

The Relationship Between Emotion Recognition and The Symptoms of Attention Deficit and Impulsivity in Adult Patients with Attention Deficit Hyperactivity Disorder



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SUMMARY

Purpose: Interpersonal relationship disorders in adults with Attention Deficit Hyperactivity Disorder (ADHD) can be associated with the impairment of non-verbal communication. The purpose of our study was to compare the emotion recognition, facial recognition and neuropsychological assessments of adult ADHD patients with those of healthy controls, and to thus determine the effect of neuropsychological data on the recognition of emotional expressions.

Methods: This study, which was based on a case-control model, was conducted with patients diagnosed with ADHD according to the DSM-IV-TR, being followed and monitored at the adult ADHD clinic of the Psychiatry Department of the Istanbul University Istanbul Medical Faculty Hospital. The study group consisted of 40 adults (27.5% female) between the ages of 20-65 (mean age 25.96±6.07; education level: 15.02±2.34 years) diagnosed with ADHD, and 40 controls who were matched/similar with the study group with respect to age, gender, and education level. In the ADHD group, 14 (35%) of the patients had concomitant diseases. Pictures of Facial Affect, the Benton Face Recognition Test, and the Continuous Performance Test were used to respectively evaluate emotion recognition, facial recognition, and attention deficit and impulsivity of the patients.

Results: It was determined that, in comparison to the control group, the ADHD group made more mistakes in recognizing all types of emotional expressions and neutral expressions. The ADHD group also demonstrated more cognitive mistakes. Facial recognition was similar in both groups. It was determined that impulsivity had a significant effect on facial recognition.

Conclusion: The social relationship disorders observed in ADHD can be affected by emotion recognition processes. In future studies, it may be possible to investigate the effects that early psychopharmacological and psychotherapeutic interventions administered for the main symptoms of ADHD have on the impairment of emotion recognition.

Key Words: Adult ADHD, emotion, neuropsychology, face

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a neuropsychiatric syndrome accompanied by the lack of attention, impulsivity and hyperactivity (American Psychiatric Association, 1994). In a previous study, the prevalence of ADHD among adults was determined to be 4.4% (Kessler et al., 2006), while in another study identified a prevalence of 3.4% for ADHD among adults (Fayyad et al., 2007). In a

previous study conducted in Turkey, the prevalence of ADHD among adults admitted to the general psychiatry outpatient clinic was determined to be 1.6% (Alyanak et al., 2011).

During the development and progression of ADHD from childhood to adulthood, it is generally observed that, in comparison to controls, adults with ADHD display lower levels of performance and success, have fewer friends, display lower performance at work, are less capable of showing psychological

Received: 13.09.2013 - Accepted: 22.07.2014

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doi: 10.5080/u7713

adaptation, are less likely to complete their education by their mid-twenties, and have lower self-confidence and social skills (Mannuzza and Klein, 2000). In a study that evaluated hyperactive children up until adulthood; it was demonstrated that, in comparison to controls, hyperactive individuals lost their jobs more often, had lower occupational performance and efficiency, and had less developed interpersonal relationship skills (Barkley et al., 2006). These social, occupational and relational problems might be associated with the fundamental characteristics of ADHD. It is believed that weak social skills can also be caused by problems related to non-verbal communication, such as the improper use of facial expression, intonation, mimics, and written words (Robertson, 1987). Previous studies have demonstrated that social skill disorders, pervasive developmental disorders, behavioral disorders and mental retardation can all lead to the impairment of facial emotion recognition (Braverman et al., 1989, Rojahn et al., 1995, Stevens et al., 2001). In the past two decades, there has been a rapid increase in the number of studies evaluating the effect of ADHD on facial emotion recognition. The majority of these studies have demonstrated that, in comparison to controls, children with ADHD exhibited a higher frequency of facial emotion recognition disorders (Cadesky et al., 2000, Corbett and Glidden, 2000, Shapiro et al., 1993, Pelc et al., 2006, Sinzig et al., 2008).

Facial emotion recognition disorders associated with ADHD have also been observed among adults (Miller et al., 2011; Rapport et al., 2002); however, the number of studies on adults is more limited than the number of studies on children. A previous study conducted by Miller et al. (2011) used the Diagnostic Analysis of Nonverbal Accuracy (DANVA) assessment tool developed by Nowicki and Duke (1994) to evaluate facial emotion recognition in ADHD patients of the predominantly inattentive subtype (ADHD-PI), in ADHD patients of the combined subtype (ADHD-C), and in healthy controls. The results of this study demonstrated that the ADHD-PI group displayed lower performance than the control group in recognizing fear; however, no significant differences were identified in this respect between the ADHD-PI and the ADHD-C groups (Miller et al., 2011). In another study, 28 adults with ADHD and 28 controls were evaluated with respect to their emotion recognition ability and the emotional violence they encountered. This study was performed by using the DANVA and the tachistoscopic emotion recognition test previously developed by Ekman and Friesen, which involves photographs that illustrate six types of emotional expression (happiness, sadness, anger, disgust, fear and neutral). In both tests, the performance of the ADHD group was observed to be lower than that of the control group (Rapport et al., 2002). In studies on emotion recognition among children and adults with ADHD, it is often observed that the individuals with ADHD make more mistakes

in recognizing expression of fear and anger that are related to threats (Corbett and Glidden, 2000; Singh et al., 1998; Cadesky et al., 2000; Pelc et al., 2006; Rapport et al., 2002; Williams et al., 2008). It was demonstrated that mistakes relating to negative facial expressions (sadness, anger, disgust, fear) were more frequent and significant than mistakes relating to positive facial expressions (happiness) (Rapport et al., 2002; Singh et al., 1998). Studies on individuals with adult ADHD identified no differences between the two groups with respect to facial recognition (Rapport et al., 2002; Kovner et al., 1998; Murphy, 2002).

Although the results of studies performing neuropsychological evaluations on adults with ADHD are controversial and subject to debate, these studies have nevertheless indicated certain disorders. The test that is the most frequently used to support and confirm a diagnosis of ADHD among adults is the continuous performance test (CPT), which assesses the inattention, impulsivity and vigilance of the subjects (Spren and Strauss, 1998). The most commonly reported measurements in CPTs are the omission error score, which indicates the number of targets that the subject failed to click or respond to, and the commission error score, which indicates the times that the subject clicked or responded despite the lack of a target (Delongis, 1991). Certain studies have demonstrated that adults with ADHD have higher levels of omission (which is an indicator inattention) and commission (which is an indicator impulsivity) than the controls (Seidman et al., 1997; Epstein et al., 2001). Various studies have demonstrated that attention deficit and impulsivity are related to emotion recognition (Miller et al., 2011; Shin et al., 2008; Sinzig et al., 2008).

The main purpose of this study was to identify the differences between adults with ADHD and healthy controls with respect to facial emotion recognition and facial recognition. Based on previous studies on ADHD in children and adults, it was expected that ADHD patients would experience more difficulty than the control group in recognizing emotions, and that these patients would display more errors in the recognition of negative expression than in the recognition of positive expressions. Both groups were expected to be similar with respect to facial recognition. Our second aim was to neuropsychologically evaluate and compare attention deficit (as indicated by omission) and impulsivity (as indicated by commission) between the two groups. It is expected that the ADHD groups would display more inattention and impulsivity than the control group. Another subject of our study includes the evaluation of the relationship between the main symptoms of ADHD and facial emotion recognition.

METHODS

Sample

The study group consisted of ADHD patients who were followed and monitored at the ADHD Outpatient Clinic of the Psychiatry Department of the Istanbul Medical Faculty Hospital. Patients were diagnosed with ADHD when they exhibited attention deficit symptoms and/or at least six of the hyperactivity/impulsivity symptoms described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR), and in the situation where these symptoms were identified before the age of seven and displayed in at least two environments such as the workplace or home. The control group consisted of Istanbul Medical Faculty personnel, the Medical Faculty students, and the Medical Faculty workers. Patients exhibiting the following clinical conditions and characteristics were excluded from the study: Psychosis; bipolar disorder; a history of significant neurological disorders (e.g. head trauma, stroke, epilepsy); major depressive period within the past six months; substance and/or alcohol abuse or addiction within the one-year period preceding the study; psychiatric conditions involving severe suicidal ideations; pervasive developmental disorders; mental retardation; severe physical diseases; and the lack of the necessary level of education to read and understand the self-report scales. Participants in the control group were also excluded from the study in case they exhibited one of the abovementioned clinical conditions or characteristics; individuals diagnosed with ADHD were also excluded from the control group. The study was planned to be conducted with 40 adults diagnosed with ADHD between the ages of 20-65, and with 40 healthy controls with similar/matching age, gender and level of education. A total of 48 individuals from the ADHD outpatient clinic were initially invited to the study; however, during the initial meeting, two of the invited individuals were excluded due to a diagnosis of major depression, while another one of these individuals was excluded for reason that he lacked the necessary level of education to read and understand the self-report scales. In addition, five of the invited individuals refused to participate to the study on grounds that they could not allocate time for the tests. A total of 45 individuals were invited to the control group; however, one of these individuals was excluded from the study due to a diagnosis of major depression, while four of these individuals did not participate to the study on grounds that they could not allocate time for the tests. According to the DSM-IV-TR, 35 of the patients in the study group were of the predominantly inattentive subtype, while 5 of the patients were of the combined subtype. Within the ADHD group, 14 of the patients were identified as having concomitant diagnoses. Five of these patients had a diagnosis of specific phobia, while the other patients were using selective serotonin reuptake inhibitors (SSRIs) for conditions such Depressive Disorder Not Otherwise Specified,

dysthymia, panic disorder and generalized anxiety disorder. All patients within the ADHD group were using methylphenidate. Before being included into the study, patients in both groups were briefly informed regarding the purpose of the study. Approval for the study protocol was obtained from the Istanbul Medical Faculty Ethics Committee.

Methods

After informed consents forms were read and signed by patients who accepted to take part in the study, the patients were evaluated using a sociodemographic data form. The patients then completed the Wender Utah Rating Scale (WURS) (Ward et al., 1993) and the Adult ADHD Self-Report Scale (ASRS) (Kessler et al., 2005). The WURS and the ASRS forms were used to evaluate both groups, and to better distinguish the patients with ADHD. All study participants were interviewed by the first author by using Structured Clinical Interview Form for DSM-IV-TR Axis I Disorders (First et al., 1997). The form allowed the identification of conditions that could be considered as exclusion criteria, while also allowing the formation of a control group without any psychopathology. Photographs were used as Pictures of Facial Affect (POFA) in order to determine the subjects' ability to recognize emotional expressions. The Benton Face Recognition Test (Benton et al., 1983, Keskinliç, 2008) and the CPT (Zaimoğlu et al., 1995) were administered to both groups. The evaluation of the CPT, the facial recognition assessments, and the facial emotion recognition assessments were performed by a clinical psychologist specialized in neuropsychology. The explanation of the study, the recording of sociodemographic information and the evaluation of the scales took 45 to 60 minutes to complete, and were performed by the first author. Before the neuropsychological tests were performed on the same day, the study participants were allowed to rest for as long as they wished to. If it was not possible to perform the neuropsychological tests on the same day, a second session was scheduled on a different day to complete these tests. The study participants were asked to avoid using any stimulant medication in the 24 hours preceding the neuropsychological tests.

Clinical Assessment Tools

Sociodemographic Data Form

The Sociodemographic Data Form was a semi-structured form prepared by the researchers. This form was used to record the patient's personal information, address, telephone number, age, gender and level of education. The hand preference of the patients was also indicated on this form; information regarding the handedness of the patients was learned verbally, by directly asking the patients.

Table 1. The Demographic Characteristics of the ADHD and Control Groups.

		ADHD (n= 40)		Control (n= 40)		X ²	p
		n	%	n	%		
Gender	Female	11	28%	11	28%	0.00	0.599
	Male	29	73%	29	73%		
Hand Preference	Left	2	5%	0	0%	2.05	0.247
	Right	38	95%	40	100%		
Age	Mn.	Sd		Mn.	Sd	U	p
		25,96	6.07	25.96	6.07	790.5	0.927
		15,02	2.34	15.70	2.72	622.0	0.074

Mn. = Mean; Sd = Standard deviation.

The Structured Clinical Interview Form for DSM-IV-TR Axis I Disorders (SCID-I)

SCID-I is a diagnostic interview form that was initially developed by Spitzer, Gibbon in Williams in 1987 (Spitzer et al., 1987), and which was later adapted for the DSM-IV-TR by First et al., in 1997. In this study, the SCID-I was used to evaluate and identify possible exclusion criteria among the patients and control. The validity and reliability studies for Turkish adaptation of the SCID-I were previously performed by Çorapçıoğlu et al., (Çorapçıoğlu et al., 1999).

Wender Utah Rating Scale (WURS)

The WURS is a 25-item scale that allows the qualitative evaluation of recent and childhood ADHD symptoms in order to support/confirm ADHD diagnoses for adults. It is a five-point Likert-type self-report scale in which every item is scored between 0 and 4 (0 = not at all, 4 = very much) (Ward et al., 1993). A validity and reliability study for the Turkish adaptation of the WURS was previously performed, and the cutoff score for the scale was determined as 36 (Öncü et al., 2005).

Table 2. Comparison of the Scale and Test Scores for the ADHD and Control Groups.

	ADHD (n= 40)		Control (n= 40)		U	p	Effect Size (r)
	Mean	Sd	Mean	Sd			
WURS	46.57	13.16	8.05	5.57	2.00	0.000***	-0.861
ASRS							
Total Score	46.12	9.13	18.15	8.55	7.50	0.000***	-0.853
The Attention Deficit Sub-Scale	23.92	5.11	9.25	4.85	46.00	0.000***	-0.813
The Hyperactivity/Impulsivity Sub-Scale	22.12	5.31	8.95	4.74	38.50	0.000***	-0.820
Benton Face Recognition Score	47.87	3.08	48.22	3.02	742.00	0.568	-0.063
CPT							
Number of Correct Answers	50.92	2.77	52.57	1.61	485.00	0.002**	-0.345
Number of Omissions (CPT)	3.10	2.77	1.42	1.61	479.50	0.002**	-0.351
Number of Commissions (CPT)	2.75	3.62	1.15	2.00	484.80	0.002**	-0.351
POFA							
Total number of correctly identified emotions	52.42	5.36	55.05	3.50	564.50	0.023*	-0.254
Total number of erroneously identified emotions	7.32	4.67	4.95	3.50	534.50	0.012*	-0.287
Error Rate for the Emotion of Happiness	0.15	0.42	0.02	0.15	719.50	0.090	-0.189
Error Rate for the Emotion of Sadness	2.27	1.94	2.07	1.70	747.00	0.603	-0.058
Error Rate for the Emotion of Anger	1.35	1.64	0.75	0.83	650.00	0.126	-0.171
Error Rate for the Emotion of Fear	0.87	1.47	0.67	1.24	742.50	0.536	-0.069
Error Rate for the Emotion of Disgust	1.72	1.60	1.12	1.13	639.50	0.110	-0.178
Error Rate for Neutral Emotion	0.95	1.08	0.30	0.64	513.50	0.002**	-0.354

*p<0.05, **p<0.01, ***p<0.001

WURS: Wender Utah Reporting Scale Score, ASRS: Adult Attention Deficit Hyperactivity Disorder Self-Report Scale, CPT: Continuous Performance Test, POFA: Pictures of Facial Affect.

Table 3. The Pearson Correlation Analysis between the Emotion recognition Variables of the ADHD Groups and the Results of the CPT and Study Scales.

		WURS	ASRS	CPT Number of Correct Answers	Number of Omissions	Number of Commissions
Total number of erroneously identified emotions	r	0.275	0.074	-0.162	0.156	0.447
	p	0.086	0.652	0.317	0.337	0.004**
Error Rate for the Emotion of Happiness	r	0.158	-0.163	0.053	-0.056	-0.058
	p	0.331	0.316	0.745	0.730	0.722
Error Rate for the Emotion of Sadness	r	-0.025	0.004	-0.138	0.128	0.195
	p	0.877	0.982	0.395	0.432	0.228
Error Rate for the Emotion of Anger	r	0.119	0.014	-0.219	0.218	0.325
	p	0.466	0.931	0.174	0.178	0.041*
Error Rate for the Emotion of Fear	r	0.401	0.202	-0.071	0.072	0.580
	p	0.010*	0.212	0.662	0.657	0.000***
Error Rate for the Emotion of Disgust	r	0.232	0.062	-0.143	0.145	0.169
	p	0.150	0.704	0.378	0.372	0.298
Error Rate for Neutral Emotion	r	0.101	-0.012	0.169	-0.177	0.068
	p	0.536	0.940	0.297	0.274	0.675

*p<0.05 **p<0.01 ***p<0.001

CPT: Continuous Performance Test

WURS: Wender Utah Rating Scale

ASRS: Adult Attention Deficit and Hyperactivity Disorder Self-Report Scale.

Adult Attention Deficit Hyperactivity Disorder Self-Report Scale (ASRS)

The ASRS is a scale that was developed by the World Health Organization to screen adults for ADHD (Kessler et al., 2005). The scale is a five-point Likert-type scale in which every item is scored between 0 and 4. The scale is further divided into the two sub-scales “attention deficit” and “hyperactivity/impulsivity,” each consisting of nine items. The scale items focus on determining the frequency of each symptom within the past six months. Individuals who score 24 points or greater in either one of the scales are considered as being “highly likely to have ADHD.” On the other hand, individuals who score between 17-23 points in either one of the scales are considered as being “likely to have ADHD,” while those who score between 0-16 points are considered as not having ADHD. The validity and reliability study for the Turkish

adaptation of the ASRS was previously performed by Doğan et al. (2009).

Pictures of Facial Affect (POFA)

The POFA is a series of 110 black-and-white digital photographs with a thickness of 35 mm that illustrate six types of emotional expressions. The POFA were initially developed by Paul Ekman in 1976 (Ekman and Friesen 1976). In his study, Ekman used six types of commonly observed and distinctive emotional expressions. These emotional expressions include the facial expressions associated with happiness, sadness, fear, anger, disgust and surprise. Within the context of this study; at total of 60 pictures were selected from the 110 pictures developed by Ekman. These selected pictures included 10 pictures for each one of the following five types of affects/expressions (for a total of 50 pictures): happiness, sadness, anger, fear and disgust. The remaining 10 pictures were pictures

Table 4. Linear Regression Analysis Regarding the Effect of the Number of Omissions on Emotion recognition in the ADHD group.

Dependent Variable	Independent Variable	β	t	p	F	Model (p)	R2
Total number of erroneously identified emotions	Constant	5.744	6.807	0.000	9.473	0.004	0.178
	Number of Commissions	0.575	3.078	0.004*			
Error Rate for the Emotion of Anger	Constant	0.946	3.017	0.005	4.488	0.041	0.082
	Number of Commissions	0.147	2.118	0.041*			
Error Rate for the Emotion of Fear	Constant	0.228	0.944	0.351	19.274	0.000	0.319
	Number of Commissions	0.235	4.390	0.000**			

*p<0.05, **p<0.001

Table 5. Linear Regression Analysis Regarding the Effect of the WURS on Emotion recognition in the ADHD group.

Dependent Variable	Independent Variable	β	t	p	F	Model (p)	R2
Error Rate for the Emotion of Fear	Constant	0.946	3.017	0.139	7.288	0.01*	0.139
	WURS	0.147	2.118	0.01*			

*p<0.05

WURS: Wender Utah Rating Scale.

that illustrated neutral expressions. The pictures had dimensions of 17.5x25 cm, and were shown on paper that had dimensions of 21x30 cm. The pictures were randomly ordered, and the study participants' answers regarding the pictures were noted by the researchers. While the pictures were being shown to the study participants, no time limitations were imposed. The pictures used in the study were selected among those which, according to a study by Ekman, could be recognized by at least 80% of college students in the United States. The study participants were given a written list that provided possible names/descriptions for the emotional expressions shown on the pictures. After each photograph they looked at, the study participants were asked to select from the list the corresponding emotion that best described the picture. Each correct answer was scored as 1 point, while each wrong answer was scored as 0 points. No validity study for this method has been previously performed in Turkey.

Benton Face Recognition Test

The Benton Face Recognition Test is a standardized test that assesses individuals' ability to recognize and distinguish familiar human faces without and distinctive facial expressions (Benton et al., 1983). During the test, subjects are required to identify faces under different lighting conditions and visual angles. The validity and reliability assessment of this test was previously performed in Turkey by Keskinkılıç (2008). In this study, we employed a 13-page short form in which a maximum score of 27 points could be obtained. There were no time limitations for this test. Each correct answer was scored as 1 point.

Continuous Performance Test (CPT)

The CPT is a test that evaluates continuous attention, selective attention and response inhibition. In this study, the CPT was administered by using letters that appeared and disappeared on a computer screen. The study subjects were asked to press a button whenever they saw a letter "A" after seeing a letter "Z." The target stimulus constituted 36% of all stimuli in the test. The evaluation of the CPT was performed in a computer environment; the evaluated parameters included total number of correct answers, the number of omissions (i.e. failing to press the button after the target letter were shown)

and the number of commissions (i.e. pressing the button even if the target letter were not shown). The omissions score was indicative of problems relating to continuous attention, while the commission score was indicative of problems relating to response inhibition and impulsivity. The computer adaptation of the test was previously prepared by Zaimoğlu et al., (1995).

Statistical Analysis

The distribution characteristics of the variables were evaluated using the Kolmogorov-Smirnov Test. As the parameters did not display a normal distribution, they were evaluated using non-parametric tests. The comparison of categorical data was performed using the Chi-square (X2) test, while the evaluation of numerical data was performed using the Mann-Whitney U test. For scores and quantitative variables; mean and standard deviation values were shown on the relevant tables. The level of effect size were determined in order to evaluate the differences between the ADHD patients and the controls with respect to the scale scores, the CPT scores, the facial recognition scores and facial emotion recognition scores; to evaluate the effect of the patient and control groups on all these data; and to express the relative size of the differences between the groups. To this end, the correlation coefficient (r) was calculated by dividing the Z value (determined by using the Mann-Whitney U test) with $\sqrt{N}$ value. A value of $r = 0.1$ is considered as corresponding to a low-level effect size; a value of $r = 0.3$ is considered as corresponding to a moderate level effect size; and a value of $r = 0.5$ is considered as corresponding to a high-level effect size (Cohen, 1988). To identify the relationship of inattention and impulsivity with the facial emotion recognition scores in both the patient and control group, the Pearson correlation analysis was employed. To identify the effect of the CPT and scale scores on facial emotion recognition, linear regression analysis was employed. Thus, values that demonstrated significant relationship in the Pearson correlation analysis were evaluated by using regression analysis. In this context, the number of commissions and the WURS score were considered as independent variables; while the total error rate in recognizing facial emotions, the total error rate in recognizing angry expressions, and the total error rate in recognizing frightened expressions were considered as dependent variables. The results were evaluated within a 95% confidence and by using a statistical significance level of $p<0.05$, with $p<0.01$ and $p<0.001$ being considered as indicating a high level of statistical significance. Data analysis was performed using SPSS 15.0 (Statistical Program for Social Sciences).

RESULTS

The ADHD and control groups were not significantly different from one another with respect to age (25.96 ± 6.07 and 25.96 ± 6.07 , respectively; $U = 790.5$, $p = 0.927$), gender (n (female) = 11 (27.5%), n (male) = 29 (72.5%) ($X^2 = 0.00$, $p = 0.59$) and level of education (15.02 ± 2.34 years and 15.70 ± 2.72 years, respectively; $U = 622.0$, $p = 0.074$). With regards to concomitant diagnoses; it was observed that 4 (10%) of the patients in the ADHD group had a Depressive Disorder Not Otherwise Specified, while 5 (12.5%) of the patients had specific phobia, 1 (2.5%) had dysthymia, 2 (5%) had a panic disorder, and 2 (5%) had generalized anxiety disorder. In the ADHD groups, right and left hand preferences were reported by 38 and 2 patients, respectively, while a right hand preference was observed in all of the healthy controls. No significant difference was identified between the two groups with respect to hand preference ($X^2 = 2.05$, $p = 0.247$). Table 1 shows the distribution of age, gender, level of education and hand preferences in the ADHD and control groups.

Significant differences were identified between the ADHD and control groups with respect to the WURS scores (46.5 ± 13.1 and 8.0 ± 5.5 , respectively; $U = 2.00$, $p = 0.000$, $z = -7.698$, $r = -0.861$); the ASRS-Attention Deficit sub-scale scores (23.9 ± 5.1 and 9.2 ± 4.8 , respectively; $U = 46.00$, $p = 0.000$, $z = -7.272$, $r = -0.813$); the ASRS-Hyperactivity/Impulsivity sub-scale scores (22.1 ± 5.3 and 8.9 ± 4.7 , respectively; $U = 38.50$, $p = 0.000$, $z = -7.334$, $r = -0.820$); and the total ASRS scores (46.1 ± 9.1 and 18.1 ± 8.5 , respectively; $U = 7.50$, $p = 0.000$, $z = -7.629$, $r = -0.853$). In the ADHD group, the WURS scores (46.57 ± 13.16) were higher than the cutoff score, while the scores for the ASRS-Attention Deficit and the ASRS-Hyperactivity/Impulsivity sub-scales (23.9 ± 5.1 and 22.1 ± 5.3 , respectively) were both slightly lower than the score that is considered to indicate a “high likelihood of having ADHD” (Table 2). As expected, the ADHD patients demonstrated a lower performance in the CPT than the healthy controls. In comparison to the control group, the ADHD group had a lower number of correct answers in the CPT (52.57 ± 1.61 and 50.92 ± 2.77 , respectively; $U = 485.00$, $p = 0.002$, $z = -3.092$, $r = -0.345$). Compared to the control group, the ADHD group also had higher omission scores (1.42 ± 1.61 and 3.10 ± 2.77 , respectively; $U = 479.50$, $p = 0.002$, $z = -3.144$, $r = -0.351$) and higher commission scores (1.15 ± 2.00 and 2.75 ± 3.62 , respectively; $U = 484.80$, $p = 0.002$, $z = -3.140$, $r = -0.351$). The effect size was determined to be moderate (Table 2).

No significant difference was identified between the ADHD and control groups with respect to the Benton Face Recognition Test scores (47.8 ± 3.08 and 48.2 ± 3.02 , respectively; $U = 742.00$, $p = 0.568$, $z = -0.571$, $r = -0.063$).

The correct recognition of facial emotions was significantly lower in the ADHD group in comparison to the control group (52.42 ± 5.36 and 55.05 ± 3.50 , respectively; $U = 564.50$, $p = 0.023$, $z = -2.277$, $r = -0.254$). A significant difference between the ADHD and control groups was identified only with respect to the recognition of neutral facial expressions (0.95 ± 1.08 and 0.30 ± 0.64 , respectively; $U = 513.50$, $p = 0.002$, $z = -3.167$, $r = -0.354$). This difference corresponded to a moderate level effect size.

In both groups, the relationship between the emotion recognition variables and the WURS, ASRS and CPT variables was calculated using the Pearson correlation analysis. Based on these calculations; it was observed that the number of commissions in the ADHD group had a positive significant relationship with the total number of erroneously identified emotions ($r = 0.447$; $p = 0.004$), the error rate in identifying the emotion of anger ($r = 0.325$; $p = 0.041$) and the error rate in identifying the emotion of fear ($r = 0.580$; $p = 0.000$) (Table 3). A positive relationship was identified between the WURS score and the error rate in identifying the emotion of fear ($r = 0.401$; $p = 0.01$). No significant relationships were observed in the control group.

The number of commissions which is an independent variable, demonstrated a significant relationship with the number of erroneously identified emotions, the error rate in identifying the emotion of anger, and the error rate in identifying the emotion of fear, which are all independent variables; the regression analysis that was performed to determine the predictive ratio of these three independent variables identified a model with a statistically significant predictive power (respectively $F = 9.47$, $p = 0.004$; $F = 4.48$, $p = 0.041$; $F = 19.27$, $p = 0.00$). In this context; increases in the number of commissions were associated with increases in the total number of erroneously identified emotions, and also in the error rate in the identification of the emotions of anger and fear ($\beta = 0.575$; $\beta = 0.147$; $\beta = 0.235$, respectively). It was especially observed that the error rate in the recognition of the emotion of fear had a strong relationship with (or, in other words, a strong predictive power for) the number of commissions variable ($R^2 = 0.319$) (Table 4). In addition to this, the WURS score had a significant relationship with the error rate in the recognition of the emotion of fear, and a regression analysis between these two also provided a significant model ($F = 7.288$, $p = 0.01$) (Table 5).

DISCUSSION

The purpose of our study was to investigate the difference between adult ADHD patients and healthy controls with regards to facial emotion recognition and facial recognition, and to evaluate the effect of attention deficit and impulsivity

as measured by the CPT on the ADHD group's ability to recognize facial emotions.

In agreement with our first hypothesis, we observed a significant difference between the two groups with respect to facial recognition. This finding is in parallel with previous ADHD studies (Kovner et al., 1998; Murphy, 2002; Rapport et al., 2002). In addition, the ADHD patients had a higher error rate than the control group in recognizing facial emotions. Similar results were reported in studies conducted on adult (Rapport et al., 2002) and child ADHD patients (Cadesky et al., 2000; Corbett and Glidden, 2000). In contrast to these studies, however, it was observed that the error rate for the neutral expression was higher in our study. This could be associated with the fact that the neutral expression is not as pronounced or distinctive as the expressions for happiness, sadness, anger, fear and disgust, and also with the fact that ADHD patients have a higher probability than healthy controls in confusing neutral expressions with other emotions. In addition to this, the problems encountered by adult ADHD patients in processing emotional stimulus may also lead them to make more errors with regards to the neutral expression (Ibanez et al., 2011). It is generally recommended that such findings are further evaluated by performing studies with tests that require subjects to "recognize facially expressed emotions" (Kerr and Neale, 1993), or to "read the mind through the eyes" (Baron-Cohen et al., 2001). Although no significant differences were identified in our study between the ADHD and control groups in expressions other than the neutral expression; the difficulty experienced by ADHD patients in recognizing facial expressions can still be explained based on the impairment of their ability to empathize (Braaten et al., 2000). The emotional expression that had the highest frequency of correct identification by the ADHD patients was "happiness," while the emotional expression that had the lowest frequency of correct identification was "sadness." This finding is in agreement with the results of other studies which indicated that the correct identification of positive emotional expressions was more frequent among ADHD patients than the correct identification of negative emotional expressions. This could be associated with the fact that a positive emotion such as happiness can be distinguished more easily from other emotional expressions, while negative emotions such as anger and disgust have subtle tones that are more difficult to distinguish. A previous study reported that the verbal and non-verbal attention deficits of ADHD patients lead them to evaluate and consider the characteristics of stimuli in an erroneous and incomplete manner. It was reported that, as a result of this, ADHD patients are able to only pay attention to strong and pronounced stimuli in their surroundings, while overlooking the subtle tones and details involved in communication (Corbett and Glidden, 2000). Small children with ADHD are less capable of recognizing emotional

cues than older children (Shapiro et al., 1993). In our study, the ADHD group identified fewer facial emotions than the healthy control group. This was an important observation, in that it indicated that the impairment of facial emotion recognition in ADHD is not only limited to childhood.

The attention deficit and impulsivity of adults with ADHD was further confirmed by the CPT. The CPT data of our study was in agreement with previous studies which indicated that ADHD patients made more omissions (Seidman et al., 1997) and commissions (Epstein et al., 2001) than the controls. In our study, it was observed that an increase in impulsivity in the ADHD group was associated with a decrease in the total number of correctly identified emotions, and also with an increase in the error rate associated with the recognition of the emotions of anger and fear. The lack of any significant relationship within the control group suggested that the difficulties encountered by the ADHD patients in recognizing emotions were mainly related to their disease. Linear regression analyses demonstrated that impulsivity had an effect on the general recognition of emotions, and on the ability to recognize the emotions of anger and fear. Thus, impulsivity was associated with reduced recognition of emotions. A previous study on children with ADHD reported that errors in the recognition of facial emotions were mainly associated with the symptoms of ADHD (Sinzig et al., 2008). In another study, the impairment of emotion recognition among children with ADHD was found to be related with attention deficit (Shin et al., 2008). The correlation and regression analyses performed in our study demonstrated that the errors in recognizing emotions were especially associated with impulsivity. In a previous study, it was demonstrated that children with the hyperactive/impulsive sub-type of ADHD displayed impairments in their ability to identify facial emotional expressions in comparison to the controls, especially with respect to the emotions of anger and sadness (Pelc et al., 2006). In contrast; another study demonstrated that an increase in attention deficit symptoms in adult patients with ADHD was associated with an improved recognition of facial expressions denoting sadness, while an increase in hyperactivity/impulsivity symptoms in these patients was associated with a worsening of the recognition of facial expressions denoting sadness (Miller et al., 2011). Many cases with orbitofrontal lesions are known to display impulse and antisocial behaviors. It is reported that the hyperactive/impulse type of ADHD may be associated with impaired orbitofrontal functions (Dinn et al., 2001). The interpretation of anger is also known to be mainly associated with the orbitofrontal cortex (Fine and Blair, 2000). This association possibly explains the relationship observed between facial expressions of anger and impulsivity. Structural and functional imaging studies have reported that ADHD is associated with the functional impairment of the amygdala (Plessen et al., 2006; Volkow et al., 2007).

The interpretation of fear in humans is known to be associated with the activity of the amygdala (Calder et al., 1996). The abnormal reward processing model – which is one of the main theoretical models of ADHD (Sagvolden et al., 2005) – is based on the mesolimbic dopamine pathway that involves the amygdala (Lindwall and Bjorklund, 1983). It is known that childhood ADHD is excessively sensitive to reward delay, which is associated with the severity of hyperactivity symptoms (Scheres et al., 2010). It is possible to state that these data and observations provide an indirect explanation for the relationship observed in our study between impulsivity and facial expressions relating to fear.

Although the study data seemed to indicate that ADHD symptoms were mainly responsible for the errors committed in the identification of facial expression denoting anger, fear and neutrality; previous studies appear to suggest that impairments in underlying emotional processes might be the actual cause for the errors in emotion recognition (Yuill and Lyon, 2007).

Our study had certain limitations. Although the study participants were matched/similar with respect to age, gender and level of education; no information was collected regarding their level of intelligence, which has the potential to influence their performance during the tests. This was because there is currently no intelligence test in Turkey whose validity and reliability studies have been performed for adults, and which could hence be used to obtain sound and reliable results. Another reason was because the study participants consisted of adults who were high school and university graduates, which reduced any possibility of mental retardation among the participants. These approaches were intended to minimize the effect of intelligence differences on the performance of the tests. Another limitation of the study was the fact that the patients' hand preference was asked and determined verbally. Using the Edinburgh Handedness Inventory (Oldfield, 1971) to determine the hand preference would have provided information regarding the percentage use of each hand. Although the pictures of facial affect are based on universal emotions, no validity and reliability study has been performed in Turkish for this method. The fact that we used an emotion recognition tool for which no validity studies have been performed in Turkey represented another limitation of our study. In addition, a prospective study starting from childhood and progressing until adulthood would potentially provide more information regarding the changes in facial emotion recognition. Another limitation of our study was the fact that the ADHD group consisted of individuals highly educated individuals who had relatively easy access to specialized clinic and drug treatment. The inclusion of patients from all socioeconomic and educational levels, and also of patients from rural areas, would have allowed us to obtain results of greater validity and applicability. In addition,

performing functional imaging on the relevant regions of the brain in adult ADHD patients would have allowed the identification of concrete relationships between brain function and the impairments observed in facial emotion recognition. In this context, the fact that we did not use tests that evaluate the areas of neuropsychological function in the brain represented another methodological limitation of our study. In addition to this, future studies that evaluate individuals with ADHD according to the sub-types of the disease are likely to provide further information regarding the relationship between emotion recognition and ADHD symptoms. To the best of our knowledge, our study represents the first study in Turkey evaluating facial recognition and facial emotion recognition in adults with ADHD. We believe that our study will contribute to the medical literature and the limited number of studies that have been previously conducted on this subject.

In our study, it was determined that ADHD in adults generally impaired their ability to recognize facial expressions, neutral expressions and expressions denoting anger. It was also determined that symptoms of impulsivity reduced the patients' ability to correctly recognize emotions. As the social relationship disorders observed in ADHD patients might be ultimately related to altered emotion recognition processes, future studies on early psychopharmacological and psychotherapeutic interventions/treatments for the basic symptoms of ADHD should also investigate the effects of these treatments on emotion recognition impairments.

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