADHD, Hyperactive/Impulsive Type

ADHD-I: ADHD, Inattentive Type

AI: Anterior Insula

CD: Conduct Disorder

CPT: Continuous Performance Test

DA: Dopamine

DLPFC: Dorsolateral Prefrontal Cortex

DSM-II: Diagnostic and Statistical Manual of Mental Disorders, Second Edition

DSM-III: Diagnostic and Statistical Manual of Mental Disorders, Third Edition

DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition

DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition

fMRI: Functional Magnetic Resonance Imaging

IFG: Inferior Frontal Gyrus

LC: Locus Coeruleus

LC-NE System: Locus Coeruleus-Norepinephrine System

MNS: Mirror Neuron System

NE: Norepinephrine

ODD: Oppositional Defiant Disorder

OFC: Orbitofrontal Cortex

PET: Positron Emission Tomography

PFC: Prefrontal Cortex

PCC: Posterior Cingulate Cortex

TPJ: Temporoparietal Junction

ToM: Theory of Mind

VTA: Ventral Tegmental Area

VM: Ventromedial Cortex

vmPFC: Ventromedial Prefrontal Cortex

1. INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by more severe and persistent inattention and/or hyperactive and impulsive behaviors (American Psychiatric Association, 2013). It is the most common psychiatric disorder in children and if left untreated, it negatively has an impact on children's psychological, social and academic lives (Doğangün and Yavuz, 2011; Ercan, 2008)

ADHD has an impact on the quality of life of individuals not only with its core symptoms but also with the impairments it creates in social functioning. Current research suggests that impairments in social cognitive abilities in ADHD may negatively have an impact on the individual's social skills that lead to impairments in general functioning (Parke et al., 2021; Uekermann, 2010). Social cognition is not a single ability, yet it covers the capability to perceive and sense another individual's emotions from body postures and faces. Furthermore, there are more complex and complicated capacities of social cognition such as ToM, humor processing and last but not least empathy (Uekermann et al., 2010).

An increasing body of research has investigated social cognition in individuals with ADHD, revealing impairments in both the cognitive and affective components of social processing (Parke et al., 2018; Caillies et al., 2014; Bora & Pantelis, 2016). In this context, the functionality of social cognitive skills such as empathy is also considered in relation to ADHD. Hence, one statement for the insufficiency in social behavior in ADHD is the deficient level of empathy. Cognitive empathy refers to an individual’s capability to understand and comprehend the emotions of individuals without directly experiencing them (Walter, 2012) and is usually considered within the framework of *Theory of Mind*.

In recent studies, it is claimed that ADHD gives rise to substantial impacts on social cognitive level in addition to behavioral level. Numerous novel studies have investigated the relationship between ADHD and empathy (Parke et al. 2018; Kats-Gold et al., 2007; Bora and Pantelis, 2016) and highlighted that the children diagnosed with ADHD have struggled with social cognition skills such as emotion recognition. The difficulties they experience in the social cognitive domain are considered to be related with the executive functions especially in attentional processes. The person's general ability to pay attention or executive function abilities such as switching between perspectives may play a significant role in the ability to empathize (Mairon et al., 2023). Thus, in terms of potential processes of empathy components, a claim can be made that effective attentional control is related with high cognitive empathy (Goodhew and Edwards, 2022). In fact, some studies have observed that cognitive empathy performance decreases as the level of attention deficit increases (Shin et al., 2008). Tsal et al. (2005) used neuropsychological assessment tools such as the Continuous Performance Test (CPT) to measure different components of attention and showed that individuals with ADHD made significantly more errors, especially in tasks requiring sustained and selective attention. Johnstone and Galetta (2013) reported that children with ADHD had difficulty maintaining their attention continuously which refers to sustained attention and made more omission errors.

In this study, the relationship between attention skills and empathy levels of children diagnosed with ADHD was examined. In order to measure the attention performances of children, the computer-based Go/No-Go paradigm was used, and their empathy levels were measured using the Reading the Mind in the Eyes Test (RMET). In addition to that, The T-DSM-IV-S scale and socio-demographic form filled out by parents.

1.1. Aim of the Study

The main purpose of the study is to examine the relationship between attention skills and empathy levels in children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). Even though there are numerous studies stressing the relationship between empathy and ADHD in existing literature, there is limited research in the literature directly examining attention skills and empathy in children diagnosed with ADHD especially in Turkiye. Therefore, another important purpose of the study is to contribute to the existing and limited knowledge about this relationship. The sub-objectives of the research are to evaluate whether children's empathy and attention skills differ according to demographic variables (gender, age, parental unity, family type, etc.). In line with the stated objectives, the hypotheses of the research are shaped as follows:

H1: There is a significant relationship between attention skills and empathy in children diagnosed with Attention Deficit Hyperactivity Disorder.

H2: The Reading the Mind in the Eyes Test (RMET) scores of children diagnosed with ADHD will be significantly lower than those of typically developing children in the same age group.

H3: Attention skills assessed through the Go/No-Go test will show significant differences between children diagnosed with ADHD and the control group.

The sub-questions that the research seeks to answer are listed as follows:

1. Do participants' attention levels differ according to their socio-demographic information (gender, age, family education level, economic status, family type, etc.)?
2. Do participants' empathy levels differ according to their socio-demographic information (gender, age, family education level, economic status, family type, etc.)?
3. Are there differences in children's attention performance and empathy levels according to the core symptoms of ADHD (inattention, hyperactivity/impulsivity)?

2. GENERAL INFORMATION

2.1. Attention Deficit/Hyperactivity Disorder

‘’Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by short attention span/disorganization, hyperactivity and impulsivity‘’ (American Psychiatric Association, 2013). It is the most common psychiatric disorder in children and if left untreated, it negatively has an impact on children's psychological, social and academic lives (Doğangün and Yavuz, 2011; Ercan, 2008).

Even though the alterations in name of the ADHD, it has an extensive and rich history (Wolraich et al., 2019). To begin with, Sir Alexander Crichton, a Scottish physician, mentioned the earliest clinical description of attention disorders similar to ADHD in his book published in 1798 (Lange et al., 2010). Crichton's descriptions in the book give several indications of the key features of the Inattentive subtype of ADHD in the DSM-IV. Although the descriptions about attention disorders that Crichton made in the late 18th century indicate some proof for the existence of ADHD (Lange et al., 2010), the first person to describe ADHD is accepted and known as George F. Still, a British pediatrician in 1902 (Palmer & Finger, 2001). He expressed this disorder as “a severe deficiency of moral control” in children who were hyperactive, had learning difficulties, were unable to maintain focus, and exhibited behavioral problems (Doğangün and Yavuz, 2011). Although these symptoms negatively affected the child's academic success and social relationships, no abnormalities were observed in the child's cognitive functions (Barkley, 2015). The basic idea put forward by Still coincides with important findings in modern ADHD research (Lange et al., 2010). A number of important articles on the treatment of hyperactive children were published between 1937 and 1941 (Barkley, 2015) and in 1937, Charles Bradley defined impulsivity as an organic problem and carried out the first trials of psychostimulants (Görmez, 2017). Consequently, by the 1970s, the utilization of psychostimulants became the preferred method of treating ADHD (Barkley, 2015).

After the viral encephalitis epidemic, the symptoms were thought to be a behavioral consequence of the epidemic (Doğangün and Yavuz, 2011) and these children are defined as individuals who are impulsive, have disorders in attention and movement regulation, and have deficiencies in other cognitive abilities, such as memory. The large number of children affected by this condition has significantly increased professional and educational interest in this behavioral disorder (Barkley, 2015). Following the publication of Still's lectures, there was increasing awareness of the possibility that some defective forms of attention may result from early brain damage. This in the end gave rise to the introduction of descriptive terms such as "minimal brain damage" and "minimal brain dysfunction" in the 1950s and 1960s (Doğangün and Yavuz, 2011; Kos and Richdale, 2004).

With the publication of DSM-II in 1968, ADHD began to appear in the psychiatric literature. It was referred to as “Hyperkinetic Syndrome,” (Doğangün and Yavuz, 2011) indicating hyperactivity and attention deficits but excluding impulsivity as a core feature (Baumeister et al., 2012). The DSM-III renamed the “Attention-Deficit Disorder” (ADD) with or without hyperactivity, shifting the focal point from hyperactivity to inattention as the defining symptom in 1980 (Conners, 2000). Furthermore, the DSM-III-R (DSM-III-R) presented the term “Attention-Deficit/Hyperactivity Disorder” (ADHD) and merged inattention and hyperactivity-impulsivity into a single symptom list in 1987 (APA, 1987; Abdelnour et al., 2022). In 1994, the DSM-IV revisited the concept of subtypes, describing three distinct categories (Mahone and Denckla, 2017). In addition to that, in 2013 the new term ‘presentations’ was introduced by DSM-5 rather than ‘subtypes. It pursued three primary appearances: Inattentive, Hyperactive/Impulsive, and Combined (APA, 2013; Wolraich et al., 2019).

Subtypes of ADHD

1. Combined presentation: Diagnostic criteria for both inattention and hyperactivity have been met within the past 6 months.
2. Predominantly inattentive presentation: In its simplest definition, attention deficit is the inability of an individual to indicate the same interest, attention, and intelligence in areas related to their own duties and responsibilities as they do in areas they are interested in. In the last 6 months, the diagnostic criterion for inattention has been met, but the diagnostic criteria for hyperactivity/impulsivity have not been met.

3. Predominantly hyperactive/impulsive presentation: Hyperactivity is the condition in which a child, adolescent, or adult is more active or impulsive than expected for their age or social status. When the diagnostic criteria are examined, the diagnostic criteria for activity/impulsivity have been met in the last 6 months, but the diagnostic criteria for inattention have not been met (Ercan, 2018; American Psychiatric Association, 2013)

Table 1. DSM-5 Diagnostic Criteria for Attention-Deficit/Hyperactivity Disorder (American Psychiatric Association, 2013)

Diagnostic Criteria
A. A persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development, as characterized by (1) and/or (2): **1. Inattention**: Six (or more) of the following symptoms have persisted for at least 6 months to a degree that is inconsistent with developmental level and that negatively impacts directly on social and academic/occupational activities: a. Often fails to give close attention to details or makes careless mistakes in schoolwork, at work, or during other activities b. Often has difficulty sustaining attention in tasks or play activities c. Often does not seem to listen when spoken to directly d. Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace e. Often has difficulty organizing tasks and activities f. Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort g. Often loses things necessary for tasks or activities h. Is often easily distracted by extraneous stimuli i. Is often forgetful in daily activities
2. Hyperactivity and impulsivity: Six (or more) of the following symptoms have persisted for at least 6 months to a degree that is inconsistent with developmental level and that negatively impacts directly on social and academic/occupational activities: a. Often fidgets with or taps hands or feet or squirms in seat. b. Often leaves seat in situations when remaining seated is expected c. Often runs about or climbs in situations where it is inappropriate. d. Often unable to play or engage in leisure activities quietly. e. Is often "on the go," acting as if "driven by a motor" f. Often talks excessively. g. Often blurts out an answer before a question has been completed h. Often has difficulty waiting his or her turn i. Often interrupts or intrudes on others
B. Several inattentive or hyperactive-impulsive symptoms were present prior to age 12 years

Table 1. DSM-5 Diagnostic Criteria for Attention-Deficit/Hyperactivity Disorder (American Psychiatric Association, 2013) (continued)

C. Several inattentive or hyperactive-impulsive symptoms are present in two or more
D. There is clear evidence that the symptoms interfere with, or reduce the quality of, social, academic, or occupational functioning.
E. The symptoms do not occur exclusively during the course of schizophrenia or another psychotic disorder and are not better explained by another mental disorder (e.g., mood disorder, anxiety disorder, dissociative disorder, personality disorder, substance intoxication or withdrawal).

2.1.1. Epidemiology of ADHD

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most diagnosed childhood disorders worldwide (American Psychiatric Association, 2013). Due to the high prevalence rate of ADHD, wide variety of studies have been conducted on the epidemiology of ADHD worldwide (Özaslan et al., 2015), and researchers have made significant efforts to determine the prevalence of this disorder in the last decade (Özbay and Kayhan, 2024). Various factors such as data source, type and number of assessments, age variables, interview and assessment method, and diagnostic criteria affect the prevalence rate (Staller and Faraone, 2006), and therefore, different rates of ADHD prevalence have been reported in many studies (Özbay and Kayhan, 2024).

Numerous systematic reviews and meta-analyses have been investigated to summarize the prevalence of the disorder, and to examine the variability in prevalence predictions (Popit et al., 2024). To be more specific, one of the most comprehensive meta-analyses of the prevalence rate of children and adolescents diagnosed with ADHD was completed by Polanczyk et al (2007). In research, 9,105 records and 303 articles were scanned and as a result, the global prevalence of ADHD was calculated to be 5.29 %. In addition to this, another researcher Willcutt (2012) published a second comprehensive review of the prevalence of ADHD and the review included 86 studies of children and adolescents. The meta-analysis results estimated the prevalence of ADHD in children and adolescents to be between 5.9% and 7.1%, depending on the source of information used for diagnosis. Polyzack et al (2012) updated the two most comprehensive systematic reviews addressing ADHD prevalence worldwide, including 135 studies published between 1985 and 2012 in their final model and found that the current findings of ADHD prevalence in the world are estimated approximately between 5.29% to 7.1%. Furthermore, Salari et al. (2023) conducted a wide meta-analysis examining children aged 12 and under, and in this study, they stated that the prevalence of ADHD was 7.6% according to the results of 53 different studies. Last but not least, the meta-analysis research conducted in 2024 addressed that the prevalence of ADHD was found to be 1.6%. ADHD prevalence was determined in different age groups such as children, adolescents and adults (Popit et al., 2024).

Although meta-analyses address the general prevalence rates of ADHD, it is seen that these rates vary not only at the general level but also depending on certain factors. The most important population factors affecting prevalence rates include gender, age, and sample type (Skounti et al., 2007). Salari et al. (2023) investigated the prevalence of ADHD in children and adolescents and stated that the prevalence rate is approximately 5.6% in young people aged between 12 to 18 and 7.6% in children aged between 3 to 12. The general estimated prevalence of ADHD in clinical studies was 4.2% (Popit et al., 2023). Erskine et al. (2013) conducted a comprehensive meta-analysis study examining the prevalence of ADHD between the ages of 5 and 19 and emphasized that there is a significant age effect. When the results are examined, the prevalence of ADHD increases in girls and boys until the age of 9 and decreases as age increases. Faraone et al. (2006) found a pattern of decline similar to that model in their meta-analysis of ADHD follow-up studies whereby only 15% of those originally diagnosed with ADHD still met the full diagnostic criteria at 25 years of age.

The vast variety of the studies have claimed that the predominantly inattentive type (ADHD-I) is the more common subtype of ADHD, followed by combined (ADHD-C) and lastly hyperactive-impulsive type (ADHD-HI) (Skounti et al., 2007; Ayoe et al., 2023). In addition to that, numerous research focusing on children frequently indicate that the prevalence of ADHD is higher in boys than in girls (Polanczyk and Rohde, 2007; Özaslan and Bilaç, 2015). In a 2023, meta-analysis study based on gender, Ayano et al. (2023) stated that the prevalence of Attention Deficit Hyperactivity Disorder was twice as high in boys (10%) compared to girls (5%). The study also claimed that there are certain studies conducted based on gender that have emphasized that ADHD-I which is Inattentive type is the most common subtype in both girls (2.21%) and boys (4.05%) (Ayano et al., 2023).

There are some studies to determine the prevalence of ADHD in Türkiye (Erşan et al., 2004; Ercan, 2010; Gül et al., 2010; Güler et al., 2014). Türkiye's multi-ethnic and multi-cultural characteristics make it essential to discover the prevalence and subtypes of ADHD in different regions of Türkiye (Gül et al., 2010). Ercan et al. (2013) conducted a study in İzmir province of Türkiye and examined a 4-year longitudinal study examining the prevalence rates of ADHD and ODD and ADHD prevalence was determined as 13.38% in the initial wave and 12.53% in the second wave. Erşan et al. (2004) conducted another study on primary school children in Sivas province of Türkiye. In general, the prevalence of ADHD was found to be 8.1% (Erşan et al. 2004).

2.1.2. Etiology of ADHD

Attention Deficit Hyperactivity Disorder (ADHD) is a heterogeneous condition with multifactorial etiology. Despite intensive research, its exact causes are not fully understood since ADHD is not a single pathophysiological entity but stem from the interaction of genetic, social, and physical factors (Thapar et al., 2013). Both environmental and genetic factors contribute to the onset of the disorder, and these effects vary among individuals (Dark et al., 2018). Research suggests that ADHD involves multiple genetic and environmental factors that act together to create a range of neurobiological predispositions (Curatolo et al., 2010). This condition is likely to have causes that vary across individuals and may even result from the interaction of multiple factors within the same case “biopsychosociocultural model” (Doğangün and Yavuz, 2011).

2.1.2.1. Genetic Factors

There is robust evidence that genetic factors play a chief role in the etiology of ADHD (Balogh et al., 2022; Thapar et al., 2011). Twin, family and adoption studies have demonstrated the magnitude of the genetic contribution (Thapar et al., 2011). Family studies have shown that the disorder is more common in first-degree relatives of individuals diagnosed with ADHD. For instance, if one parent has an ADHD diagnosis, the rate of this disorder in children varies between 20-54% (Akgün et al., 2011). In addition, meta-analyses conducted on parents of children diagnosed with ADHD show that the relative risk for ADHD diagnosis in these individuals is two to eight times higher (Faraone and Doyle, 2001). Genetic studies show that familial transmission of ADHD is shaped by a genetic basis yet, it should not be forgotten that genetic factors may affect not only the onset of ADHD but also its course and consequences (Thapar et al., 2011). According to the study by Faraone et al. (2005), the heritability rate of ADHD is estimated to be approximately 76%. Similarly, a recent meta-analysis shows this rate between 77-88% with data from twin studies (Jensen et al., 2001; Biederman and Faraone, 2005). One of the complexities of ADHD is that genetic factors can create indirect risk effects through the interaction with environmental factors. Genes can alter susceptibility to environmental risks (gene-environment interaction) such as environmental toxins or psychosocial adversities. This means that genetic and environmental risk impacts cannot be considered separate (Thapar et al., 2011).

2.1.2.2 Environmental Factors

The evaluated data suggest that environmental conditions, as well as genetic factors, may play a role in the etiology of ADHD (Akgün et al., 2011). Many studies suggest that delivery and pregnancy complications increase the risk of ADHD. Complications related with ADHD often give rise to the inclusion of chronic exposure to the fetus. Maternal smoking during pregnancy is the chronic exposure that has been broadly under research. By exposing the fetus to nicotine, maternal smoking may damage the brain at critical times in development. Since nicotinic receptors regulate dopaminergic activity that leads to dopaminergic dysregulation and it may cause ADHD (Biederman and Farone, 2002). In addition, researchers have found general associations between ADHD and a range of pregnancy complications (sickness, excessive nausea, and excessive weight loss or gain) and birth problems (Nunez-Jaramillo et al., 2021; Jensen et al., 2001). Prenatal and/or postnatal exposure to diverse toxins is thought to increase the risk of ADHD (Thapar et al., 2013). Heavy metal exposure is one of the environmental components most related with ADHD. A study of school children indicated higher levels of mercury in the saliva of children with ADHD (6-7 years old) (Núñez-Jaramillo et al.,2021). Dysregulation/exposure to environmental factors such as nicotine, ethanol, copper, iron, zinc, magnesium, lead, and manganese can also interfere with neurotransmission (Kessi et al., 2022).

The emphasis of the psychosocial environment in the etiology of ADHD has also been the subject of research (Öncü and Şenol). Even though psychosocial risks such as low income, family distress, and parenting styles provide a solid causality for some psychiatric disorders, they are not considered as causes of ADHD, they have generally been observed as associated factors (Thapar and Cooper, 2016). Some researchers have claimed that ADHD severity is related with family stressors and psychosocial distress (Jensen et al., 2001). In a review of 42 studies examining the relationship between ADHD and socioeconomic difficulties in 2015, it was highlighted that 35 studies revealed a positive relationship between ADHD and socioeconomic difficulties (Gül and Öncü, 2018). Psychosocial effects are thought to play an initial role in the development of ADHD and accelerate its emergence. In ADHD cases, psychosocial characteristics such as serious problems between parents, a history of psychiatric disorders in the mother and father, and the individual being the only or first child in the family have been reported to be more common than in healthy controls. It has been observed that children living in orphanages have short attention spans and are hyperactive as a result of long-term emotional deprivation (Doğangün and Yavuz, 2011).

The clarification of the three subtypes of ADHD and the interest in attentional symptoms have led to the emergence of various neurocognitive and neurobiological theories about the etiology of ADHD in a more specific brain localization (Curatolo et al., 2010).

Two neurotransmitters which are dopamine (DA) and norepinephrine (NE), play essential roles in numerous cognitive functions such as attention, concentration, and motivation. Dysfunctions in the DA and NA systems, specifically in the frontal lobe, play a key role in the etiology of ADHD. Psychostimulants and selective norepinephrine reuptake inhibitors, that are usually used in the treatment of ADHD, indicate therapeutic effects by aim at the dopamine (DA) and norepinephrine (NE) systems, and strengthen the role of these neurotransmitters in the pathophysiology of ADHD (Doğangün and Yavuz). Similarly, Dark et al. (2018) highlight the long-known role of monoaminergic dysregulation, particularly in the noradrenergic and dopaminergic systems, as a foundational pathophysiological mechanism in ADHD. Dopaminergic neurons are commonly located in the diencephalon and midbrain. They are organized into several pathways such as the midbrain limbic system, and the midbrain cortex pathways. Specifically dopaminergic signaling and these pathways have been found to contribute remarkably to the pathophysiology of ADHD (Cai et al., 2021). Krause et al. (2003) maintain robust evidence for the role of the dopamine transporter (DAT) gene in ADHD and highlight that disruptions in dopamine reuptake mechanisms play a significant role in ADHD. Furthermore, Tripp and Wickens (2009) claimed the delayed dopamine signaling observed in children with ADHD may describe their abnormal sensitivity to delayed reinforcement. Hence, this dysfunction gives rise to an impaired reward response and contributes to the fundamental behavioral symptoms of the disorder. In addition, imaging studies stated that structural and functional alterations in dopamine-related brain regions strengthen the role of dopaminergic dysregulation in ADHD (Dark et al. 2018; Tripp and Wickens, 2009). In general, dysregulation of the norepinephrine and dopamine systems may give rise to main components of the neurobiological etiology of ADHD. On one hand, Studies by Cai et al. (2021) and Krause et al. (2003) emphasize the chief role of dopamine in reinforcement mechanisms and neural circuits. On the other hand, Tripp and Wickens (2009) stress the impact of dopamine on reward processing. Hence, these observations disclose the complex interplay of neurotransmitter dysfunctions in forming the behavioral and cognitive profile of ADHD.

ADHD is characterized by changes in numerous brain regions that reflect underlying impairments in neurodevelopmental processes (Dark et al., 2018). Brain imaging researchers have indicated smaller proportions in certain areas, specifically prefrontal cortex (PFC) and the basal ganglia regions which are rich in dopamine receptors. Children diagnosed with ADHD display a 5–10% reduction in the volume of these structures compared with children without ADHD (Jensen, 2000). Moreover, Sapkale and Sawal (2023) state structural impairments in the frontal lobe. These alterations may trigger slower brain growth and impair the capability to delay attention. Neurodevelopmental delays, particularly in subcortical and cortical regions, are most obvious in childhood. Yet, some reductions persist into adulthood in individuals with persistent ADHD symptoms (Drechsler et al., 2020). Behavioral phenotype of ADHD aligned with consistent reduced brain volumes and hypoactivations of regions that related with inhibition and attention (Dark et al.,2018). The PFC region plays a vital role in regulating attention, emotion, and behavior and impairments in PFC function and structure are observed to lead to ADHD symptoms (Arnsten, 2009a). Novel models propose that certain ADHD symptom aspects are related to deficits in distinct brain circuits, giving an emphasis to the role of abnormal connectivity and cortical dysfunction (Purper-Ouakil et al., 2011). Neuroanatomical evidence also suggests that normal brain asymmetry is lost in ADHD, accompanied by reduced total brain volume and region-specific reductions in cortical thickness (Jensen, 2000; Drechsler et al., 2020). The regulation mediated by the PFC, which is top-down attention, is particularly affected in ADHD. Children diagnosed with ADHD often have struggled with sustained attention on less interesting tasks yet are easily attracted to more salient stimuli. This pattern is associated with PFC dysfunction (Arnsten, 2009a). Moreover, Purper-Ouakil et al. (2011) stated that the genetic factors in the neuroanatomical alterations of ADHD, emphasizing the contribution of neurodevelopmental genes that are active at all stages of brain development. Extensive research has been conducted to help define the anatomic, functional, and genetic features of ADHD, as well as environmental contributing factors, and it has become clear that there are differences in brain size and activity levels in the catecholamine system. Similarly, although there is a strong familial pattern for ADHD, there is no specific heritable gene pattern. Additionally, the risk of ADHD is increased by environmental factors such as preterm birth, maternal alcohol intake or smoking during pregnancy, childhood lead exposure, and head trauma, but these factors are contributory, not diagnostic (Wolraich et al., 2019).

2.1.3. Comorbidity of ADHD

ADHD is mostly seen with several comorbid disorders (Cuffe et al., 2020). People diagnosed with ADHD may have more complex clinical presentations in addition to core symptoms. Studies have stressed that comorbidity enhances the intensity of symptoms that negatively have an impact on functionality (Bélanger et al., 2018; Brown, 2008). It is stated by Muhammedi et al. (2021) that anxiety such as separation anxiety mostly seen in younger age and social phobia or generalized anxiety disorders more often seen in older groups of individuals diagnosed with ADHD. In addition to that, Larson et al. (2011) stated that children diagnosed with ADHD had three or more comorbid disorders and its prevalence approximately 20%. Lastly, Cuffe et al. (2020) reported that children with mood or anxiety disorders with ADHD had remarkably lower academic achievement than children with ADHD alone. These findings propose that pure ADHD or in combination with other psychiatric disorders give rise to poor consequences in various functional areas.

2.1.4 Diagnostic Evaluation and Differential Diagnosis

Clinical diagnosis and comprehensive assessment of current and earlier symptoms essential for ADHD (Posner et al., 2020). Assessments should be considered in relationships, work, school, and home settings which includes conducting a psychiatric interview with the family and child, learning the child's developmental and medical history (specifically about attention and behavior topics), gathering information from the teacher, and, if necessary, conducting some tests or examinations and conducting a physical examination to rule out underlying medical conditions (Sapkale and Sawal, 2023; Ercan, 2018). In addition, differential diagnosis should be considered since ADHD is very often seen together with other disorders. ADHD is very often seen together with other psychiatric disorders; thus, all cases diagnosed with ADHD should be questioned. In this way, both the determination of comorbid diagnoses and the differential diagnosis will be made.

2.2. Attention

‘’Everyone knows what attention is.” This declaration by William James (1890) demonstrates the fundamental yet vague nature of attention. Contrary to James’s statement about attention, researchers usually point out that there is no single definition of attention since the term encompasses a diversity of psychological phenomena (Hommel et al., 2019; Raz, 2004). It indicates a set of brain processes that enable adaptive and effective behavioral selection (Krauzlis et al., 2021). The complexity of attention stems from its wide phenomenology and its diverse uses, both in scientific research and in everyday language (Styles, 2005).

Historically, psychologists have problems defining the term 'attention'. For instance, James emphasized the subjective experience of attention, whereas Aristotle defined it as a narrowing of the senses. However, as researchers such as Styles (2005) and Krauzlis et al. (2021) have stated, attention is not a single term, but rather a collection of subsystems and processes with various functions and anatomies. This diversity has placed the concept of attention at the center of many disciplines, from psychopathology to cognitive psychology and even animal behavior (Luck and Vecera, 2002). With numerous articles and studies published in recent years, the scientific study of attention has expanded and gained importance significantly. (Steven, 2002). Attention is critically important in various ways, such as managing the brain's limited cognitive resources and reducing information overload (Lindsay, 2020). Despite all its entanglement, attention remains vital to understanding human cognition, making it a cornerstone of psychological and neuroscientific research.

2.2.1. Components of Attention

2.2.1.1 Selective Attention

Selective attention indicates the processes that lead an individual to select and concentrate on specific input for further processing. At the same time suppressing distracting and irrelevant information. Competing information can occur both internally, as in habitual responses and distracting thoughts and externally, as in visual stimuli (Stevens and Bavelier, 2012). That is, the most well-known feature of attention across situations and tasks is selectivity. Attention often involves selecting responses, certain stimuli and related information for behavioral action and cognitive processing while ignoring others. Moreover, it leads individuals to give their focus on relevant stimuli such as consciously directing attention to reading material or reflexive orientation to loud environmental stimuli (Cohen, 2014).

Selectivity has been considered a crucial element in many cognitive theories of attention and has been conceptualized as two processes which are filter (Broadbent,1958) and the attenuation (Treisman,1964) (Cohen, 2014). The attention model developed by Broadbent (1958) explains the processing of information by dividing it into certain stages. According to this model, all information coming from the outside world is first kept in sensory memory for a very short time. Then, a mechanism called a ‘’filter’’ evaluates the incoming messages according to their physical characteristics such as tone of voice and permits only the information that is attended to to pass to the following phase. In the detector stage, the selected information is processed at a more complex level to determine its content and meaning. Finally, this processed information is stored in short-term memory for approximately 10–15 seconds and transferred to long-term memory if necessary. This model is also referred to as the bottleneck model since the filter allows only a limited amount of information to be further processed, just as the bottle neck restricts the flow of liquid (Goldstein, 2011). In addition to this, in 1964, Treisman developed the attenuation theory of selective attention. According to this theory, stimuli from the environment are not completely blocked; instead, they enter the sensory register by being attenuated (i.e., with low intensity) according to their level of importance. Thus, information that is not paid attention to is not completely excluded, but continues to be processed, albeit at a lower level. Dichotic listening experiments conducted by Treisman have shown that individuals can make sense of messages they do not pay attention to in certain situations (Treisman, 1964).

2.2.1.2 Sustained Attention

Sustained attention may require perceptual alertness in some situations, while in other situations it may involve executive attention processes without requiring a high level of alertness to sensory stimuli. Attention is often distributed over time, and its temporal dynamics are evident in everyday experience. Especially when distractors are present, human performance is rarely stable over time, even on automatic tasks. Although sustained attention is defined as the capacity to focus on a stimulus or task for an extended period of time, it is difficult to precisely define this type of attention in terms of cognitive processes or to directly associate it with a specific brain region (Cohen, 2014). There is little research that extensively addresses sustained attention (Huang et al., 2023) and neuropsychological assessments that measure this type of attention require subjects to continuously direct their attention to a specific task and maintain it for a period of time, such as 15–20 minutes (Tucha et al., 2017). Despite some of the brain regions such as the frontal cortex and cingulate cortex are associated with sustained attention, clear pathways have not been identified. Both external and internal factors have an impact on sustained attention. Thus, individuals are unable to maintain their attention for long periods of time due to information overload, and low sustained attention is linked to attention disorders such as ADHD (Huang et al., 2023).

2.2.1.3. Divided Attention

Divided attention can be described as the distribution of attention between two or more tasks, allowing individuals to engage in activities such as listening to music, driving, and planning their day at the same time. Task difficulty and practice are the two factors that affect the ability of divided attention. Since attention plays a fundamental role in the successful completion of tasks, individuals can only effectively focus on one task at a time. Hence, when attention is directed to multiple sources of information simultaneously, cognitive resources are divided, leading to a decrease in performance (Goldstein, 2011).

2.2.2. Neuropsychological Models of Attention

Specific attentional processes play a role in the selective processing of information in the brain. Attentional processes are also carried out by a system of neural networks in which different brain regions are densely interconnected. Based on this principle, two models have been proposed (Posner and Petersen 1990, Mesulam 1990).

2.2.2.1. Posner and Petersen Attention Model; Attention Network Theory

The attention model developed by Posner and Petersen (1990) explains attention processes in the human brain through three basic networks which are executive networks, orienting, alerting. The executive network consists of the participation of the anterior cingulate cortex and medial frontal cortex which manages cognitive conflicts and selects suitable responses. While the orienting network is related with specific brain regions such as parietal cortex which gives rise to attention to be focused on a specific stimulus, the alerting network represents the basic preparation mechanism of the attention system by maintaining a general level of alertness through specific regions of the brainstem and right hemisphere. The authors updated the article they published in 2012 with this model, emphasizing the neurotransmitters that provide attention, and the frameworks of individual differences. In the new model, it was stated that, based on neurotransmitters, the alerting network noradrenaline, the orienting network acetylcholine, and the executive network dopamine system progressed. It was also stated that attention networks mature at different speeds depending on their developmental processes, are affected by genetic factors, and vary between individuals (Petersen and Posner, 2012).

2.2.2.2. Mesulam Attention Model

Mesulam (1981) claimed that attention is not regulated by a single center in the brain but by a large neural network, and attention processes consist of components such as spatial orientation, selective attention, and executive control. This model consists of three basic cortical areas which are the frontal cortex manages attention processes and ensures the distribution of movement; the parietal cortex collects sensory information and assumes the function of spatial orientation; and the cingulate cortex regulates motivation by measuring the value of stimuli. The interaction of these structures ensures that attention is directed to specific stimuli, other stimuli are suppressed, and target-focused attention is maintained (Mesulam, 1990). In addition to that, Mesulam (1990) explained the attentional system operates not in a central region but through dynamic interactions between different cortical and subcortical regions of the brain. According to him, cognitive functions such as attention, language, and memory are carried out through the joint work of extensive neurocognitive networks. This model emphasizes the multi-layered structure of attention processes by revealing that attention is shaped not only by sensory inputs but also by executive functions and motivational mechanisms.

2.2.2.3. Mirsky Attention Model

Mirsky et al. (1991) developed a model that proposes that attention is a multidimensional construct and is divided into five basic components which are focus-execute, sustained attention, encoding, arousal, and response variability. Of these components, sustained attention and focus-execute are particularly associated with attention deficit hyperactivity disorder (ADHD). They suggest that there are marked impairments in the "focus-execute" and "sustain" components of attentional function in children with ADHD. It has been stated that these impairments are associated with difficulties in sustaining attention and executing goal-directed behaviors. Later studies have shown that the impairment of these components of attention in ADHD is associated with the prefrontal cortex and striatal regions (Mirsky and Duncan, 2001). In individuals with ADHD, poor sustained attention gives rise to difficulty sustaining attention throughout a task, while impairments in focus and executive functions are linked to impulsivity and planning difficulties. This model provides an important framework in that it demonstrates that ADHD is not only associated with attention span but also with a multidimensional impairment resulting from the effects of different subcomponents of attention.

2.2.3. Neurobiology of Attention

The neurobiology of attention is formed by particular brain regions and numerous neurotransmitter systems. When specific brain regions are examined, the regions that play a main role in regulating attention are the anterior cingulate cortex (ACC) and the prefrontal cortex. The ACC provides the link between executive functions and attention, managing error detection and cognitive control processes (Bush et al., 2000). The prefrontal cortex is the brain region that plays a role in executive control functions, allowing attention to be selectively directed. This brain region is particularly associated with goal-oriented attention processes (Miller & Cohen, 2001). Problems such as inattention and impulsivity may stem from certain dysfunctions of the prefrontal cortex. Attention is a complex system that manages several different neuronal circuits and therefore does not represent a single mechanism. The complex systematicity of attention has been observed as a result of data obtained from different neuroimaging techniques such as PET and fMRI (Raz, 2004). Advances in the field of neuroscience have made physiological analysis of higher cognitive functions, such as attention, possible, and research specifically on attention shows that the attention function constitutes a specialized system in the central nervous system (Güneş, 2004).

The brain region most frequently activated in functional neuroimaging studies of attention is the anterior cingulate cortex (ACC). The ACC has been observed to be active in both traditional affective and a range of cognitive processes. Hence, this region contributes to a form of attention that regulates both emotional and cognitive processing and may serve as a regulatory mechanism of the brain (Raz, 2004). Functional neuroimaging methods such as PET and fMRI have provided chief insights into the different roles of the ACC (anterior cingulate cortex) in cognitive and emotional processes; two subdivisions have been identified within this structure which are the dorsal cognitive area (ACcd) and the rostral-ventral emotional area (ACad). The cognitive subdomain functions within a broad attentional network that regulates attention and executive functions, guiding response selections through sensory input. The ACcd is particularly activated in tasks requiring high cognitive effort, such as divided attention tasks, that require stimulus-response selection among competing streams of information (Bush et al., 2000). The ACC and lateral frontal cortex are among the primary target regions of the ventral tegmental dopamine system. Brain studies have indicated that the ACC plays a central role in this dopaminergic network. In more detail, neuroimaging studies have shown that the ACC is liberally activated in tasks that involve inhibition of a dominant response, and that these systems affect the dorsal ACC, prefrontal cortex, and parts of the basal ganglia. This has enabled researchers to examine its functional contributions to the executive attention network (Raz, 2004).

In addition to that, the posterior cingulate cortex (PCC) region communicates with other cortical regions and multimodal association areas in the inferior parietal lobe, which have an impact on attention. Studies have stated that the PCC region is more active during introspective attention than during external attention, suggesting that the region contributes to selective attention for internal stimuli. Paralimbic regions, particularly the anterior cingulate cortex (ACC), play a major role in the processes of monitoring events and conflicts, forming response intentions, and maintaining continuity and temporal coherence in behavior (Cohen, 2014). Neuroimaging studies have found a significant relationship between the volume of the right anterior cingulate cortex (ACC) and success on a go/no-go task in children aged 5 to 16 years (Bush et al., 2000). These findings reveal that attentional processes are carried out through two separate networks and that pathologies occurring in the midline frontal cortex, basal ganglia (especially caudate nucleus), anterior prefrontal cortex and right anterior parietal cortex depending on these networks may affect attention (Berger & Posner, 2000). The frontal lobes are the largest structures in the brain and play a fundamental role in higher-level cognitive processes, especially executive functions (Filley, 2002). The prefrontal cortex (PFC) is a critical structure in terms of cognitive functions because the neural activity of this region is directed not only at specific stimuli or motor actions but also at the representation of task-related rules and mappings. In this context, a holistic framework is presented that explains the role of the PFC in executive functions such as attention and inhibition (Miller and Cohen, 2001). It is known that they have specialized functions in cognitive processes such as selective and sustained attention. There is strong evidence in the literature that supports the right frontal lobe's specialization in sustained attention capacity. Among all cortical areas in the brain, frontal lobe damage is most often associated with generalized attention disorders, and this reveals the key role of this region in the holistic functioning of the attention system (Filley, 2002). That is, the prefrontal cortex (PFC) plays a chief role in cognitive and executive functions such as attention and inhibitory control, and its dysfunction is a core feature of psychiatric disorders such as ADHD (Xing et al., 2017). Brain regions associated with sustained attention include the anterior supplementary motor cortex, occipital cortex, prefrontal cortex, right parietal areas, right temporoparietal junction, insula, thalamus, and cerebellum (Fisher, 2019). In addition, neuroimaging studies have indicated that the anterior cingulate cortex (ACC) and dorsolateral prefrontal cortex (DLPFC), especially located in the right hemisphere, regulate attentional transitions between visual-spatial cognitive processes through a top-down control mechanism (Kondo, 2000)

Attention control is regulated by the interaction of various neurotransmitters. In this context, dopamine (DA) and norepinephrine (NE) play a fundamental role in attentional processes because catecholaminergic projections from the ventral tegmental area (VTA) and locus coeruleus (LC) significantly affect the attention-related functions of the prefrontal cortex (PFC) (Xing et al., 2017). In particular, the LC-NE system plays a decisive role in the regulation of cognitive demands such as attentional control and working memory (Unsworth & Robinson, 2017). In addition, it has been shown that dopamine and norepinephrine systems function together in attention regulation and that pharmacological agents used in the treatment of ADHD target these two systems. Drugs such as methylphenidate and amphetamine are reported to be effective as dual inhibitors that block the reuptake of dopamine and norepinephrine (Marshall et al., 2019; Perugi, 2022). These findings reveal the close relationship between irregularities in the DA and NE systems and ADHD, pointing to the fundamental roles of these neurotransmitters in attention processes.

2.2.3.1. Two Processes of Attention: Top-Down and Bottom-Up Mechanisms

Attention is a cognitive function regulated by the dynamic interaction of top-down and bottom-up processes. Research on attention in the visual system has increased significantly in the last few decades, and attention is often treated as two different processes (Katsuki, 2013).

Top-down attention refers to the conscious directing of attention to specific features, objects, or spatial regions. Furthermore, top-down attention is considered as sustained; individuals usually direct attention to specific objects, features, or spatial regions for long periods of time, whereas bottom-up attention is directed temporarily (Pinto et al., 2013). The main effect of top-down attention is increased neural activity directed to a specific location, feature, or object. Suppression of neural responses to behaviorally irrelevant stimuli has also been observed. Higher cortical areas, particularly the prefrontal cortex (PFC) and posterior parietal cortex (PPC), appear to be the primary sources of top-down attentional control (Katsuki & Constantinidis, 2013). The PFC and PPC regions can provide top-down signals for the directing of attention to some extent (Katsuki & Constantinidis, 2012). Top-down processing is a process that transmits information from “higher” to “lower” centers, prioritizing information derived from previous experience over sensory stimuli (Dosenbach et al., 2008). This process is mediated by multiple brain regions, including the prefrontal, frontal, and parietal cortex, as well as the insula, cerebellum, and thalamus, and is subdivided into at least two separate control networks.

Bottom-up attention begins with the progression of basic visual processing along ventral and dorsal visual cortical pathways. Bottom-up information is transmitted from the visual cortex to the prefrontal cortex (PFC) (Katsuki & Constantinidis, 2013). Bottom-up approaches explain an individual's ability to detect targets and initiate target-directed attentional processes largely through the sensory salience of targets. Targets recruit higher cortical areas from lower centers upward, triggering attention (Sarter et al., 2001). Bottom-up processing is a one-way information processing process that starts with sensory input, through perceptual analysis, and ends with motor output. In this process, there is no feedback flow from "higher" centers to "lower" centers (Corbetta & Shulman, 2002).

Top-down and bottom-up attention processes have largely similar overall effects, even though the cause of attentional allocation is different. Existing research suggests that bottom-up and top-down attention may have different effects, but this does not mean that the two processes are completely independent. The prefrontal cortex is not critical for simple, automatic behaviors such as automatically orienting to an unexpected sound or movement. Such automatic behaviors rely heavily on “bottom-up” processing. However, when behavior must be guided by internal states or intentions, that is, when “top-down” processing is needed, the participation of the prefrontal cortex becomes important in regulating this process (Miller & Cohen, 2001).

2.2.4 Attention and ADHD

ADHD is a neurodevelopmental disorder, and numerous studies have shown that children with ADHD experience various cognitive difficulties in attention processes. Inattention is one of the core symptoms of ADHD, and these children have difficulty focusing, paying attention to details and maintaining attention for long periods of time (Tucha et al., 2011). Mirsky et al. (1999) emphasized that one of the most prominent symptoms of individuals with ADHD is the inability to maintain attention on a specific task and that such attention deficits should be carefully examined with neuropsychological assessments.

Attention processes in children with ADHD are affected multidimensionally. Studies have shown that these individuals exhibit impairments in many attention components such as sustained, selective, divided attention, and attention flexibility (Tucha et al., 2011). Sustained attention deficit is one of the most common attention deficits in individuals with ADHD. These individuals have struggled with focusing and maintaining attention on a specific task for a long time, and this negatively affects their academic success and daily functioning (Heaton, 2001; Marchetta et al., 2008). In their study, Marchetta et al. (2008) stated that individuals diagnosed with ADHD showed slower and more variable reaction times in tasks requiring sustained attention, and that this was an attention deficit specific to ADHD. Impairments in the selective attention process were also observed in individuals with ADHD which have difficulty focusing on necessary information by filtering out irrelevant stimuli and make more errors in the face of distracting elements (Mueller et al., 2017). In a study conducted by Tsal et al. (2005), it was shown that children diagnosed with ADHD had impairments in selective attention, executive attention, sustained attention, and orienting processes. In particular, it was stated that these children had difficulty ignoring irrelevant distracting information and responding appropriately to tasks requiring sustained attention. Chen et al. (2002) found that children with ADHD had general dysfunction not only in the sustained attention process but also in the covert shift of attention, and that the left posterior attentional system was particularly affected in this process. Similarly, Sinzig et al. (2008) showed that children with ADHD showed significant differences compared to their healthy peers, especially in the sustained attention and divided attention processes.

The impairments in the attention processes of individuals with ADHD have also been supported by neuropsychological tests. Tsal et al. (2005) used neuropsychological assessment tools such as the Continuous Performance Test (CPT) and the Stroop test to measure different components of attention and showed that individuals with ADHD made significantly more errors, especially in tasks requiring sustained and selective attention. In addition, a study by Pitzianti (2016) acknowledged that children with ADHD had significant impairments in attention processes such as alertness, selective attention, divided attention, and sustained attention, and emphasized that these impairments were related to both the selectivity and intensity of attention. These findings indicate that ADHD is not just a simple inattention problem, but rather a complex neurodevelopmental disorder involving many different components of attention (Konrad et al., 2006).

Over the past two decades, significant advances have been made in the neurobiology of attention and impulse control, and how alterations in these circuits may contribute to ADHD symptoms has been improved. Much of this research has focused on the prefrontal cortex (PFC), which plays a chief role in regulating attention and behavior and has extensive connections with sensory and motor cortices and subcortical structures such as the basal ganglia and cerebellum (Arnsten, 2009b). The hallmark symptoms of ADHD, such as impaired behavioral inhibition, increased motor activity, and inattention, are likely due to deficits in circuits that regulate attention and movement (Brennan & Arnsten, 2008). The PFC’s regulatory influence on posterior cortical and subcortical structures has been shown to be impaired in individuals with ADHD, resulting in reduced top-down control of attention, behavior, and emotion (Arnsten & Pliszka, 2011).

Functional neuroimaging studies have revealed alterations in PFC circuits in individuals with ADHD, with poor PFC activation during attention and behavior regulation. Furthermore, optimal PFC function requires a balance between norepinephrine (NE) and dopamine (DA) levels (Arnsten, 2009b). Methylphenidate and amphetamine block reuptake at norepinephrine and dopamine transporters, whereas atomoxetine more selectively targets the norepinephrine transporter (Arnsten & Pliszka, 2011).

Functional neuroimaging studies have examined brain activations in individuals with ADHD during neuropsychological tasks requiring attention and response inhibition. In these studies, significant differences were observed in the neural systems of individuals with ADHD. These findings indicate structural and functional changes in the frontal cortical, subcortical, and cerebellar circuits in individuals with ADHD (Biederman & Faraone, 2005). In the study by Cubillo et al. (2010), motor response inhibition and cognitive flexibility processes in adults with ADHD were examined with functional magnetic resonance imaging (fMRI) using Stop and Cognitive Switch tasks. In the study, it was determined that adults who were diagnosed with ADHD in childhood and whose symptoms continued showed decreased activation in bilateral fronto-striatal regions during these tasks. In addition, decreased activation was observed in the parietal lobe during the Cognitive Switch task. During the stop task, decreased functional connectivity was found between the right inferior prefrontal cortex and frontal-frontal, fronto-striatal and fronto-parietal networks. The findings suggest that childhood-onset ADHD is associated with neurofunctional disorders that persist into adulthood. Another study using the Go/No-Go paradigm found that children with ADHD made more errors when faced with increased cognitive load during a task, and that while typically developing children activated ventral frontostriatal regions for successful performance, children with ADHD used a more extensive and distributed network. It has been suggested that this network includes the dorsolateral prefrontal cortex, inferior parietal lobe, and posterior cingulate cortex, and that this may be a compensatory mechanism due to delayed development of frontostriatal circuits (Durston et al., 2003). Another study showing decreased negative connectivity between task-positive and task-negative networks in children with ADHD showed that this connectivity continues to develop with age and is associated with deficits in attentional vigilance. The study suggests that there may be a distinct neurobiological phenotype in at least a subgroup of children with ADHD and that this connectivity pattern could be used as a biomarker of attention deficits (Mills et al., 2018). In addition to the basic neurobiological mechanisms of ADHD, it has been suggested that environmental factors may also have an effect on ADHD symptoms. It has been stated that the PFC requires an optimal level of catecholamines for attention and behavior regulation, and therefore conditions such as fatigue (insufficient catecholamines) or stress (excessive catecholamines) may mimic ADHD symptoms. In particular, it has been stated that family stressors such as divorce, illness, or death, or social stressors experienced at school may lead to attention and behavioral problems in children that resemble ADHD symptoms. In such cases, misdiagnosis and treatment with stimulant medications may worsen symptoms (Brennan & Arnsten, 2008).

In particular, the inattention symptom of ADHD negatively affects not only cognitive processes but also social functioning. Difficulties in directing and sustaining attention to motivationally important tasks are a core feature of this disorder. For instance, inattention can make it difficult for a child to learn basic educational skills, which can lead to poor academic performance, followed by anxiety, depression, low self-esteem, and negative behaviors (Bush, 2010). Attention problems can also affect a child's ability to function socially and process social information. When the core symptoms of ADHD are evaluated separately, the symptom of inattention is found to be associated with greater difficulties in understanding emotional and nonverbal cues. Inattention is found to be more strongly associated with social perception, whereas hyperactivity and impulsivity are more strongly associated with behavioral performance. In other words, inattention leads to social perception problems, while impulsivity and disinhibition are more associated with social performance problems (Semrud-Clikeman, 2010).

2.3. Social Cognition

Even though social cognition has been defined in various ways in the literature, it is mainly considered as the ability to sense and comprehend the mental states of others. In individuals, social cognition is overall related with the process of thinking about individuals and forming impressions of them (Green et al., 2008). More complex features of social cognition include abilities such as empathizing, reasoning about mental states and sense of humor (Uekermann et al., 2010). The most heavily researched aspects of social cognition are emotion recognition and theory of mind (ToM); two partially overlapping but distinct cognitive domains (Mitchell & Phillips, 2015).

2.3.1 Empathy: Definition and General Information

Individuals are social beings, and their social interaction style mostly relies on their ability to understand the mental states of other individuals. Empathy allows an individual to comprehend their social environment in the context of the moment and to predict the behavior of other individuals (Bošnjaković & Radionov, 2018) and in this respect, it plays a critical role in emotional and social relationships (Gonzalez-Liencres et al., 2013).

Empathy is a very wide concept and for that reason has been portrayed in several ways by researchers (Baron-Cohen et al., 2013; Segal et al., 2017; Decety & Jackson, 2006). Baron-Cohen et al. (2013) explain empathy as the capacity to feel what others feel. Segal et al. (2017) on the other hand, claim that empathy is the ability to feel and be aware of the emotions and experiences of individuals. In spite of there are diverse explanations of empathy, there is a common unanimity in the literature on three basic components: (a) an emotional response felt toward another; (b) the ability to think from another individual's point of view (cognitive perspective); and (c) the ability to regulate emotion (Decety and Jackson, 2006).

Empathy is a significant concept in psychology and social sciences, and it is a relatively novel term historically. The term “empathy” was first used in English in 1908 as synonymous with the German term “Einfühlung” (Lanzoni, 2018) means “feeling from within” and was used especially by German aestheticians. It is claimed that the concept was first presented into the psychology literature by Theodor Lipps in 1897 (Ersoy & Köşger, 2016). Many personality theorists used the concept of empathy in the 1930s, yet this concept was adopted by Rogerian therapists, especially in the 1950s (Eisenberg & Strayer,1990). The most properly known definition of empathy is based on Carl Rogers’ approach. According to Rogers, empathy is the process of an individual putting themselves in another person’s shoes, feeling their feelings and evaluating scenes from their perspective (Ay & Kılıç, 2019). In the client-centered psychotherapy approach, empathy is one of the headstones of the theoretical structure (Ersoy & Köşger, 2016).

Rogers proposed that the therapist's empathic understanding has two important functions for the client. First, it eases the client's capability to identify, clarify, and verbalize the details of their experiences. Secondly, a client who feels properly understood and accepted feels less lonely, and more connected (Tudor, 2011).

2.3.2. Components of Empathy

Affective empathy includes the feelings that emerge through reactions to another individuals' emotions which means that the individual shares the emotion experienced by the other (Ratka, 2018; Krämer et al., 2009). According to Baron-Cohen et. al. (2013), affective empathy focuses on emotional processes that involve sharing both the most positive and the most challenging human circumstances (Bošnjaković & Radionov, 2018). Blair (2005) determined two core forms of emotional empathy. The first is the reactions to external emotional indicators such as the tone of voice, bodily movements or facial expressions of others and the other one is the reactions to other stimuli with emotional meaning. Walter (2012) highlighted that a rich concept of affective empathy consists of an isomorphic emotional response to another individual emotional state, and a certain level of cognitive awareness. These empathic processes are related with mechanisms such as emotion recognition, and shared pain. In this context, the "simulation theory" can be considered since this theory suggests that individuals internally model their own cognitive and emotional mechanisms to be able to understand the emotional states of other individuals (Baron-Cohen et al., 2013).

Cognitive empathy refers to an individual's capability to understand and comprehend the emotions of individuals without directly experiencing them (Walter, 2012). This type of empathy emphasizes cognitive processes such as understanding others' feelings, taking perspective, and recognizing different perspectives (Bošnjaković & Radionov, 2018). To be more specific, an individual can mentally comprehend that the other person is upset; yet they do not experience this emotion themselves (Walter, 2012). Cognitive empathy is associated with theory of mind (ToM), which means the process of understanding and interpreting mental states of others. Hence, ToM refers to individuals' ability to grasp the emotions, beliefs, and intentions of others and to foresee their behaviors (Soylu, 2023). Theory of mind is stated under two subheadings: Affective theory of mind refers to individuals' ability to make deductions regarding the emotions of other individual; Cognitive theory of mind involves composing mental representations of the other individual's intentions and thoughts (Walter, 2012; Soylu, 2023).

2.3.3. Neurobiology of Empathy

The neuroscience of empathy, in its comprehensive definition, deals with how the brain understands, responds, and represents the internal mental states of individuals (Rameson and Lieberman, 2009) and in recent years, there has been increasing interest in the neural mechanisms of empathy in the field of cognitive neuroscience (Rameson and Lieberman, 2009; Walter, 2012). Based on neurobiological perspective, there are three neural systems that play a prominent role in empathy which are the mirror neuron system, the emotional empathy system, and the mentalizing (cognitive) empathy system (Walter, 2012).

The mirror neuron system (MNS) has been offered as one of the superior candidates for biological empathy, which has been associated with the brain's mirroring mechanism (Corradini & Antonietti, 2013). Looking at the history of the system, mirror neurons are a specific class of visual motor neurons discovered in the early 1990s by Giacomo Rizzolatti's team in the frontal-motor area F5 of the monkey premotor cortex (Praszkier, 2016). According to Rajmohan and Mohandas (2007), the Mirror Neuron System (MMS) is a special group of neurons that become active as if imitating the actions and behaviors of other individuals. In addition to that, the involvement of this system plays a role in neurocognitive functions such as theory of mind, social cognition and empathy. The main reason system is called as the 'mirror neuron system' is that it has been shown that there is a resonance mechanism in the primate brain that allows shared representations to be formed between interacting individuals, and this mechanism creates a common representation by mirroring the actions of one individual to another (Molnar-Szakacs, 2011). Fabbri-Destro (2008) highlighted that numerous brain imaging studies have identified the ventral premotor cortex and inferior parietal lobule, along with the caudal segment of the inferior frontal gyrus (IFG) as the primary components of the human mirror neuron system. These mirror neurons have been acknowledged as part of a system that is thought to have many cognitive functions which consist of imitation, mentalizing and empathy (Walter, 2012). The mirror neurons are basic neural structures that develop empathy that enables individuals to internally simulate both the causes and consequences of observed actions (Praszkier, 2016). Hence, the system is considered as one of the most appropriate mechanisms supporting imitation, emotional contagion, and empathy (Keysers & Fadiga, 2008). The inferior frontal gyrus and the rostral posterior parietal cortex are anatomical locations of mirror neurons in individual (Iacobani & Dapretto, 2007), and amygdala, anterior insula and the inferior frontal gyrus are brain regions directly related with the empathy (Pfeifer et al., 2008). In a study conducted by Pfeifer et al (2008) stated that the activation levels in regions of the right inferior frontal gyrus were directly related to children's levels of empathy. The neural correlates and brain areas associated with empathy are the anterior and posterior cingulate cortex, IFG, ACC, ventromedial prefrontal cortex (VMPFC), insula and amygdala. (Ersoy and Köşger, 2016; Rajmohan and Mohandas, 2007). Furthermore, Ersoy and Köşger (2016) stated that empathy impairments are frequently observed in prefrontal cortex lesions. Despite the brain regions and neural correlates have been identified, there are differences in the brain regions of the components of empathy which are cognitive and affective empathy (Baron-Cohen et al., 2013). To be more specific, in the meta-analysis study by Fan et al. (2011), it was identified that there is a dorsal-ventral division of the aMCC, with the dorsal aMCC being more involved in cognitive forms of empathy whereas the ventral part being more involved in emotional forms of empathy.

Cognitive empathy refers to the ability to understand an individual's emotions (Walter, 2012) and the cognitive component of empathy consists of mentalizing or known as ToM which is the capability to infer the mental states of individuals which involves executive functions such as self-regulation, working memory and the attention (van Dongen, 2020). There is a great amount of study examining the brain regions and neural correlates of both cognitive empathy and the cognitive component of empathy which are perspective taking and ToM processing. These components are supported by a network involving the medial temporal lobe, the anterior mid-cingulate cortex, the temporoparietal junction (TPJ) and ventromedial and dorsomedial prefrontal cortex (Trieu et al., 2019; Princeton et al., 2007; Shamay-Tsoory and Aharon-Peretz, 2007). Overall, functional neuroimaging and lesion studies suggest that the networks involved in cognitive empathic functions are mediated by a contribution, particularly from the ventromedial prefrontal cortex (vmPFC) (Baron-Cohen et al.,2013).

Moore et al. (2015) found that individuals with higher levels of cognitive empathy exhibit greater activation in the anterior insula region that plays a crucial role in both cognitive and affective empathy processes. Another study examined the neural basis of cognitive empathy and found that the left inferior temporal gyrus and the fusiform gyrus played an important role in higher-level visual processing and face perception (Princeton et al., 2007). Both cognitive and emotional theory of mind (ToM) depend on the presence of a prefrontal cortex. However, cognitive ToM is impaired by more widespread prefrontal damage (including ventromedial and dorsolateral regions), whereas impairments in emotional ToM are generally associated with limited damage to the ventromedial prefrontal cortex only (Shamay-Tsoory and Aharon-Peretz, 2007). This study also indicates that cognitive empathy is particularly associated with the ventromedial (VM) cortex and impairment in cognitive empathy and Theory of Mind (ToM) skills was observed in individuals with VM damage (Shamay-Tsoory et al., 2009).

Affective empathy relates to the capacity to share the emotions of individuals and internalize those emotions (Moore et al., 2016) and it is also suggested that it is related with the brain regions such as anterior cingulate cortex, inferior frontal gyrus and insula and the amygdala via the vmPFC (Dvash and Shamay-Tsoory, 2014). According to the meta-analytic study by Lamm et al. (2011), the insular and medial/anterior cingulate cortex play a significant role in empathy for pain. In the study conducted by Fan et al. (2011), it was found that activations in these three brain regions were not limited to a specific type of emotion. On the contrary, activation was observed in the dACC-aMCC-SMA and anterior insula (AI) regions on both sides when participants showed empathy for various emotions in others, such as pain, fear, happiness, disgust, and anxiety. Moore et al. (2016) investigated affective empathy during a working memory task and found that individuals with high affective empathy had decreased activity in the bilateral amygdala and right insula. The amygdala is often associated with emotional processing and threat perception, while the insula plays an important role in both emotional and internal awareness processes.

In studies on the neural basis of empathy, not only brain activation but also the effects hormones and neurotransmitters are taken into account (Walter, 2012) and in this context, one of the most examined neuropeptides in terms of its effect on social cognition is oxytocin (Ebert & Brüne, 2018). Oxytocin regulates social behavior in many species (Permatasari & Syafradduin, 2022), and acts as a neuromodulator and neurotransmitter in these areas by making direct projections to brain regions associated with social cognition, such as the amygdala, hippocampus, striatum, brainstem, and anterior cingulate (Perez-Rodriguez et al., 2015). Scientific evidence suggests that oxytocin levels are consistently associated with empathy (Permatasari & Syafradduin, 2022). Yamasue and Domes (2018) claims that short-term oxytocin administration increases social cognitive functions such as emotion recognition and social attention, and that these effects may be explained by attentional biases toward social stimuli commonly observed in individuals with autism spectrum disorder. Geng et al. (2018) reported that oxytocin administration increased empathy and was associated with reduced activation specifically in the amygdala and anterior insula. Hubble et al. (2017) also acknowledged that oxytocin increases emotional empathy, especially for the emotion of fear.

Emotional awareness is not adequate for the healthy functioning of the empathy process but also the cognitive processes appear to actively contribute to the functioning (Decety, 2008). Moreover, the person's general ability to pay attention or executive function abilities such as switching between perspectives may play a significant role in the ability to empathize (Mairon et al., 2023). Goodhew and Edwards (2021) stated that in terms of potential processes of empathy components, a claim can be made that effective attentional control is related with high cognitive empathy. According to Decety (2008), empathy is supported by both bottom-up and top-down processes. When lower-level processes are automatically activated by the perception of direct emotional expressions, higher-level processes consist of more complicated functions such as directing attention and perspective taking. It is stated that the prefrontal cortex is a mediator in these processes and is in constant interaction with attention systems (Decety, 2008). In addition to this, experimental research indicates crucial relationships between attention and empathy. For instance, Goodhew and Edwards (2022) stressed a remarkable relationship between attention control and cognitive empathy. They claimed that individuals with high task-switching skills have high levels of cognitive empathy; yet individuals with high attention-focusing skills may have low levels of emotional empathy. Findings propose that attention control components may have distinct impacts on empathic processes.

The relationships between attention and empathy have been examined also at the neurobiological level. To give a solid example, Choi and Watanuki (2014) found that attentional processes when discriminating facial expressions differ according to the level of empathy of individuals. Pessoa et al. (2022) found that entire brain regions, including the amygdala, fusiform gyrus, vmPFC, OFC, and calcarine fissure, respond differently to emotionally charged faces, and only when sufficient attentional resources are available to process these faces. Another study found that, as in the amygdala, the increased responses to fearful and/or happy faces compared to neutral faces in these brain regions were not automatic but instead required attention. Thus, they found that all brain regions that responded differently to emotional faces, such as the insula, nucleus accumbens, anterior cingulate gyrus, and orbitofrontal cortex, did so only when sufficient attentional resources were available to process these faces. (Pessoa et al., 2002b) Finally, Morelli and Lieberman (2013) acknowledged in their study based on the findings, attention influences empathic processing and may lead to empathic dysfunction in certain mental disorders.

2.3.5. Empathy and ADHD

ADHD has an impact on the quality of life of individuals not only with its core symptoms but also with the impairments it creates in social functioning. Current research suggests that impairments in social cognitive abilities in ADHD may negatively have an impact on the individual's social skills that lead to impairments in general functioning (Parke et al., 2018; Uekermann, 2010). Uekermann et al. (2010) acknowledged that social cognitive impairments in ADHD may be due to dysfunctions in the regions of the brain that play a critical role in social cognition. In this context, there is an important relationship between social cognitive impairments and empathic functioning, and fronto-striatal dysfunctions are noteworthy in areas where these areas overlap.

The behavioral inhibition model proposed by Barkley (1997) argues that the fundamental neuropsychological disorder of ADHD is a deficit in response inhibition. The model proposes that these executive functions regulate behavior through internal representations and that disruptions in this system result in a behavioral structure that is more dependent on external stimuli. In this context, secondary problems such as attention deficit and social cognitive difficulties are thought to be primarily related to disruptions in executive functions. Therefore, it can be argued that higher-level social cognitive skills such as empathy, especially the cognitive empathy component, may be impaired due to executive function deficiencies in ADHD (Caillies et al., 2014).

An increasing body of research has investigated social cognition in individuals with ADHD, revealing impairments in both the cognitive and affective components of social processing (Parke et al., 2018; Caillies et al., 2014; Bora & Pantelis, 2016). In this context, the functionality of social cognitive skills such as empathy is also considered in relation to ADHD. To be more specific, Caillies et al. (2014) conducted research about the social cognition of children with ADHD, people's repetitive mental states, and their understanding of irony. They found that children with ADHD have difficulty with cognitive ToM processes, which is due to executive dysfunctions. A comprehensive meta-analysis study was conducted by Bora and Pantelis (2016) and according to the study, individuals with ADHD showed lower performance in ToM and emotion recognition tests compared to the control group, and these deficits were most evident in the recognition of emotions such as anger and fear.

There is limited literature examining the relationship between ADHD and empathy since most of the research based on empathy and neurodevelopmental disorders have generally focused on ASD and ODD/CD (Fantozzi et al., 2021). Despite the literature on this context being limited, several novel studies have investigated the relationship between ADHD and empathy (Fantozzi et al. 2021; Parke et al. 2018; Braaten and Rosen, 2000; Kats-Gold et al., 2007; Maire et al., 2018; Maron et al., 2008; Maoz et al.,2019). In the systematic review conducted by Fantozzi et al. (2021), it was observed that drug treatment in ADHD patients give rise to the improvement of the social cognition skills, ToM and the empathy abilities. In addition to systematic review, a study conducted by Parke et al. (2018) compared differences in social cognitive abilities in children diagnosed with ADHD and acknowledged that children with ADHD scored lower than the control group on measures of emotion recognition, pragmatic language, cognitive ToM, and cognitive empathy. Braaten and Rosen (2000) examined differences in empathy and emotional self-regulation in boys with and without ADHD and found that boys with ADHD appeared to have less empathic than boys without ADHD. Another study highlighted that boys at risk for ADHD have poorer emotion recognition skills compared to boys who are not at risk (Kats-Gold et al., 2007). Maire et al. (2019) also found that children diagnosed with ADHD performed lower than typically developing children on a facial emotion recognition task. Moreover, Maoz et al. (2019) conducted a study that aimed to investigate empathy differences between children with ADHD and healthy controls, and the main result of the study was that children with ADHD showed lower self-reported empathy and deficits in ToM. Apart from these studies directly applied to children diagnosed with ADHD, the families of these children have also been the subject of research, and some studies have claimed that children with ADHD show less empathy (e.g., picture-story measurement, facial expressions, etc.) and exhibit behaviors that are perceived as less empathic by their parents (Maron et al., 2008).

Recent neuroscientific research has increasingly addressed the interaction and relationship between social cognition, empathy, and ADHD (Lee et al., 2021; Novak et al., 2024; Fantozzi et al., 2021). In the study conducted by Lee et al. (2021), structural differences in brain structures related to empathy in adolescents diagnosed with ADHD were examined. The results of the study revealed that the volume of the left posterior insula and supramarginal cortex decreased in the ADHD group, while the volume of the left nucleus accumbens increased. However, no significant relationship was found between these regions and empathy levels in the ADHD group. On the other hand, in the control group, cognitive empathy levels were significantly associated with the thickness of the left superotemporal cortex, and emotional empathy levels were significantly associated with the volume of certain brain regions in the right hemisphere. These findings suggest that empathy functioning in ADHD may be based on a different neurobiological basis than in normally developing individuals. Novak et al. (2024) reviewed the relevant literature on the neural basis of ToM deficits in children and adolescents with ADHD between 1970 and 2023 using neuroimaging and electrophysiological studies. Based on all these reviews, the studies demonstrated that children diagnosed with ADHD exhibited electrophysiological abnormalities in the occipital cortex during the ToM task. In addition to the structural and functional findings highlighted above, pharmacological interventions (especially psychostimulants) have also been suggested to modulate social cognitive functioning in individuals with ADHD. Empathy is a critical component of social behavior and is frequently impaired in ADHD, but recent theoretical frameworks suggest that improvements in empathy and social cognition after pharmacological treatment may be mediated by the modulatory effects of these medications on the underlying neural circuitry associated with ADHD and may involve broader cognitive and socioemotional processes (Fantozzi et al., 2021)

3. METHODS

3.1. Sample

The sample of the study consists of children between the ages of 7 and 12 currently living in Istanbul. A total of 53 participants participated in the study; 27 children diagnosed with ADHD and 26 children without a diagnosis.

The ADHD group was selected from children between the ages of 7 and 12 who applied to the child psychiatry department of Çakmak Erdem Hospital in Istanbul. The subject group consists of 27 children, 23 boys (85.2%) and 4 girls (14.8%) and mean age was $\bar{X} = 9.44$ (SD = 1.28). They are diagnosed with ADHD by a child and adolescent psychiatrist according to DSM-5 diagnostic criteria and their diagnosis follow-up is ongoing.

The control group consists of 26 children, 17 boys (65.4%) and 9 girls (34.6%) and age was calculated as $\bar{X} = 8.88$ (SD = 1.07). The control group consisted of children from a variety of schools who were not diagnosed with ADHD and who reported no significant school failure or behavioral problems.

3.2. Universe of the Research

The research universe consists of children between the ages of 7-12 currently living in Istanbul. The sample selection is different in two groups. The ADHD group consists of children between the ages of 7-12 who applied to the child psychiatry department of Çakmak Erdem Hospital in Istanbul. ADHD diagnosis was made by a child psychiatrist according to DSM-5 criteria. The control group consists of children between the ages of 7-12 from various schools in Istanbul. The sample was determined by simple random sampling method and a total of 53 participants were included in the study, 27 children diagnosed with ADHD and 26 children without a diagnosis.

3.2.1. Research Inclusion Criteria

For ADHD group

1. Diagnosis of ADHD according to DSM-V criteria
2. Aged between 7-12 years
3. Having pure ADHD diagnosis
4. Willingness to participate in the study

For control group

1. Clinically considered to have sufficient cognitive ability
2. Healthy children without any psychiatric illness
3. Aged between 7-12 years
4. Willingness to participate in the study

3.2.2. Research Exclusion Criteria

For ADHD group

1. Presence of any medical or neurological illness
2. Presence of comorbid disorder
3. Being outside the age range of 7-12 years
4. Having used ADHD medication in the last 24 hours.
5. Lack of willingness to participate

For control group

1. Clinically considered to have insufficient cognitive level
2. Presence of any psychiatric illness
3. Presence of any medical or neurological illness
4. Being outside the age range of 7-12 years
5. Lack of willingness to participate

3.3. Data Collection Tools

Sample Scale Set: Socio-demographic Form, Turgay DSM-IV disruptive behavior disorders rating scale (T-DSM-IV-S), Reading the Mind in the Eyes Test (RMET), Go/No-Go Test.

3.3.1. Socio-demographic Data Form

The socio-demographic information form prepared by the researcher consists of information about the participants and their families. Form includes details such as age, gender, education level, psychiatric history and family history, number of siblings, and family type. The aim of the socio-demographic form was to obtain information about demographic variables that are thought to predict the attention and empathy abilities of the sample group.

3.3.2. Turgay DSM-IV Disruptive Behavior Disorders Rating Scale

This scale, T-DSM-IV-S, was developed by Turgay (1995) based on the DSM-IV diagnostic criteria. It consists of 41 questions, with 9 addressing attention deficit (Items 1 to 9), 9 addressing hyperactivity and impulsivity (Items 10 to 18), 8 addressing oppositional-defiant disorder (Items 19 to 26), and 15 addressing conduct disorder (Items 27 to 41). The scale was developed by converting the DSM-IV criteria into question form without altering their meaning.

Each item is on a 4-point Likert type and is scored as 0 = not at all, 1 = somewhat, 2 = quite a lot, 3 = very much. The scale is filled out by the parents of children suspected of having ADHD. For a diagnosis of ADHD, at least 6 of the 9 items querying attention deficit must be scored as 2 or 3. In addition, at least 6 of the 9 items querying hyperactivity and impulsivity must be scored as 2 or 3. For a diagnosis of Oppositional Defiant Disorder (ODD), at least 4 of the 8 items must be scored as 2 or 3. For Conduct Disorder (CD), at least 2 of the 25 items must be scored as 2 for a duration of 6 months or 1 year (Ercan et al., 2016). The reliability and validity study in Turkiye was done by Ercan et al. (2001). Cronbach's alpha coefficients for the six subscales are 0.88 for Inattention (IA), 0.95 for Hyperactivity/Impulsivity (IB), 0.89 for Oppositional Defiant Disorder (ODD), and 0.85 for Conduct Disorder (CD).

3.3.3. Reading the Mind in the Eyes Test (RMET)

Reading the Mind in the Eyes test (RMET) was applied to evaluate the empathy levels of the participants in the study. It measures individuals' ability to identify the mental states of others and assesses the cognitive empathy component. The Reading the Mind in the Eyes Test was developed by Baron-Cohen et al. in 1997. In 2001, Baron-Cohen et al. revised the adult form and prepared a version suitable for use for children. The child form consists of 28 photographs by adding 3 more photographs to the 25 photographs in the adult form. All the photographs are standardized in one size (15×10 cm) and are all black and white. In addition, all of them are selected to depict the same area of the face (from the middle of the nose to the eyebrows). The locations of the four words for each item are randomly selected and each question has only one correct answer. They are asked to choose from among the 4 words they think best express the emotion shown in the photograph. It includes cognitive state terms that are not related to emotions and are also emotional. However, the words used in the child form are simpler so that children can understand emotional and cognitive state expressions. The maximum score that can be obtained from the test is 28, and high scores indicate good social cognition and theory of mind skills. The odds ratio is 0.25, and a person can only perform significantly above chance by scoring 13 and above (Binominal test). The child form was both translated into Turkish and validated by Alev Girli in 2014. The Cronbach Alpha internal consistency value for the adult form was found to be 0.71 and for the child form, 0.72. It was found to be valid and reliable in distinguishing healthy/normally developing individuals from those with "social cognition" problems. In addition, it covers functions such as face perception and emotion recognition. The Turkishized form will be used in the planned thesis (Girli, 2014). A sample item from the RMET test is shown in *Figure 1*.

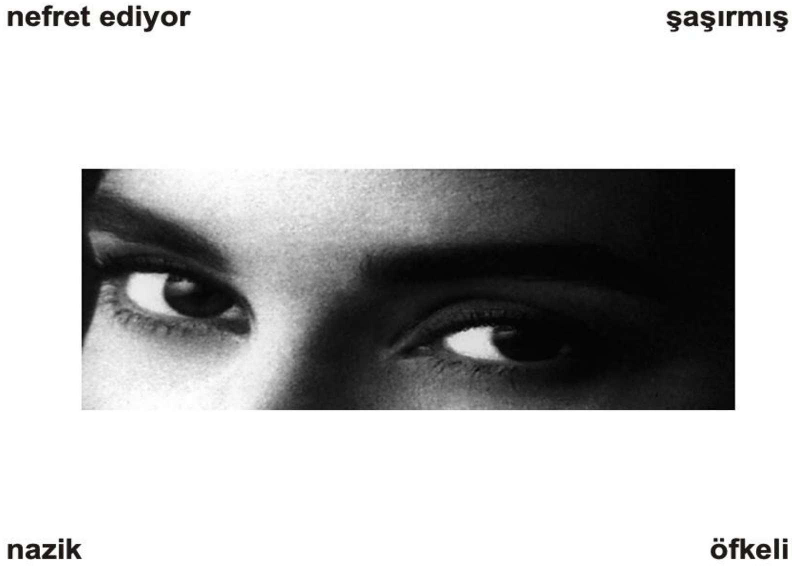

Figure 1. Example item from the Reading the Mind in the Eyes Test

3.3.4. Go/No-Go Test

The Go/No-Go test is a widely used cognitive task to assess attentional control. There are many versions of the test, and its validity and reliability studies were conducted by Halperin and colleagues (1991). This test, which measures the ability to sustain attention, is based on the ability to follow random changes in the stimulus stream. In other words, the paradigm measures sustained attention and selective attention (Criaud and Boulinguez, 2013). It also measures problems related to attention and impulsivity in ADHD. In the test, the participant is asked to give a motor response to a certain stimulus and not to give this response to another stimulus. The high rate of "Go" stimuli in the test means that the motor response is made so strong. Motor impulsivity is measured by the number of motor responses to "no-go" stimuli in the test (Chamberlain and Sahakian, 2007).

The go-nogo paradigm design applied in this study was created with OpenSesame 3.3.5, Python 3.7.6 program. In the study, participants were applied to a computer-based Go/No-Go task, and it was performed by letters appearing and disappearing on the computer screen. The subject's task was to press the 'b' key on the keyboard as fast as possible when any letter (target-pass traces) other than the letter 'X' ('X' is the distractor stimulus) appeared on the screen. The experiment consists of a total of 200 stimuli, 36 of which are No-Go trials (X) and 164 of which are Go Trials (e.g. "S", "F", "A"). Each randomly selected letter from the alphabet appeared on the screen for 300 ms. The avarage interstimulus interval (+) following each stimulus was approximately 3750 ms. The letters appeared randomly and at a random speed. The letters fell on the screen one by one. It is not known when and how many repetitions each letter will appear. The '+' visual after each letter prepared the participants for the next visual and reduced the effect of the previous visual. The test lasted approximately 13 minutes. An example trial of the Go/No-Go test is presented in *Figure 2*.

The responses given by the participants during the test were recorded in an excel file. Then, the data of the participant in the excel file was converted into data to be calculated via SPSS. The data in Excel was analyzed on variables such as omission error (not pressing), commission error (incorrect pressing) and average reaction time (ms). Omission error indicates the number of times target stimuli were missed which related with the inattention. Commission error shows the number of responses to stimuli other than the target stimulus which related with the impulsivity. Pressing the "b" key when the letter "x" is displayed. Reaction time (ms) shows the average time between the subject's perception of the target stimulus and the response which means the time it takes to press the "b" key after the letter presentation. Then, all the participants' data were collected in a single excel file to be analyzed in SPSS 30.0.

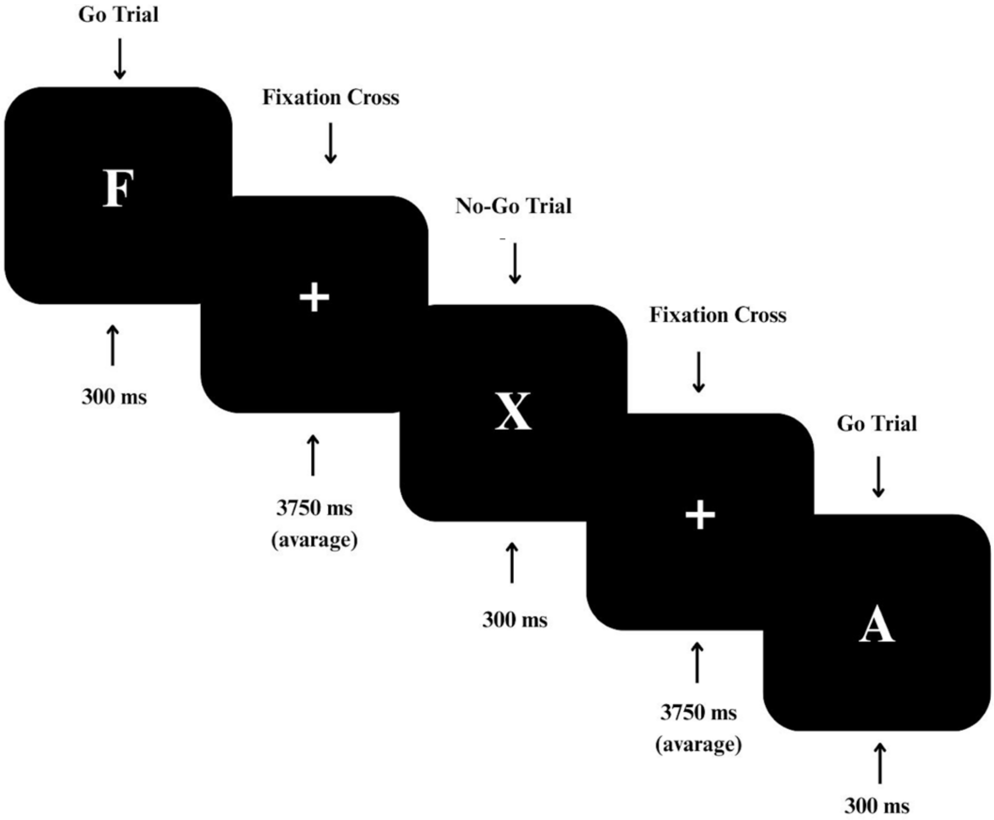

Figure 2. Sample trial from Go/No-Go test

3.4. Procedure

Prior to the research, the necessary permissions were obtained from the Üsküdar University Non-Interventional Research Ethics Committee and from Istanbul Çakmak Erdem Hospital for the ADHD group. Since the study included children under the age of 18, approval was obtained from the parents of both the ADHD diagnosed and control group participants, and a Parent Consent Form was filled out.

For the ADHD group, data collection was conducted in the “test room” of Istanbul Çakmak Erdem Hospital, child psychiatry department. Children diagnosed with ADHD who were taking medication were off medication for at least 24 hours before the test. Each child was first administered a computerized Go/No-Go task. Following this, the Reading the Mind in the Eyes Test (RMET) was applied using a tablet device. Before starting each task, which are computer-based go/no-go and RMET tests, the researcher gave verbal instructions and was present in the room with children throughout the testing session to monitor and direct the child as needed. The total duration of the research is approximately 25 minutes, depending on each participant. At the same time, parents or guardians of the children were informed about the procedures and asked to complete a sociodemographic form and the Turgay DSM-IV Based Disruptive Behavior Disorders Screening and Rating Scale. The same procedure was applied to the control group, consisting of children from various backgrounds and schools. Data for this group were collected at a counseling center. Instructions were given by the researcher in person, and the tasks and scales were administered under the same conditions as those used for the ADHD group.

3.5. Research Permissions

3.5.1. Ethical Approval

The Presidency of the Non-Clinical Research Ethics Committee of Üsküdar University, Republic of Turkey, has unanimously decided that there is no ethical or scientific objection to the conduct of the study with its letter dated 29/06/2024 and numbered 61351342/020-234. It is presented *in Appendix 1.*

3.5.2. Institutional Permission

On 2.10.2024, official permission was obtained from Istanbul Çakmak Erdem Hospital to conduct the research with participants diagnosed with ADHD. All procedures adhered to the ethical standards. Presented in *Appendix 2.*

3.5.3. Parental Informed Consent

Since the participants were children under the age of 18, written parental informed consent was obtained from their parents or legal guardians before data collection. Participants were included in the study voluntarily. All procedures were conducted in accordance with ethical standards. Presented in *Appendix 3.*

3.6. Data Analysis

IBM SPSS (Statistical Package for Social Sciences) 30.0 program was used for the analysis of all data related to the study. To begin with, the normality distribution of the continuous variables included in the study was evaluated with Kolmogorov-Smirnov and Shapiro-Wilk tests. Non-parametric analysis methods were preferred for variables that did not show normal distribution. Within the scope of descriptive statistics, mean, standard deviation, median, minimum and maximum values for variables were calculated. Hence, frequency and percentage distributions were presented for categorical variables. In comparisons between two groups, an independent sample t-test or Mann-Whitney U test was applied according to the distribution of the variable. In comparisons involving three or more groups, one-way analysis of variance (ANOVA) or Kruskal-Wallis test was used according to the normality condition. To analyze the relationship between variables, Spearman or Pearson correlation analyses were applied. Predictive relationships of variables were also examined with regression analyses. Moreover, Cronbach's Alpha reliability coefficient was calculated to evaluate the internal consistency of the scales which are RMET and T-DSM-IV-S. The significance level was accepted as $p<.05$ for all statistical analyses.

3.7. Research Model

This study was designed with a quantitative and relational screening model aiming to examine the relationship between attention skills and empathy levels in children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD).

Internal consistency coefficients and test of normality of the scales presented in Table 2 and Table 3 and Table 4.

Table 2: Internal consistency coefficients (Cronbach's alpha) of the scales

Scale Name	Subscale	Cronbach's α
T-DSM-IV-S	Inattention (IA)	.924
	Hyperactivity/Impulsivity (HI)	.897
	Oppositional Defiant Disorder (ODD)	.783
	Conduct Disorder (CD)	.687
Reading the Mind in the Eyes Test	Whole scale (unidimensional)	.761

**Cronbach's alpha values above .70 are considered acceptable.*

Although the internal consistency of the Conduct Disorder (CD) subscale was found to be acceptable (α = .687), this subscale was not included in the analysis of the study. Similarly, the Oppositional Defiant Disorder (ODD) subscale was also excluded from the analysis. This is because only children with symptoms of inattention and/or hyperactivity-impulsivity without comorbid diagnoses such as ODD or CD were included in the study. Therefore, only the Inattention (IA) and Hyperactivity/Impulsivity (IB) subscales of the T-DSM-IV-S were used in the analyses.

Table 3. Tests of normality (Shapiro–Wilk and Kolmogorov–Smirnov) for T-DSM-IV-S

Subscale	**Variable Type**	**Shapiro–Wilk (p)**	**Kolmogorov–Smirnov (p)**
Inattention (IA)	Total Score	.003	.006
Inattention (IA)	Diagnostic Criterion	<.001	<.001
Hyperactivity/Impulsivity (HI)	Total Score	.002	.018
Hyperactivity/Impulsivity (HI)	Diagnostic Criterion	<.001	<.001
Oppositional Defiant Disorder (ODD)	Total Score	.004	.017
Oppositional Defiant Disorder (ODD)	Diagnostic Criterion	<.001	<.001
Conduct Disorder (CD)	Total Score	<.001	<.001
Conduct Disorder (CD)	Diagnostic Criterion	<.001	<.001
Total Scale Score	Total Score	.015	.025

Table 4. Tests of normality (Shapiro-Wilk and Kolmogorov–Smirnov) for RMET, Go/No-Go task variables, and demographic measures

Variable	Shapiro–Wilk (p)	Kolmogorov–Smirnov (p)
RMET Total Score	.011	.005
Commission Error	.214	.200
Omission Error	< .001	< .001
Reaction Time (ms)	.008	.200
Age	.004	<.001
Number of Siblings	< .001	<.001

Both Shapiro–Wilk and Kolmogorov–Smirnov tests were used to assess normality, given the sample size of 53. In cases of inconsistency between tests, Shapiro–Wilk results were prioritized due to its higher sensitivity to deviations from normality in small to moderate samples.

4. RESULT

4.1. Frequency Distribution of Socio-demographic Characteristics of Participants

In this section, the socio-demographic characteristics of the children and their parents participating in the study are presented with frequency and percentage distributions. Information on variables such as the gender, age, number of siblings, and employment status of the parents, economic status of the family, family type, parent's marital status are together are given in Table 5 and Table 6.

Table 5. Sociodemographic Characteristics of Parents

Variables		N	%
Mother's Education Level	Primary School	7	13.2
	High School	14	26.4
	University	27	50.9
	Postgraduate	5	9.4
Father's Education Level	Primary School	6	11.3
	High School	20	37.7
	University	20	37.7
	Postgraduate	7	13.2
Mother's Employment Status	Employed	24	45.3
	Unemployed	28	52.8
	Retired	1	1.9
Father's Employment Status	Employed	53	100.0
Parental Marital Status	Married	51	96.2
	Divorced	2	3.8

Table 5. Sociodemographic Characteristics of Parents (continued)

Family Type	Nuclear Family Extended Family Single-Parent Family	51 1 1	96.2 1.9 1.9
Economic Status	High Medium	23 30	43.4 56.6
Psychiatric Family History	Yes No	6 47	11.3 88.7

Table 6. Sociodemographic Characteristics of Children

Variables		N	%
Diagnostic Status	Control Group Diagnosed Group	26 27	49.1 50.9
Gender	Boy Girl	40 13	75.5 24.5
Age	7 8 9 10 11 12	3 14 16 13 5 2	5.7 26.4 30.2 24.5 9.4 3.8
Current Medication Use	Not using medication Currently using medication	34 19	64.2 35.8
Number of Siblings	One Two Three Four	10 26 16 1	18.9 49.1 30.2 1.9
Only Child Status	Only Child Status Not Only Child Status	10 43	18.9 81.1

Subjects and control groups were compared in terms of sociodemographic variables such as gender, age, economic status, family type, parental marital status, parents' education levels, mother's employment status, number of siblings, and only child status presented in Table 7 and Table 8. According to the Mann-Whitney U and Chi-square test results, no statistically significant differences were found between the groups (p>.05).

Table 7. Group comparisons of socio-demographic variables

Variable	**ADHD Group (n = 27)**	**Control Group (n = 26)**	**χ^2 (p)**	**Fisher's Exact (p)**
Gender	18 / 7	16 / 10	.094	.119
Mother's Education	2.52 ± 0.94	2.62 ± 2.63	.617	–
Father's Education	2.59 ± 0.75	2.46 ± 0.99	.285	–
Mother's Employment	1.63 ± 0.57	1.50 ± 0.51	.524	–
Economic Status	1.65 ± 0.49	1.48 ± 0.51	.206	.271
Family Psychiatric History	1.19 ± 0.40	1.04 ± 0.20	.092	.192
Only Child	1.78 ± 0.42	1.85 ± 0.37	.525	.728
Family Type	1.11 ± 0.42	1.00 ± 0.00	.368	–
Parental Marital Status	1.07 ± 0.27	1.00 ± 0.00	.157	.491

**Chi-square test*

Table 8. Group comparisons of socio-demographic variables

Variable	ADHD Group (Mean ± SD)	Control Group (Mean ± SD)	U	p-value
Age	9.44 ± 1.28	8.88 ± 1.07	276.500	.171
Number Of Siblings	2.15 ± 0.82	2.15 ± 0.68	346.000	.923

**Mann-Whitney U Test*

4.2. Characteristics of the ADHD Group

Under this heading, only the findings related to children diagnosed with ADHD are presented. First, the distribution according to ADHD subtypes is shown; it was determined that 70% of the children had the inattentive predominant type, 25% had the combined type and only one had the hyperactivity/impulsivity predominant type. Then, within the scope of the T-DSM-IV-S scale sub-dimensions, the mean scores and distributions of the ADHD group for inattention (IA), hyperactivity/impulsivity (IB), combined (IA+IB), oppositional defiant disorder (ODD) and conduct disorder (CD) are presented. Attention performances related to the Go/No-Go test (reaction time, omission error, commission error) were also evaluated in this group.

The ADHD subtypes were determined based on the Turgay DSM-IV Disruptive Behavior Disorders Scale. Children meeting six or more criteria for inattention were classified as predominantly inattentive type, whereas those meeting six or more criteria in both inattention and hyperactivity/impulsivity domains were classified as combined type. Participants in the ADHD group were classified according to subtype characteristics. Among the 27 children diagnosed with ADHD, 19 (70.37%) were identified as inattentive predominant type; 7 (25.93%) as combined type; and 1 (3.70%) as hyperactivity/impulsivity predominant type (Presented in ***Fig. 3***)

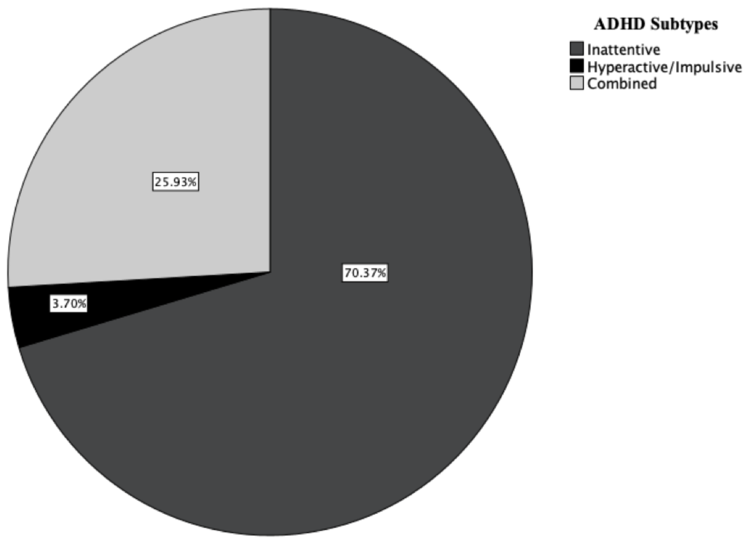

Figure 3. Distribution of ADHD Subtypes Among Participants

The Table 9 indicates the T-DSM-IV-S scores of children diagnosed with ADHD, and the median, mean, standard deviation and minimum-maximum values for its sub-dimensions. The data reflect group-specific descriptive statistics.

Table 9. Mean, standard deviation, and range values of the T-DSM-IV-S for the ADHD group

Variable	Median (Min–Max)	Mean ± SD
Inattention Score (IA)	16.00 (11.00–25.00)	16.74 ± 3.35
Inattention Criterion Score	6.00 (2.00–9.00)	6.40 ± 1.25
Hyperactivity/Impulsivity Score (IB)	12.00 (4.00–25.00)	12.40 ± 6.07
Hyperactivity/Impulsivity Criterion	4.00 (0.00–9.00)	3.66 ± 2.88
Combined (IA+IB) Score	30.00 (16.00–47.00)	29.15 ± 7.96
Combined (IA+IB) Criterion Score	10.00 (6.00–17.00)	10.07 ± 3.21

Table 9. Mean, standard deviation, and range values of the T-DSM-IV-S for the ADHD group (continued)

ODD Score	9.00 (.00-12.00)	7.29 ± 3.60
ODD Criterion	2.00 (.00-3.00)	1.62 ± 1.21
CD Score	.00 (.00-5.00)	1.03 ± 1.37
CD Criterion	.00 (.00-1.00)	.07 ± .26
Total T-DSM-IV-S Score	40.00 (18.00–62.00)	37.89 ± 11.58

ADHD: Attention Deficit Hyperactivity Disorder, T-DSM-IV-S: Turgay DSM-IV Disruptive Behavior Disorders Rating Scale, ODD: Oppositional Defiant Behaviors, CD: Conduct Disorder

The ODD and CD subscales of the Turgay DSM-IV-Based Disruptive Behavior Disorders Screening and Rating Scale (i.e., Conduct Problems and Oppositional Defiant Behaviors) were not included in the analysis, since no comorbid psychiatric diagnoses were present in the ADHD group. The ODD and CD scores were included descriptively to show the absence of comorbid diagnoses. These variables were not used in further statistical analyses**.**

Table 10. Descriptive statistics for Go/No-Go task and RMET performance in the ADHD group

Variable	**Median (Min–Max)**	**Mean ± SD**
Commission Error	0.47 (0.05–0.97)	0.46 ± 0.25
Omission Error	0.10 (0.00–0.45)	0.13 ± 0.13
Reaction Time (ms)	622.00 (347.12–1053.43)	626.92 ± 198.28
RMET Total Correct Score	15.00 (2.00–23.00)	14.63 ± 4.79

RMET: Reading the Mind in the Eyes Test

4.3. Comparison of Test Scores Between ADHD and Control Groups

In this section, the performances of the ADHD and control groups regarding empathy (RMET) and attention skills (Go/No-Go test) were compared. The RMET and Go/No-Go scores of the ADHD subtypes were also compared. In addition, the T-DSM-mbetween the groups. Independent sample t-test was used for variables with normal distribution, and Mann-Whitney U test was used for variables without normal distribution.

4.3.1. Independent t-Test and Mann-Whitney U Results

Table 11. Comparison of T-DSM-IV-S Scores Between ADHD and Control Groups

Variable	**ADHD Group Median (Min–Max)**	**Control Group Median (Min–Max)**	**u**	**z**	**p-value**
IA Score	16.00 (11.00-25.00)	3.50 (0.00-11.00)	1.000	-6.241	**<.001**
IB Score	12.00 (4.00-25.00)	3.00 (0.00-12.00)	66.000	-5.084	**<.001**
Combined Score (IA+IB)	30.00 (16.00-47.00)	5.50 (1.00-19.00)	9.000	-6.091	**<.001**
Total T-DSM-IV-S Score	40.00 (18.00-62.00)	10.50 (1.00-35.00)	29.500	-5.723	**<.001**

* *Mann Whitney U test*
* *p<.05*
* *IA: Inattention, IB: Hyperactivity/Impulsivity*

As a result of the analyses presented in Table 11, significant differences were found between the T-DSM-IV-S scores of the ADHD and control groups. According to the Mann-Whitney U analysis; it was shown that the ‘inattention scores’ in the ADHD groups (M = 16.00) were significantly higher compared to the control group (M = 3.50) (z = -6.241, p < .001). Similarly, hyperactivity/impulsivity scores were significantly higher in the ADHD group (M = 12.00) than in the control group (M = 3.00) (z = -5.084, p < .001).

In addition to that, a significant difference was also found between the groups in terms of total symptom score (IA + IB): in the ADHD group (M = 30.00) and in the control group (Median = 5.50) (z = -6.091, p < .001). Finally, in terms of total T-DSM-IV-S score, the scores of the ADHD group (M= 40.00) were significantly higher than those of the control group (M=10.50) (z = -5.723, p < .001).

Table 12. Comparison of Go/No-go Scores Between ADHD and Control Groups

Variable	ADHD Group (Median [Min–Max] / Mean±SD)	Control Group (Median [Min–Max] /Mean±SD)	df/ U	t/z	p-value
Commission Error	0.46 ± 0.25	0.42 ± 0.23	50.928	-.667	.578
Omission Error	0.10 (0.00- 0.45)	0.01 (0.00-0.25)	200.500	**-2.701**	**< .007***
Reaction Time (ms)	622.00 (347.12-1053.43)	540.85 (385.11- 972.36)	294.000	-1.014	.311

** Mann Whitney U test, independent sample t-test*
** z values reported for Mann- Whitney U test and t values for t-test*
** p<.05*

When the performances of the ADHD and control groups in the Go/No-Go test were compared (presented in Table 12), a statistically significant difference was found between the groups in terms of omission error rates, with the subject group had higher omission error (z= -2.701, p = .007). The Mann-Whitney U test for reaction time did not show a significant difference (z= -1.014, p = .311). Since the commission error variable showed a normal distribution, an independent sample t-test was applied and no significant difference was observed between the groups (t= -.667, p = .578).

Table 13. Comparison of RMET Scores Between ADHD and Control Groups

Variable	ADHD Group Median (Min–Max)	Control Group Median (Min–Max)	u	z value	p-value
RMET Total Correct Scores	15.00 (2.00-23.00)	20.00 (7.00-24.00)	158.000	**-3.446**	**<.001**

** Mann Whitney U test*
** RMET: Reading the Mind in the Eyes Test*

When the Reading the Mind in the Eyes Test (RMET) scores were compared between children diagnosed with ADHD and the control group (Table 13), a statistically significant difference was found between the groups (z = -3.446, p < .001). The RMET scores of the control group (M = 19.00) were significantly higher than those of the ADHD group (M = 15.00).

Table 14. Comparison of Go/No-Go Task and RMET Scores Between ADHD Subtypes

Variable	Inattentive Predominant Type (Median [Min–Max] / Mean±SD)	Combined Type (Median [Min–Max] / Mean±SD)	df/U	t/z	p value
Commission Error	0.48 ± 0.24	0.38 ± 0.24	10.441	.988	.867
Omission Error	0.10 (0.00–0.45)	0.15 (0.00–0.39)	63.000	-.203	.839
Reaction Time	614.12 (347.12–1053.43)	642.68 (419.50–823.26)	65.000	-.087	.931
RMET Total Score	15.00 (8.00–22.00)	19.00 (2.00–23.00)	46.500	-1.164	.245

** Mann Whitney U test, independent t-test*
** z values reported for Mann- Whitney U test and t values for t-test*
** p<.05*

Since RMET score, Reaction Time, and Omission Error variables did not show normal distribution, they are presented as median (minimum–maximum) in Table 14. Commission Error is presented as mean ± standard deviation (Mean±SD) due to normal distribution. As seen in Table 14, RMET scores, omission error rates and reaction time values were compared according to ADHD subtypes using the Mann Whitney U test; commission error rates were compared using the independent t- test. As a result of the analyses, no statistically significant difference was found between the subtypes (p> .05).

4.3.2. Correlation Analysis

The relationship between Reading the Mind in the Eyes Test (RMET) scores and Turgay Scale scores was examined using the Spearman rank correlation coefficient in Table 15. A significant and negative correlation was found between RMET and inattention (IA) scores (r = –.360, p = .008). In addition, a significant negative correlation was found between RMET total correct scores and Combined Score (r=-.367, p= .007). There was signigicant negative correlation between RMET and Total T-DSM-IV-S Score (r=-.338, p= .013).

Table 15. Correlation Between RMET Scores and T-DSM-IV-S Subscale Scores

Variable	**Spearman's ρ (r)**	**p value**
Inattention Score (IA)	-0.360**	**.008**
Hyperactivity/Impulsivity Score (IB)	-0.271	.050
Combined (IA+IB) Score	-0.367**	**.007**
Total T-DSM-IV-S Score	-0.338*	**.013**

*** Correlation is significant at the 0.01 level*

** Correlation is significant at the 0.05 level*

The relationship between the Go/No-Go test variables and the correct scores of the RMET measuring empathy skills was evaluated using the Spearman correlation coefficient. As a result of the analysis, a negative and statistically significant relationship was found between the RMET and the omission errors (r=-0.434, p< .001). No significant relationship was found between the RMET score and commission error (p= .115). Furthermore, no significant relationship was found between RMET score and reaction time (ms) (p= .038). Presented in Table 16.

Table 16. Correlation Between RMET Scores and Go/No-Go Scores

Variable	**Spearman's ρ (r)**	**p value**
Commission Error	-0.183	.189
Omission Error	-0.493**	**<.001**
Reaction Time (ms)	-0.234	.092

*** correlation is significant at the 0.01 level*

4.3.3. Regression Analysis

Table 17. Regression Analysis Predicting Empathy (RMET) Scores from Go/No-Go Variables

Predictor Variable	**R^2**	**β (Beta)**	**t**	**p**
Omission Error	.188	-0.434	-3.440	**.001**
Commission Error	.048	-0.219	-1.604	.115
Reaction Time (ms)	.082	-0.286	-2.134	**.038**

** Dependent variable: Reading the Mind in the Eyes Test (RMET) total correct score.*
** $p < .05$*

The simple linear regression analysis indicated that there is a significant relationship between omission error rate and RMET scores (R^2 = .188, β = -0.434, t = -3.440, p = .001). The regression analysis testing the relationship between commission error rate and RMET scores did not indicate any significant results (R^2 = .048, β = -0.219, t = -1.604, p = .115). Moreover, the regression analysis examining the relationship between reaction time and empathy levels yielded a significant result (R^2 = .082, β = -0.286, t = -2.134, p = .038) presented in Table 17.

Table 18. Regression Analysis Predicting Empathy (RMET) Scores from T-DSM-IV-S Subscale Criterion

Predictor Variable	**R^2**	**β (Beta)**	**t**	**p**
Inattention Criterion (IA)	.163	-0.404	-3.154	**.003***
Hyperactivity/Impulsivity Criterion (IB)	.035	-0.187	-1.358	.180
Combined (IA+IB) Criterion	.122	-0.349	-2.662	**.010***

* *Dependent variable: Reading the Mind in the Eyes Test (RMET) total score*
* *p < .05*

Simple linear regression analyses were conducted to examine the extent to which empathy levels measured using the RMET could be predicted by ADHD symptom criteria based on T-DSM-IV-S. The Inattention Criterion (IA) subscale contributed significantly to the model (R^2 = .163, β = -0.404, t = -3.154, p = .003). Similarly, the Combined Criterion which is both IA and IB criterion subscale was also able to significantly predict empathy scores (R^2 = .122, β = -0.349, t = -2.662, p = .010). Yet, it was found that the Hyperactivity/Impulsivity Criterion subscale (IB) did not significantly predict empathy levels (p = .180) presented in Table 18.

Table 19. Regression Analysis Predicting Empathy (RMET) Scores from T-DSM-IV-S Subscale Scores

Predictor Variable	R^2	**β (Beta)**	**t**	**p**
Inattention Score (IA)	.132	-0.364	-2.787	**.007***
Hyperactivity/Impulsivity Score (IB)	.064	-0.252	-1.861	.068
Combined (IA+IB) Score	.111	-0.333	-2.525	**.015***
Total T-DSM-IV-S Score	.096	-.337	-2.555	**.014***

**Dependent variable: Reading the Mind in the Eyes Test (RMET) total score*
** $p < .05$*

Simple linear regression analysis was conducted to examine the extent to which RMET scores could be predicted by total and subscale scores gathered from the T-DSM-IV-S scale. According to the analysis results, Inattention Score (IA) was able to significantly predict RMET scores ($R^2 = .132$, β = -0.364, t = -2.787, p = .007). Combined Score (IA + IB) ($R^2 = .111$, β = -0.333, t = -2.525, p = .015) and Total T-DSM-IV-S Score also significantly negatively predicted empathy ($R^2 = .096$, β = -0.337, t = -2.555, p = .014) respectively. Nevertheless, Hyperactivity/Impulsivity Score (IB) was not a statistically significant predictor (p = .068).

4.4. Effect of Demographic Variables on Test Scores

The impacts of demographic features of the participants on cognitive performance measurements which are total RMET score, commission error, omission error and reaction time of Go/No-Go test were analyzed. In the analysis, Mann-Whitney U test was utilized for variables with binary categories, and Kruskal-Wallis test was applied for more than two categorical variables. Since test scores and scale did not display normal distribution, non-parametric tests were preferred.

According to the analysis results, no statistically significant difference was found in terms of test scores in demographic variables such as education level, economic level, psychiatric background of family, family type and marital status of children (p> .05). In addition, since the father's employment status was collected in a single variable for the entire sample (n=53), analysis was not performed.

Tablo 20. Comparison of RMET and Go/No-Go Test Scores by Gender

	Variable		Median (Min-Max)	t/z	df/U	p value
Gender	RMET Total Score	Boy Girl	17.00 (2.00-24.00) 20.00 (12.00-23.00)	-1.463	189.500	.144
	Omission Error	Boy Girl	0.07 (.00- .39) 0.01 (.00- .45)	**-.2.221**	153.500	**.26**
	Commission Error	Boy Girl	.46 ± 0.24 0.37 ± 0.22	1.142	51	.259
	Reaction Time (ms)	Boy Girl	581.18 (361.71- 1053.43) 545.07 (347.12-869.26)	-.269	247.000	.788

***** Mann Whitney U test, independent t-test***
***** z values reported for Mann- Whitney U test and t values for t-test***
***** p<.05***
***** Total number of participants — Boy: 40, Girl: 13***

According to the Mann-Whitney U test result, a statistically significant difference was found in the omission error rates between boy and girl participants (z= -2.221, p = .026). Yet, no significant difference was observed in terms of total RMET score and average reaction time (ms) (p > .05). According to the Independent t-test, no significicat differences was found in terms of gender and comission error (t= 1.142, p= .259).

Table 21. Comparison of RMET and Go/No-Go Test Scores by Mother's Employment Status

	Variable		Median (Min–Max)	t/z	df/u	p value
Mother's Employment Status	RMET Total Score	Working Not Working	18.00 (2.00-24.00) 17.50 (7.00-23.00)	-.369	316.000	.712
	Omission Error	Working Not Working	.06 (.00- .45) .04 (.00- .25)	-.231	323.000	.817
	*Commission Error	Working Not working	0.42 ± 0.24 0.46 ± 0.25	-.524	50	.603
	Reaction Time (ms)	Working Not Working	609.49 (418.94- 968.27) 540.40 (347.12- 1053.43)	-1.267	267.000	.205

**** Mann Whitney U test, Independent t-test***
**** z values reported for Mann- Whitney U test and t values for t-test***
**** p<.05***

**** Total number of participants — Working: 24, Not Working: 28***

According to the Mann-Whitney U test analysis, no significant difference was found in terms of total RMET score, omission error, commission error and average reaction time (ms) according to the mother's working or unemployed status (p> .05).

Table 22. Comparison of RMET and Go/No-Go Test Scores by Economic Status

Variable			Median (Min- Max)	t/z	df/u	p value
Economic Status	RMET Total Score	Good	18.00 (2.00-23.00)	-.162	336.000	.871
		Medium	18.00 (7.00-24.00)			
	Omission Error	Good	0.04 (.00-.45)	--.217	333.000	.828
		Medium	0.05 (.00-.39)			
	Commission Error	Good	0.47 ± 0.18	.931	49.915	.330
		Medium	0.41 ± 0.28			
	Reaction Time (ms)	Good	611.87 (347.12- 1026.79)	- .305	328.000	.760
		Medium	543.65 (361.71- 1053.43)			

**** Mann Whitney U test, Independent t-test***
**** z values reported for Mann- Whitney U test and t values for t-test***
**** p<.05***

**** Total number of participants — Good: 23, Medium: 30***

According to independent t-test, no significant diferences was found in terms of economic status and commission error (t= .931, p= .330). According to the Mann-Whitney U test analysis, no significant difference was found in terms of total RMET score, omission error and average reaction time (ms) according to the family's economic status (p> .05).

Table 23. Comparison of RMET and Go/No-Go Test Scores by Psychiatric Family History

	Variable		Median (Min- Max)	t/Z	df/U	p value
Psychiatric Family History	RMET Total Score	Yes No	17.00 (10.00-21.00) 18.00 (2.00-24.00)	-.479	124.000	.632
	Omission Error	Yes No	.01 (.00-.21) .05 (.00- .45)	-1.331	94.000	.183
	Commission Error	Yes No	0.42 ± 0.22 0.44 ± 0.24	.179	51	.858
	Reaction Time (ms)	Yes No	465.08 (385.11-968.27) 587.30 (347.12- 1053.43)	-.505	123.000	.613

**** Mann Whitney U test, Independent t-test***
**** z values reported for Mann- Whitney U test and t values for t-test***
**** p<.05***

**** Total number of participants — Yes: 6, No: 47***

According to the Mann-Whitney U test analysis, no significant difference was found in terms of total RMET score, omission error, commission error and average reaction time (ms) according to the psychiatric family history (p> .05).

Table 24. Comparison of RMET and Go/No-Go Test Scores by Only Child Status

	Variable		Median (Min- Max)	t/Z	df/U	p value
Only Child Status	RMET Total Score	Yes	17.00 (2.00-22.00)	-.479	194.000	.632
		No	18.00 (7.00-24.00)			
	Omission Error	Yes	.10 (.00-.31)	-.378	198.500	.705
		No	.04 (.00-.45)			
	Commission Error	Yes	0.59 ± 0.24	2.290	51	.026
		No	0.40 ± 0.23			
	Reaction Time (ms)	Yes	609.51 (361.71- 823. 26)	-.159	208.000	.974
		No	552.35 (347.12- 706.31)			

**** Mann Whitney U test, Independent t-test***
**** z values reported for Mann- Whitney U test and t values for t-test***
**** p<.05***

**** Total number of participants — Yes: 10, No: 43***

According to the Mann-Whitney U test, a statistically significant difference was found in commission error rates between only child status (z= -2.072, p = .038). However, no significant difference was observed in terms of total RMET score, omission error rate and reaction time (p > .05).

Table 25. Comparison of RMET and Go/No-Go Test Scores by Mother's Educational Level

Variable			Median (Min–Max)	H (p)
Mother's Educational Level	RMET Total Score	Primary School	16.00 (7.00- 19.00)	2.550 (.466)
		High School	4.14 (10.00- 24.00)	
		University	18.00 (8.00- 23.00)	
		Postgraduate	19.00 (2.00- 22.00)	
	Omission Error	Primary School	0.21 (.01-.39)	**7.904 (.048)**
		High School	0.03 (.00- .25)	
		University	0.03 (.00- .29)	
		Postgraduate	0.16 (.00-45)	
	Commission Error	Primary School	0.48 ± 0.25	3.884 (.274)
		High School	0.52± 0.26	
		University	0.38± 0.23	
		Postgraduate	0.50± 0.19	
	Reaction Time (ms)	Primary School	491.09 (419.50- 972.36)	.885 (.829)
		High School	540.85 (347.12- 869.26)	
		University	587.39 (385.11- 1053.43)	
		Postgraduate	611.90 (428.81- 696.90)	

**Kruskal-Wallis H Test*

According to the Kruskal-Wallis H Test, omission error values indicated a significant difference according to the mother's education level (H= 7.904, p = .048). No significant difference was found in terms of total RMET score, commission error and average reaction time (ms) ($p > .05$).

Table 26. Comparison of RMET and Go/No-Go Test Scores by Age and Number of Siblings

		Spearman's ρ (r)	p value
Age	RMET Skoru	.233	.093
	Commission Error	-.010	.786
	Omission Error	-.176	.209
	Reaction Time	-.359**	**.008**
Number of Siblings	RMET Skoru	.020	.889
	Commission Error	-.093	.268
	Omission Error	-.160	.506
	Reaction Time	-.099	.889

** Correlation is significant at the 0.01 level (2-tailed)*
** Spearman Correlation*

Spearman rank correlation analysis was applied to examine the correlation between age and number of siblings of the participants with total RMET scores and Go/No-Go scores. As a result of the analysis, a statistically significant and negative relationship was found between age and average reaction time (ms) ($r = -.359$, $p = .008$). However, no significant relationship was found between age and RMET score, commission error and omission error ($p > .05$). There was also no significant correlation between the number of siblings and RMET score and attention performance on the Go/No-Go test (commission error, omission error and reaction time) ($p > .05$).

5.DISCUSSION

The aim of the study was to investigate the relationship between the attention skills and empathy levels of children diagnosed with ADHD. In addition, it was examined whether the attention and empathy performances of children diagnosed with ADHD differed compared to the control group. Furthermore, the role of socio-demographic variables in the ADHD and control groups on cognitive performance was also evaluated. Within the scope of the study, the attention performances of the groups were measured with the Go/No-Go test. Cognitive empathy levels were measured using the Reading the Mind in the Eyes Test (RMET). The T-DSM-IV-S scale was filled out by the parents and ADHD indicators and subtypes were evaluated. When the findings were examined, it was indicated that the ADHD group showed significant differences in attention performances and cognitive empathy levels, especially with attention deficit symptoms, compared to the control group.

The sample of this study consists of children between the ages of 7-12 and because of that the age variable represents a limited range. Therefore, the average age in the study is expected to be low. Salari et al. (2023) state that the prevalence of ADHD is higher especially in childhood (3-12 years) than in adolescence. Various research and meta-analysis studies report that ADHD and symptoms are more common at a young age (Erskine et al., 2013; Faraone et al., 2006; Mohammadi et al., 2019). From this perspective, the age range of our study corresponds to a periodic distribution that is both important in terms of the probability of ADHD diagnosis and in line with the literature. When the study was evaluated in terms of gender distribution, it was found that the proportion of boys in the ADHD group was higher than in the control group, yet the difference was not found to be statistically significant. When the gender distribution of both groups examined, of the 27 children in the ADHD group, 23 were boys (85.2%) and 4 were girls (14.8%), while of the 26 children in the control group, 17 were boys (65.4%) and 9 were girls (34.6%). Similarly, Günay Ay and Kılıç (2019b) studied the associated factors in adolescents diagnosed with ADHD and found no difference between the groups in terms of age and gender. Lee et al. (2021) examined the differences in empathy in ADHD groups and stated that no significant result was found in terms of gender and age. Despite this, the finding is consistent with studies in the literature that ADHD is more common in boys than in girls (Polanczyk and Rohde, 2007; Ayano et al., 2023; Willcut, 2012). Ayano et al. stated in a 2023 meta-analysis based on gender that the prevalence of Attention Deficit Hyperactivity Disorder was twice as high in boys (10%) as in girls (5%). According to Willcutt's (2012) meta-analysis, ADHD and its diagnosis in children are approximately 2-3 times more common in boys than in girls. The findings support that there were more boys than girls in the ADHD group in our study. Furthermore, no difference was found between the groups in terms of marital status and economic status of the parents in the study. Günay Ay and Kılıç (2019) emphasized that differences in terms of socioeconomic level were among the limitations of the study and emphasized that in future studies, having similar groups in terms of socioeconomic level would increase the power of the study and the interpretability of the results obtained. Based on this aspect, in our study, it was thought that similarity in terms of economic level could positively affect the power of the study. The groups were found to be similar in terms of parents' education levels and employment status. No statistically significant difference was found between the groups in terms of family type. Studies on this subject in the literature are quite limited. In addition, no statistically significant difference was found between the groups in variables such as only child and number of siblings. Similarly, Kılıçel (2021) did not find a significant difference between the ADHD and control groups in terms of age, gender, number of siblings and family structure. Lee et al. (2021) and Maoz et al. (2017) also found no difference in demographic characteristics, such as gender, between the two groups in their study. In addition, no difference was found between the groups in terms of family psychiatric history. This finding is not consistent with the knowledge that ADHD has a high genetic heredity (Balogh et al. 2022; Thapar et al. 2011; Faraone et al., 2005). In addition, Günay Ay and Kılıç (2019b) reported that psychiatric family history and divorce rate were statistically significantly higher in families in the ADHD group. The reasons for this result may be the limited sample in the study and the family's unawareness or failure to report psychiatric history, especially ADHD. Overall, these results indicate that both the control and ADHD groups have a homogeneous structure in terms of basic sociodemographic variables. It is also emphasized in the literature that the relationships between sociodemographic factors and ADHD are not clear and that contradictory findings have been reported (Polanczyk and Jensen 2008). It is also stated that demographic characteristics may alter depending on factors such as sample type, measurement methods and cultural context.

In this study, it was seen that according to the ADHD subtypes, the most common subtype was predominantly inattentive type with 70.37%, followed by Combined Type with 25.93% and Hyperactivity and Impulsivity predominant Type with 3.70%. This distribution is compatible with the literature and most studies on the frequency of ADHD subtypes in childhood (Skounti et al., 2007; Ayano et al., 2023; Willcutt, 2012). In the meta-analysis study conducted by Ayano et al. (2023), it was determined that the most common subtype among the types was ADHD-I. This result also found several studies (Willcut, 2012; Salari et al., 2023)

Both scale and test scores compared between ADHD and control group according to the attention, empathy levels and behavioral symptoms. T-DSM-IV-S scale used in the study to assess ADHD diagnosis and subtypes of ADHD. The subscle of the T-DSM-IV-S also used to examine the inattention and hyperactivity/impulsivity scores of both groups. Attention levels of both groups assessed with the Go/No-Go test. In addition to the paradigm, Inattention (IA) subscale of T-DSM-IV-S taking into consideration to measure attention levels. To measure empathy levels, reading the mind in the eyes test (RMET) is utilized. Initially, both ADHD and control group's scale and test scores examined to see if there are significant distinctions. Moreover, the relationships between attention skills and empathy levels were evaluated with Spearman and Pearon correlation analysis. Last but not least, the predictive impact of attention levels on empathy was tested with regression analysis and the effect of specific demographic variables on performance was also examined separately.

In our research, the inattention (IA), hyperactivity/impulsivity (IB) and total scale scores obtained from the T-DSM-IV-S were found to be significantly higher in the ADHD group compared to the control group ($p<.001$). This finding verifies the power of the scale to distinguish between the ADHD group and the control group that is consistent with previous validity studies (Ercan et al., 2001). In addition, since only pure ADHD diagnosis were included in the study, the oppositional defiant disorder (ODD) and conduct disorder (CD) subscales of T-DSM-IV-S were not included in the analyses. There are numerous studies on empathy in the literature regarding ADHD and its comorbid disorders, especially autism, ODD and CD. Ay and Kılıç (2019) found that emotional and cognitive empathy levels were statistically significantly lower in the ADHD group accompanied by ODD. However, they emphasized that this relationship between ODD and low empathy could be bidirectional and reported that the question of whether oppositional behaviors affect empathy is an issue that needs to be answered in future studies. The inclusion of children diagnosed with ADHD without comorbid diagnosis in our study makes an important contribution to the existing literature.

In this study, cognitive empathy levels in children were assessed using the Reading the Mind in the Eyes Test (RMET). The correct scores of the children's responses were evaluated. RMET results used in the study show that the cognitive empathy levels of children in the ADHD group were significantly lower than the control group ($p<.001$). This result indicates that children diagnosed with ADHD have difficulties in social cognitive processes, especially in cognitive empathy skills. These findings are consistent with the literature (Tatar and Cansız, 2020; Mary et al., 2023; Bora and Pantelis, 2016; Braaten and Rosen, 2000; Maire et al., 2018; Novak et al., 2024; Fantozzi et al., 2023). In particular, the meta-analysis study by Fantozzi et al. (2023) indicated that social cognitive processes are impaired in ADHD and this impairment is related with dysfunctions in various brain regions at the neurodevelopmental level. The weakness in executive functions in children with ADHD can give rise to empathic responses. In the systematic review study conducted by Novak et al. (2024), it was stated that children with ADHD exhibited significant electrophysiological differences in the frontal, parietal and temporal regions during ToM tasks. Mary et. al. (2023) also conducted research and found that the children diagnosed with ADHD performed poorly in correct responses of RMET scores than the healthy control group. In the study it is also stated that in the some of the research suggests that there are some structural and functional differences in brain regions which are the prefrontal cortex, anterior cingulate cortex, temporoparietal junction, and amygdala involved in social cognition in individuals with ADHD. In addition, some studies have observed that individuals with ADHD exhibit lower performance in social cognition tests compared to control groups, and it has been stated that this is due to difficulties in social cognitive processes (Braaten and Rosen, 2000; Maire et al., 2018). Nevertheless, there are few studies that could not find statistical differences between empathy skills in ADHD individuals. Gumustas et. al. (2017) claimed that there were no statistical differences between subject and control group according to facial expression recognition skills.

In this study, when the Go/No-Go performances of the ADHD and control groups were compared, a statistically significant difference was found in terms of omission error which is the response rate of children in the ADHD group to target stimuli was significantly lower (p = .007). Omission errors are much more related with sustained attention since it displays a deficit in stimulus detection (Acosta-López et al., 2021). This finding is in line with existing literature (Metin et al., 2014; Tatar and Cansız, 2020; Dekkers et al., 2017; Baijot et al., 2017; Acosta-López et al., 2021). To give a solid example, in the study by Baijot et al. (2017), the omission error rate was higher in the ADHD group, but no significant difference was found in terms of commission error and reaction time. Similarly, Johnstone and Galetta (2013) reported that children with ADHD had difficulty maintaining their attention continuously and made more omission errors. Metin et al. (2014) acknowledged that ADHD group made more omission errors than control group. On the other hand, no significant difference was found between the groups in terms of commission error and average reaction time. This may have a relation with the fact that the ADHD group mainly consisted of predominantly inattentive or combined subtypes. Some studies such as Johnstone and Galetta (2013), Metin et al. (2024), Hwang et al. (2020) did not observe a significant difference in commission error rates, but some studies (Tatar and Cansız, 2020; Barnard et al., 2015; Epstein et al., 2003) reported that individuals with ADHD make commission errors more frequently. These differences may be related to the structure of the paradigms used in the studies, the level of task difficulty, and sample characteristics. Moreover, no significant difference was found between the groups in terms of reaction time (p = .311). However, some meta-analyses and studies have shown that children with ADHD respond both slower and more variable (Metin et al., 2014; Huang-Pollock et al., 2012). The fact that this finding was not observed in our study may be explained by the limited sample size, the data range used for reaction time, or individual differences. This finding proposes that in samples where attention deficit is prominent in the profile of ADHD, sustained attention processes in particular may be associated with higher-level cognitive functions such as empathy.

In this study, the subtypes of the ADHD group were determined as the predominantly inattentive type being the most common, combined type and lastly predominantly hyperactive/impulsive type. Since the hyperactivity/impulsivity subtype was detected in only one child, only the predominantly inattentive and combined types were evaluated in the t-test/Mann-Whitney tests. When these subtypes were compared, no significant difference was found in terms of Go/No-Go test performance and total RMET scores. The failure to observe distinctions between the subtypes can be described by the limited sample size in the first place and the imbalance between subtypes. In addition, the sensitivity of the tests or the inability of the criteria used to sufficiently differentiate behavioral symptoms based on the subtype may have given rise to this result. This finding particularly displays that the subtype differences mentioned in some literature may not always be clearly observed at the behavioral level. To be more specific, in a comprehensive study conducted by Bezdijan et al. (2019), significant differences in Go/No-Go performance among ADHD subtypes were observed only in girls, while no difference was found among boys. In the study conducted by Şahin et al. (2018), no significant differences were found between ADHD subtypes which are predominantly inattentive and combined subtypes in terms of ToM performances and Groen et al. (2008) also stated in study that the ADHD subtypes did not impact the results. Despite, there are studies examining the association between ADHD subtypes and empathy, empathy levels are observed to be lower in combined type than in the predominantly inattentive subtype (Maoz et al., 2013; Schwenck et al., 2011; Strassner 2006). Yet, the study by Pelc et al. (2006) highlighted that children with predominantly hyperactive/impulsive type made significantly more errors in recognizing emotional facial expressions than control children. Overall, the number of studies comparing empathy skills according to subtypes of ADHD is quite limited and controversial.

In this study, the relationship between total RMET scores and T-DSM-IV-S subscales and scores was examined. According to the Spearman correlation coefficient, a significant negative relationship was found between the inattention (IA) subscale score and total RMET score ($p = .08$). This result indicates that increasing inattention symptoms may be associated with a decrease in children’s cognitive empathy levels. In this study, total scale score and IA (inattention) and IB (hyperactivity/impulsivity) scores also displayed a significant negative correlation with total RMET score. This result indicates that empathy levels may be lower in cases where inattention and hyperactivity/impulsivity symptoms are seen together. However, no significant relationship was found between hyperactivity/impulsivity (IB) scores and RMET. This finding proposes that deficits in cognitive empathy are more related with the inattention subscale. The significant relationship between inattention and empathy is supported by some studies in the literature (Yan et al., 2019; Sinzing et al., 2007; Andrade et al., 2012;

Uekermann et al., 2010; Shin et al., 2008). Yan et al. (2019) conducted the first meta-analysis investigating the relationship between the subcomponents of empathy and executive functions and emphasized that executive functions are linked to cognitive empathy. In particular, they found that the relationship between cognitive empathy and executive function is stronger. Similarly, Sinzing et al. (2007) revealed strong correlations between the recognition of facial and eye expressions and sustained attention. Andrade et al. (2012) stated that inattention may negatively have an impact on the interpretation of social cues which may reduce the quality of empathic responses. Uekermann et al. (2010) reported that attention and executive function disorders negatively affect social cognition processes, especially empathy. The relation between attention and empathy can be explained at a neurobiological level. Goodhew and Edwards (2022) stated a strong relationship between attention control and cognitive empathy in their study. Based on fMRI studies, they stated that the temporo-parietal junction region (TPJ) was activated in tasks that required both attention control and measured cognitive empathy. Morelli and Lieberman (2013) acknowledged in their study based on the findings; attention has an effect on empathic processing and may lead to empathic dysfunction in certain mental disorders.

In this study, total RMET scores were compared with the Go/No-Go test and a statistically significant negative relationship was found in the relationship between omission error rates ($p < .001$). This result reveals that when attention errors increase, children's cognitive empathy levels decrease. Omission error refers to the failure to respond appropriately and in a timely manner to a stimulus and is often associated with attentional maintenance disorders in the literature. Bezdjian (2019) stated that the symptom domains of both attention deficit which display as difficulties in sustaining attention and impulsivity that is related with the having difficulties in inhibitory responding and control are represented in the Go/NoGo paradigm. In this context, the finding in our study shows that there is a significant relationship between cognitive empathy and sustained attention processes. Some previous studies have also emphasized the effect of attention processes on empathy performance (Sinzing et al., 2008; Shin et al., 2008; Uekermann et al., 2010; Cadesky et al., 2000). For example, Shin et al. (2008) stated that deteriorations in children's ability to recognize facial expressions are due to inattention and impulsivity rather than misinterpretation of social cues. Similarly, Sinzig et al. (2007) found strong correlations between the number of errors and correct answers in the attention and inhibition tasks related to recognizing facial and eye expressions. In addition, Cadesky et al. (2000) reported that children with ADHD tend to have struggled to efficiently capture and process cues related to social situations. This study proposes that the weakness in social cognitive skills in ADHD may stem not only from interpretation but also from more basic cognitive processes such as directing attention to stimuli. Therefore, impairments in attention processes can be considered as a determining component of the level of empathy. In addition, this relationship between omission error and RMET supports the effect of attention deficit symptoms on empathy performance not only at the scale level but also at the neuropsychological test level. Increased attention errors may make it difficult for children to focus on social stimuli in a timely manner and to infer mental states from these stimuli. fMRI studies show that brain regions that are activated in empathic processes overlap with regions involved in attentional processes. For instance, the TPJ is a common region that is activated in both attentional orientation and cognitive empathy processes (Corbetta et al., 2008; Schuwerk et al., 2017). Pessoa et al. (2002) showed that brain responses to emotional stimuli only occur under conditions of attention, and that areas such as the amygdala, orbitofrontal cortex, and anterior cingulate respond to emotional expressions only when attention is active. Despite that, no significant relationship was found between RMET scores and commission error and reaction time. This may have been found since commission error is more related to impulsivity and the predominantly hyperactivity/impulsivity subtype was found in only one child in the study. When all these findings are evaluated together, empathy should be considered as a multidimensional process that is not limited to emotional sensitivity but is shaped by the active participation of cognitive control, attention, and executive functions.

A linear regression analysis was used to indicate that the omission error rate obtained from the Go/No-Go test was a significant variable in predicting the level of cognitive empathy ($p = .001$). This result displays that as the attentional errors increase, children’s RMET performances decrease. It indicates that performances of cognitive empathy (RMET) have a relation to cognitive functions such as sustained attention in addition to social processes. Similar types of findings have been stated in the existing literature that inattention is may a determinant of the empathy levels (Goodhew and Edwards, 2022; Yan et al., 2019; Choi and Watanuki, 2014). Pessoa et al. (2002) conducted fMRI studies aiming to allocate brain responses to emotional facial expressions, and the findings revealed that the amygdala cingulate cortex, insula, nucleus accumbens, fusiform gyrus, and orbitofrontal cortex were activated only in response to emotional expression in attended faces. In this context, when examining the relationship between attention and empathy, it can be emphasized that the accurate perception and interpretation of emotional facial expressions is associated with effective empathic responses, and this is possible with the active participation of attention. Decety (2008) also states that emotional awareness alone is not sufficient for the healthy functioning of empathy processes; cognitive processes such as attention also actively contribute to this functioning. Likewise, Shin et al. (2008) and Uekermann et al. (2010) also reported that attention functions have a significant effect on social cognition. On the other hand, no significant relationship was found between commission error rate and RMET scores ($p = .115$). This situation shows that in our study; impulsivity level does not have a direct effect on cognitive empathy skills. Similarly, it is stated in the literature that measures reflecting impulsivity such as commission error do not show a direct connection with empathy (Bezdijan et al., 2009; Uekermann et al., 2010). A weak yet significant relationship was found between RMET total correct scores and average reaction time (ms) ($p = .038$). This finding proposes that increased information processing time may negatively impact on the ability to correctly recognize social cues.

In another regression analysis of the study, the predictability of empathy levels of children diagnosed with ADHD based on T-DSM-IV-S was examined. It was examined that children who met only the inattention (IA) criterion had significantly lower RMET total correct scores ($p = .003$). The scale's criterion of IA is only valid for ADHD group, yet in study, we also found that the regression analyses revealed that inattention (IA) scores significantly predicted RMET total correct scores ($p = .007$). As explained before, there is numerous research focused on ADHD and empathy relations and found statistical significant results. Mary et al. (2016) showed in their study that children with ADHD exhibited low performance in theory of mind tasks such as RMET and this performance gradually altered in a good way when attention deficit of children was controlled. This finding proposes that deficiencies in empathy skills especially cognitive empathy in this study may stem from the impairments of cognitive processes such as attention. Impairments in cognitive processes, specifically attention deficit may negatively affect cognitive empathy in particular. For instance, individuals with attention deficits may have difficulty focusing on the emotional expressions of others and their empathic responses may stay on the surface (Marton et al., 2009). Similarly, it was found that RMET scores were significantly lower for children who met both inattention and hyperactivity/impulsivity criteria (p = .010) and sum of IA and IB scores, and the total T-DSM-IV-S were negative predictors of empathy levels. In contrast, no significant relationship was found with empathy levels in children who met only the hyperactivity/impulsivity (IB) criterion, and the hyperactivity/impulsivity (IB) subscale was not a significant predictor (p = .068). These results show that cognitive empathy level is more closely related to ADHD, especially the inattention symptom cluster, and suggest that impulsivity symptoms do not have a direct effect on empathy. However, since the hyperactivity/impulsivity type was less prominent in the sample, this may have affected these findings. For this reason, conducting a study where the ADHD-H type of ADHD is also more prevalent may affect the results differently. In addition, this analysis reveals that low empathy skills are associated not only with symptom severity but also with clinical variables such as meeting diagnostic criteria.

When the impacts of demographic features on empathy and attention test performance were investigated, several significant findings were obtained. Initially, a negative statistically significant relationship was found between average reaction time (ms) and age of the participants. This result proposes that attentional processes may develop and progress with age. Klotz et al. (2012) found that reaction times improved with increasing age in children diagnosed with ADHD, and this result is consistent with our study. In addition, a significant difference was found between mother education level and omission error. This finding suggests that maternal education status may have indirect impacts on children's attention skills. It is possible that mothers with higher education levels provide environmental conditions that support their children's attention development. When previous studies were examined, it was observed that the resources were very limited in terms of the direct relationship between maternal education level and attention performance in children. For this reason, it is thought that this result in the study will contribute to the literature in this respect. However, when general studies were examined, it was found that symptoms of oppositional defiance and attention deficit in children were associated with the quality of life of mothers (Chen et al., 2014). A significant difference was found between gender and omission error (p=.026). The omission error that boys did in the test was much higher than girls in the study. This result may be explained by the small number of girls in the study. This result may have been found because there were fewer girls in both groups. However, the gender difference is still consistent with the literature. It has been reported that attention and attention-related processes are more common in boys, especially in children diagnosed with ADHD, and therefore, boys make more errors than girls in tasks requiring attention processes (Willcut, 2012; Mahone et al., 2011). In addition, a significant difference was found between being an only child and commission error rates ($p = .038$). This suggests that only children may experience a different level of cognitive load or social stimuli in attention-impulsivity processes compared to those with siblings. However, further research is needed on the causality of these differences.

This study examined the relationship between attention skills and cognitive empathy levels in children diagnosed with ADHD using scale-based and neuropsychological tests. Therefore, the study has a holistic approach and strengths. In the study, the use of both psychometric, T-DSM-IV-S and RMET, and behavioral Go/no-Go test tools together allowed the evaluation of children's performances from different perspectives. In addition, unlike many studies, our study included children diagnosed with pure ADHD and did not include comorbid disorders which contributed to the evaluation of the relationship between empathy and attention specific to ADHD and minimize the impact of confounding variables. Our study did not consider empathy as a general social skill. Instead, it aimed to fill an important gap in the literature by examining it specifically at the level of cognitive empathy. Using a test which is RMET directly assesses cognitive empathy, enhances the conceptual lucidity of the study. Our study focused on children between the ages of 7 and 12, which allowed us to examine a critical and important stage during which both social cognition skills and attention functions are actively developing.

Some limitations should be taken into consideration in interpreting the findings of the study. Our study has a small and limited sample size (n=53). This situation also causes a lack of diversity among additional ADHD subtypes, which may have reduced statistical power. The research is cross-sectional in nature. In this case, the relationships between variables should be interpreted only at a correlational level and not within a cause-effect framework. Children's empathy skills were assessed only using the RMET, and this test does not include emotional empathy. Measuring empathy which is a multidimensional concept with only a single test may have narrowed the scope of the measurement. Attention is a multidimensional process and although the Go/no-Go test is an effective test in assessing attention processes, it is not sufficient to fully assess all attention functions.

6. CONCLUSIONS AND RECOMMENDATION

This study was conducted to examine the relationship between attention abilities and cognitive empathy in children diagnosed with ADHD. In the study, children's attention performance was measured with the Go/No-Go test. Cognitive empathy levels were measured by applying the Reading the Mind in the Eyes Test. In addition, the T-DSM-IV-S scale and the Socio-demographic form were given to the parents of the participants.

When the results of the study were evaluated, significant differences were found between the T-DSM-IV-S scores (IA, IB, Total Scale Score) of the ADHD and control groups. Furthermore, it was found that the cognitive empathy levels of children diagnosed with ADHD were statistically significantly lower compared to the control group. In addition, it was observed that the omission errors in the Go/no-Go test of the ADHD group were higher compared to the control group. These findings propose that the difficulties experienced by children diagnosed with ADHD in cognitive empathy abilities may be associated with the impairments in attention processes.

When the correlation analysis results were examined; a significant negative correlation was found between RMET and inattention (IA) scores. There was also a significant and negative correlation found between RMET total correct scores and combined (both IA and IB) and total scale score. In addition, a negative statistically significant relationship was found between the RMET total correct score and the omission error.

When regression analyses were examined, it was shown that attention deficit symptoms and criterion (IA) significantly predicted RMET total correct scores. In addition, omission error of Go/No-Go task rates is also found as a significant predictor of empathy levels. A weak but significant relationship was found between average reaction time (ms) and RMET total correct scores. Yet, no significant regression relationship was observed with commission error. Lastly, hyperactivity/impulsivity scores and creation (IB) levels were not predictive of empathy.

In addition, the impacts of demographic variables on attention and empathy processes were also analyzed. It was found that gender and mother’s education level had an impact on omission error. Moreover, it was found that being an only child had a significant effect on commission error and age of the children had a significant impact on average reaction time (ms). These results displayed that attention performance may be associated not only with ADHD symptoms but also with certain environmental and developmental factors.

Taking everything into consideration, the results of this study clearly show that there is a significant relationship between attention skills and cognitive empathy in children with ADHD. Deficiencies in cognitive empathy are associated with the impairments in social functioning skills experienced by children. Therefore, a training and education program specifically targeting attention deficits may have a positive impact on children's cognitive empathy skills and thus contribute positively to the social problems experienced by children. Most of the time, the social functioning area of ADHD particularly leaves unnoticed by parents compared to other visible symptoms. Although scientific research in this area is increasing, providing psychoeducation to families in this area may enable them to recognize the impairment in social functioning earlier and to create more effective clinical intervention programs accordingly.

In future studies, the sample size can be increased, and the generalizability of the findings can be expanded by including different ranges of age groups in the studies. Only cognitive empathy was measured in the study. In future studies, empathy can be addressed in a multi-faceted manner and more comprehensive studies can be conducted that include both cognitive and emotional empathy. Psychometric and neuropsychological tests were used in the study. Yet, in future studies, more neurobiologically based studies can be conducted using neuroimaging techniques such as EEG and fMRI. Although the main purpose of the study was not to compare ADHD subtypes, larger-scale comparative studies conducted according to ADHD subtypes in future studies may reveal more clearly how the relationship between attention and empathy differs at the subtypes of ADHD.

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Appendix 3. Parental Consent Form

VELİ ONAY FORMU

Sizi Üsküdar Üniversitesi Sağlık Bilimleri Fakültesi Nörobilim Bölümü öğretim üyesi Prof. Dr. Barış METİN danışmanlığında yüksek lisans öğrencisi Şeyma Soyal tarafından yürütülecek olan ‘’Dikkat Eksikliği ve Hiperaktivite Bozukluğu tanısı almış çocuklarda dikkat yetenekleri ve empati ilişkisi’’ adlı çalışmaya davet ediyoruz.

Bu çalışmada çocuğunuzla ilgili dikkat süreçleri ve empati yetenekleri nöropsikolojik testler yoluyla değerlendirilecektir. Uygulama yaklaşık 30-35 dakika sürecektir.

Araştırmanın amacı, DEHB tanısı almış çocuklarda dikkat yetenekleri ile empati arasındaki ilişkiyi anlamak ve bu bağlamda daha etkili müdahaleler geliştirmek için bir temel oluşturmaktır.

Araştırma sonucunda çalışmadan elde edilen bulgular ve literatürdeki mevcut bilgiler
ışığında konu ile yapılacak eğitsel ve akademik çalışmalara rehberlik ederek önemli katkılar sağlayacağı düşünülmektedir.

Çalışmada çocuğunuzun psikolojisi olumsuz yönde etkilenecek hiçbir uygulama
bulunmamakta ve kendisine gönüllü olmak kaydı ile çalışmaya katılacağı söylenerek
açıklama yapılacaktır. Çocuğunuzun dolduracağı testlerde cevapları kesinlikle gizli tutulacak ve bu cevaplar sadece bilimsel araştırma amacıyla kullanılacaktır. Bu formu imzaladıktan sonra da çocuğunuz katılımcılıktan ayrılma hakkına sahip olacaktır.

Söz konusu araştırmaya hiçbir baskı ve zorlama olmaksızın çocuğumun bu çalışmaya
katılmasını kabul ediyorum.

İmza:	Açıklamayı yapan kişinin
Adı / Soyadı:	Adı / Soyadı:
Tarih:	İmzası:

Appendix 4. Sociodemographic Information Form

SOSYODEMOGRAFİK BİLGİ FORMU

Tarih:

Formu dolduran kişi: Anne ( ) Baba ( )

Telefon Numarası:

Çocuğun Anne Ad-Soyad:

Doğum Tarihi veya Yaşınız:

Eğitim Durumunuz: İlköğretim ( ) Lise ( ) Üniversite ( ) Lisansüstü/Doktora ( )

Mesleki Durumunuz: Çalışıyor ( ) Ev Hanımı ( ) Emekli ( )

Medeni Durumunuz: Evli ( ) Bekar ( ) Boşanmış ( ) Eşini Kaybetmiş ( )

Çocuğun Baba ad-soyad:

Doğum Tarihi veya Yaşınız:

Eğitim Durumunuz: İlköğretim ( ) Lise ( ) Üniversite ( ) Lisansüstü/Doktora ( )

Mesleki Durumunuz: Çalışıyor ( ) Çalışmıyor ( ) Emekli ( )

Medeni Durumunuz: Evli: ( ) Bekar ( ) Boşanmış ( ) Eşini Kaybetmiş ( )

Kaç çocuğunuz var?

Çocuklarınızın; Adı ve soyadı / Yaşı- Doğum Tarihi / Cinsiyeti / Eğitim Durumu

1.

2.

3.

4.

5.

Aile Tipiniz;

1. 2. 3. Çekirdek aile (anne-baba ve çocuklar)

Geniş aile (anne baba ve çocuklarla birlikte diğer akrabalardan bir yada birkaçı ile birlikte)

Tek ebeveyn olarak (anne/baba boşanmış, anne/baba vefat etmiş: anne ile beraber/ baba ile beraber)

4. Diğer (Açıklayınız: …………………………………………….)

Ailenizin ekonomik durumu sizce nasıl? İyi ( ) Orta ( ) Kötü ( )

Toplam aylık geliriniz: Aylık Gelirim Yok ( ) 15.000'e kadar ( ) 15.001- 30.000 ( ) 30.001- 45.000 ( ) 45.001+ ( )

Ailede ilaç ilaç kullanmayı gerektirecek bilinen bir rahatsızlığı olan var mı? Evet ( ) Hayır ( )

Evet ise belirtiniz:

Ailede psikiyatrik bir tedavi alan birileri var mı? Evet ( ) Hayır ( )

Evet ise belirtiniz:

Çocuğunuzun daha önce ruhsal (psikolojik) sorunları nedeniyle bir kliniğe başvurusu var mı? Var ( ) Yok ( )

Var ise tanısını belirtiniz:

Çocuğunuz daha önce ruhsal (psikolojik) sorunları nedeniyle bir tedavi aldı mı? Evet ( ) Hayır ( )

Evet ise belirtiniz:

Appendix 5. Reading the Mind in the Eyes Test (RMET)

G	Item	A	B	C	D
M	1	jealous	scared	relaxed	hate
F	2	hate	surprised	kind	cross
M	3	unkind	cross	surprised	sad
F	4	friendly	sad	surprised	worried
M	5	relaxed	upset	surprised	excited
F	6	feeling sorry	making somebody do something	joking	relaxed
M	7	hate	unkind	worried	bored
F	8	feeling sorry	bored	interested	joking
M	9	remembering	happy	friendly	angry
F	10	annoyed	hate	surprised	thinking about something
M	11	kind	shy	not believing	sad
F	12	bossy	hoping	angry	disgusted
M	13	confused	joking	sad	serious
F	14	thinking about something	upset	excited	happy
M	15	happy	thinking about something	excited	kind
F	16	not believing	friendly	wanting to play	relaxed
M	17	made up her mind	joking	surprised	bored
F	18	angry	friendly	unkind	a bit worried
M	19	thinking about something	sad	angry	bossy
F	20	angry	daydreaming	sad	interested
M	21	kind	surprise	not pleased	excited
F	22	interested	joking	relaxed	happy
M	23	playful	kind	surprised	thinking about something
F	24	surprised	sure about something	joking	happy
M	25	serious	ashamed	confused	surprised
F	26	shy	guilty	daydreaming	worried
M	27	joking	relaxed	nervous	sorry
F	28	ashamed	excited	not believing	pleased

Appendix 6. Turgay DSM-IV-Based Disruptive Behavior Disorders Rating Scale

Adı – Soyadı: Yaşı:

Cinsiyeti: Tarih: …../…../…..

Belirtilerin süresi: Son Tanı:

Ölçeği yanıtlayan kişinin Yakınlık derecesi:

Questions	0 (Hiç yok)	1 (Biraz)	2 (Oldukça fazla)	3 (Çok fazla)
1. Çoğu zaman dikkatini ayrıntılara veremez ya da okul ödevlerinde, işlerinde ya da diğer etkinliklerinde dikkatsizce hatalar yapar.				
2. Çoğu zaman üzerine aldığı görevlerde ya da yaptığı etkinliklerde dikkati dağılır.				
3. Doğrudan kendisine konuşulduğunda çoğu zaman dinlemiyormuş gibi görünür.				
4. Çoğu zaman emirlere uyamaz ve görevlerini tamamlayamaz.				
5. Görevleri düzenlemekte ve planlamakta zorluk çeker.				
6. Zihinsel çaba gerektiren görevlerden kaçınır ya da sevmez.				
7. Gerekli eşyaları kaybeder (kalem, kitap, ödev vs.).				

8. Dış uyaranlarla dikkati kolayca dağılır.				
9. Günlük etkinliklerinde unutkandır.				
10. Oturduğu yerde kıpırdanıp durur.				
11. Çoğu zaman sınıfta ya da oturması beklenen diğer durumlarda oturduğu yerden kalkar ve dolaşır				
12. Çoğu zaman uygunsuz olan durumlarda koşuşturup durur ya da tırmanır. (ergenlerde sadece kendisinin algıladığı huzursuzluk duyguları olabilir).				
13. Çoğu zaman, sakin bir biçimde, boş zamanları geçirme ya da oyun oynama zorluğu vardır.				
14. Çoğu zaman hareket halindedir ya da bir motor tarafından idare ediliyormuş gibi davranır.				
15. Çoğu zaman çok konuşur				
16. Çoğu zaman soruları soru tamamlanmadan önce cevabını yapıştırır.				
17. Çoğu zaman sırasını bekleme güçlüğü vardır.				
19. Sık sık öfkelenir.				
20. Sık sık büyükleriyle tartışmaya girer.				
21. Büyüklerinin isteklerine ya da kurallarına uymaya çoğu zaman etkin bir biçimde karşı gelir ya da bunları reddeder.				

22. Çoğu zaman, isteyerek, başkalarını kızdıran şeyler yapar.				
23. Kendi yaramazlıkları için çoğu zaman başkalarını suçlar.				
24. Çoğu zaman alıngandır, çabuk darılır ya da başkalarınca kolay kızdırılır.				
25. Çoğu zaman içerlerler, kızgın ve güceniktirler.				
26. Çoğu zaman kincidir ve intikam almak ister.				
27. Çoğu zaman başkalarına kabadayılık eder, gözdağı verir ya da korkutur.				
28. Çoğu zaman kavga-dövüş başlatır.				
29. Başkalarının ciddi bir biçimde fiziksel olarak yaralanmasına neden olacak bir silah kullanmıştır (Örn. bir değnek, taş, kırık şişe, bıçak, tabanca)				
30. İnsanlara karşı fiziksel olarak acımasız davranmıştır.				
31. Hayvanlara karşı fiziksel olarak acımasız davranmıştır.				
33. Birisini cinsel etkinlikte bulunması için zorlamıştır.				
34. Ciddi hasar vermek amacıyla isteyerek yangın çıkarmıştır.				
35. İsteyerek başkalarının malına mülküne zarar vermiştir (yangın çıkarma dışında)				
36. Bir başkasının evine, binasına ya da arabasına zorla				
37. Bir şey elde etmek, bir çıkar sağlamak ya da yükümlülüklerinden				

kaçınmak için çoğu zaman yalan söyler (yani başkalarını "atlatır")				
38. Hiç kimse görmeden değerli şeyler çalmıştır. (örn. kırmadan ve içeri girmeden mağazalardan mal çalma, sahtekârlık)				
39. 13 yaşından önce başlayarak, ailenin yasaklamasına karşın çoğu zaman geceyi dışarıda geçirmiştir.				
40. Ana babasının ya da onların yerini tutan kişilerin evinde yaşarken en az iki geceleyin evden kaçmıştır. (ya da uzun bir süre geri dönmemişse bir kez)				
41. 13 yaşından önce başlayarak, çoğu zaman okuldan kaçmıştır.				