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ORIGINAL PAPER

The Role of Simple Emotion Recognition Skills among School Aged Boys at Risk of ADHD

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Abstract Poor social skills and behavioral problems are a major component of ADHD. The different explanations offered so far, such as cognitive deficits and deficient self regulation, have not been able fully to account for the various aspects of the social dysfunction, suggesting that other mechanisms might underlay this impairment. Our study sought to assess the emotion recognition of Israeli boys at risk of ADHD, and to evaluate its associations with their social skills. A group of 111 boys (grades 4 and 5) were assigned to an At-risk ($n = 50$) and a control ($n = 61$) group based on their scores in an ADHD symptoms questionnaire. The two groups were matched on age, socio-economic status and class and school environment. Group comparisons revealed that compared to their non-At-risk counterparts, At-risk boys have impaired emotion recognition. Finally, multiple groups Structural Equation Modeling analyses (SEM) demonstrated that emotion misrecognition plays a significant role in the At-risk children's social functioning and behavioral problems compared to its role in the social competence and behavioral problems among the comparison group. Implications for the understanding and treatment of social skills problems among children at risk of ADHD are proposed.

Keywords ADHD · Social skills · Emotion recognition · Emotional competence

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Attention Deficit Hyperactivity Disorder (ADHD) is a disorder diagnosed in childhood or adolescence which is characterized by elevated levels of inattention and hyperactivity/impulsivity (APA, 2000). ADHD prevalence rates are between 2% and 17% in the general population of school-aged children in different countries (Scahill & Schwab Stone, 2000). These deficiencies are pervasive undermining children's optimal development, damaging their self-esteem, and are difficult to manage by parents and teachers. The high frequency of the disorder has drawn much attention from researchers and clinicians in an attempt to understand the mechanisms that underlie it and its manifestations, and to find the best treatment for it. However, several aspects of the disorder are yet to be understood, for instance ADHD children's deficit in social skills (Nixon, 2001). Existent research sees in cognitive deficiencies the main cause of the social impairments that accompany ADHD (Barkley, 1997; Nixon, 2001); little is known, however, about other plausible domains such as deficiencies in emotional skills. We propose that the study of ADHD children's emotional competence may constitute an important complement to the study of these children's social skills deficiencies. In the present research we explore the assumption that deficits in emotional competence, mainly the impaired recognition of facial affect (Friedman et al., 2003) are a significant factor in the development of ADHD social skills and behavioral problems.

ADHD and social skills

Numerous studies have confirmed the behavior problems and social competence impairments of children with ADHD, stressing their high levels of aggression, defiant, disruptive and intrusive behavior, poor peer interactions and impaired interpretation of social situations (Henker & Whalen, 1989; Henker & Whalen, 1999; Nixon, 2001; Stormont, 2001).

The main indicator of social competence within this body of research is the judgment of competence by others, specifically measures of peer acceptance (Nixon, 2001). Studies show that children with ADHD receive low ratings in peer-nomination and peer-ratings measures. According to Guevremont and Dumas (1994) as much as 50% of children with ADHD are rejected by their peers. Other studies portray these children to be less desirable to play and work with, and rejected after only a minimal exposure to peer interaction (Nixon, 2001; Stormont, 2001).

Furthermore, research comparing ADHD to other childhood disorders associated with social problems, such as Spina Bifida and Learning Disabilities has shown that ADHD has the most significant effect on social skills and behavior problems (Fussell, Macias, & Saylor, 2005). In social interactions ADHD children are reported to act in an intrusive, annoying, aggressive, disruptive and boisterous manner (Henker & Whalen, 1989; Landau & Moore, 1991). They argue, violate the rules, and exhibit negative classroom behaviors and verbal and physical aggression (Guevremont & Dumas, 1994). In their peer interactions, children with ADHD tended to use more controls/commands (Cunningham & Siegel, 1987), engage in less reciprocal verbal interactions, and are more withdrawn (Clark, Cheyne, Cunningham, & Siegal, 1988).

Suggested explanations for the social competence problems among ADHD children focus on social and cognitive skills, such as understanding of social behavior, problem solving, behavioral inhibition (Barkley, 1997) and evaluation of consequences of behavior (Nixon, 2001). Among the various explanations are inadequate social information processing (Milich & Dodge, 1984), poor attention to relevant cues (Guevremont & Dumas, 1994) and failure to represent social events adequately, which leads to processing deficits in the subsequent steps of the cognitive chain, and causes less advanced and even maladaptive social responses (Milch-Reich, Campbell, Pelham, Connely, & Geva, 1999). It is also suggested that a lack of age-appropriate interpersonal skills, including the capacity to initiate and disengage from social encounters, as well as atypical social agendas and goals that are considered unsuitable, are the basis of faulty social skills (Whalen & Henker, 1985). The later are considered to be a result of the hyperactive child's need to satisfy sensation seeking by looking for social disruption in a stimulus-poor environment (Zentall & Zentall, 1983). Other studies propose that behavioral disinhibition, characteristic of ADHD, leads to various executive functions deficits resulting in ADHD children's inappropriate social behavior (Barkley, 1997).

The aforementioned different explanations have been only partially successful in accounting for the deficits in social competence of children with ADHD, covering only some of the various social deficits presented by these children (Nixon, 2001). Theories of behavioral disinhibition focus mainly on expressive impairments, which are caused by the key symptoms of ADHD, and do not provide explanations for these children's receptive deficits such as poor social cues interpretation (Friedman et al., 2003). Studies that focus on deficits in social knowledge do not specify the mechanisms which might underlie the various impairments of ADHD children in this domain, and their results concerning these deficits are inconsistent (Nixon, 2001). The partial success of explanations of ADHD children's social deficits, suggests that there might be additional explanatory factors that might account for the social competence deficiencies of these children. One such explanatory factor may be ADHD children's emotional competence.

Emotional competence and social skills

The review of the theoretical and empirical literature on the associations between emotional competence and social skills shows that emotions play an important role in the child's ability to function properly in social situations, and suggests that deficits in emotional competence might lead to a lack of social skills and to inappropriate behavior (Saarni, 1999). Indeed, a growing number of studies stress the importance and the centrality of emotions in the etiology, presentation and course of various psychopathologies (see e.g., Flack & Laird, 1998).

Emotional competence has been defined as including three general facets: (a) understanding or appraisal of emotion—the ability to correctly identify, appraise and understand emotional expressions of others and internal emotional states of oneself and another, (b) regulation of emotions—the ability to manage and alter one's emotional experience, especially its intensity and duration, to manage strategically one's expression of emotion in communicative contexts (Thompson, 1994), and (c) expression of emotion—the ability to communicate one's emotions through verbal (language) and non-verbal (facial and vocal expressions, gestures, posture) means. These are intertwined, and cannot develop without each other (Saarni, 1999). A growing body of research has established a strong association between the development of emotional competence and social skills in the general population, and demonstrated that the development of emotional competence is crucial for the child's ability to interact with others, and therefore is considered to be a prerequisite of social competence (see e.g., Saarni, 1999).

Mostow, Izard, Fine, and Trentacosta (2002) have established that the relations between emotional and social competence are unilateral. In their longitudinal study involving elementary school children, emotion knowledge assessed through the ability to recognize and label emotions predicted children's social competence, and not vice versa,

showing that there is a positive relationship between these two competencies (Mostow et al., 2002). Other studies have also shown that the ability of children in elementary grades to recognize and label emotions is strongly linked to their social adjustment (Izard et al., 2001; Walden & Field, 1990) and academic achievement (Izard et al., 2001).

One of the more basic and necessary skills of emotional competence is the recognition of emotional expressions. It was Darwin (1872) who first noted that emotional expressions are a basic mechanism of social communication. One cannot appraise the emotion of the individual he/she interacts with, without the ability to recognize his/her emotional expressions. Recognizing emotional expressions is a key component of a broader cognitive skill—nonverbal processing ability—which has been linked to important personal and academic outcomes (Nowicki & Duke, 1992), and contributes to the ability to represent social situations appropriately, leading to more effective social interactions (Feldman, Philippot, & Custrini, 1992). Studies have shown that most people can successfully recognize expressed emotions elicited in everyday social interactions (Izard, Huebner, Risser, McGinness, & Dougherty, 1980), and this ability improves with increasing age and IQ among children (Izard, 1971). However, individuals in some clinical populations (autism, mental retardation, schizophrenia and other disorders) are less accurate in recognizing emotions (Singh et al., 1998); this inaccuracy results in impaired abilities to interact in social situations and in forming relationships.

Emotional competence, social skills and ADHD

Two main models specify the different mechanisms that underlie ADHD, each leading to different emotional competence deficits assumed to cause faulty social skills and behavioral problems. According to Barkley's (1997) model, the deficit in behavioral inhibition is the key mechanism that underlies this disorder allowing for the impairments in four executive neuropsychological functions: (a) working memory, (b) self-regulation of affect-motivation arousal, (c) internalization of speech, and (d) behavioral analysis and synthesis, which in turn generate a set of impairments resulting in inappropriate behavior and social skills deficiencies. For example; deficiencies in self-regulation of affect are seen as underlying decreased empathy, increased emotional responsivity to provoking situations, poor ability to anticipate emotional reactions to future events and so forth (Barkley, 1997). This model, which focuses on executive functions, engaged by the frontal lobes, does not predict impairments in recognition of affective stimuli, a process that is managed by the right hemisphere (Heilman, Voeller, & Nadeau, 1991; Posner & Raichle, 1994; Shapiro, Hughes, August, & Bloomquist, 1993), and that has been found to be closely related to social functioning (Feldman, Philippot, & Custrini, 1992; Nowicki & Duke, 1992). According to Barkley (1997), the only emotional competence impairment that is responsible of ADHD children's inappropriate behavior and deficient social skills is their faulty self control and emotion regulation, which stem from their behavioral disinhibition (Barkley, 1997).

An alternative model of ADHD—the posterior-right-hemisphere model—suggests that separate systems for attention exist in the frontal lobes and in the posterior right hemisphere, producing separate deficits (Posner & Raichle, 1994; Shapiro et al., 1993). Dysfunction of the right hemisphere causes deficiencies in attentional deployment and in processing of emotional cues (Heilman, Voeller, & Nadeau, 1991; Pollak & Wismer Fries, 2001). Research shows that a depletion of *norepinephrine* exists in ADHD (Shaywitz & Shaywitz, 1988), and that these *norepinephrine* depleted pathways act on the posterior-right-hemisphere (Pennington, 1991), putting subjects with ADHD at risk for impairments in the ability to evaluate affective stimuli and sustain attention (Shapiro et al., 1993). Neurological studies provide evidence relating inattention and social deficits, typical of children with ADHD, to dysfunctions in the right hemisphere (Stefanatos & Wasserstein, 2001; Gross-Tsur, Shalev, Manor, & Amir, 1995); these findings suggest that emotion misrecognition might be responsible for these children's social skills deficits.

Though the research supporting ADHD children's impaired self regulation is extensive, and it is quite apparent that behavioral disinhibition is responsible for these children's inappropriate social behavior, it is possible that it is not the only factor that contributes to the ADHD impaired social skills. Focusing on ADHD children's emotion recognition abilities might contribute to the explanation of their faulty social skills. The main purpose of this study is to investigate ADHD children's capacities for emotion recognition and to evaluate their role vis a vis their social skills and behavior problems.

Emotion recognition and ADHD

Several studies have been conducted to assess clinically diagnosed ADHD children's emotion recognition skills using different paradigms. Singh et al. (1998), using an emotion recognition task where children are requested to match photographs of facial affect (Ekman & Friesen, 1975) to story stems presented to them, has shown that children with ADHD make more mistakes in emotion recognition, and fail to recognize anger correctly compared to the reported rates of mistakes produced by children in the general population (Singh et al., 1998). Another study showed that children with ADHD exhibit difficulties in identifying emotions, especially in live situations (Norvilitis, Casey, Brooklier, & Bonello, 2000). Furthermore, ADHD children were shown

to be less accurate than controls in identifying their own and their partner's emotional expressions; in addition, when presented with vignettes involving social situations, they performed worse than controls in identifying the emotions felt by the characters and in selecting facial drawings depicting the character's emotion (Casey, 1996). In a different study, where emotion recognition of various non-verbal cues (facial expressions, postures, gestures and tone of voice) of ADHD and ADHD/LD (ADHD with learning disabilities) children's were evaluated, only the ADHD/LD presented deficient abilities in emotion recognition (the sample size of the study was limited, 15 subjects per group, reducing the probability to reach significant effects and appropriate power) (Hall, Peterson, Webster, Bolen, & Brown, 1999). Using a similar technique, Cadesky, Mota, and Schachar (2000) showed that children with ADHD do have impaired ability to identify emotions, but compared to children with conduct problems, the ADHD group made random errors presenting no bias in their misrecognition of emotions. The authors concluded that ADHD children have encoding deficit rather then specific distortions in emotion interpretation (distortions would present themselves as a specific pattern of mistakes, rather than random errors) (Cadesky, Mota, & Schachar, 2000).

It is important to note that the above reviewed studies presented the children with relatively complex tasks (matching facial affect to story stems, identifying emotions based on the protagonist's beliefs and thoughts, and so on) involving working memory functions, and thus engaging the frontal lobes. In order to better understand ADHD children's specific difficulties, it may be important to evaluate the ability to recognize emotional cues using an approach that does not involve working memory.

Shapiro et al. (1993) attempted to evaluate ADHD children's abilities to recognize emotional cues, testing the alternative model of ADHD, by presenting ADHD children with various emotion recognition tasks where emotional cues had to be recognized in faces and prosody. The results of their study showed that children with ADHD performed poorly on prosody recognition and on a Cross-Modal task, where they are required to match prosody and facial expression, but their performance on other tasks was the same as controls (Shapiro et al., 1993). In a later study Corbett and Glidden (2000) tested ADHD children's emotion recognition capacities using a prosody recognition task and a simple recognition of facial affect task, where children were asked to recognize the expressions in pictures from the Ekman and Friesen (1975) compilation. In this study, the ADHD children were found to have impaired emotion recognition skills, providing further support for the alternative model of ADHD according to which ADHD children indeed suffer from impairments in recognition of affective stimuli (Corbett & Glidden, 2000).

Though the studies presented here present diverse findings, they do suggest impairments in ADHD children's emotion recognition. However, these studies did not analyze the nature of the specific recognition errors made by the ADHD children, and no relations between the poor emotion recognition and social skills were assessed. The present study was intended to further the understanding of the role of emotion recognition processes in ADHD children's social skills and behavioral problems.

The present study

Two main aims were pursued in the present study: First the direct evaluation of emotion recognition skills of children at risk of ADHD. Second, the exploration of the effects emotion recognition has on At-risk children's social skills and behavioral problems. We hypothesized that (1) children at risk of ADHD will exhibit higher levels of behavioral problems and lower social skills scores than the non-At-risk children. This hypothesis is aimed to validate the group selection showing that the At-risk sample presents social and behavioral problems. (2) At-risk children will be expected to present lower levels of emotion recognition skills, presenting more recognition errors and longer reaction times, compared to their non-At-risk counterparts, and (3) the children's impairment in emotion recognition will be related to their social skills and behavioral problems, and these associations will be stronger among the At-risk children. That is, risk of ADHD will exacerbate the association between misrecognition of affect and social problems.

Method

Participants

The study sample consisted of 111 Israeli boys in fourth and fifth grades, students in regular elementary schools. None of the children attended special education classes or received medications for ADHD. Only boys were included in this study because the prevalence of girls with ADHD is three times lower then that of boys (American Academy of Pediatrics, 2000), reducing the chances to gather a sufficient sample of girls exhibiting symptoms of ADHD. In addition, it might be noted that girls with ADHD are generally less symptomatic (especially exhibiting less impulsivity and aggressiveness) (Newcorn et al., 2001), and their emotion recognition abilities are expected to differ then those of boys (Leppanen & Hietanen, 2001). The study group consisted of 50 students at risk of ADHD (At-risk group) (age range = 9.10–11.70 years, $M = 10.55$ years, $SD = .62$) and who were not receiving any medication for ADHD during the research period. The comparison group was selected from the

same classes attended by the At-risk group thus minimizing the differences regarding age, socio-economic status and class and school environment, and consisted of 61 students who were found to be low on ADHD and other symptoms (ODD, hyperactivity and cognitive problems) measured by the CRS-R-S—the non-At-risk group (age range = 9.10–11.60 years, $M = 10.36$ years, $SD = .61$). Six elementary schools participated in the study, all of which were regular education schools serving children of middle SES and similar racial back-grounds. Most of the participating students were born in Israel, the remaining 15% of the children in both groups were immigrants, but lived in Israel for at least four years.

Measures

Demographic characteristics

Information regarding parental education (years of schooling) was obtained. Parental education has been found to be the most robust socio-demographic predictor of child behavior (Bornstein, Hahn, Suwalsky, & Haynes, 2003), influencing positively on social competence and negatively on emotional and behavioral problems in young children (Hoglund & Leadbeater, 2004), and to be the best substitute for SES at large (Bornstein et al., 2003). The children's age and immigration status was obtained as well, since these variables might influence the children's social and emotional competence.

Conners rating system-revised

The CRS-R-S (Conners, 1997) is the most common scale used for screening ADHD (Demaray, Elting, & Shaefer, 2003). In this study the short version of the CRS-R was filled in by the teachers. This short version contains 28 items, takes about 5 minutes to administer, and is commonly used for screening. The teacher scales usually provide the most economical and objective way to obtain relevant assessment information because they provide an ideal means for describing academic, social, and emotional behaviors in the classroom (Conners, 1997). Furthermore, teacher's perspective has been found to be critical in the diagnosis of ADHD; the DSM-III-R (APA, 1994) recommended giving teacher reports of symptoms greater weight than to parents' reports when diagnosing this disorder (Wolraich, Feurer, Hannah, Pinnock, & Baumgaertel, 1998). Teacher ratings have also shown better sensitivity, specificity and classification accuracy when screening for ADHD (Tripp, Schaughency, & Clarke, 2006).

The CRS-R-S contains 4 subscales measuring oppositional defiant disorder, cognitive problems, hyperactivity and ADHD, the last is being used for screening for ADHD. Each subscale is scored on a 4-point Likert-style scale ranging from "not true at all" to "very much true." All the subscales have a mean T-score of 50 ($SD = 10$) and T-scores of 65 and above are considered to be clinically significant (Conners, 1997; Demaray, Elting, & Shaefer, 2003). Norms for the CRS-R-S teacher version were created on a large group ($N = 1{,}897$) of children and adolescents, aged 3–17 years, from a regular education classes from over 200 schools (see Demaray, Elting, & Shaefer, 2003 for a review). The scales have excellent psychometric properties (reliability ranges from 0.75 to 0.90 for various subscales) (Conners, 1997). In the present study the scales showed indeed high internal reliability (Cronbach alpha of 0.94 for oppositional scale, 0.96 for hyperactive scale, 0.94 for cognitive problem scale and 0.98 for ADHD scale).

Social skills rating system

The SSRS (Gresham & Elliot, 1990) consists of three questionnaires, for children, parents and teachers, and it allows obtaining a complete picture of the child's social skills and behavioral problems. The questionnaires consist of four subscales: Cooperation, Assertion, Self-Control and Empathy (in children's version only), and the teacher and parent versions also include the Problem Behavior Scale, which evaluates the child's social skills, and his externalizing problems (such as aggressive acts and poor temper control), internalizing problems (such as sadness and anxiety) and hyperactivity (such as fidgeting and impulsive acts). Lastly, the teacher version includes an Academic Competence Scale. The reported reliability for these scales ranges between 0.83 and 0.94 (Demaray & Malecki, 2002).

In this study only the teacher version was administered, since the teachers' evaluations of the social skills dimensions were found to represent children's skills more accurately in previous research (see Diperna & Volpe, 2005 for review). In the psychometric evaluation of the scale among children with ADHD, the results for the teacher version supported the factor structure and the internal consistency of the original scale, and it was found to discriminate between ADHD and control groups (Van Der Oord et al., 2005). In this study, the SSRS-teacher scale showed excellent internal reliability properties (Cronbach alpha for cooperation scale was 0.95, assertion 0.86, self control 0.92, externalizing problems 0.95, internalizing problems 0.88 and hyperactive behaviors 0.89).

Peer rating

Peer rating is a sociometric status measurement which allows the child to rate the likeability of his classmates (Choi & Heckenlaible-Gotto, 1998 adapted from Gresham, 1982). Each child receives a form with his classmates names listed

on the side. For each classmate the child rates whether he would like to play with this child, and in the next column, whether he would like to work with this child. Each child is rated on a five point scale ranging from "would not like at all" to "would like very much," with smiley and frowned faces symbolizing the amount of likeability. This measure of sociometric status is considered to be more reliable and valid than peer nominations in assessing children's overall social competence (Gresham, 1981; Hughes & Sullivan, 1988; McConnell & Odom, 1986).

In this study only the boys filled the forms, since previous studies demonstrated that sociometric peer ratings are gender biased against opposite-sex peers (Hayden-Thomson, Rubin, & Hymel, 1987), that is, children in middle childhood have been shown to be biased against the opposite sex, giving unreliable scores when rating the social acceptability of their opposite sex peers. The boys in this study rated only a number of their male classmates (those that participated in the study and two or three more), rather then all of them. This procedure was less complicated for the child, and since at least ten children received the same names they needed to rate, a sufficient number of ratings was obtained for each child.

Recognition of facial affect—computerized task

The emotion face recognition is a task designed to assess the subject's ability to recognize facial emotion expressions. In this task Ekman and Friesen (1975) facial expression photographs are used. All are black and white high quality photographs, depicting one the four basic emotions (happiness, fear, sadness and anger) modeled by men and women. The pictures for the original study were developed and used with adults, but they were implemented with children in later research (Ellis et al., 1997; Leppanen & Hietanen, 2001; Singh et al., 1998).The photographs used in this study were those that at least 80% of the subjects who participated in the original study (Ekman & Friesen, 1975) agreed upon the meaning of their expression. For this task, 6 sets of pictures were compiled, each including the four emotions ("happy," "sad," "scared" and "angry") posed by men and women—8 pictures per set, thus constructing a compilation of 48 photographs.

The task is administered using a computer in the following way. Each photograph is presented to the subject on a computer screen. When the target expression is recognized; the subject has to press the appropriate button on a keyboard, signaling his answer. To minimize the involvement of motor abilities, four adjacent computer keys were connected together by a hard plastic sticker for each of the emotions, to make the task of pressing easier ("5," "6," "7" and "8" comprised one long button symbolizing the choice "happy," "R," "T," "Y," "U" comprised the choice "sad," "F," "G," "H," "J" comprised the choice "scared" and "V," "B," "N," "M" comprised the choice "angry"). All the buttons were equally accessible, positioned in the middle of the keyboard. The buttons were marked with a sticker, with the label of each emotion written on it; for instance for the long button that should be pressed when a face expressing "happy" appears on screen, the Hebrew word "happy" was written in large, print, color letters. The color of the letters for each emotion was different to make the selection of the button easier. When the button is pressed, the photograph disappears, and 500 milliseconds later the next photograph is presented.

The first two sets (16 photographs) constitute the training stage, which purpose is to familiarize the subject with the task, and to allow him to practice the response execution. The next four sets (32 photographs) are the test stage, where the child is asked to identify each expression as quickly and as accurately as he can. Reaction times and the child's response answer are registered.

All the photographs are high quality digital images stored in a JPEG format, 512*768 in size, and are presented on a neutral background, in the center of the screen. The order of the pictures of various emotions and posers is presented randomly for each child, to prevent a pattern which may influence the subject's responses.

This task allowed measurement of the speed of the emotion recognition, its accuracy, by quantitative scoring of correct and incorrect responses, and the nature of the recognition errors, by qualitative scoring of the incorrect responses (for example, whether the child responded "angry" instead of "scared").

Intelligence estimation

The Vocabulary and Blocks subset from the WISC-R95 were administered to evaluate the children's IQ. These subsets have the highest correlations with verbal and performance IQs, and therefore give the best representation of the child's IQ (Wechsler, 1976).

Procedure

Upon receiving consent from six elementary schools to participate in the study all the boys in grades 4–5 were given forms including a short description of the study, allowing their parents to sign if they objected to the child's participation. Teachers completed the CRS-R-S questionnaires on each boy in their classroom. When all the CRS-R-S and consent forms were gathered the children were selected to the study and comparison groups. Of 344 children approached, 19 (5.5%) delivered their parent's objections to the study, only 3 (0.87%) of which met the criteria for being at risk of

Table 1 Group comparison of demographic characteristics

Variables	At risk of ADHD ($n = 50$)		Comparison ($n = 61$)			
	M	*SD*	*M*	*SD*	*F* (1,110)	η^2
Age (years)	10.55	.62	10.36	.61	2.58	.02
Parental education (years of schooling)						
Mother	11.36	3.59	13.55	3.29	11.11***	.09
Father	10.46	2.99	13.55	3.43	25.10***	.19
Intelligence						
Blocks	9.17	3.39	10.84	2.88	7.90**	.07
Vocabulary	7.14	1.69	9.53	1.77	52.45***	.33
	%	*n*	%	*N*	χ^2	
Immigration status of the child (Immigrated to Israel)	13%	6	12.1%	7	.02	

**$p < .01$; ***$p < .0001$ (two tailed test).

ADHD. Boys whose parents objected to their children's participation were not interviewed. All the questionnaires and the procedure of the study have been approved by the Israeli Ministry of Education.

The selection of children at risk of ADHD was based on the CRS-R-S (Conners, 1997) as completed by the children's teachers. Children were assigned to groups according to the guidelines of the Conners user's manual (Conners, 1997) which recommends a T-score of 65 as the cutoff point (Conners, 1997). This score has been reported to be a clinically significant cutoff point in other studies (Demaray, Elting, & Shaefer, 2003). Boys who matched the criteria for ADHD, e.g., received a T-score of over 65 on the ADHD scale of the CRS-R-S, were selected for the study group, and boys who were low on all the symptoms measured by the CRS-R-S (received less than 50 on all scales) qualified for the comparison group. Out of the children who met the criteria for the study group 6 (10.71%) were reported to be receiving medication, therefore these children were excluded.

Each child had one session with an experimenter where he completed all the tasks and questionnaires presented to him. All the experimenters were behavioral science graduate students who were trained to interview elementary school aged children. The sessions were conducted in a quiet room in the school, during school hours individually with each child. Each child was asked by a researcher to participate in a research study conducted by Ben-Gurion University, and if consenting, was taken to the interview room where he received further explanation about the research and was assured that all the information will remain confidential, and will be shown neither to teachers nor to parents. Each session lasted approximately one hour, and the children received a candy upon their completion.

The teachers completed the SSRS on each of the participating children after first completing the CRS-R-S on each boy in their classes for screening purposes.

Results

Analytic strategy

We first tested group differences regarding demographic variables and IQ. Then we compared the groups on the study variables (social skills, behavioral problems and emotional misrecognition measures), controlling for the relevant demographic variables. Finally, we examined the effects of emotional misrecognitions on children's social skills and behavioral problems: A latent construct "misrecognition of emotion" was specified, and its affect on social skills and behavioral problems were explored using multiple group Structural Equation Modeling (*SEM*; Hoyle & Smith, 1994) in order to determine whether group qualifies (i.e. risk of ADHD exacerbates) these effects (group × emotional misrecognition interaction effect on outcomes).

Sample demographics

We performed a Multivariate Analysis of Variance (MANOVA) in order to compare groups on parental education as well as the immigration status, age and IQ of the index child (see Table 1). Significant differences were found regarding parental education and children's intelligence ($F(5,105) = 12.59$; $p < .0001$) for *M, SD*, *Multivariate Fs*, and *effect sizes* see Table 1. As can be seen, compared to the children in the At-risk group, children without risk of ADHD had more educated parents and their intelligence level was higher. Accordingly, in subsequent analyses, wherever relevant, these two variables were controlled for. No significant differences between the groups in terms of the age of the index child were found. The χ^2 test was used to compare the frequencies of immigrant vs. Israel-born children in the two groups. The difference was not significant.

Hypothesis I: Lower social skills scores and higher behavioral problems scores are expected among children at risk of ADHD

Table 2 Comparison of behavioral problems in the two groups

Variables	At risk of ADHD ($n = 50$)		Comparison ($n = 61$)			
	M	*SD*	*M*	*SD*	$F(1, 110)$	$\acute{\eta}^2$
Externalizing behavior	7.40	3.73	1.97	2.86	35.97***	.26
Internalizing behavior	6.02	2.55	2.50	2.72	17.49***	.14

***$p < .0001$.

Behavioral problems

A 2 × (2) MANCOVA with group as a between factor and behavioral problems (externalizing and internalizing behavioral problems as reported by the teacher) as within subjects repeated measure variable was performed to compare the level of behavioral problems between the At-risk and the comparison groups; parental education and IQ were covaried. This analysis was performed in order to validate the distinction between the two groups. Significant differences were obtained ($F(2,104) = 25.39$; $p < .0001$, for *M*, *SD*, *Univariate F*s and *effect sizes* see Table 2), the At-risk children were reported by their teachers as having more externalizing and internalizing behavioral problems then the comparison group, thus providing further support for the existence of problems typical of ADHD children among the at risk of ADHD boys.

Social skills

Two multivariate analyses of covariance (MANCOVA), with group as a between subjects variable and social skills as a within subjects repeated measure variable, were performed to compare social skills reports from different sources (teacher and peers) between the two groups. Levels of parental education and children's IQ were covaried. In the first 2 × (3) MANCOVA we compared social skills as reported by the teachers and in the second 2 × (2) MANCOVA peer ratings of the children's social skills were compared. Significant differences were obtained ($F(3,103) = 35.16$; $p < .0001$ and $F(2,104) = 19.41$; $p < .0001$, for the teacher's, and peer reports respectively, for *M*, *SD*, *Univariate F*s and *effect sizes*, see Table 3). A significant effect for *group,* was found with children at risk of ADHD scoring lower in all aspects of social skills according to teacher reports and peer ratings. In general, children in the comparison group exhibited higher levels of cooperation, assertion, self control and peer acceptance.

Hypothesis II: Children at risk of ADHD were expected to present more errors and longer reaction times in the emotion recognition task

A 2 × (13) MANCOVA with group as a between factor and the emotion recognition scores as within subjects repeated measure was performed to compare the level of emotion recognition among the At-risk and the comparison groups; parental education and IQ were covaried. Significant results were found for the Emotion recognition task ($F(13,93) = 2.08$; $p < .05$) for *M*, *SD*, *Univariate F*s and *effect sizes*, see Table 4. Group effects on reaction time and specific errors were significant as expected: At-risk children presented longer reaction times and made more recognition errors than the comparison group; the main mistakes were the confusion between different emotions (happy, sad, and angry) with scared, and the confusion of anger with sadness.

Hypothesis III: Risk of ADHD was expected to moderate the effect of emotion recognition on social skills and behavioral problems

Emotion recognition-data reduction

The emotion recognition computerized task provided 14 measures of recognition of facial affect: reaction time, total number of errors and 12 measures of failed recognition of facial expressions—three specific errors for each of the four emotions (happy, sad, scared and angry), for instance: scared instead of happy. We computed four measures of misrecognition for each of the emotions in the following way: For each emotion the three possible FA (false alarm)

Table 3 Comparison of social skills in the two groups

Variables	At risk of ADHD ($n = 50$)		Comparison ($n = 61$)			
	M	*SD*	*M*	*SD*	$F(1, 110)$	$\acute{\eta}^2$
Teacher report						
Cooperation	7.21	4.30	17.33	3.35	101.35***	.49
Assertion	7.98	4.60	12.45	4.17	7.46**	.07
Self control	9.50	3.99	16.69	3.68	48.96***	.32
Peer report						
("play with")	3.47	.75	4.16	.47	17.59***	.14
("work with")	3.01	.77	4.19	.53	39.00***	.27

**$p < .01$; ***$p < .0001$.

Table 4 Comparison of emotion recognition of facial affect in the two groups

Variables	At risk of ADHD ($n = 50$)		Comparison ($n = 61$)			
	M	*SD*	*M*	*SD*	$F(1, 110)$	$\acute{\eta}^2$
Reaction time (ms.)	2224.60	528.48	1988.33	541.52	4.54*	.04
Scared instead of happy	.62	.90	.34	.57	4.50*	.04
Scared instead of sad	2.16	1.86	1.06	1.35	7.41**	.07
Scared instead of angry	1.22	1.22	.80	.89	6.11*	.06
Sad instead of angry	1.08	1.29	1.18	1.27	4.00*	.04

*$p < .05$; **$p < .01$.

errors (child identifies a specific emotion while a different emotion presented) were summed (for instance, for the emotion sad the errors "sad instead of happy," "sad instead of scared" and "sad instead of angry" were summed), then a "D" score was calculated by subtracting the number of correct responses for this emotion (Hit) from the number of the FA errors for the specific emotion (for the emotion sad, the number of correct responses, e.g. correct recognition of the emotion sad, was subtracted from the number of FA errors made for this emotion). Thus, four measures of "D" scores (high D scores represents low emotional recognition performance or low detective sensitivity) were calculated, each representing the difference between incorrect and correct responses for each of the four emotions. Since the measure for the emotion "happy" was found to have a low variance, it seems that very few children confused this emotion with the other three, this measure was dropped from subsequent analyses.

The effect of emotion misrecognition of facial affect on social skills and on behavioral problems was examined using a Structural Equation Modeling (*SEM*; Hoyle & Smith, 1994) strategy that permitted the evaluation of these effects while assessing measurement errors in the dependent and independent variables. Two separate *SEM*s were performed, one for social skills and another for behavior problems. Multiple group SEM analysis was performed with AMOS software (version 4.0; Aurbackle, 2000) using the maximum likelihood method. Model fit was assessed using the following indices: χ^2 divided by degrees of freedom (χ^2/df), the Non-Normed Fit Index (*NNFI*, Bentler & Bonett, 1980), the Comparative Fit Index (*CFI*, Bentler, 1990), and the Root Mean Square of Approximation (*RMSEA*, Steiger, 1980). Although a nonsignificant p value has traditionally been used as a criterion for not rejecting an SEM, this criterion is overly strict and sensitive for models with many variables (Kelloway, 1998). Therefore, in the present study, alternative criteria that reflect real-world conditions were also used. A model in which χ^2/df was ≤ 2, *CFI* and *NNFI* were greater then 0.90, and the *RMSEA* index was between 0.00 and 0.06 with confidence intervals between 0.00 and 0.08 (Hu & Bentler, 1998, 1999) was deemed acceptable. These moderately stringent acceptance criteria clearly reject inadequate or poorly specified models, while accepting for consideration models that meet real-world criteria for reasonable fit and representation of the data (Kelloway, 1998).

Tables 5 and 6 present the correlations among the observed variables that were used as indicators of the latent variables of the models. It can be seen that there are significant high correlations in the expected direction among the At-risk group.

Table 5 Correlations between emotion misrecognition, social skills and behavioral problems for the comparison group

Variables	2	3	4	5	6	7	8	9
Emotion misrecognition								
1. Sad	.451***	.283*	.086	.038	.080	−.067	−.090	−.118
2. Scared	–	.286*	.047	−.021	.023	−.039	−.083	−.100
3. Angry	–	–	.023	.046	.038	.033	−.045	−.079
Social skills								
4. Peer rating	–	–	–	.367**	.199	.149	−.024	−.146
5. Assertion	–	–	–	–	.580***	.544***	−.338**	−.365**
6. Self control	–	–	–	–	–	.764***	−.787***	−.788***
7. Cooperation	–	–	–	–	–	–	−.603***	−.768***
Behavioral problems								
8. Externalizing behaviors	–	–	–	–	–	–	–	.830***
9. Hyperactive behaviors	–	–	–	–	–	–	–	–

Note. $N = 61$.

*$p < .05$; **$p < .01$; ***$p < .0001$ (two-tailed test).

Table 6 Correlations between emotion misrecognition, social skills and behavioral problems for the group at risk of ADHD

Variables	2	3	4	5	6	7	8	9
Emotion misrecognition								
1. Sad	.573***	.478***	−.205	−.132	−.239	−.267	.314*	.227
2. Scared	–	.544***	−.129	−.132	−.404**	−.152	.435**	.244
3. Angry	–	–	−.018	−.035	−.179	−.220	.217	.239
Social skills								
4. Peer rating	–	–	–	.210	.474**	.689***	−.400**	−.310*
5. Assertion	–	–	–	–	.443**	.487***	.093	.176
6. Self control	–	–	–	–	–	.594***	−.575***	−.484***
7. Cooperation	–	–	–	–	–	–	−.324*	−.408**
Behavioral problems								
8. Externalizing behaviors	–	–	–	–	–	–	–	.675***
9. Hyperactive behaviors	–	–	–	–	–	–	–	–

Note. $N = 50$.

$^{*}p < .05$, $^{**}p < .01$; $^{***}p < .0001$ (two-tailed test).

Misrecognition of emotions and social skills

Two latent constructs were defined: Misrecognition of Emotions and Social Skills. A latent construct—Misrecognition of Emotions that assessed errors in emotion recognition of facial affect—determined by three indicators (three measures of difference between incorrect (FAs) and correct (Hits) recognition for each of the three negative emotions: sad, scared and angry) was specified. A second latent construct—Social Skills, determined by four indicators (self-control, assertion and cooperation, as reported by teachers, and peer ratings of social acceptability) was specified.

Misrecognition of emotions and social skills: Structural model

A model including the latent constructs Misrecognition of Emotions and its effect on Social Skills was specified and estimated simultaneously for both groups using SEM multiple group analysis. The model had a moderate fit to the data and in accordance to modification indices improvement in the model fit was achieved by controlling for the shared variances between cooperation and peer rating, and cooperation and assertion. Accordingly we controlled for these significant associations. This model (see Fig. 1) was found to fit the observed data well ($\chi^2(22) = 19.35$, $p = .624$, $\chi^2/df = .879$, *NNFI = 1.025, CFI* = 1.000, *RMSEA* = .000).

A significant effect for the Misrecognition of Emotions on Social Skills was found in the At-risk group only ($\beta = -.40$, $t = -2.01$, $p < .05$), accounting for 16% of the variance of the Social Skills latent variable. A nonsignificant effect was found in the comparison group ($\beta = .03$, $t = 0.18$, $p > .05$). According to the Critical Ratio criteria for parameters comparisons the difference between groups on the effects of the Misrecognition of Emotions on children's Social Skills was found to be significant ($t = 1.97$; $p < .05$) indicating that risk of ADHD significantly moderates the effect of Misrecognition of Emotions on Social Skills. Specifically, our findings suggest that among children at risk of ADHD (but not among non-At-risk children) a deficient recognition of facial affect significantly impairs their social skills (see Fig. 1).

Misrecognition of emotions and behavioral problems

The latent construct Misrecognition of Emotions—determined by the same three indicators as specified in the previous mode was used in this analysis too. In addition, for this model the latent construct—Behavioral Problems—determined by two indicators (externalizing behaviors and hyperactive behaviors) was also specified. The variable "internalizing behaviors" was not included as an indicator for this latent construct because its correlations with the other indicators were non-significant among the At-risk group.

Misrecognition of emotions and behavioral problems: Structural model

A model with the latent construct Misrecognition of Emotions effect on Behavioral Problems was specified and estimated simultaneously for both groups using SEM multiple group analysis. The model (see Fig. 2) was found to fit the observed data well ($\chi^2(10) = 7.43$, $p = 0.684$, $\chi^2/df = 0.743$, *NNFI = 1.033, CFI* = 1.000, *RMSEA* = .000).

As can be seen in Fig. 2 a significant effect for Misrecognition of Emotions effect on Behavioral Problems was found in the At-risk group only ($\beta = .42$, $t = 2.34$, $p < .05$), accounting for 18% of the variance of the Behavioral Problems latent variable. No significant effect was found in the comparison group ($\beta = -.17$, $t = -.99$, $p > .05$). According to Critical Ratio criteria for parameters comparisons the difference between the Misrecognition of Emotions on Behavioral Problems between the two groups was found to be significant

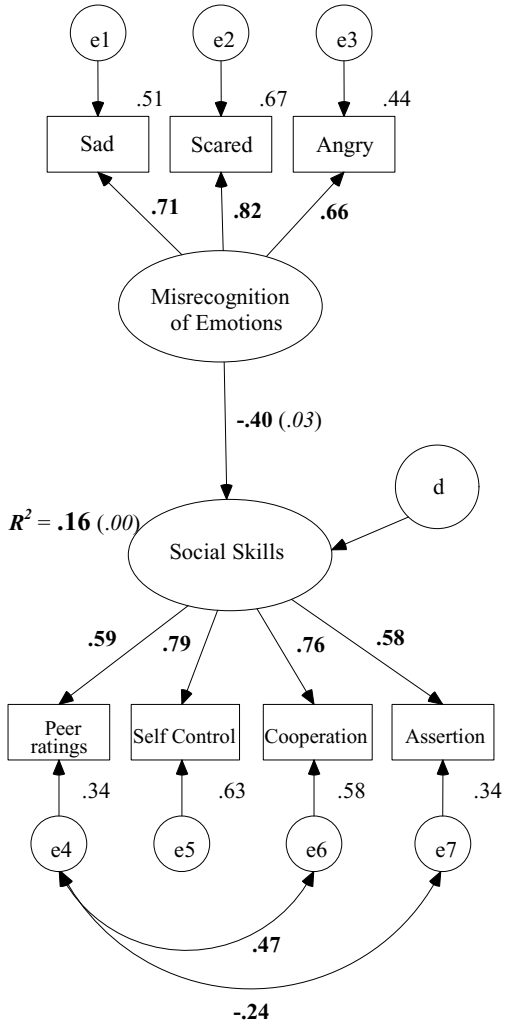

Fig. 1 The effect of misrecognition of emotions on social skills in the At-risk of ADHD group. *Note*. Rectangles indicate measured variables and large circles represent latent constructs. Small circles reflect residuals (e) or disturbances (d); bold numbers above or near endogenous variables represent the amount of variance explained (R^2). Unidirectional arrows depict hypothesized directional, or "causal," links. Standardized maximum likelihood parameters are used. Bold estimates are statistically significant. The numbers in parentheses represent the values in the comparison group

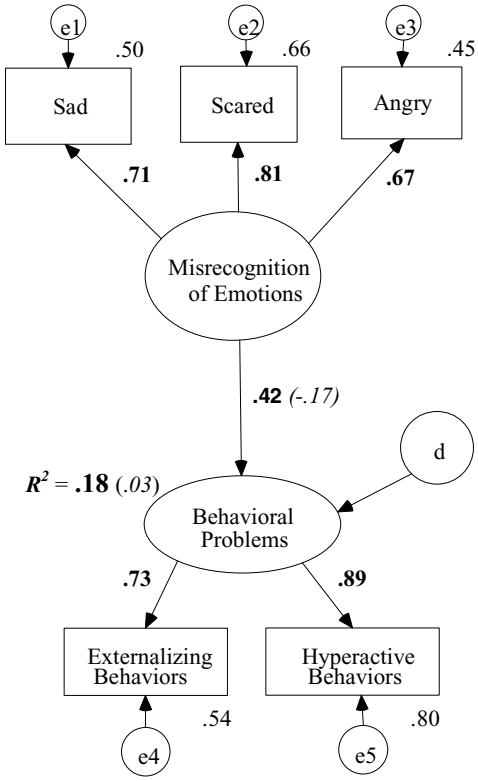

Fig. 2 The effect of misrecognition of affect on behavioral problems in the At-risk of ADHD group. *Note*. Rectangles indicate measured variables and large circles represent latent constructs. Small circles reflect residuals (e) or disturbances (d); bold numbers above or near endogenous variables represent the amount of variance explained (R^2). Unidirectional arrows depict hypothesized directional, or "causal," links. Standardized maximum likelihood parameters are used. Bold estimates are statistically significant. The numbers in parentheses represent the values in the comparison group

($t = -2.08$, $p < .05$) indicating that risk of ADHD significantly moderates the effect of Misrecognition of Emotions on Behavioral Problems, specifically, we found that among children at risk of ADHD (but not among non-At-risk children) a deficient recognition of facial affect significantly exacerbates their behavioral problems (see Fig. 2).

Discussion

This study proposed that boys at risk of ADHD have poorer emotion recognition skills than non-At-risk boys, and that this deficiency is related to their social skills impairments. Our findings supported this assumption, as At-risk boys were found to have impairments in simple emotion recognition skills as compared to non-At-risk boys, similar in age and socio-economic background, and attending the same schools. Impaired recognition of facial affect was found to associate with social skills and behavioral problems in the At-risk group only.

The boys at risk of ADHD were found to exhibit several specific emotion recognition errors. They tended to confound different emotions (happy, sad, and angry) with scared and confused anger with sadness while judging the emotions depicted in facial expression. These boys also needed more time to recognize the emotional expression presented to them, but these longer reaction times did not seem to improve their recognition accuracy.

The At-risk boys in this study exhibited lower social skills and higher behavioral problems compared to the non-At-risk boys, similarly to the findings of other studies exploring ADHD children's social skills (Guevremont & Dumas, 1994;

Hanker & Whalen, 1989; Hanker & Whalen, 1999; Nixon, 2001; Stormont, 2001). Compared to the non-At-risk boys, they were rated by their teachers as less cooperative, less assertive, and as having less self control, and higher levels of externalizing and internalizing behavioral problems. The At-risk boys were also rated by their peers as less desirable to play and study with.

Emotion recognition

This study contributes to the research on emotion recognition of facial affect in the ADHD population by directly assessing simple recognition processes. While in most existing studies emotion recognition has been evaluated through complex tasks, requiring higher order executive functions (Shapiro et al., 1993), such as the comprehension of story stems, identification of the emotion felt by the protagonist, and matching the emotion to a relevant picture of facial affect, the task implemented in the present study did not emphasize these mechanisms. Furthermore, this study evaluated not only the children's accuracy in their emotion recognition, but measured also the children's reaction time for facial expressions recognition.

The finding that boys at risk of ADHD have impaired emotion recognition capacities does not support dominant models in the ADHD literature (e.g. Barkley, 1997) that consider deficits in inhibition and executive functions to be the key symptom underlying this disorder. According to these EF (executive functions) models, individuals with ADHD should exhibit intact emotion recognition because of the nonexecutive nature of this skill (Barkley, 1997). The findings of this study point to the alternative models of ADHD which assume that though executive disfunction has been found to be related to ADHD it does not explain the variability of symptoms exhibited by individuals with this disorder and has not proved to be necessary to diagnose it (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006; Sonuga-Barke, 2003). Recent models of ADHD propose that there are other pathways accountable for the disorder, such as delay aversion, which is associated with the individual's motivational style rather then his cognitive deficit (Sonuga-Barke, 2003) or "hot" executive functions, required in situations demanding emotional involvement or appraisal of affective stimuli (Castellanos, Sonuga-Barke, Milham, & Tannock, 2006).

Our findings also support the Corbett and Glidden's (2000) report on deficient emotion recognition skills among children with ADHD, and are in line with the research exploring the right hemisphere hypothesis of ADHD children. Several studies have investigated the right hemisphere model of ADHD demonstrating that abnormalities in the right hemisphere are indeed characteristic of ADHD and they account for various symptoms presented by this disorder (Aman, Roberts, & Pennington, 1998, Sandson, Bachna, & Morin, 2000), such as inattention, slower reaction times, visuospatial problems and poor social skills (Garcia-Sanchez, Estevez-Gonzalez, Suarez-Romero, & Junque, 1997; Stefanatos & Wasserstein, 2001). Behavioral and neurological studies with healthy and brain damaged subjects, has established that emotion recognition involves right hemisphere parietotemporal systems (Borod et al., 1998; Gainotti, 2000; Indersmitten & Gur, 2003; Pollak & Wismer Fries, 2001) and that this process does not emphasize higher order executive functions (Barkley, 1997; Gainotti, 2001).

The slower reaction times presented by the boys at risk of ADHD in the emotion recognition task, further supports the right hemisphere hypothesis, according to which subjects with right hemisphere abnormalities demonstrate slower reaction times in various tasks (Landau, Auerbach, Gross-Tsur, & Shalev, 2003; Mitchell, Chavez, Baker, Guzman, & Azen, 1990; Stefanatos & Wasserstein, 2001). This finding is also in line with previous research on ADHD showing that slow reaction times are typical of individuals with ADHD (Lijffijt, Kenemans, Verbaten, & Engeland, 2005; Landau, Auerbach, Gross-Tsur, & Shalev, 2003).

Another main finding of this study concerns the nature of the recognition errors made by the At-risk boys. The recognition errors found to affect the At-risk boys' social skills and behavioral problems implied the confounding of various emotions with each one of the negative emotions (sad, scared and angry). Furthermore, these children confused different emotions (happy, sad, and angry) with the emotion 'scared,' whereas they were as good as the comparison group boys in recognizing the emotion 'scared'; in addition the At-risk group also confused anger with sadness. Different stimuli elicited much more frequent recognitions of expressions of sadness and fear among the At-risk than the non-At-risk boys. Boys at risk of ADHD thus present a negative bias, attributing much more sadness and fear than was expected according to the stimuli presented. One possible explanation for the negative bias can be the negative affect that has been found to be typical of individuals with ADHD. Research has shown that children and adults with ADHD tend to have increased emotion reactivity and intensity regarding their own negative emotions (Braaten & Rosen, 2000; Rapport, Friedman, Tzelepis, & Van Voorhis, 2002), and that these children exhibit exaggerated negative emotional responses in negative emotion induced situations such as frustration (Melnick & Hinshaw, 2000; Wigal et al., 1998). Research on aggressive children shows that aggressive boys tend to interpret ambiguous nonverbal information as more hostile compared to the nonaggressive children (Dodge & Coie, 1987), suggesting that these children have deficits in emotional information encoding, leading to the negative bias while interpreting emotional cues. It is possible that due to the dominance of the negative experience in the ADHD

children's lives they are constantly expecting negative stimuli in their surroundings and are more prone to attend to cues associated with negative emotions.

The negative bias in emotion recognition presented by the At-risk boys in this study challenges the findings of Cadesky, Mota, and Schachar (2000) who found that even though ADHD children did make more emotion recognition errors, their errors were random, presenting no detectable bias. The authors concluded that ADHD children have poorer emotion recognition due to inattention and other regulatory process and they do not suffer from specific distortions in the interpretation of emotional cues (Cadesky, Mota, & Schachar, 2000). The findings of the present study suggest that these children's impaired emotion recognition might stem not only from inattention but also from biased emotion recognition, specifically, from a tendency to interpret emotional expressions as fearful or sad.

The role of emotion recognition in At-risk boys' social skills

The present study revealed that associations between emotional recognition and social functioning were obtained for the boys at risk of ADHD only. That is errors in emotion recognition of facial affect are related to higher levels of behavior problems and lower social skills in the At-risk population only. This interesting finding suggests that the risk of ADHD moderates the effect of emotion misrecognition on social functioning. It is important to note that we did study these associations when the independent construct (emotion misrecognition) and social skills and behavioral problems measures were assessed from independent sources (target child task performance, teacher and peer reports respectively) thus allowing to control for shared source and method variance. The moderation effect found suggests that risk of ADHD may serve as vulnerability factor.

We propose the following explanation for the moderating effect of the risk of ADHD: When a child who is not at risk of ADHD judges the emotions of others incorrectly, his social functioning may still be appropriate because his other skills (cognitive and emotional) are intact, compensating for the emotion recognition impairment. For instance, intact attention and regulation processes, working memory, reasoning and problem solving abilities may all contribute to the child's proper social functioning (Barkley, 1997). A child at risk of ADHD, on the other hand, might have fewer compensatory recourses when failing to recognize an emotion and will thus show poor social skills. Hence, the risk of ADHD exacerbates the effect of emotion recognition deficiencies on social functioning.

It is important to note here that the tasks implemented in previous studies were more complex and required the children to match pictures of facial affect to emotions described to them verbally (Izard et al., 2001), or to identify the emotions felt by a child in the vignettes presented to them (Mostow et al., 2002).Thus, previous research evaluated not only emotional information processing skills, but also the children's working memory, deduction and decision making abilities. Findings by Leppanen and Hietanen (2001) seem to support this study's finding regarding the moderation effect of the risk of ADHD by showing that emotion recognition, measured by a task similar to the one implemented in the current study, was not related to the social skills of normal boys in their study (Leppanen & Hietanen, 2001).

The present study's findings suggest that boys at risk of ADHD present impairment in basic emotional recognition tasks, specifically presenting a negative bias overestimating fear and sadness; this impairment seems to have a specific negative effect on these boys' behavior and social skill. Moreover, it is suggested that inattention and hyperactivity symptoms put the children at risk by aggravating the negative effect of faulty emotion recognition on their social skills.

Conclusions

Two main implications follow from the current research. First, our findings show that boys at risk of ADHD do suffer from receptive difficulties, exhibiting impairments in emotion recognition of facial affect and bias towards negative emotions, suggesting that behavioral disinhibition and impaired executive functions may not be the exclusive causes for the symptoms they exhibit. Other mechanisms may be involved in the disorder. Second, the results demonstrate the important role that emotion recognition skills play in the At-risk boys' social functioning, underscoring that emotion regulation might not be the only cause of their inappropriate social behavior.

The results presented here may contribute to the understanding of the deficits and the experiences that characterize individuals who are at risk of ADHD. This study also provides a basis for interventions intended to improve the ADHD children's basic social skills by improving their emotion recognition abilities.

Study limitation and future research

The findings of this study must be addressed within its limitations. First, the boys at risk of ADHD for this study were selected using the CRS-R-S questionnaire, which is accurate in screening for ADHD but is not a diagnostic instrument, thus the sample used in this study is not a clinical one. In future research the selection of a clinically diagnosed sample is recommended. Second, the sample in this study consists of boys only. It is very common to include only boys in studies on ADHD because the prevalence of the disorder is higher among boys (Newcorn et al., 2001), nevertheless

the results of this study should be interpreted with caution limiting the conclusion to boys only. In future research a sample of girls should be included in order to reach a fuller understanding of the nature of emotion recognition within the whole ADHD population. Third, the sample sizes of the two groups were not sufficient to explore a more complex model examining the associations between emotion recognition and both social and behavioral problems, therefore we suggest increasing the sample sizes in future research. Finally, the cross-sectional design of the study limits its conclusions; in order to establish a causal role between emotion recognition and social skills a longitudinal design is warranted.

The results of this study provide some support for the right hemisphere hypothesis of ADHD, but more research implementing neuroimaging techniques and various emotional information processing tasks with ADHD children is needed to verify this hypothesis. Additional research is needed to understand the nature of ADHD specific misrecognitions of emotions, mainly the confusion of various emotions with the emotions of fear and sadness. Finally, though this study's findings support a view of emotion recognition as contributing to At-risk ADHD boys' impaired social skills, additional research is needed to understand the interplay between this and other emotional and cognitive impairments that may affect their social adjustment.

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