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Facial emotion recognition in children with or without Attention Deficit / Hyperactivity Disorder: impact of comorbidity.

La reconnaissance des émotions faciales des enfants avec ou sans Trouble Déficit de l'Attention Hyperactivité : l'impact de la comorbidité.

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La reconnaissance des émotions faciales des enfants avec ou sans Trouble Déficit de l'Attention Hyperactivité : l'impact de la comorbidité.

Abstract

Objectives: This study sought to assess facial emotion recognition deficit in children with Attention Deficit Hyperactivity Disorder and to test the hypothesis that it is increased by comorbid features. **Method:** Forty children diagnosed with Attention Deficit Hyperactivity Disorder were compared with 40 typically developing children, all aged from 7 to 11 years old, on a computerized facial emotion recognition task (based on the Pictures of Facial Affect). Data from parents' ratings of Attention Deficit Hyperactivity Disorder and comorbid symptoms (on the Conners' Revised Parent Rating Scale) were also collected. **Results:** Children with Attention Deficit Hyperactivity Disorder had significantly fewer correct answer scores than typically developing controls on the emotional task while they performed similarly on the control task. Recognition of sadness was especially impaired in children with Attention Deficit Hyperactivity Disorder. While Attention Deficit Hyperactivity Disorder symptoms were slightly related to facial emotion recognition deficit, oppositional symptoms were related to a decrease in the number of correct answer on sadness and surprise recognition. **Conclusion:** Facial emotion recognition deficit in children with ADHD might be related to an impaired emotional process during childhood. Moreover, Oppositional Defiant Disorder seems to be a risk factor for difficulties in emotion recognition especially in children with Attention Deficit Hyperactivity Disorder.

Key words: Attention Deficit Hyperactivity Disorder – emotion recognition - facial expressions - comorbidity – opposition.

Résumé

Objectif : Cette étude a pour premier but d'évaluer les capacités de reconnaissance des émotions faciales chez des enfants atteints de Trouble Déficit de l'Attention Hyperactivité en les comparant à celles d'enfants au développement typique. Dans un second temps, l'objectif est de tester l'hypothèse qu'un déficit dans la reconnaissance des émotions faciales peut être exacerbé par la sévérité des symptômes comorbides externalisés (l'oppositionalité), internalisés (l'anxiété) et émotionnels (la labilité émotionnelle). **Méthode** : Quarante enfants de 7 à 11 ans diagnostiqués avec un Trouble Déficit de l'Attention Hyperactivité ont pris part à cette étude ainsi que 40 enfants du même âge non atteints de ce trouble. Pour évaluer la reconnaissance des émotions faciales, un test sur ordinateur a été construit à partir des images contenues dans les Pictures of Facial Affect. Ce test a été construit en trois parties : une phase d'entrainement, une phase de test (reconnaissance des émotions faciales) et une phase contrôle (reconnaissance de formes géométriques). Des données

concernant la symptomatologie du Trouble Déficit de l'Attention Hyperactivité, externalisée, internalisée et émotionnelle ainsi que la sévérité de celles-ci ont été recueillies par questionnaires remplis les parents (Conners' Revised Parent Rating Scale). **Résultats** : De manière catégorielle (analyses de variance), les enfants atteints de Trouble Déficit de l'Attention Hyperactivité ont, de manière significative, moins de réponses correctes sur la tâche de reconnaissance des émotions faciales, alors qu'ils ont autant de réponses correctes sur la tâche de reconnaissance de formes géométriques. La reconnaissance de l'émotion de tristesse apparaît comme la plus déficitaire chez les enfants atteints de ce trouble. De manière dimensionnelle (analyses de régression linéaire), les symptômes du Trouble Déficit de l'Attention Hyperactivité semblent avoir peu de lien avec les capacités de reconnaissance des émotions faciales. En revanche, les symptômes oppositionnels apparaissent comme associés à des difficultés de reconnaissance des émotions faciales particulièrement celle de la tristesse et celle de la surprise. **Conclusion** : Les capacités de reconnaissance des émotions faciales semblent entravées chez les enfants atteints du Trouble Déficit de l'Attention Hyperactivité. Ces difficultés peuvent relever d'un handicap ou d'un retard dans le développement des processus émotionnels durant l'enfance. De plus, le Trouble Oppositionnel avec Provocation semble apparaître comme un facteur de risque de difficultés exacerbées dans la reconnaissance des émotions faciales.

Mots clés : Trouble Déficitaire de l'Attention Hyperactivité – reconnaissance des émotions – expressions faciales – comorbidité – opposition

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a complex neurodevelopmental disorder. Most children with ADHD experience social difficulties, tend to have fewer friends and are prone to be rejected by peers [1]. The possibility of a general deficit in social cognition in ADHD [2] has been proposed to explain the difficulty in successfully interacting with others. Interestingly, it has been hypothesized that this deficit is due to specific difficulties in the ability to recognize emotions from facial expressions [3–5].

Previous studies have shown that children and adolescents with ADHD perform worse on a facial emotion recognition task than typically developing controls do. They are less accurate in identifying facial affect [3–15] and slower to recognize them [4]. They exhibit a flawed performance when presented with a variety of facial emotions as represented in static pictures [3–8,10,12–14], by dynamic presentation or cartoon images [6], by pictures or videos in context [8,12] and when requested to match facial emotions with corresponding situations [11,15]. More specifically, children with ADHD performed worse than typically developing children in recognizing negative emotions such as anger, fear, sadness and disgust [3,5,6,14]. However, other studies failed to find any differences in emotion recognition between children and/or adolescents with ADHD and controls [16,17].

Beyond the classical symptomatology of inattention, hyperactivity and impulsivity, comorbid features are frequently associated with the disorder. Both externalizing (such as Oppositional Defiant Disorder, ODD) and internalizing (such as anxiety) disorders are commonly observed in ADHD children [18,19]. Moreover, children with ADHD and comorbid externalizing disorders are even more

socially impaired than those with 'pure' ADHD: in parents' and teachers' reports, they were rated as having fewer social skills and in peer sociometric nominations, they were less accepted/liked and more rejected/disliked (for review, see [20]). Additionally, research on emotional lability has shown this clinical feature to be frequent in children with ADHD [21]. This complex picture of behavioral and/or emotional symptoms means that the profiles of children suffering from ADHD are heterogeneous and exacerbates the impairment associated with the core symptoms of ADHD.

While the majority of studies suggest that children with ADHD exhibit a facial emotion recognition deficit, their conclusions are limited because comorbidity has not often been taken into account to date. Overall comorbid ODD in ADHD children seems to play a role in facial emotion recognition deficit [22] and a significant association was found between opposition and anger recognition in children with ADHD [23,24]. In addition to externalizing symptoms, internalizing symptoms are also thought to affect the perception of emotion. Correlations between anxiety and/or depression scores and impairment in the recognition of some negative emotions have been observed in ADHD patients [6,14]. Moreover, in adults with ADHD, the intensity of their emotional responses (e.g. self-report of how intensely they experience affects) has been related to an emotion recognition deficit [25]. However, this hypothesis has not been tested in a children sample with ADHD.

On the whole, studies have reported a facial emotion recognition deficit in ADHD but the influence of comorbid features has received little attention. This study assesses the facial emotion recognition of children with ADHD by taking into account simultaneously the contribution of clinical features frequently associated with ADHD such as externalizing (e.g. opposition), internalizing (e.g. anxiety) and emotional (e.g. emotional lability) symptoms. We hypothesized that children with ADHD would be more impaired than children without ADHD in emotion recognition abilities and this deficit would be partially explained by comorbid features.

Method

Participants

Eighty children aged 7 to 11 years old participated in the study. Forty children with ADHD were recruited in an outpatient clinic specialized in ADHD diagnosis. Forty typically developing children matched the ADHD group in age and gender.

The clinical group: The criterion for inclusion in the ADHD group was having a DSM-IV diagnosis of ADHD given by a child psychiatrist. The diagnosis was confirmed by the administration of the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (KIDDIE-SADS-PL [26]). Exclusion criteria were Intellectual Quotient < 70, history or evidence of neurological disorders or impairment such as epilepsy or concussion, pervasive developmental disorder, psychosis, manic episode and non-corrected visual deficit. If children were taking methylphenidate, they had to discontinue it at least 24 hours prior to the experiment (in the final sample, 14 children were receiving such treatment).

The control group: The inclusion criteria for the control group were: absence of present diagnosis or history of ADHD as confirmed by the KIDDIE-SADS-PL and any elevated T-score (>60) on

the Cognitive Problem, Hyperactivity and ADHD Index in Conners' Revised Parent Rating Scale (CPRS-R [27]). Exclusion criteria were history or evidence of intellectual disability, neurological disorders or impairment such as epilepsy or concussion, pervasive developmental disorder, psychosis, manic episode and non-corrected visual deficit.

Measures

ADHD and comorbidity were diagnosed with the KIDDIE-SADS-PL [26], a semi-structured clinical interview, with a trained interviewer and at least one parent. To include children in the ADHD group, diagnoses from the KIDDIE-SADS had to be confirmed by a child psychiatrist.

The CPRS-R is a parent-report measure of ADHD symptoms and associated features. It consists of 80 items measuring 7 features: opposition, cognitive problems/inattention, hyperactivity, anxiety/shyness, perfectionism, social problems and psychosomatic; and indexes: ADHD, CGI (with CGI-Restlessness and CGI-Emotional Lability) and DSM-IV. T-scores were calculated depending on age and gender [28].

The facial emotion recognition task

The facial emotion recognition task was created with the model of the MultiMorph© [29,30] and contained three parts completed by the child in this order: facial emotion recognition practice, the facial emotion recognition task, and a control task. The first part, which all children did once, allows them to familiarize themselves with the procedure. The control task consisted of a simple task of recognizing geometric forms in order to compare the results with those of the facial emotion recognition task. It detects whether a potential deficit on the facial emotion recognition task can be assigned to a methodological bias (errors because of answering too fast, not understanding instructions, being distracted, etc.) or to a specific impairment in the facial emotion recognition process.

For the first two parts, the pictures used were adults' faces expressing fear, sadness, disgust, surprise, joy, anger and neutral expression from the Pictures of Facial Affect [31]. In order to detect discrete deficits, morphs from the Multimorph© were added by blending each facial emotion with a neutral expression. The 6 emotions were presented at full (original pictures) and half-(morphing) intensity. During the practice, two faces expressing the six emotions at both half- and full-intensity and a neutral expression were presented representing 14 trials. In the facial emotion recognition task, 4 faces each expressing the six emotions at both half- and full-intensity and a neutral expression were presented in the same way representing 52 trials. The control task included pictures of 6 geometric forms (circle, square, triangle, star, cross, arrow) and one black screen (no form) representing 52 trials.

The facial emotion recognition task was designed to limit as much as possible the influence of inattention (pictures were presented with no time limit for answering) and impulsivity (no speed requirement in instructions, opportunity to correct the answers up to 8 times). Moreover, because children with ADHD might have difficulties with long tasks, the task was designed to last less than 10 minutes.

Instructions (available from corresponding author) were adapted from Yuill & Lyon's study [15], which showed that children with ADHD perform as well as control children provided the experimenter explains the test and regulates the rapidity of the child's answer.

Children were asked to indicate their answers on a keyboard showing the seven choices as soon as the emotion or the form was recognized. Tags with emotion and geometric form labels were stuck on the keyboard buttons. There was no feedback on the child's answers in order to assess their facial emotion recognition abilities and not their learning abilities. All task details are available from corresponding authors.

Procedure

All children and their parents received information about the study, its aim and their rights. A consent form was signed by at least one parent before planning a date for the experiment. A link to a WebInterface, LimeSurvey [32], was sent by e-mail with a code created for each child, thereby allowing parents to fill in the CPRS-R. Demographic information was obtained from parents prior to testing. During the experiment, children were placed in front of the computer for the facial emotion recognition task in an office with as few distractors as possible. Instructions were written on screen and read by the examiner to the child.

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The procedure was submitted by the regional ethics committee (Comité de Protection des Personnes Sud-Ouest et Outre Mer III) and approved by the national committee on informatics rights (Commission Nationale de l'Informatique et des Libertés).

Statistical analysis

All statistical analyses were performed with R software [33]. Means, standard deviations, frequencies and percentages were calculated in order to describe the sociodemographic, clinical and facial emotion recognition variables of the sample. Group matching was tested with the chi-squared and Mann Whitney U-test as appropriate.

A first mixed ANOVA was performed with group (ADHD-control) as between-factor, task (emotion recognition-geometric form recognition) as within-subject factor and number of correct answers as dependent variable. A second mixed ANOVA was performed with group (ADHD-control) as between-factor, emotion type (fear-sadness-disgust-anger-surprise-joy-neutral) and intensity of emotion (half-low) as within-subject factor and number of correct answers as dependent variable. After each mixed ANOVA, contrast analysis was used to identify where the difference lay. Then, a Pearson correlation was performed to test whether the severity of ADHD symptoms could be correlated with the severity of the emotion recognition deficit in the ADHD group.

To test the hypothesis that ADHD and comorbid symptoms are associated with an emotion recognition deficit, multiple linear regression models with backward selection were built with the following factors: age, gender, inattention, hyperactivity, opposition, anxiety and emotional lability scores. Dependent variables were mean number of correct answers on the facial emotion recognition task and scores by emotion.

Results

Five children in the ADHD group could not complete the task because of a computer hitch (n=3), too much agitation (n=1) and perseverations (n=1). One child in the ADHD group and 3 children in the control group were excluded from the analysis because too many data were missing.

The final sample included 34 children in the ADHD group and 37 children in the control group. There was no group difference regarding age, $U=647.5$, $p=.83$, and gender, $\chi^2(1)=0.25$, $p=.62$. In terms of schooling, the ADHD group had repeated a year significantly more often, $\chi^2(1)=6.42$, $p=.01$ and they had significantly higher rates of learning disorders, $\chi^2(1)=8.9$, $p<.01$. They had significantly higher CPRS-R scores (all $p<.001$). Group statistics are shown in Table 1.

(Table 1 about here)

Children with ADHD treated with methylphenidate did not differ from children with ADHD not treated with methylphenidate in terms of inattention severity symptoms, $U=119.5$, $p=.48$, hyperactivity, $U=100$, $p=.17$, anxiety, $U=115.5$, $p=.40$, opposition, $U=176$, $p=.21$, and emotional lability, $U=148$, $p=.79$.

Group effect for facial emotion recognition scores

The first mixed ANOVA with group and task as factors revealed that group was a significant factor for number of correct answers, $F(1, 69)=5.41$, $p<.05$, $\eta^2=.045$ (small effect size). The interaction between group and task was non-significant, $F(1,69)=3.51$, $p=.07$ but trend. Contrast analysis revealed that children with ADHD had significantly lower scores on the emotion recognition task, $p<.01$, but not in the geometric form recognition task, $p=.10$.

The second mixed ANOVA with group, emotion type and intensity of emotion as factors revealed that group became non-significant, $F(1,69)=1.25$, $p=.27$ when these factors were taken into account. The interaction between group and emotion was significant, $F(6,414)=3.26$, $p<.01$, $\eta^2=.026$ (small effect size). However, the interaction between group and intensity was not, $F(1,69)=.07$, $p=.8$, as was the interaction between group, emotion and intensity, $F(6,414)=1.42$, $p=.22$.

Contrast analysis revealed that children with ADHD had significantly lower scores only for full-intensity sadness recognition, $p<.05$. Lastly, the correlation between ADHD total score and global number of correct answers on the emotion recognition task was non-significant : $r=.06$, $p=.72$ in the ADHD group. Facial emotion recognition means, standard deviations and contrast analysis results are summarized in Table 2.

(Table 2 about here)

Type of errors in ADHD group

Considering type of errors in children with ADHD, all half-intensity emotions were mistaken for neutral expression, in 26% of total errors for fear and up to 79% for sadness.

Surprise was mainly mistaken for fear in 15%-54% of errors and fear for surprise in 44%-46%. Joy was also mainly mistaken for surprise in 31%-71% of errors. Disgust was misidentified as anger in 37%-62% of errors and anger as disgust in 11%-40%. Sadness, especially at full-intensity, was mistaken with negative emotions in 60% of errors, but not with one in particular. Percentages of errors are shown in Table 3.

(Table 3 about here)

Relationship between facial emotion recognition deficit and comorbid features

Multiple regressions are shown in Table 4. Only variables from the most parsimonious model according to the Akaike Information Criterion (AIC) were included in the results. While previous results showed a significant group effect, the severity of hyperactivity expressed as a dimensional score was no longer predictive of facial emotion recognition deficit. Inattention was only predictive of lower anger recognition score, $\beta=-.05$, $p<.05$. Opposition predicted lower global facial emotion recognition scores, $\beta=-.31$, $p<.01$, lower sadness recognition scores, $\beta=-.05$, $p<.01$, and lower surprise recognition, $\beta=-.04$, $p<.01$.

The main factor explaining facial emotion recognition scores was age predicting a higher global score, $\beta=1.89$, $p<.001$, higher disgust recognition, $\beta=.23$, $p<.05$, joy recognition, $\beta=.29$, $p<.05$, surprise recognition, $\beta=.3$, $p<.01$ and neutral recognition, $\beta=.3$, $p<.01$, scores.

(Table 4 about here)

Discussion

Children with ADHD performed worse than normally developing children on the facial emotion recognition task. Globally, they had lower scores than control children in recognizing sadness. Inattention symptoms were slightly associated with anger recognition deficit whereas oppositional symptoms were associated with global recognition deficit, especially sadness and surprise recognition deficits. Hyperactivity, anxiety and emotional lability remained non-significant.

Facial emotion recognition deficit in children with ADHD

Children with ADHD performed worse than typically developing children on the facial emotion recognition task. The small effect sizes on facial emotion recognition deficits suggest a small but potentially significant clinical relevance. Moreover, as the correlation between ADHD severity score and emotion recognition score was non-significant, the intensity of emotion recognition deficit seemed not to vary with severity of ADHD symptoms.

However, there is no consistency to date in research about whether only the recognition of some emotions type is impaired in children with ADHD or if the deficit is more global. Some studies found a facial emotion recognition deficit only for negative emotions [3,5,6,14] while others did for all emotions [7,15]. Methodological differences across studies may result in varying the task difficulty and may therefore lead to differences in the number of correct responses to each emotion presented. Joy, anger and sadness expressions have often been used in facial emotion recognition tasks but other expressions of emotion have received less attention. Moreover, neutral expression

has rarely been included as a choice of answer. As a result, comparing the sadness recognition deficit we found with deficits in previous works is complex. However, a global emotion recognition deficit might be assumed as all scores were lower in the ADHD group.

Facial emotion recognition deficit in children with ADHD: an emotional developmental delay?

Analysis of mistakes is underused in research despite the fact that it allows the severity of the facial emotion recognition deficit to be determined. Patterns of mistakes in children with ADHD were not aberrant: expressions of an emotion were not recognized or were confused with another emotion having the same valence and/or the same expression characteristics (eyes wide open, lips pressed/showing teeth, wrinkled nose, etc.). Indeed, at half-intensity, all emotions except surprise were not recognized as they were misidentified as neutral expression. At full-intensity, sadness, disgust and anger were confused with negative emotions while joy was mostly confused with surprise, which can be considered equally as a positive or a negative emotion. In fact, sadness was misidentified as fear and disgust, anger as disgust and disgust for anger, all negative emotions. There was a particular confusing association between fear and surprise presumably because of a similarity in facial expression (eyes and mouth wide open).

Facial emotion recognition deficits in children with ADHD may be due to difficulties in precisely labeling the expression of an emotion, whereas identifying the global valence appears to be a less demanding task. This deficit can occur at a perceptual state and/or later. For example, it might result from an incomplete extraction of information on the face to precisely recognize the emotion and/or from a cognitive-verbal impairment to precisely understand and label the emotion.

Moreover, accurate recognition of joy and sadness appears as early as 5-6 years of age in the development of facial emotion recognition in children, while accurate recognition of disgust appears later around 12 years old [34]. However, facial emotion recognition still develops from 8 to 11 years of age [35]. Since ADHD is a neurodevelopmental disorder, emotional development might be delayed. It might also result from atypical developmental trajectories of emotion recognition in children with ADHD compared with children without ADHD.

Comorbid opposition as a severity factor for facial emotion recognition deficit

Unlike the results of Yuill & Lyon (2007) [15] and Noordermeer et al. (2015) [24] who did not find any connection between ODD and facial emotion recognition accuracy, this study found that sadness and surprise recognition were increased by oppositional symptoms. This means that oppositional symptoms as a dimensional feature could adversely impact facial emotion recognition abilities.

The development in facial emotion recognition abilities is closely linked to the child's environment (parents, peers, teachers). ODD often leads to brusque interactions with parents, teachers and peers who find it difficult to put up with the child's irritability, defiance and/or vindictiveness [36,37]. The frequency and intensity of these expressions of negative emotions when children with ODD interact with others could make them insensitive to such emotions (half-intensity sadness was mainly misidentified with neutral expression in this study) or lead them into misinterpreting negative emotions because of their frequent co-occurrence (full-intensity sadness was mainly misidentified with disgust, fear and anger). This is all the more the case in children with

ADHD comorbid with ODD as ADHD also leads to brusque interactions with others (for review, see [20]).

This study may also fill a gap in the literature about whether the emotional features of children with ADHD impact their facial emotion recognition abilities or not. Anxiety and emotional lability were not related to facial emotion recognition deficit in ADHD children. With regard to anxiety, research has emphasized that anxious children were impaired in facial emotion recognition and/or had an attentional bias toward some emotions (for review, see [38]). It can be hypothesized that a specific type of anxiety such as social, performance or separation anxiety might impact facial emotion recognition but not anxiety as a whole feature. To our knowledge, this has not yet been investigated.

Opposition and emotional lability are overlapping concepts. It was surprising that opposition accounted for a facial emotion recognition deficit in children with ADHD whereas emotional lability did not. However, ODD has been deconstructed in three dimensions: 'hurtful', 'headstrong' and 'irritable' [39]. 'Hurtful' and 'Headstrong' may be more related to facial emotion recognition difficulties because they generate conflicts in relationships more frequently. Dedicated investigations are needed to further explore facial emotion recognition in children with ADHD with or without ODD in comparison with ODD only.

This study has some limitations. Firstly, the small sample size limited the power of the study. This might have resulted in undetected effects especially regarding the impact of comorbid features on facial recognition deficit. Secondly, the ADHD group included children treated by methylphenidate. As methylphenidate seems to have an impact of facial emotion recognition abilities [14,40], some children treated for months by methylphenidate in this study may have experienced an increase in facial emotion recognition even after discontinuing their treatment 24 hours prior to the experiment. This could have led to underestimating the strength of the association between ADHD and facial emotion recognition deficit. Then, children with ADHD performed similarly to typically developing children on the control task. The difference between the two groups was not significant in contrast analysis but the interaction between group and task was also non-significant. This could have led to overestimating the facial emotion recognition in children with ADHD as they finally might experience more difficulties in completing the overall task. Last, parental reporting of inattention symptoms does not necessarily provide a measure of sustained attention that could potentially impact the facial emotion recognition task. Moreover, the inattention score had a low variance in the ADHD group as it is a core symptom of ADHD (SD=7.31). It might have had a limited impact in the regression models.

These emotional aspects of ADHD should be highlighted in research and practice. As social impairment in children with ADHD has been linked with impairment in social cognition, facial emotion recognition deficit could represent a mediator of this association. The development of facial emotion recognition should be sustained in children with ADHD, especially comorbid with ODD, in order to help them to label emotions, as is already undertaken in some cognitive remediation programs.

To conclude, the present findings suggest that children with ADHD have an impaired development in facial emotion recognition especially when an opposition dimension is present. Their

deficit in sadness recognition seems to relate globally to ODD. However, anxiety and emotional lability do not seem to interfere in facial emotion recognition. As ODD is a frequent comorbid condition with ADHD and because it may contribute to social problems in children with ADHD, the deficit in facial emotion recognition should be addressed in interventions.

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Table 1. Clinical and demographic features of the sample

	ADHD (n=34) n(%) or M±SD	Control (n=37) n(%) or M±SD	p-value
Gender (male)	24 (71%)	23 (62%)	.62
Age at testing (years)	9.18 ± 1.31	9.08 ± 1.42	.83
Grade retention			
1 or more	9 (26%)	1 (3%)	.01*
No	25 (74%)	36 (97%)	
ADHD subtype			
Combined	25 (74%)	-	-
Inattentive	8 (24%)	-	-
Hyperactive/Impulsive	1 (3%)	-	-
Oppositional defiant disorder	6 (18%)	-	-
Learning disorder	14 (41%)	3 (8%)	.003**
Anxiety disorder	3 (9%)	1 (3%)	-
Treated with methylphenidate	14 (41%)	-	-
Conners' Parent Rating Scale			
Cognitive Problems/inattention	75.21 ± 7.31	47.38 ± 5.80	<.001***
Hyperactivity	75.53 ± 11.65	47.30 ± 5.51	<.001***
Opposition	66.91 ± 12.82	45.65 ± 5.7	<.001***
Anxiety/timidity	65.26 ± 12.17	50.46 ± 8.97	<.001***
Emotional lability	64.94 ± 13.93	45.57 ± 6.84	<.001***

*p<.05; **p<.01; ***p<.001

Table 2. Means, standard deviations and group comparison on correct answers to facial emotion recognition test

	ADHD (n=34) M±SD	Control (n=37) M±SD	Contrasts p-values
Practice	7.88 ± 2.56	8.49 ± 2.01	-
Emotion recognition	27.09 ± 7.65	30.57 ± 5.73	p=.03*
Control task	50.15 ± 2	50.86 ± 1.42	p=.10
Half fear	1.74 ± 1.02	1.76 ± 1.12	p=.43
Full fear	2.32 ± 1.34	2.76 ± 1.04	p=.99
Half sadness	.94 ± 1.04	1.7 ± 1.1	p=.81
Full sadness	1.76 ± 1.26	2.49 ± 1.12	p=.02*
Half disgust	.79 ± .77	1.27 ± .96	p=.50
Full disgust	2.12 ± 1.34	1.89 ± 1.1	p=.91
Half anger	1.09 ± .9	1.51 ± 1.19	p=.79
Full anger	2.68 ± 1.15	2.89 ± 1.2	p=.17
Half surprise	1.32 ± 1.3	1.57 ± 1.12	p=.99
Full surprise	2.47 ± 1.6	2.68 ± 1.23	p=.82
Half joy	3.12 ± 1.17	3.46 ± .8	p=.95
Full joy	3.44 ± 1.02	3.86 ± .42	p=.08†
Neutral	3.29 ± 1.19	2.73 ± 1.47	p=.99

† p<.10; * p<.05; **p<.01; ***p<.001

Table 3. Type of errors in the ADHD group.

Errors on : / Confused with :	Half - fear	Full - fear	Half - sadness	Full - sadness	Half - disgust	Full - disgust	Half - anger	Full - anger	Half - surprise	Full - surprise	Half - joy	Full - joy	Neutral
Fear	/	/	9%	23%	6%	5%	13%	16%	15%	54%	4%	0%	10%
Sadness	7%	11%	/	/	10%	10%	13%	9%	2%	8%	0%	0%	24%
Disgust	10%	13%	5%	24%	/	/	11%	40%	2%	2%	4%	0%	5%
Anger	5%	9%	4%	13%	37%	62%	/	/	4%	6%	8%	0%	19%
Surprise	44%	46%	2%	4%	3%	3%	16%	13%	/	/	31%	71%	19%
Joy	8%	13%	0%	3%	1%	0%	5%	16%	6%	10%	/	/	24%
Neutral	26%	9%	79%	33%	43%	21%	41%	7%	70%	19%	54%	29%	/

Table 4. Multiple regression analyses predicting facial emotion recognition deficit

Outcomes / Factors	Global β (CI 95%) p	Fear β (CI 95%) p	Sadness β (CI 95%) p	Disgust β (CI 95%) p	Anger β (CI 95%) p	Joy β (CI 95%) p	Surprise β (CI 95%) p	Neutral β (CI 95%) p
Age	1.89 (.83, 2.95), p=.0007***	NS	.24 (-.1, .58), p=.17	.23 (-.08, .54), p=.03*	.25 (-.07, .57), p=.12	.29 (.04, .53), p=.02*	.6 (.24, .96), p=.001**	.3 (.09, .5), p=.005**
Gender	NS	-.94 (-1.93, .05), p=.06†	NS	-1.01 (-1.91, -.11), p=.15	NS	.66 (.05, 1.27), p=.03*	NS	NS
Inattention	NS	NS	NS	NS	-.05 (-.09, -.01), p=.01*	NS	NS	NS
Hyperactivity	NS	NS	NS	NS	NS	NS	NS	NS
Opposition	-.31 (-.51, -.11), p=.003**	NS	-.05 (-.08, -.18), p=.003**	NS	.03 (-.006, .07), p=.09†	-.02 (-.04, .004), p=.12	-.04 (-.07, -.007), p=.02*	NS
Anxiety	NS	NS	NS	NS	NS	NS	NS	NS
Emotional lability	.20 (-.0004, .39), p=.05†	NS	NS	NS	NS	NS	NS	.02 (-.003, .03), p=.09†
Model signification	F(3,67)=8.12, p=.0001*** R²adj=.23	F(1,69)=3.56, p=.06† R²adj=.04	F(2,68)=6.14, p=.004** R²adj=-.13	F(2,68)=3.05, p=.05† R²adj=.06	F(3,67)=3.09, p=.03* R²adj=.08	F(3,67)=5.06, p=.003** R²adj=.15	F(2,68)=9.04, p=.0003*** R²adj=.19	F(2,68)=5.46, p=.006** R²adj=.11

NS= non-significant ; † p<.10 ; * p<.05 ; ** p<.01 ; *** p<.001