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Recognition of Emotional Facial Expressions in Attention-Deficit Hyperactivity Disorder

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In ADHD, impaired interpersonal relationships have been documented. They have been hypothesized to be secondary to impairment of receptive nonverbal language. Recognition of emotional facial expressions is an important aspect of receptive nonverbal language, and it has been demonstrated to be central to organization of emotional and social behavior. This study investigated the identification of facial expression of four emotions (joy, anger, disgust, and sadness) in a group of 30 children aged 7-12 years who met the DSM-IV criteria for ADHD disorder of the predominantly hyperactive-impulsive type and have no comorbid mental retardation, specific learning difficulties, developmental coordination disorder, pervasive developmental disorders, conduct disorder, bipolar disorder, or substance abuse, and in 30 matched unimpaired control children. The test used includes 16 validated photographs depicting these emotions in varying intensities constructed by morphing. Children with ADHD exhibited a general deficit in decoding emotional facial expressions, with specific deficit in identifying anger and sadness. Self-rating of the task difficulty revealed lack of awareness of decoding errors in the ADHD group as compared with control subjects. Within the ADHD group, there was a significant correlation between interpersonal problems and emotional facial expression decoding impairment, which was more marked for anger expressions. These results suggest suboptimal nonverbal decoding abilities in ADHD that may have important implications for therapy. **© 2006 by Elsevier Inc. All rights reserved.**

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Introduction

Attention-deficit hyperactivity disorder (ADHD) is a neurobehavioral syndrome characterized by inattention, impulsivity, and hyperactivity [1]. The precise pathophysiology of this disorder is currently unknown [2]. Associations with environmental factors, including obstetric complications, fetal or infantile exposure to a number of substances, and rearing conditions, have been studied. Various molecular genetic associations have also been described, including some involving genes related to dopamine transmission, but their relevance remains inconclusive. Several lines of evidence seem to suggest catecholaminergic dysregulation. Attention-deficit hyperactivity disorder is the most frequent neurobehavioral disorder in primary school-age children, where referral to specialist attention is most likely, affecting an estimated 8-12% of these children [1,2]. Children with attention-deficit hyperactivity disorder may experience associated problems including school difficulties, academic underachievement, low self-esteem, and impaired social interaction with parents, siblings, peers, and teachers [3,4]. The latter may be so prominent that some authors have considered impaired interpersonal relationships as central to the psychopathologic behavior of children with attention-deficit hyperactivity disorder [4,5]. Interpersonal problems have been associated with deficits in nonverbal communication, and in particular with its receptive aspects [6]. In this respect, correct decoding of emotional facial expressions seems particularly important [6]. In view of the clinical heterogeneity of attention-deficit hyperactivity disorder, several subtypes have been defined, namely predominantly inattentive, predominantly hyperactive-impulsive, and combined types

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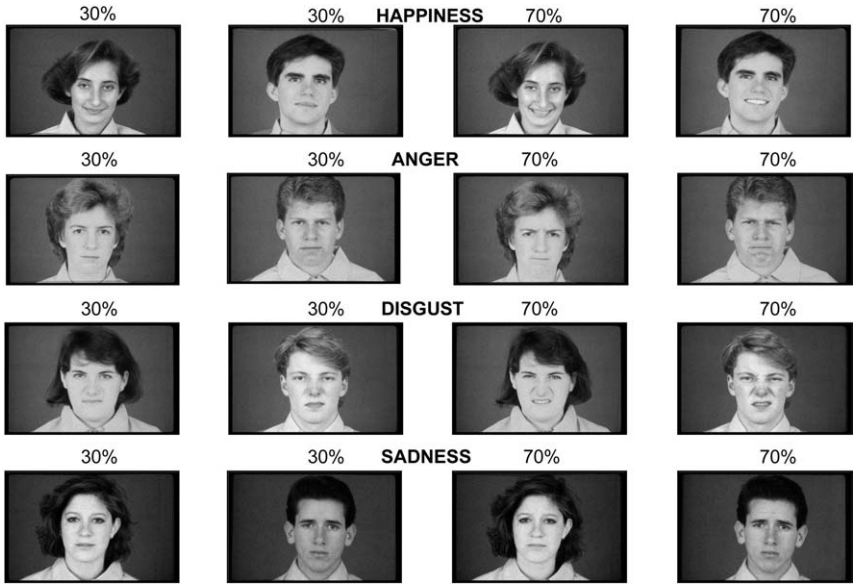

Figure 1. Emotional facial expressions used in this study.

[1]. In this study, the identification of emotional facial expressions in 30 children with predominantly hyperactive-impulsive attention-deficit hyperactivity disorder was compared with that of 30 normal control subjects.

Material and Methods

Study Group

Thirty children (7 females, 23 males) aged between 7 and 12 years (8 ± 1.2) with attention-deficit hyperactivity disorder of the predominantly hyperactive-impulsive type according to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) criteria participated in the study. None had associated mental retardation, specific learning difficulties, developmental coordination disorder, pervasive developmental disorders, conduct disorder, bipolar disorder, or substance abuse. All attended age-appropriate mainstream school. Twenty-two children were taking methylphenidate (0.4-1.2 mg/kg/day during the school periods), but all medication was withdrawn at least 10 days before participation in the study.

Normal Control Children

Thirty sex- and aged-matched children with no impairment and no medication served as control subjects.

Emotion Facial Expression Decoding Procedure

A series of emotional facial expressions constructed and validated by Hess and Blairy [7] was used. These authors selected facial expressions of happiness, anger, sadness, and disgust performed by two male and two female actors (Fig 1) from a series of standardized emotional facial expressions [8]. A series of intermediate expressions differing in emotional intensity levels by 10% steps was constructed based on the neutral face (0% of emotional intensity level) and full-blown emotional facial expression (100% of emotional intensity level) of the same actor and using the computer program Morph 1.0. On the basis of our previous experience in different (adult) populations [9], the 30% and 70% intensity levels seemed to have the most ecological validity compared with full-blown expressions. From this series, a set of 2 (intensity levels: 30% and 70%) × 4 (emotions: happiness, anger, disgust, and sadness) × 2 (actors) stimuli constituted the stimulus material. These 16 stimuli were presented in a random order on a personal computer. The experimenter explained to the participants that their task was to identify emotions portrayed on the presented photographs. Each of the 16 expressions were rated by participants on four 7-point intensity scales presented successively, respectively labeled "happiness", "sadness", "anger", and "disgust". On the intensity scales, 0 corresponded to "not at all" and 6 to "very intensely". After completion of the emotion rating of each expression, participants rated the difficulty in assessing the corresponding emotional facial expressions on a 7-point scale with 0 corresponding to "not at all" and 6 to "very intensely". This additional measure was used to evaluate the subject's awareness of eventual deficits in emotional facial expressions decoding. The image of the face remained on the screen until all scales were completed. Informed consent was obtained from the children and parents.

Assessment of Interpersonal Problems

After completion of the emotional facial expressions decoding task, the child filled in the pediatric questionnaire adapted from the Inventory of Interpersonal Problems [10].

Statistical Analysis

Statistical analyses were performed using the Statistica 5.0 software. Analysis of variance was used for comparisons between sets of data. Significance was defined as $P < 0.05$. Spearman test was used for correlation measures.

Ethical Aspects

The study protocol was approved by the Ethics Committee of the Free University of Brussels (ULB). Participants and one parent gave informed consent.

Table 1. Emotional facial expression decoding accuracy and awareness of decoding skills in children with attention-deficit hyperactivity disorder and control subjects

	Happiness						Sadness					
	Accuracy Score			Awareness Score			Accuracy Score			Awareness Score		
	30%	70%	Total	30%	70%	Total	30%	70%	Total	30%	70%	Total
ADHD												
mean	1.36	1.77	3.14	1.23	1.41	2.64	**0.45**	**1.14**	**1.60**	0.77	1.09	1.86
S.D.	0.58	0.43	0.77	0.75	0.80	1.26	**0.60**	**0.71**	**0.96**	0.75	0.81	1.17
Controls												
mean	1.48	1.88	3.36	1.40	1.72	3.12	**0.96**	**1.64**	**2.60**	1.00	1.48	2.40
S.D.	0.59	0.33	0.76	0.50	0.54	0.88	**0.61**	**0.64**	**1.08**	0.65	0.71	1.11
F	0.46	0.93	1.00	0.80	2.50	2.40	**8.2**	**6.6**	**11.33**	1.24	3.00	2.60
P	0.50	0.34	0.32	0.35	0.12	0.13	**0.006**	**0.01**	**0.001**	0.27	0.09	0.11
	Anger						**Disgust**					
	Accuracy Score			Awareness Score			Accuracy Score			Awareness Score		
	30%	70%	Total	30%	70%	Total	30%	70%	Total	30%	70%	Total
ADHD												
mean	0.41	**0.82**	**1.23**	0.73	**0.68**	1.41	0.77	1.50	2.36	**0.59**	1.18	**1.77**
S.D.	0.50	**0.66**	**1.07**	0.70	**0.72**	1.14	0.75	0.74	1.18	**0.50**	0.91	**1.11**
Controls												
mean	0.60	**1.64**	**2.24**	0.68	**0.24**	1.92	1.00	1.68	2.68	**1.08**	1.36	**2.44**
S.D.	0.65	**0.57**	**0.88**	0.75	**0.72**	1.26	0.65	0.56	0.85	**0.81**	0.64	**1.00**
F	1.25	**20.9**	**12.7**	0.05	**7.00**	2.00	1.2	0.9	1.13	**6.00**	0.60	**4.70**
P	0.27	**0.00004**	**0.0009**	0.82	**0.01**	0.15	0.27	0.34	0.30	**0.02**	0.43	**0.03**

Abbreviation:
ADHD = Attention-deficit hyperactivity disorder
Boldfaced data indicate statistical significance.

Results

All children could answer the questionnaires and complete the task. Overall, children with attention-deficit hyperactivity disorder made significantly more emotional facial expressions decoding errors than control children ($F = 23.15$, $P < 0.001$). However, there were differences according to the displayed emotional facial expressions. Decoding accuracy for the different emotional facial expressions presented with 30% intensity, 70% intensity, and compound (30% + 70%) results are displayed in Table 1. No significant differences were evident in emotional facial expressions decoding accuracy between children with attention-deficit hyperactivity disorder and control children for happiness and disgust emotional facial expressions. Decoding accuracy was significantly lower in children with attention-deficit hyperactivity disorder than in control subjects for anger emotional facial expression with 70% intensity ($F = 20.90$, $P < 0.001$) and compound 30% + 70% results ($F = 12.70$, $P < 0.001$). Decoding accuracy was also lower in children with attention-deficit hyperactivity disorder than in control children for sadness emotional facial expression at all intensities (30%: $F = 8.20$, $P = 0.006$; 70%: $F = 6.60$, $P = 0.01$; 30% + 70%: $F = 11.30$, $P = 0.001$). Self-rating of the task difficulty revealed overall lack of awareness of decoding errors in the attention-deficit hyperactivity disorder group as compared with control subjects ($F = 7.00$, $P < 0.01$). Compared with control children, those with attention-deficit hyperactivity disorder manifested significantly lower awareness of errors for anger (70%: $F = 7.00$, $P = 0.01$) and disgust (30%: $F=6.00$, $P = 0.02$; 30% + 70%: $F = 4.70$, $P = 0.03$) emotional facial expressions. The attention-deficit hyperactivity disorder children group produced a mean Inventory of Interpersonal Problems score of 74.60 ± 31.60, whereas control children had a mean Inventory of Interpersonal Problems score of 21.10 ± 8.60 ($F = 66.10$, $P < 0.001$). Within the attention-deficit hyperactivity disorder group, there was a significant inverse correlation between Inventory of Interpersonal Problems scores and overall decoding accuracy ($r = -0.67$, $P < 0.001$). The correlation between interpersonal problems and accuracy in decoding emotional facial expressions was highest for anger displayed at 70% intensity ($r = -0.84$, $P < 0.001$, Table 1). No such correlations were found in control children. Despite a tendency for lower awareness error scores with higher Inventory of Interpersonal Problems scores, there was no significant correlation between these parameters in either group.

Discussion

In this study, an emotional facial expressions decoding task previously developed in adults, but increasingly used in pediatric neuropsychological studies [11-13], was utilized. Children with predominantly hyperactive-impulsive attention-deficit hyperactivity disorder made significantly more errors when labeling emotional facial expressions than control children. This finding is consistent with impaired processing of nonverbal cues previously reported in attention-deficit hyperactivity disorder [14,15]. This

outcome may be due nonspecifically to inattention and impulsivity, which are cardinal feature of attention-deficit hyperactivity disorder [1]; or to alterations in motivational processes [16]. Deficits in executive functioning in these children result in poor performance in visual and auditory tasks that require attention [17,18].

Impaired emotional facial expressions labeling could also be partly explained by perception impairments. Perceptual problems have been documented in several domains in attention-deficit hyperactivity disorder, with particular emphasis on visual-perceptual deficits [19]. Such deficits have been implicated as underlying other difficulties presented by children, such as in drawing, writing, and reading [19,20]. More specific perceptual deficits are not excluded, as studies of discrimination of emotional facial expressions have documented difficulties in patients with a variety of acquired focal lesions, particularly in the right inferior parietal cortex and in the right mesial anterior infracalcarine cortex [21]. It is noteworthy that in the latter study [21], no patients with left hemisphere lesions manifested emotional facial expressions decoding abnormalities. Right hemisphere dysfunction has been incriminated in attention-deficit hyperactivity disorder on the basis of neuropsychological [22], magnetic resonance imaging [23], blood perfusion [24], and transcranial magnetic stimulation findings [25]. Various other brain areas have been implicated in attention-deficit hyperactivity disorder, including the temporal and parietal cortex and basal ganglia. These regions have also been tentatively linked to processing of emotional facial expressions.

We found that children with attention-deficit hyperactivity disorder had significantly more difficulties in identifying emotional facial expressions of anger and sadness. A similar difficulty of children with attention-deficit hyperactivity disorder in recognizing anger emotional facial expression was observed previously [26]. This difficulty may be related to the complex dynamics of self-perception of anger and distorted empathy in attention-deficit hyperactivity disorder [27,28]. In another study [29], children with attention-deficit hyperactivity disorder tended to reciprocately mistake anger for disgust. This finding contrasts with the general tendency displayed by children with a history of abuse [30] or with conduct disorder [15] to misinterpret emotions as anger. The latter authors concluded that social problems in children with conduct disorder result from biased perception of emotion, whereas in attention-deficit hyperactivity disorder they result from a failure to attend to the appropriate cues of affect. It is also possible that children with attention-deficit hyperactivity disorder specifically learn to ignore anger and sadness, as suggested by studies supporting the protective role of positive relationships within the family and school environment [31].

The finding of much higher levels of interpersonal problems in attention-deficit hyperactivity disorder than control children and of a correlation between emotional facial expressions decoding errors and their interpersonal problems points to a possible functional link between these aspects. Correct recognition of emotional facial expressions plays a major role in the development and regulation of interpersonal relationships. Marked differences in the ability to correctly perceive displayed emotion have been observed between accepted and rejected children [32]. A study of 196 children aged 8-11 years demonstrated a correlation between good emotional facial expressions decoding abilities and high sociometric status [33]. Emotional facial expressions decoding abilities have also been demonstrated to correlate with social competence of children [34]. The correlation between anger emotional facial expression decoding errors and Inventory of Interpersonal Problems in attention-deficit hyperactivity disorder appears particularly relevant.

The present study focused on a sample of patients with attention-deficit hyperactivity disorder of the predominantly hyperactive-impulsive type. This subtype of attention-deficit hyperactivity disorder was defined as distinct from a subtype where symptoms of inattention predominate and a combined subtype [1]. These subtypes were developed empirically from the DSM-IV field trials [35]. Differences in school performance according to this typology have been reported in a large series, children with predominantly inattentive attention-deficit hyperactivity disorder having more academic problems than children with predominantly hyperactive-impulsive type [36]. However, no differences were observed in measures of neuropsychological functioning among the three attention-deficit hyperactivity disorder subtypes [37]. Moreover, evaluation of the stability of these subtypes over time has revealed that children diagnosed as having the predominantly hyperactive-impulsive type rarely remain in that classification, suggesting that the subtypes cannot be viewed as permanent nominal categories [38]. It is therefore difficult to anticipate if different results could be anticipated in the other subtypes, although the inattention might be expected to induce more nonspecific decoding errors.

The results of the present study underline the importance of providing children with attention-deficit hyperactivity disorder with explicit, consistent messages; this could include systematic verbal reinforcement. Awareness of impairment in decoding emotional facial expressions should improve communication both within the family and school settings. In particular, awareness of mislabeling of emotional facial expressions of anger and sadness could decrease the intensity of problematic situations arising from the child's disruptive behaviors. This point appears to be especially critical considering that children with attention-deficit hyperactivity disorder were less aware of their emotional facial expressions decoding difficulties than control children.

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