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RESEARCH ARTICLE

Is Emotion Recognition Related to Core Symptoms of Childhood ADHD?

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Abstract

Objective: Children with attention deficit/hyperactivity disorder (ADHD) have some problems in social relationships which may be related to their deficit in recognizing emotional expressions. It is not clear if the deficit in emotion recognition is secondary to core symptoms of ADHD or can be considered as an independent symptom. This study aimed to evaluate the ability of detecting emotional faces and its relation to inattention and hyperactivity-impulsivity in children with ADHD compared to a typically developing (TD) group. Methods: Twenty-eight boys diagnosed as having ADHD, aged from seven to 12 years old were compared to 27 TD boys using a computerized Facial Emotion Recognition Task (FERT). Conners' Parent Rating Scale (CPRS) and Continuous Performance Test II (CPT II) were also administered to assess the severity of inattention and impulsivity. **Results:** The percentages of angry, happy and sad faces detected by children with ADHD were significantly lower ($p<0.05$) compared to the control group. The time spent in recognizing happy faces was higher in the ADHD group ($p=0.04$). The sequential regression analyses showed a significant association between angry and sad targets recognition and inattention ($P<0.05$), as well as between oppositionality and angry faces detection ($P<0.05$) when hyperactivity-impulsivity was added to the model. **Conclusion:** It can be concluded that children with ADHD suffer from some impairments in recognizing angry, happy and sad faces. This deficit may be related to inattention and hyperactivity-impulsivity.

Key Words: *ADHD, emotion recognition, inattention, impulsivity*

Résumé

Objectif: Les enfants souffrant du trouble de déficit de l'attention avec hyperactivité (TDAH) ont des problèmes de relations sociales qui peuvent être liés à leur déficit de reconnaître les expressions émotionnelles. Il n'est pas déterminé si le déficit de reconnaissance des émotions est secondaire aux symptômes de base du TDAH ou s'il peut être considéré comme étant un symptôme indépendant. Cette étude visait à évaluer la capacité de détecter les expressions émotionnelles faciales et sa relation à l'inattention et à l'hyperactivité-impulsivité chez les enfants souffrant du TDAH comparativement à un groupe au développement typique (DT). **Méthodes:** Vingt-huit garçons de 7 à 12 ans ayant reçu un diagnostic de TDAH ont été comparés avec 27 garçons au DT à l'aide du test informatisé de reconnaissance des émotions faciales (FERT). L'échelle d'évaluation des parents (CPRS) et le test de performance continu II (CPT II) de Conners ont aussi été administrés pour évaluer la gravité de l'inattention et l'impulsivité.

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Résultats: Les pourcentages de visages fâchés, heureux et tristes détectés par les enfants souffrant du TDAH étaient significativement plus faibles (p < 0,05) que ceux du groupe témoin. Le temps passé à reconnaître les visages heureux était plus élevé dans le groupe du TDAH (p = 0,04). Les analyses de régression séquentielle indiquaient une association significative entre la reconnaissance des visages fâchés et tristes et l'inattention (P < 0,05), ainsi qu'entre l'oppositionnalité et la détection des visages fâchés (P < 0,05) quand l'hyperactivité-impulsivité était ajoutée au modèle. **Conclusion:** Il est possible de conclure que les enfants souffrant du TDAH présentent un déficit de reconnaissance des visages fâchés, heureux et tristes. Ce déficit peut être lié à l'inattention et à l'hyperactivité-impulsivité.

Mots clés:*TDAH, reconnaissance des émotions, inattention, impulsivité*

Introduction

ADHD is a common problem in youth manifested by inattention, hyperactivity and impulsivity (American Psychiatric Association, 2000). It has also been reported that children with ADHD have some difficulties in their social relationships which are characterized as negative and conflictual (Greene, Biederman, & Faraone, 2001), and aggressive towards others (Guevremont, 1994). These annoying and aversive social behaviors are associated with peer rejection (Hoza, Mrug, Gerdes, & Hinshaw, 2005; Mrug, Hoza, Pelham, & Gnagy, 2007) and its long-term outcomes (Bagwell, Schmidt, Newcomb & Bukowski, 2001). To explain potential causes of these social problems, some factors have been suggested including deficits in social skills knowledge (Pfiffner & McBurnett, 1997), impairment in reading or responding to social cues (Hoza, 2007), and social information processing deficit (Matthys, Cuperus, & van Engeland, 1999), which may be due to poor attending to social cues rather than interpreting them (Cadesky, Mota, & Schachar, 2000). Behavioral disinhibition and executive dysfunction are other reported explanations (Barkley, 1997).

Proper development of emotional competence has a crucial role in social reciprocity (Saarni, 1999). Emotional competence has three components including understanding emotional cues, inducing and expressing emotions, and regulating them (Thompson, 1994). It has been shown that impairment in detecting emotions from faces is associated with low social competence and low popularity in peer groups (Edwards, Manstead, & Macdonald, 1984; Philippot & Feldman, 1990). Some authors showed that an ineffective appraisal of others' emotional state suggests a problem in primary cognitive functioning related to emotion detection (Kats-Gold, Besser & Priel, 1998). It is suggested that poor social ability in ADHD is related to an overall difficulty to process emotions. For instance, some evidence shows a failure in children with ADHD to attend to salient emotional signals. This problem may be due to a primary deficiency in encoding these signals (Williams et al., 2008).

Several studies report that performance of children with ADHD on emotion recognition tasks is worse than normal children (Kats-Gold et al., 2007), especially in detecting emotional expressions of faces (Da Fonseca, Seguier, Santos, Poinso, & Deruelle, 2009; Buitelaar, van der Wees, Swaab–Barneveld, & van der Gaag, 1999). Facial emotional recognition is the basic skill in emotion development (Saarni, 1999). It has been shown that children with ADHD have more errors in detecting facial emotions, especially anger (Hoza, 2007).

This deficit has also been found in boys at risk of ADHD (Kats-Gold et al., 2007). However, there are inconsistent findings regarding emotion detection deficits in children with ADHD (Lee, Hung, Lam, & Lee, 2009). Some studies found that these children's accuracy is poor in detection of sadness and happiness (Kats-Gold et al., 2007; Pelc, Kornreich, Foisy, & Dan, 2006), while others showed deficits in recognition of emotional expression of fear and anger (Williams et al., 2008).

Krauel (Krauel et al., 2008) found that children with pure ADHD were not significantly different from normal individuals in remembering positive pictures; however, this ability was poorer in children suffering from comorbid ADHD with oppositional defiant disorder and conduct disorder. On the other hand, the essential role of disinhibition is suggested in regulation of emotion (Barkley, 1997). It is argued that social and emotional problems in ADHD are due to core symptoms of impulsivity and inattention rather a basic deficiency in recognizing emotion (Singh et al., 1998; Cadesky et al., 2000). Walcott and Laundau (2004) reported that boys with ADHD could not mask their emotions when they were asked to. They found that less effective emotion regulation was correlated with impulsivity and greater disinhibition.

With regard to the inconsistent underlying factors proposed for emotional problems in children with ADHD, we aimed to evaluate: 1) if emotion recognition in children with ADHD is worse than typically developing youth; and, 2) whether these assumed deficits can be explained by core symptoms of ADHD (inhibition and inattention).

Methods

Participants and Procedure

Among referrals to a child and adolescent psychiatry clinic at Roozbeh psychiatric hospital in Tehran, the capital of Iran, twenty-eight boys aged 7-12 years with ADHD-combined type participated in this study. The control group consisted of 27 typically developing boys recruited from mainstream schools matched on the age and intelligence quotient (IQ).

All participants were Farsi speaking and came from urban area. The diagnosis was made first by a board-certified child and adolescent psychiatrist based on DSM-IV-TR criteria, using clinical assessment and interview with the children and parents. To confirm the diagnoses, pervasiveness of the symptoms, and functional impairment, all participants were interviewed by a fellow in child and adolescent psychiatry using the Kiddie-Schedule for Affective Disorders and Schizophrenia – Present and Life time version – Persian Version (K-SADS- PL-PV). If the diagnoses based on clinical assessment and K-SADS interview were not consistent, the researchers discussed the information and reached a consensus to confirm the final diagnoses. All children with any comorbid psychiatric or neurological disorders were excluded. All children with ADHD were drug naïve.

Conners' Parent Rating Scale-Short Version (CPRS-SV) was completed by all participants' parents to evaluate the severity of core symptoms of ADHD. For all children, Raven Colored Matrices and Conners' Continuous Performance Test II (CPT II) were used to assess intellectual ability and inattention/impulsivity, respectively. The two groups performed a computerized facial emotion recognition task (FERT) as well.

Measures

Kiddie-Schedule for Affective Disorders and Schizophrenia-Present and Lifetime version (K-SADS-PL)

K-SADS-PL is a semi structured diagnostic interview which evaluates current, past, and lifetime diagnostic status in six to 18-year-old individuals (Kaufman et al., 1997). The psychometric properties of the Farsi version of K-SADS-PL were good to excellent for most major psychiatric disorders in a clinical inpatient sample (Shahrivar, Kousha, Moallemi, Tehrani-Doost, & Alaghband-rad, 2010).

Conners' Parent Rating Scale (CPRS)

This is a questionnaire (Conners, 1997) to assess the symptoms of ADHD and related behavior problems in three to 17-year-old children and adolescents. Tehrani-Doost,& Shahrivar (unpublished) found that the psychometric properties of the CPRS were good in an Iranian clinical population.

Raven's Progressive Matrices (RPM)

RPM (Raven, Court, & Raven, 1988) is a standard measure for non-verbal intelligence and perceptual reasoning. RPM has been validated and standardized for five to 18-year-old children and adolescents in Iran (Baraheni, 1972).

Conners' Continuous Performance Test II (CPT II)

The 5th version of Conners' Continuous Performance Test II (Conners & Staff, 2004) contains six blocks including 20 trials each. The inter stimulus intervals (ISIs) are one, two, and four seconds and the whole time taken to complete the task is 14 minutes. The participant should press a button whenever a non-target alphabetic letter was presented on the monitor and inhibit the response in case of seeing the letter "X". The most important variables are omission (as indicator of inattention) and commission (as indicator of impulsivity) errors.

Facial Emotion Recognition Task (FERT)

To assess the ability of the participants to recognize basic emotions and neutral expressions, we developed a computerized facial emotion recognition task based on the Cohn-Kanade face database (Kanade, Cohn, & Tian, 2000). One hundred faces were randomly divided in happy, sad, angry and neutral expressions. Each emotion was shown to the participants 25 times, using three male and two female faces randomly. The resolution of each picture was 397*425 and presented for 2500 milliseconds. The interval between the pictures was 1500 milliseconds. Participants should press four colored buttons related to the mentioned emotions after being trained how to use the buttons. An example block including six pictures was used first to show the participants how to do the task. Then they were instructed to use the buttons by themselves during the second trial. There was also a guide sheet to cue them how to perform the task. The variables were the number of correct responses and the time taken to response.

Statistical analysis

The data were analyzed using the SPSS software (Version 16.0). After checking the data for normal distribution, the parametric procedures were used to analyze them. A multivariate analysis of variance (MANOVA) was used to assess the statistical significance of the effect of ADHD as the independent variable on the FERT variables. The differences between the two groups regarding the CPRS and CPT indices were analyzed using the independent t test. To evaluate the differences among the FERT variables within each group, a repeated measure analysis of variance (ANOVA) was used. To test if the differences between the groups can be explained by the CPRS and CPT II variables, sequential regression analysis was performed. We entered the data from CPRS first and then data from FERT to test if the facial recognition task could account for any group differences above and beyond the differences in CPRS. Again we did the analyses entering the data from CPT II first and then FERT.

Table 1. Comparison of the CPRS and CPT II variables between the ADHD and TD groups

	ADHD group (N=28)		TD group (N=27)		
Variable	Mean	SD	Mean	SD	P
CPRS					
Oppositionality					
Raw scores	9.03	4.22	3.81	2.51	0.000
T scores	64.64	11.66	49.96	6.92	
Inattention					
Raw scores	11.92	4.78	2.03	2.10	0.000
T scores	67.42	10.48	46.03	4.42	
Hyperactivity					
Raw scores	10.82	5.01	2.92	3.33	0.000
T scores	72.89	13.68	52.18	9.22	
ADHD Index					
Raw scores	24.17	7.31	6.81	4.77	0.000
T scores	68.42	8.53	47.62	5.96	
CPT II					
Omissions	29.6	31.56	13.14	17.85	0.02
Commissions	22.71	6.17	19.11	7.98	0.06
Hit Reaction Time	499.98	102.92	465.88	83.56	0.18

CPRS: Conners'Parent Rating Scale, CPT: Continuous Performance Test, TD: typically developing

Results

There was no significant difference regarding the ages of the ADHD group (M=8.75 years, SD=1.39) and the TD children (M=9.46 years, SD=1.45) ($p<0.07$). The ADHD (M=96.35, 15 SD=10.38) and TD (M=100.48, SD=9.40) groups were matched on their IQs as well.

With regard to the CPRS, all variables were significantly higher in children with ADHD ($p<0.001$). Among the CPT variables, the only significant difference was found in terms of omissions (t=2. 39, p=0.02) (Table 1).

Comparing the FERT variables between the two groups, MANOVA showed that children with ADHD had lower performance in detection of all emotions including anger, happiness, and sadness ($p<0.05$). The two groups showed no difference in recognizing the neutral faces. The response time to detect emotions was significantly higher in children with ADHD compared to the TD group just in detecting happiness (f=4.19, p=0.04) (Table 2).

Considering emotion detection as the main factor, a repeated measure ANOVA showed significant differences within groups regarding the FERT measures in the two groups (p=0.000). Both groups detected happy and neutral faces better than the angry ones (p=0.000). The ADHD group recognized happy and neutral targets more accurately than sad targets (p=0.000). This finding was similar in the TD group. There were no significant differences in detection of angry targets compared to sad faces in each group. The TD children recognized happy targets more accurately than neutral faces (p=0.03).

Table 3 shows the results of sequential regression analysis of the FERT measures against the CPRS and CPT II variables in the ADHD group. We entered oppositionality first as Model 1. It was not significantly associated with any of the FERT emotions before adjustment for other CPRS variables. Then inattention and hyperactivity-impulsivity scores were added to oppositionality as Model 2 and 3, respectively. There was a significant association between the CPRS variables and angry face recognition in Model 2 (Oppositionality + Inattention) and Model 3 (Oppositionality + Inattention + Hyperactivity-Impulsivity). The three variables together explained 31% of the variance in angry faces recognition. The sad target detection was also related significantly to the CPRS measures while oppositionality and inattention were taken into account (Model 2). This model could predict 24% of the variance in sad target detection.

Based on the results displayed in Table 4, oppositionality was significantly associated with angry faces detection of the FERT emotions (p=0.028, t=-0.586) after adjustment for other CPRS variables (inattention and

Table 2 Comparison of the FERT measures between the ADHD and TD groups based on MANOVA

	ADHD group (N=28)		TD group (N=27)				
Variable	Mean	SD	Mean	SD	F	P	Partial Eta Squared
Angry Target Accuracy	0.56	0.27	0.71	0.25	4.25	0.04	0.07
Happy Target Accuracy	0.94	0.07	0.99	0.01	10.07	0.003	0.16
Neutral Target Accuracy	0.91	0.08	0.93	0.1	0.61	0.43	0.01
Sad Target Accuracy	0.52	0.27	0.78	0.18	16.3	0.000	0.23
Mean target RT (Angry)	2620.34	519.66	2884.6	1016.7	1.35	0.24	0.02
Mean Target RT (Happy)	1786.32	434.74	1572.42	313.25	4.19	0.04	0.07
Mean Target RT (Neutral)	2203.35	533.5	2324.15	907.62	0.33	0.56	0.007
Mean Target RT (Sad)	2614.64	782.91	2815.07	1003.79	0.63	0.42	0.01

TD: typically developing, RT: Reaction Time, FERT: facial emotion recognition task, MANCOVA: multivariate analysis of covariance

Table 3. Sequential regression analysis of the FERT measures against the CPRS and CPT II variables

CPRS & CPT II Variable	ADHD group (N=28) FERT Variables							
	Angry		Happy		Neutral		Sad	
	R^2	F(P)	R^2	F(P)	R^2	F(P)	R^2	F(P)
CPRS								
Oppositionality	0.035	0.943 (0.340)	0.031	0.843 (0.367)	0.000	0.001 (0.977)	0.056	1.551 (0.224)
Oppositionality + Inattention	0.303	5.421 **(0.011)**	0.032	0.412 (0.667)	0.000	0.004 (0.996)	0.237	3.873 **(0.034)**
Oppositionality + Inattention + Hyperactivity-Impulsivity	0.312	3.625 **(0.027)**	0.101	0.903 (0.454)	0.008	0.064 (0.978)	0.237	2.485 (0.085)
CPT II								
Omissions	0.009	0.237 (0.630)	0.004	0.100 (0.754)	0.027	0.734 (0.400)	0.042	1.127 (0.298)
Omissions + Commissions	0.012	0.146 (0.865)	0.017	0.213 (0.809)	0.028	0.354 (0.705)	0.042	0.547 (0.585)
Omissions + Commissions + Hit Reaction Time	0.014	0.117 (0.949)	0.034	0.284 (0.837)	0.095	0.844 (0.483)	0.132	1.212 (0.327)

FERT: facial emotion recognition task, CPRS: Conners' Parent Rating Scale, CPT II: Continuous Performance Test

Table 4. The standardized coefficient results of the sequential regression in the Model 3

Variable	ADHD group (N=28) FERT Variables							
	Angry		Happy		Neutral		Sad	
	Coefficient	P	Coefficient	P	Coefficient	P	Coefficient	P
CPRS								
Oppositionality	-0.586	**0.028**	0.008	0.977	0.76	0.803	0.127	0.635
Inattention	0.712	0.005	0.25	0.924	-0.005	0.986	-0.572	0.026
Hyperactivity - Impulsivity	-0.123	0.574	-0.335	0.186	-0.111	0.672	0.027	0.906
CPT II								
Omissions	-0.099	0.635	-0.052	0.800	-0.126	0.529	-0.161	0.413
Commissions	-0.068	0.755	-0.158	0.464	-0.075	0.716	-0.119	0.560
Hit Reaction Time	0.58	0.792	-0.141	0.516	-0.278	0.192	-0.320	0.129

FERT: facial emotion recognition task, CPRS: Conners' Parent Rating Scale, CPT II: Continuous Performance Test

hyperactivity-impulsivity). Inattention was negatively associated with sad (p=0.026, t=-2.371) and positively with angry (p=0.005, t=3.106) faces recognition. Analysis of the CPT II variables did not find any significant associations with the FERT measures. The sequential regression analysis of the FERT measures against the CPRS and CPT II variables in the TD group showed no significant correlations, as well.

Discussion

Problems with social relationships seen in children with ADHD may be explained by their impairment in regulating emotions. This deficit can also be interpreted by their difficulties in detecting emotional cues. This study was done to: 1) compare the facial emotion recognition in children with ADHD and typically developing (TD) children; and, 2) evaluate if this impairment is related to core symptoms of the disorder.

Our study showed that children with ADHD recognized angry, happy and sad faces less than the healthy control group. This is consistent with some studies such as Da Fonseca (Da Fonseca, Seguier, Santos, Poinso, & Deruelle, 2009) showing that children with ADHD had impairment in emotional faces recognition. Besides, Kats-Gold (Kats-Gold et al., 2007) and Pelc (Pelc et al., 2006) found that these children had less correct responses in detection of happiness and sadness. Moreover, less accuracy in detecting fear and anger was found in youth with ADHD (Williams et al., 2008). Therefore, it can be suggested that children with ADHD are less sensitive to both positive and negative emotions expressed by others. This low attention to people's facial expressions may limit their ability to modify their behavior and emotion.

The higher response time and less accuracy in recognizing happy faces in our participants with ADHD suggest that the slow reaction to detect facial emotions does not help them to improve the accuracy of recognition. This finding is in line with Katz-Gold's study (2007) in evaluating emotion recognition in boys at risk of ADHD. Consistent with our findings, there are other studies showing various impairments of emotion recognition in children and adolescents with ADHD (Kats-Gold et al., 2007; Da Fonseca et al., 2009; Shin, Lee, Kim, Park, & Lim, 2008; Pelc, Kornreich, Foisy, & Dan, 2006). For instance, children with ADHD had more errors in matching emotions to some stories compared to healthy children (Singh, Ellis, Winton, Singh & Leung, 1998) and poorer performance on matching facial emotions to prosody of speech (Shapiro, Hughes, J August, & Bloomquist, 1993). Moreover, they had less correct responses in detecting fear (Sinzig, Morsch, & Lehmkuhl,

2008) and significant impairments in recognizing fear and disgust (Boakes, Chapman, & Houghton, 2007).

Some authors argued that the deficit in emotion recognition in children with ADHD is caused by their inattention and impulsivity (Cadesky et al., 2000; Friedman et al., 2003). To address this issue, we conducted a series of sequential regression analyses among the FERT indices, and the CPRS and CPT II variables. With regards to core symptoms of ADHD, inattention (based on CPRS) showed a considerable effect on detection of both angry and sad targets. In addition, the significant negative association of oppositionality with anger detection only occurred when inattention and hyperactivity-impulsivity were entered to the model. It seems that it is the core symptoms of ADHD that are resulting in the observed significant relationship; not the symptom of oppositionality. On the other hand, Da Fonseca (2009) found when children with ADHD were to identify objects (but not emotions) missing in a complex visual scene, they performed as controls. However, they differed from normal children on the emotion recognition task. Another study assessed multiple deficits in ADHD (Sjowall, Roth, Lindqvist, & Thorell, 2013) and showed that emotion regulation and recognition had independent effects beyond the influence of neuropsychological deficits. Consistent with these studies, we did not find any association between emotion recognition deficits and inattention and impulsivity measured by the CPT in children with ADHD. Therefore, there are still some doubts about the role of cardinal symptoms of ADHD as the only factors affecting emotion recognition deficits.

Altogether, existing literature cannot clarify whether the deficits in understanding emotional information are caused by cardinal symptoms of ADHD or not. Theories of behavioral disinhibition concentrate mainly on these children's impaired emotional expression, not their probable receptive deficits (Friedman et al., 2003). Although emotion regulation is one of the main components of emotional competence, it cannot explain the impairments in emotion understanding reported in individuals with ADHD. This deficit may be interpreted more appropriately with impairment in detecting emotional cues including facial emotion recognition, which is assumed to be the first step of emotional competence (Thompson, 1994). Our findings on impaired recognition of anger, sadness and happiness can support the hypothesis of emotion detection deficit in children with ADHD, as well as the association of poor detection of negative emotions (anger and sadness) with inattention as a cardinal symptom of ADHD.

This study had strengths such as: 1) using the semi-structured interview in addition to clinical assessments to diagnose the ADHD and its comorbid conditions; and 2) excluding all co morbidities to decrease different confounding factors. However, the findings should be considered in light of the study limitations. The participants consisted of just boys and primary school children. Moreover, the findings based on the sequential regression analyses should be considered cautiously because of the small sample size of the ADHD group. In addition, although CPTII is a useful neuropsychological instrument, it cannot be used as a sensitive and specific tool to diagnose the core symptoms of ADHD (Breaux, Griffith , & Harvey, 2016).

Conclusion

Although children with ADHD show some difficulties in regulating expressed emotions, their impairment in emotional competence can also be related to deficits in detecting and understanding emotional cues. Future studies are needed to evaluate if these impairments are due to the core symptoms of ADHD or can be considered as a separate deficit.

Acknowledgements / Conflicts of Interest

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