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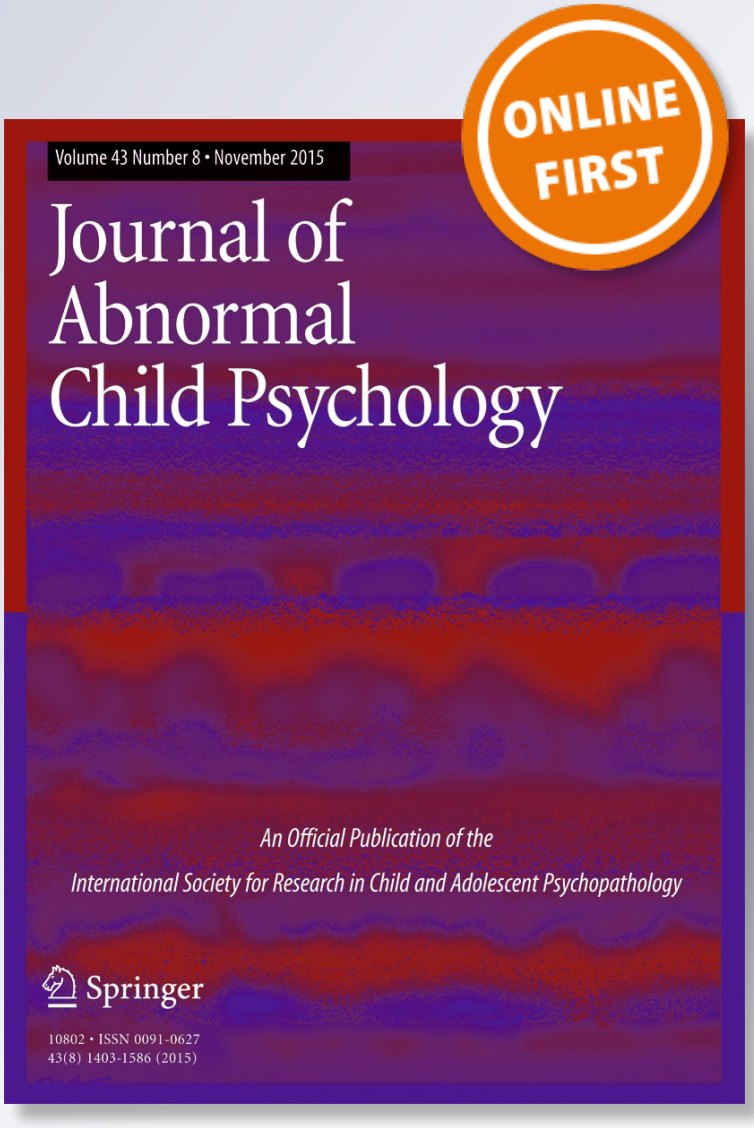

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Impaired Social Decision-Making Mediates the Association Between ADHD and Social Problems

Kathryn L. Humphreys[1] · **Chardeé A. Galán**[2] · **Nim Tottenham**[3] · **Steve S. Lee**[4]

Abstract Attention-deficit/hyperactivity disorder (ADHD) reliably predicts social dysfunction, ranging from poor social competence and elevated peer rejection to inadequate social skills. Yet, the factors mediating predictions of social problems from childhood ADHD are not well understood. In the present study, we investigated social functioning in 186 (69 % male) 6 to 10 year-old (M = 7.88, SD = 1.17) children with (n = 98) and without (n = 87) ADHD who were followed prospectively for two years. We implemented a well-validated measure of social problems as well as a novel social decision-making task assessing dynamic response to changing affective cues at the two-year follow-up. According to separate parent and teacher report, baseline ADHD symptoms positively predicted social problems at the two-year follow-up; individual differences on the social decision-making task mediated this association. This finding was replicated when ADHD dimensions (i.e., inattention and hyperactivity/impulsivity) were separately examined. These findings suggest that the deficient use of affective cues to effectively guide behavior may partially underlie poor social functioning among children with ADHD. If replicated, these preliminary findings suggest that social skills interventions that target interpretation of affective cues to aid in social decision-making behavior may improve social outcomes negatively affected by early ADHD symptoms.

Keywords ADHD · Attention-deficit/hyperactivity disorder · Social problems · Social functioning · Decision-making

Attention-deficit/hyperactivity disorder (ADHD) is characterized by an early onset of developmentally inappropriate levels of inattention and hyperactivity/impulsivity (American Psychiatric Association 2013). ADHD affects 5–10 % of school-aged children worldwide (Polanczyk et al. 2007; Scahill and Schwab-Stone 2000) and constitutes a common referral for mental health, educational, and pediatric services in the United States (Barkley 2006). Childhood ADHD prospectively predicts persistent and widely dispersed impairment (Barkley et al. 2008; Lahey et al. 2004). In particular, although not a core diagnostic feature, social problems are common among children with ADHD; they are profound, highly intractable to intervention, and persistent across time and situations (Greene et al. 1997; Hoza 2007; Hoza et al. 2005a; Mikami and Hinshaw 2003). Among children with ADHD, difficulties in social functioning uniquely predict long-term negative outcomes (Greene et al. 1997; Greene et al. 1999) suggesting that social functioning is a key consideration beyond ADHD per se.

Children with ADHD experience more peer rejection than typically developing youth (Hoza et al. 2005a; Pelham and Bender 1982); in fact, negative peer impressions are made within hours of meeting unfamiliar peers and they are highly stable (Erhardt and Hinshaw 1994). Children with ADHD are also more socially intrusive (Frankel and Feinberg 2002),

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have fewer reciprocal dyadic friendships (Gresham et al. 1998), and are rated by teachers and peers as being less socially competent (Ronk et al. 2011) relative to non-ADHD youth. In particular, social problems among children with ADHD warrant concern as they independently predict and mediate long-term maladaptive outcomes, including depression (Humphreys et al. 2013; Mikami and Hinshaw 2003) and conduct and substance problems (Greene et al. 1997). Despite the clinical significance of social dysfunction in children with ADHD, the potential mechanisms underlying these difficulties remain poorly understood.

First, the core symptoms of ADHD may directly contribute to these social difficulties. For example, hyperactive and intrusive behaviors may be off-putting to peers in social interactions (Ronk et al. 2011; Whalen et al. 1979). Specifically, Ronk et al. (2011) found that in an effort to join other children's ongoing activity, boys with ADHD relied more on disruptive attention-grabbing behaviors, which in turn were associated with significantly more negative responses from their peers and less proficient task and social performance ratings from coders. Additionally, inattention symptoms may interfere with children's ability to learn, attend to rules in games and activities, and actively participate in social interactions (Mrug et al. 2007). For example, in a standardized computer-simulated chat room paradigm, relative to control children, children with the inattentive subtype of ADHD made fewer responses and were less likely to attend to and remember the conversation (Mikami et al. 2007). Though the types of social problems related to inattention and hyperactivity may vary (Maedgen and Carlson 2000), social rejection is often a consequence (Hodgens et al. 2000). Given this, children with ADHD may be deprived of social opportunities required to learn appropriate social skills central to healthy development (Mikami et al. 2009; Tseng et al. 2014; Waschbusch et al. 2006).

However, additional explanatory factors for social dysfunction beyond the direct effect of ADHD symptoms are plausible given that peer problems persist even after ADHD symptoms improve (Lee et al. 2008). Consistent with social cognition theory, appropriate social functioning involves complex decision-making processes that require individuals to understand the emotional and motivational states of others while simultaneously engaging in traditional decision-making processes like learning, valuation, and reward processing (Lee and Harris 2013). One particularly relevant construct for social cognition is affect recognition, which is crucial for appropriate social interactions (Morrison and Bellack 1981). Although inconsistencies exist, there is some evidence that affect recognition is impaired in both children and adults with ADHD (Rapport et al. 2002; Singh et al. 1998), particularly with respect to recognition of specific emotional faces (e.g., angry; Pelc et al. 2006). Thus, ADHD impairs affect recognition, perhaps resulting in social dysfunction. In support of this theory, poor emotional understanding was associated with social skill difficulties in boys at risk for ADHD (Kats-Gold and Priel 2009). Although social decision-making may partially reflect poor affect recognition, it also reflects difficulties with using affective cues to predict how others will use this affective information to guide behaviors in social interactions. The assessment of social decision-making may require methods beyond self- or parent-report, the most common approaches to date. Self-report measures can be problematic given that children with ADHD have inflated self-perceptions of their abilities that may undermine accuracy (e.g., Hoza et al. 2004; Hoza et al. 2002). Additionally, exclusive reliance on parent report is susceptible to potential bias by parental psychopathology (Kroes et al. 2003; Youngstrom et al. 1999) as well as shared method variance if parent report is used to assess child behavior. Laboratory-based approaches have provided useful measurement improvements in other domains of functioning related to ADHD, including risk-taking (Humphreys and Lee 2011). Thus, laboratory-based tasks are promising in the ability to measure constructs that are difficult to measure via self-report, including social decision-making. The aims of the present study were to test multi-method, multi-informant ratings of childhood ADHD symptoms as predictors of individual differences in a well-validated measure of social problems assessed at a two-year follow-up. We also tested whether impaired social decision-making mediated the association of baseline ADHD symptoms and later social problems. We hypothesized that baseline ADHD symptoms would positively predict parent-reported social problems and that social decision-making would mediate this prospective association. To improve specificity of observed associations, we separately examined ADHD dimensions (i.e., inattention and hyperactivity/impulsivity) given they are differentially associated with social functioning across development (Maedgen and Carlson 2000). In a recent study, hyperactivity/impulsivity symptoms predicted impaired social relationships with teachers and peers across early and middle childhood, while symptoms of inattention predict social impairment only in middle but not early childhood, suggesting that the relationship between ADHD symptoms and social impairment may change with age (Zoromski et al. 2015). Second, we tested whether ADHD remained associated with social problems, even with statistical control of ODD, given its association with ADHD and poor social functioning (August et al. 1996; Frankel and Feinberg 2002; Matthys et al. 1999).

Method

Participants

At baseline (i.e., Wave 1), participants were 186 (69 % male) 6 to 10 year old ($M = 7.88$, $SD = 1.17$) children with ($n = 98$) and

without (n = 87) DSM-IV ADHD. Forty-nine percent of the sample was Caucasian, 10 % Hispanic, 7 % African-American, 3 % Asian, 22 % mixed, and 8 % Other or missing. Sixty-six percent of participants reported a household income of greater than $75,000 and 75 % of mothers reported obtaining college degrees. Participants were recruited using presentations to self-help groups for ADHD, advertisements mailed to local elementary schools, pediatric offices, clinical service providers, and some referrals from mental health clinics. English fluency was required for parents and children. Exclusion criteria for all participants consisted of a Full Scale IQ <70 or pervasive developmental, seizure, or neurological disorder that prevented full participation in the study. Characteristics of participants at Wave 1 (Humphreys et al. 2012; Lee et al. 2012) and Wave 2 (Jezior et al. 2015; Tung et al. 2014) have been described elsewhere. Approximately a third of the sample (32 %) regularly took psychotropic medications, though only 13 % took medication on the testing day. Table 1 provides further information on the range and severity of psychopathology in the sample.

Procedures

At Wave 1, families who contacted the investigators completed a telephone screener to determine their eligibility based on the inclusion and exclusion criteria listed above. Eligible families were then invited to the research laboratory for in-person assessments. Following signed parental consent and child assent, clinical psychology graduate students or bachelor's-level extensively trained staff separately assessed children and parents. All interviewers were initially unaware of the child's diagnostic status. Approximately two years after their original evaluation, families were invited back to the laboratory to participate in a follow-up study (i.e., Wave 2; ages 8–13) that consisted of similar procedures to Wave 1 (e.g., structured diagnostic interviews) (see Lee and Humphreys 2014), but also included the assessment of children's social decision-making. A total of 231 participants at Wave 1 were originally ascertained, and for the current study 186 participants completed Wave 2. Although a portion of the original sample was not included in the present study due to attrition, they did not differ in Wave 1 ADHD symptom severity, age, sex, or ethnicity. The Institutional Review Board approved all study procedures. Families were paid $50 for per visit.

Table 1 Child behavior checklist scores

Narrow-band scale	T score mean (SD)	Above borderline cutoff %
Anxious/depressed	56.33 (7.46)	15
Withdrawn/depressed	56.04 (7.42)	17
Somatic complaints	55.67 (6.87)	10
Social problems	57.16 (8.05)	17
Thought problems	58.32 (7.63)	22
Attention problems	61.39 (10.51)	32
Rule-breaking behavior	54.48 (5.81)	7
Aggressive behavior	56.14 (7.21)	13

Measures

Diagnostic Interview Schedule for Children – Fourth Edition (DISC-IV; Shaffer et al. 2000) DSM-IV ADHD was ascertained via the computerized DISC-IV administered to each participant's parent at Wave 1. This fully structured interview probed all ADHD symptoms, yielding separate total symptom counts for inattention (0–9), hyperactivity/impulsivity (0–9), and the total number of ADHD symptoms (0–18). The DISC-IV was also used to obtain the number of DSM-IV symptoms of oppositional defiant disorder (ODD), which ranged from 0 to 8. Test-retest reliability for ADHD diagnosed by the DISC was between 0.51 and 0.64 and for ODD was 0.54 in the DSM-IV Field Trials (Lahey et al. 1994a; Lahey et al. 1994b). Diagnostic designations from the DISC have shown predictive validity in multiple independent samples of youth with and without ADHD (Lee et al. 2008; Owens et al. 2009).

Child Behavior Checklist 6–18 (CBCL; Achenbach and Rescorla 2001) The 113-item rating scale completed by the parent yielded measures of child psychopathology at Wave 2. Responses were scored on a 3-point scale, from 0 for *not true* to 2 for *very true or often true*. The CBCL was normed on a large sample of children ages 6–18 and possesses excellent test-retest and interrater reliability, as well as adequate to excellent internal consistency (Achenbach and Rescorla 2001). The total score from the social problems narrow-band subscale was used as our measure of social problems. This scale has been shown to have high (r = 0.90) test-retest reliability and adequate validity (Achenbach and Rescorla 2001).

Teacher Report Form (TRF; Achenbach and Rescorla 2001) This rating scale completed by teachers at Wave 1 is parallel to the CBCL. Responses were also scored from 0 for *not true* to 2 for *very true or often true* and we used the total score from the ADHD Problems subscale. This scale has been shown to have adequate (r = 0.85) internal consistency and acceptable convergent validity (Nakamura et al. 2009).

Social Decision-Making Task A novel social decision-making task was developed for the present study using three faces from the NimStim set of facial expressions (Tottenham et al. 2009). The images were taken from a morphing face task in which separate images of an individual's face morphed from happy to angry (Kirsh and Mounts 2007; Li and

Tottenham 2013). The images were 506 × 650 pixels and subtended approximately 17 × 22 visual degrees on the monitor. There were a total of 27 trials composed of a series of facial images that became increasingly angry from three unique female adults (White, African American, and Asian American; nine trials per person). See Fig. 1 for visual display of the task. The task was embedded in a Halloween "trick or treat" candy acquisition game. Participants were told to press a button to "knock" on doors and earn "candy" (represented as points) for every knock they executed (i.e., more knocks earned more candy). On each trial, the faces grew increasingly angry with each successive knock made by the subjects. At a given fixed point in the trial when the face was angry, an additional knock would result in the loss of the candy earned from that trial. At the beginning of each trial, a face appeared on the screen, and with each press the face changed toward a fixed point (see Li and Tottenham 2013). Although all trials ended at a fixed point, trials began with differing emotion expressions: trials with model 1 began at 100 % happy/0 % angry, trials with model 2 began at 30 % happy/70 % angry, and trials with model 3 began with 15 % happy/85 % angry. The moment of "door slamming" and candy loss occurred at the same point for every trial. Each knock corresponded to a slight change from happy-neutral-angry, and all sets followed the same progression. The slow to anger condition required 19 knocks to each loss, the intermediate to anger condition required 13 knocks, and quick to anger condition required 7 knocks. Individual and task condition were distributed equally across each third of the task. The main outcome produced by this social decision-making task is the total number of points earned, with greater points indicating more successful social decision-making.

Data Analysis

We examined the association of baseline (i.e., Wave 1) ADHD with respect to social problems measured at a two-year prospective follow-up (i.e., Wave 2). Specifically, we used linear regression to examine predictions from the total number of Wave 1 ADHD symptoms from the DISC on Wave 2 Social Problems. In addition, we separately examined the number of Wave 1 inattention and hyperactivity/impulsivity symptoms from the DISC with respect to Wave 2 Social Problems. Wave 1 ODD symptoms were then included to determine whether ODD was associated with Wave 2 Social Problems or attenuated the effect of ADHD. Next, total ADHD symptoms at Wave 1, as well as each ADHD symptom dimension, were examined as predictors of Wave 2 social decision-making using linear regression.

To test social decision-making as a putative mediator of the association between Wave 1 ADHD symptoms, as well as each ADHD symptom dimension, and CBCL social problems, per expert recommendations (e.g., Hayes et al. 2009; MacKinnon et al. 2007), we conducted a single step test of mediation using SPSS PROCESS (Hayes 2012). To assess the indirect effect, a non-parametric bootstrap procedure using sampling with replacement (n = 1000) was implemented and 95 % bias corrected and accelerated (BCa) confidence intervals (CI) were calculated for coefficients. If the CI does not include zero, the indirect effect is considered statistically significant.

Lastly, we conducted two sets of linear regression analyses to examine whether Wave 1 ADHD Problems from the TRF predicted Wave 2 Social Problems and Wave 2 social decision-making. Following this, we again used a single step mediation procedure described above to examine whether social decision-making mediated the association between teacher reported ADHD Problems and Wave 2 Social Problems. Sex and age were included as covariates in all analyses.

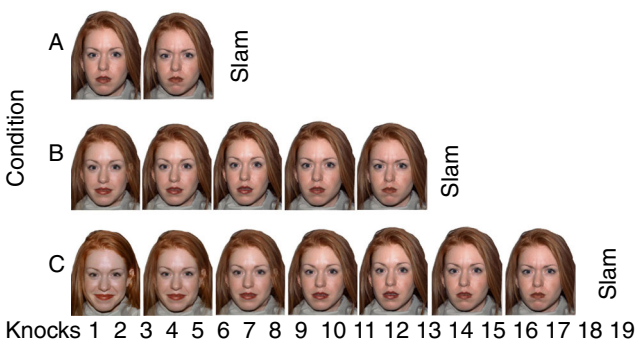

Fig. 1 Representation of the social decision-making task. Condition A = quick condition (door slams at 7 knocks). Condition B = intermediate condition (door slams at 13 knocks). Condition C = slow condition (door slams at 19 knocks)

Results

Correlation Matrix

Table 2 provides a correlation matrix and descriptive statistics for all variables of interest. Age was positively correlated with performance on the social decision-making task. Sex was associated with ADHD symptoms, but not social functioning. ADHD symptoms were positively correlated with CBCL Social Problems and negatively correlated with social decision-making.

ADHD and CBCL Social Problems

Utilizing the entire sample (i.e., those with and without ADHD), we fit a linear regression model to examine the prospective association of the number of Wave 1 ADHD symptoms (measured dimensionally) with Wave 2 CBCL Social Problems, controlling for sex and age. Wave 1 ADHD symptoms significantly predicted Wave 2 CBCL Social Problems, B = 0.34, SE = 0.04, $t(180)$ = 7.97, $p < 0.001$, 95 % CI [0.25, 0.44], and uniquely explained a quarter of the variance in Social Problems, ΔR^2 = 0.26. This analysis was repeated with

Table 2 Correlation matrix

	1	2	3	4	5	6	7	8	9
1. Age	1								
2. Sex (Male =1)	−0.07	1							
3. Wave 1 ADHD symptoms[a]	−0.08	0.17*	1						
4. Wave 1 Inattention symptoms[a]	0.00	0.14†	0.89***	1					
5. Wave 1 Hyperactivity symptoms[a]	−0.15*	0.17*	0.88***	0.55***	1				
6. Wave 1 ODD symptoms[a]	0.05	0.08	0.59***	0.42***	0.62***	1			
7. Wave 1 TRF ADHD Problems	−0.17*	0.30***	0.46***	0.39***	0.45***	0.39***	1		
8. Wave 2 CBCL Social Problems	0.02	−0.03	0.49***	0.41***	0.46***	0.31***	0.27***	1	
9. Wave 2 Social Decision-Making	0.31***	0.004	−0.16*	−0.11	−0.17*	−0.08	−0.19*	−0.21**	1
Mean (SD) or %	7.88 (1.17)	69 %	8.11 (5.50)	4.57 (3.19)	3.44 (3.05)	2.19 (2.41)	11.94 (8.47)	3.59 (3.63)	160.74 (52.98)

ADHD Attention-deficit/hyperactivity disorder. ODD Oppositional defiant disorder. CBCL Child behavior checklist

[a] Symptoms were obtained from the Diagnostic Interview Schedule for Children – Fourth Edition

†$p < 0.10$

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

the number of Wave 1 ADHD symptoms, but disaggregated into the two ADHD symptom dimensions. Both Wave 1 inattention symptoms, $B = 0.49$, $SE = 0.07$, $t(180) = 6.25$, $p < 0.001$, 95 % CI [0.35, 0.62], and hyperactivity/impulsivity symptoms, ($B = 0.58$, $SE = 0.08$, $t(180) = 7.29$, $p < 0.001$, 95 % CI [0.43, 0.73]), uniquely predicted Wave 2 CBCL Social Problems, explaining significant variance, $\Delta R^2 = 0.18$ and $\Delta R^2 = 0.23$, respectively.

Given the frequent co-occurrence of ADHD and ODD, as well as the association between ODD and poor social functioning, the analyses were repeated controlling the number of Wave 1 ODD symptoms. Crucially, ADHD symptoms remained a significant predictor of Wave 2 Social Problems, even with statistical control of Wave 1 ODD symptoms, $B = 0.34$, $SE = 0.05$, $t(179) = 6.27$, $p < 0.001$, 95 % CI [0.23, 0.45]. The number of Wave 1 ODD symptoms was unrelated to Wave 2 CBCL Social Problems when it was included with Wave 1 ADHD symptoms, $B = 0.02$, $SE = 0.12$, $t(179) = 0.19$, $p = 0.85$, 95 % CI [−0.23, 0.28].

ADHD and Social Decision-Making

Next, we used the same approach to examine the association between Wave 1 ADHD symptoms and performance on the social decision-making task assessed at Wave 2. Controlling for sex and age, the number of Wave 1 ADHD symptoms was negatively associated with total points earned on the social decision-making task, $B = -1.57$, $SE = 0.68$, $t(180) = -2.30$, $p = 0.02$, 95 % CI [−2.94, −0.25], and explained a small proportion of the variance in points, $\Delta R^2 = 0.03$. This analysis was repeated with each symptom dimension separately. Wave 1 inattention symptoms were marginally associated with points earned on the social decision-making task, $B = -2.30$, $SE = 1.17$, $t(180) = -1.96$, $p = 0.052$, 95 % CI [−4.53 0.08], and explained a small proportion of the variance in points, $\Delta R^2 = 0.02$. Hyperactivity/impulsivity symptoms negatively predicted total points earned on the social decision-making task, $B = -2.57$, $SE = 1.23$, $t(180) = -2.08$, $p = 0.039$, 95 % CI [−5.28, 0.09], and explained a small proportion of the variance in points, $\Delta R^2 = 0.02$.

ADHD and Social Problems: Mediation by Social Decision-Making

We next evaluated whether total points on the social decision-making task mediated the association between Wave 1 ADHD symptoms and Wave 2 CBCL Social Problems, controlling for sex and age (Fig. 2). Because zero was not within the 95 % CI, the indirect effect differed significantly from zero, point estimate =0.02 [0.01], 95 % CI [0.002, 0.05]. Thus, social decision-making significantly mediated the association between Wave 1 ADHD symptoms and Wave 2 CBCL Social Problems. The same approach was used to examine each symptom dimension of ADHD separately. For Wave 1 inattention symptoms the 95 % CI for the indirect effect of social decision-making did not contain zero, point estimate =0.03 [0.02], 95 % CI [0.0002, 0.08]. For Wave 1 hyperactivity/impulsivity symptoms, the 95 % CI for the indirect effect of social decision-making did not include zero, point estimate =0.03 [0.02], 95 % CI [0.001, 0.08], indicating

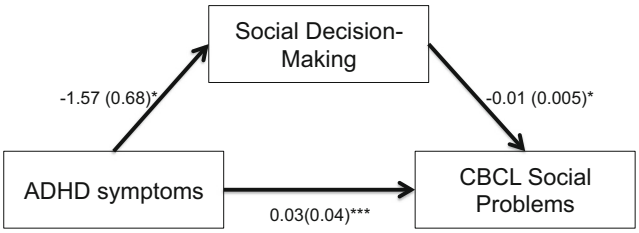

Fig. 2 Mediation model in which social decision-making mediates the association between ADHD symptoms at Wave 1 and CBCL social problems at Wave 2. Note. Coefficient (standard error). ADHD = attention-deficit/hyperactivity disorder. CBCL = Child Behavior Checklist. *$p < 0.05$. ***$p < 0.001$.

that the indirect effect of social decision-making on the association between ADHD symptoms and CBCL Social Problems was found in both symptom dimensions.

Teacher-Reported ADHD Problems

To combat potential shared reporter variance, which potentially inflates observed associations between parent-rated ADHD symptoms and CBCL Social Problems, we examined whether social decision-making mediated the association of teacher-reported Wave 1 ADHD Problems subscale from the TRF and Wave 2 CBCL Social Problems and social decision-making among children with teacher data (n = 131). Controlling for sex and age, teacher-reported Wave 1 ADHD Problems significantly predicted Wave 2 CBCL Social Problems, $B = 0.12$, $SE = 0.04$, $t(127) = 3.43$, $p < 0.001$, 95 % CI [0.07, 0.18], and uniquely explained significant variance in CBCL Social Problems, $\Delta R^2 = 0.08$. Next, we found that Wave 1 ADHD Problems from the TRF was significantly associated with the number of points earned on the social decision-making task, $B = -1.19$, $SE = 0.54$, $t(127) = -2.21$, $p = 0.029$, 95 % CI [−2.27, −0.15], and explained a small proportion of the variance in points, $\Delta R^2 = 0.03$. Lastly, we conducted the above mediation analyses substituting ADHD Problems from the TRF as the predictor. We observed a significant indirect effect of social decision-making, point estimate =0.02 [0.01], 95 % CI [0.002, 0.05], with respect to prediction of parent-rated Wave 2 CBCL Social Problems from Wave 1 TRF ADHD Problems. Thus, mediation of Wave 2 social problems by individual differences in social decision-making from early attention problems was robust to parent and teacher ratings.

Discussion

Given that ADHD is associated with poor social functioning, we examined the prospective association of multi-informant rated ADHD symptoms and social problems in a sample of 186 children with and without ADHD. The total number of ADHD symptoms, as well the inattention and hyperactivity/impulsivity dimensions separately, significantly predicted a well-validated measure of social problems at a two-year follow-up. Moreover, individual differences in performance on a social decision-making task significantly mediated the association of both parent-rated and teacher-rated ADHD symptoms with respect to social problems. Follow-up analyses revealed that the association was found in both inattention and hyperactivity/impulsivity symptom dimensions when considered separately.

Consistent with previous evidence, childhood ADHD symptoms reliably predicted social problems later in development. Relative to their typically-developing peers, children with ADHD have fewer dyadic friendships, are less accepted by their peers, and are less likely to be nominated as preferred playmates (Blachman and Hinshaw 2002; Erhardt and Hinshaw 1994; Hoza et al. 2005b). They also poorly monitor their own social behavior as reflected in self-evaluations that are discrepant from actual performance – for example, despite their reduced social effectiveness compared to controls, ADHD boys provided higher self-evaluations (Hoza et al. 2000). Thus, youth with ADHD may inaccurately perceive their own social competence. Relatedly, children with ADHD struggle in shifting roles and adjusting their behaviors in response to the rapidly changing dynamics of peer groups (Landau and Milich 1988; Waschbusch et al. 2006; Whalen et al. 1979). Collectively, these findings suggest a failure to modulate role requirements based on changing task demands. Thus, children with ADHD may struggle to efficiently and effectively alter behavioral strategies contingently on social cues. These findings are consistent with the work of Ronk et al. (2011) suggesting that children with ADHD frequently experience problematic peer entry, demonstrating a misfit between their own behavior and peers' ongoing activity. The authors suggest that this misfit may arise, in part, from a failure to accurately interpret how other children are responding to entry attempts and to then use these cues to appropriately alter behavior in order to gain acceptance from peers. Thus, of critical importance to social development, timely responses to changing task demands are necessary to alter behavior accordingly.

Although consistency in behavior may reflect deficits in social knowledge, some research suggests that children with ADHD possess adequate knowledge of appropriate social behavior, but fail to apply that knowledge in social contexts (Barkley 1997; Whalen et al. 1990). Although this study was unable to elucidate which aspects of social decision-making are impaired in children with ADHD, it suggests the primacy of social cues to effectively guide behavior. The social decision-making task requires participants to make a series of decisions based on reading affective cues in order to maximize performance. Poor performance on the task may reflect deficient encoding of key cues, interpreting the cues,

and/or knowing how to use those cues to guide behavior. There is evidence that children with ADHD exhibit emotion recognition impairments (e.g., Cadesky et al. 2000; Corbett and Glidden 2000; Kats-Gold and Priel 2009). However, children with ADHD make different types of emotion recognition errors (Kats-Gold et al. 2007; Singh et al. 1998; Williams et al. 2008); some research suggests that they have global deficits in recognizing emotions (Cadesky et al. 2000; Kats-Gold et al. 2007), whereas others indicate difficulties in accurately identifying sad and angry faces, but not disgusted or happy ones (Pelc et al. 2006; Singh et al. 1998). Still, other findings suggest that children with ADHD have deficits in encoding rather than interpreting emotional expressions (Cadesky et al. 2000). Future research should parse aspects of social decision-making to identify where in the process children with ADHD are having difficulties.

Considering poor social decision-making more broadly, these findings identify a potential mechanism by which ADHD confers risk for social difficulties. While social cognition is impaired in individuals with ADHD (Soliva et al. 2009), our findings indicate that the ability to use affective cues to guide behavior may underlie impaired social functioning in ADHD youth. Adaptive social functioning necessitates use of affective cues to discern others' intentions and goals (Premack and Woodruff 1978; Wellman 1992). Such findings are consistent with recent investigations that response inhibition, working memory, and planning did not significantly mediate the relationship between ADHD symptoms and social adjustment as indexed by parent and teacher reports (Biederman et al. 2004; Huang-Pollock et al. 2009). However, alternate research indicates that executive deficits, namely working memory and inhibition, influence and sustain social impairment through their effect on the behavioral expression of ADHD symptoms (Bunford et al. 2015). Thus, the potential relevance of addressing executive deficits in psychosocial interventions for youth with ADHD should not be dismissed.

Although parent- and teacher-rated ADHD symptoms similarly predicted deficits in social decision-making and social problems, follow-up analyses revealed that the association between ADHD symptoms and poorer prospective social functioning was mediated by social decision-making performance. Children with attentional difficulties may neglect social cues and fail to engage in reciprocated behaviors (e.g., listening, give-and-take) that are critical for successful social interactions. A recursive pattern where inattention and disengaged behavior increase the likelihood of social neglect and alienation, which may in turn limit the social interactions required for acquisition of adequate social knowledge, may be heuristic (Maedgen and Carlson 2000; Waschbusch et al. 2006). However, given the task also mediated the association between hyperactivity/impulsivity symptoms and social problems, it is possible aspects of the task are associated with impairments found in individuals with these symptoms. Hyperactivity-impulsivity may interfere with social development by adversely affecting engagement in reciprocal behaviors, such as listening and sharing (Asher et al. 1998).

The findings from the present study should be considered in light of limitations. The use of a laboratory-based technique has the advantage of not requiring informants to provide subjective assessments of social decision-making, however, the ecological-validity of such assessments are unclear. While there are advantages to using complex tasks, as this task allowed us to examine how changing facial expressions affected behavior, rather than providing simple discrete response options, a consequence is that other aspects, including risk tolerance, were not directly assessed and very likely play a role in individual differences in observed behavior. Indeed, differences in risk tolerance have been observed in children with ADHD (Humphreys and Lee 2011). Additionally, while a laboratory-based approach is a promising indicator of social decision-making, a construct that is difficult to measure via self-report alone, a multi-method, multi-informant approach to measuring social decision-making may provide a more comprehensive picture of the relationships with ADHD and social outcomes.

Furthermore, while both parent and teacher report were used to obtain measures of ADHD symptomatology, other reporters, including peer sociometrics, would be an important extension to work in this area. Similarly, our measure of social functioning, though widely used and validated, does not capture the full range of social difficulties as it is necessarily brief. More nuanced measures of social functioning would be helpful in examining which aspects are most impaired by ADHD. While we conceptualized ADHD symptoms as a predictor of impairments in social decision-making, alternative approaches have considered executive function deficits as the predictor of ADHD symptoms (e.g., Bunford et al. 2015), thus the ordering of cause and effect between symptoms and more proximal measures of decision-making requires further study. Lastly, we focused on one emotional expression, anger, as it was one emotion that children with ADHD had particular difficulties in previous research (Pelc et al. 2006). Yet, the extension of the same task to other emotional expressions would be useful in determining whether the same difficulties in behavioral responses to affective cues extend to other emotions.

In conclusion, we provide a potential explanatory mechanism for observed social problems associated with ADHD symptomatology via social decision-making. Further investigations on the cognitive and affective processing that may be responsible for poorer social decision-making are merited, may be due to deficits in the ability to use affective cues to guide behavior. While social skills intervention for children with ADHD has mixed support (e.g., Abikoff et al. 2004;

Antshel and Remer 2003; Frankel et al. 1997; Sheridan and Dee 1996), targeting specific processes, particularly social-cognitive skills (de Boo and Prins 2007) related to reading and using affective cues, may lead to more robust intervention efforts in reducing the impact of ADHD on social problems.

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References

Abikoff, H., Hechtman, L., Klein, R., Gallagher, R., Fleiss, K., Etcovitch, J., et al. (2004). Social functioning in children with ADHD treated with long-term methylphenidate and multimodal psychosocial treatment. *Journal of the American Academy of Child and Adolescent Psychiatry*, *43*, 820–829. doi:10.1097/01.chi.0000128797.91601.1a.

Achenbach, T. M., & Rescorla, L. A. (2001). *ASEBA school age forms and profiles*. Burlington, VT: ASEBA.

Antshel, K. M., & Remer, R. (2003). Social skills training in children with attention deficit hyperactivity disorder: a randomized-controlled clinical trial. *Journal of Clinical Child and Adolescent Psychology*, *32*, 153–165. doi:10.1207/15374420360533149.

Asher, S. R., Parker, J. G., & Walker, D. L. (1998). *Distinguishing friendship from acceptance: Implications for intervention and assessment. The company they keep: Friendship in childhood and adolescence* (pp. 366–405). New York, NY: Cambridge University Press.

Association, A. P. (2013). Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5). In *Diagnostic and statistical manual of mental disorders 4th edition TR*. Arlington, VA: American Psychiatric Publishing.

August, G. J., Realmuto, G. M., MacDonald, A. W., Nugent, S. M., & Crosby, R. (1996). Prevalence of ADHD and comorbid disorders among elementary school children screened for disruptive behavior. *Journal of Abnormal Child Psychology*, *24*, 571–595. doi:10.1007/BF01670101.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*, 65–94. doi:10.1037/0033-2909.121.1.65.

Barkley, R. A. (2006). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (vol. 628,). New York: Guilford Press.

Barkley, R. A., Murphy, K. R., & Fischer, M. (2008). *ADHD in adults: What the science says. ADHD in adults: What the science says*. New York, NY: Guilford Press.

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., et al. (2004). Impact of executive function deficits and attention-deficit/hyperactivity disorder (ADHD) on academic outcomes in children. *Journal of Consulting and Clinical Psychology*, *72*, 757–766. doi:10.1037/0022-006X.72.5.757.

Blachman, D. R., & Hinshaw, S. P. (2002). Patterns of friendship among girls with and without attention-deficit/hyperactivity disorder. *Journal of Abnormal Child Psychology*, *30*, 625–640. doi:10.1023/A:1020815814973.

Bunford, N., Brandt, N. E., Golden, C., Dykstra, J. B., Suhr, J. A., & Owens, J. S. (2015). Attention-deficit/hyperactivity disorder symptoms mediate the association between deficits in executive functioning and social impairment in children. *Journal of Abnormal Child Psychology*, *43*, 133–147. doi:10.1007/s10802-014-9902-9.

Cadesky, E. B., Mota, V. L., & Schachar, R. J. (2000). Beyond words: how do problem children with ADHD and/or conduct problems process nonverbal information about affect? *Journal of the American Academy of Child and Adolescent Psychiatry*, *39*, 1160–1167. doi:10.1097/00004583-200009000-00016.

Corbett, B., & Glidden, H. (2000). Processing affective stimuli in children with attention-deficit hyperactivity disorder. *Child Neuropsychology*, *6*, 144–155. doi:10.1076/chin.6.2.144.7056.

de Boo, G. M., & Prins, P. J. M. (2007). Social incompetence in children with ADHD: possible moderators and mediators in social-skills training. *Clinical Psychology Review*, *27*, 78–97. doi:10.1016/j.cpr.2006.03.006.

Erhardt, D., & Hinshaw, S. P. (1994). Initial sociometric impressions of attention-deficit hyperactivity disorder and comparison boys: predictions from social behaviors and from nonbehavioral variables. *Journal of Consulting and Clinical Psychology*, *62*, 833–842. doi:10.1037/0022-006X.62.4.833.

Frankel, F., & Feinberg, D. (2002). Social problems associated with ADHD vs. ODD in children referred for friendship problems. *Child Psychiatry and Human Development*, *33*, 125–146. doi:10.1023/A:1020730224907.

Frankel, F., Myatt, R., Cantwell, D. P., & Feinberg, D. T. (1997). Parent-assisted transfer of children's social skills training: effects on children with and without attention-deficit hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*, 1056–1064. doi:10.1097/00004583-199708000-00013.

Greene, R. W., Biederman, J., Faraone, S. V., Sienna, M., & Garcia-Jetton, J. (1997). Adolescent outcome of boys with attention-deficit/hyperactivity disorder and social disability: results from a 4-year longitudinal follow-up study. *Journal of Consulting and Clinical Psychology*, *65*, 758–767. doi:10.1037/0022-006X.65.5.758.

Greene, R. W., Biederman, J., Faraone, S. V., Wilens, T. E., Mick, E., & Blier, H. K. (1999). Further validation of social impairment as a predictor of substance use disorders: findings from a sample of siblings of boys with and without ADHD. *Journal of Clinical Child Psychology*, *28*, 349–354. doi:10.1207/S15374424jccp280307.

Gresham, F. M., MacMillan, D. L., Bocian, K. M., Ward, S. L., & Forness, S. R. (1998). Comorbidity of hyperactivity-impulsivity-inattention and conduct problems: risk factors in social, affective, and academic domains. *Journal of Abnormal Child Psychology*, *26*, 393–406. doi:10.1023/A:1021908024028.

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable moderation, mediation, and conditional process modeling. White paper. Retrieved from http://www.afhayes.com/public/process2012.pdf

Hayes, A. F., Gentry, W. A., Gilmore, D. C., Shuffler, M. L., Leslie, J. B., Gandz, J., et al. (2009). Beyond baron and kenny: statistical mediation analysis in the new millennium. *Communication Monographs*, *76*, 408–420. doi:10.1080/03637750903310360.

Hodgens, J. B., Cole, J., & Boldizar, J. (2000). Peer-based differences among boys with ADHD. *Journal of Clinical Child Psychology*, *29*, 443–452. doi:10.1207/S15374424JCCP2903_15.

Hoza, B. (2007). Peer functioning in children with ADHD. *Journal of Pediatric Psychology*, *32*, 655–663. doi:10.1093/jpepsy/jsm024.

Hoza, B., Waschbusch, D. A., Pelham, W. E., Molina, B. S. G., & Milich, R. (2000). Attention-deficit/hyperactivity disordered and control boys' responses to social success and failure. *Child Development*, *71*, 432–446. doi:10.1111/1467-8624.00155.

Hoza, B., Pelham Jr., W. E., Dobbs, J., Owens, J. S., & Pillow, D. R. (2002). Do boys with attention-deficit/hyperactivity disorder have

positive illusory self-concepts? *Journal of Abnormal Psychology*, *111*, 268–278. doi:10.1037/0021-843X.111.2.268.

Hoza, B., Gerdes, A. C., Hinshaw, S. P., Arnold, L. E., Pelham Jr., W. E., Molina, B. S. G., et al. (2004). Self-perceptions of competence in children with ADHD and comparison children. *Journal of Consulting and Clinical Psychology*, *72*, 382–391. doi:10.1037/0022-006X.72.3.382.

Hoza, B., Gerdes, A. C., Mrug, S., Hinshaw, S. P., Bukowski, W. M., Gold, J. A., et al. (2005a). Peer-assessed outcomes in the multimodal treatment study of children with attention deficit hyperactivity disorder. *Journal of Clinical Child and Adolescent Psychology*, *34*, 74–86. doi:10.1207/s15374424jccp3401_7.

Hoza, B., Mrug, S., Gerdes, A. C., Hinshaw, S. P., Bukowski, W. M., Gold, J. A., et al. (2005b). What aspects of peer relationships are impaired in children with attention-deficit/hyperactivity disorder? *Journal of Consulting and Clinical Psychology*, *73*, 411. doi:10.1037/0022-006X.73.3.411.

Huang-Pollock, C. L., Mikami, A. Y., Pfiffner, L., & McBurnett, K. (2009). Can executive functions explain the relationship between attention deficit hyperactivity disorder and social adjustment? *Journal of Abnormal Child Psychology*, *37*, 679–691. doi:10.1007/s10802-009-9302-8.

Humphreys, K. L., & Lee, S. S. (2011). Risk taking and sensitivity to punishment in children with ADHD, ODD, ADHD + ODD, and controls. *Journal of Psychopathology and Behavioral Assessment*, *33*, 299–307. doi:10.1007/s10862-011-9237-6.

Humphreys, K. L., Aguirre, V. P., & Lee, S. S. (2012). Association of anxiety and ODD/CD in children with and without ADHD. *Journal of Clinical Child and Adolescent Psychology*, *41*, 370–377. doi:10.1080/15374416.2012.656557.

Humphreys, K. L., Katz, S. J., Lee, S. S., Hammen, C., Brennan, P. A., & Najman, J. M. (2013). The association of ADHD and depression: mediation by peer problems and parent–child difficulties in two complementary samples. *Journal of Abnormal Psychology*, *122*, 854–867. doi:10.1037/a0033895.

Jezior, K. L., McKenzie, M. E., & Lee, S. S. (2015). Narcissism and callous-unemotional traits prospectively predict child conduct problems. Journal of Clinical Child & Adolescent Psychology. Advance Online publication. doi: 10.1080/15374416.2014.982280

Kats-Gold, I., & Priel, B. (2009). Emotion, understanding, and social skills among boys at risk of attention deficit hyperactivity disorder. *Psychology in the Schools*, *46*, 658–678. doi:10.1002/pits.20406.

Kats-Gold, I., Besser, A., & Priel, B. (2007). The role of simple emotion recognition skills among school aged boys at risk of ADHD. *Journal of Abnormal Child Psychology*, *35*, 363–378. doi:10.1007/s10802-006-9096-x.

Kirsh, S. J., & Mounts, J. R. W. (2007). Violent video game play impacts facial emotion recognition. *Aggressive Behavior*, *33*, 353–358. doi:10.1002/ab.20191.

Kroes, G., Veerman, J. W., & De Bruyn, E. E. J. (2003). Bias in parental reports? Maternal psychopathology and the reporting of problem behavior in clinic-referred children. *European Journal of Psychological Assessment*, *19*, 195–203. doi:10.1027//1015-5759.19.3.195.

Lahey, B. B., Applegate, B., Barkley, R. A., Garfinkel, B., McBurnett, K., Kerdyk, L., et al. (1994a). DSM-IV field trials for oppositional defiant disorder and conduct disorder in children and adolescents. *The American Journal of Psychiatry*, *151*, 1163–1171.

Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., et al. (1994b). DSM-IV field trials for attention deficit hyperactivity disorder in children and adolescents. *American Journal of Psychiatry*, *151*, 1673–1685.

Lahey, B. B., Pelham, W. E., Loney, J., Kipp, H., Ehrhardt, A., Lee, S. S., et al. (2004). Three-year predictive validity of DSM-IV attention deficit hyperactivity disorder in children diagnosed at 4–6 years of age. *The American Journal of Psychiatry*, *161*, 2014–2020. doi:10.1176/appi.ajp.161.11.2014.

Landau, S., & Milich, R. (1988). Social communication patterns of attention-deficit-disordered boys. *Journal of Abnormal Child Psychology*, *16*, 69–81. doi:10.1007/BF00910501.

Lee, V. K., & Harris, L. T. (2013). How social cognition can inform social decision making. *Frontiers in Neuroscience*. doi:10.3389/fnins.2013.00259.

Lee, S. S., & Humphreys, K. L. (2014). Interactive association of dopamine receptor (DRD4) genotype and ADHD on alcohol expectancies in children. *Experimental and Clinical Psychopharmacology*, *22*, 100–109. doi:10.1037/a0035338.

Lee, S. S., Lahey, B. B., Owens, E. B., & Hinshaw, S. P. (2008). Few preschool boys and girls with ADHD are well-adjusted during adolescence. *Journal of Abnormal Child Psychology*, *36*, 373–383. doi:10.1007/s10802-007-9184-6.

Lee, S. S., Falk, A. E., & Aguirre, V. P. (2012). Association of comorbid anxiety with social functioning in school-age children with and without attention-deficit/hyperactivity disorder (ADHD). *Psychiatry Research*, *197*, 90–96. doi:10.1016/j.psychres.2012.01.018.

Li, Y. H., & Tottenham, N. (2013). Exposure to the self-face facilitates identification of dynamic facial expressions: influences on individual differences. *Emotion*, *13*, 196–202. doi:10.1037/a0030755.

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593–614. doi:10.1146/annurev.psych.58.110405.085542.

Maedgen, J. W., & Carlson, C. L. (2000). Social functioning and emotional regulation in the attention deficit hyperactivity disorder subtypes. *Journal of Clinical Child Psychology*, *29*, 30–42. doi:10.1207/S15374424jccp2901_4.

Matthys, W., Cuperus, J. M., & Van Engeland, H. (1999). Deficient social problem-solving in boys with ODD/CD, with ADHD, and with both disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *38*, 311–321. doi:10.1097/00004583-199903000-00019.

Mikami, A. Y., & Hinshaw, S. P. (2003). Buffers of peer rejection among girls with and without ADHD: the role of popularity with adults and goal-directed solitary play. *Journal of Abnormal Child Psychology*, *31*, 381–397. doi:10.1023/A:1023839517978.

Mikami, A. Y., Huang-Pollock, C. L., Pfiffner, L. J., McBurnett, K., & Hangai, D. (2007). Social skills differences among attention-deficit/hyperactivity disorder types in a chat room assessment task. *Journal of Abnormal Child Psychology*, *35*, 509–521. doi:10.1007/s10802-007-9108-5.

Mikami, A. Y., Jack, A., & Lerner, M. D. (2009). Attention-deficit/hyperactivity disorder. In J. L. Matson (Ed.), *Social behavior and skills in children* (pp. 159–185). New York: Springer.

Morrison, R. L., & Bellack, A. S. (1981). The role of social perception in social skill. *Behavior Therapy*, *12*, 69–79.

Mrug, S., Hoza, B., Pelham, W. E., Gnagy, E. M., & Greiner, A. R. (2007). Behavior and peer status in children with ADHD: continuity and change. *Journal of Attention Disorders*, *10*, 359–371. doi:10.1177/1087054706288117.

Nakamura, B. J., Ebesutani, C., Bernstein, A., & Chorpita, B. F. (2009). A psychometric analysis of the child behavior checklist DSM-oriented scales. *Journal of Psychopathology and Behavioral Assessment*, *31*, 178–189. doi:10.1007/s10862-008-9119-8.

Owens, E. B., Hinshaw, S. P., Lee, S. S., & Lahey, B. B. (2009). Few girls with childhood attention-deficit/hyperactivity disorder show positive adjustment during adolescence. *Journal of Clinical Child and Adolescent Psychology*, *38*, 132–143. doi:10.1080/15374410802575313.

Pelc, K., Kornreich, C., Foisy, M.-L., & Dan, B. (2006). Recognition of emotional facial expressions in attention-deficit hyperactivity

disorder. *Pediatric Neurology*, *35*, 93–97. doi:10.1016/j.pediatrneurol.2006.01.014.

Pelham, W. E., & Bender, M. E. (1982). Peer relationships in hyperactive children: description and treatment. *Advances in Learning & Behavioral Disabilities*, *1*, 365–436.

Polanczyk, G., de Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: a systematic review and metaregression analysis. *The American Journal of Psychiatry*, *164*, 942–948. doi:10.1176/appi.ajp.164.6.942.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*, 515–526. doi:10.1017/S0140525X00076512.

Rapport, L. J., Friedman, S. L., Tzelepis, A., & Van Voorhis, A. (2002). Experienced emotion and affect recognition in adult attention-deficit hyperactivity disorder. *Neuropsychology*, *16*, 102–110. doi:10.1037/0894-4105.16.1.102.

Ronk, M. J., Hund, A. M., & Landau, S. (2011). Assessment of social competence of boys with attention-deficit/hyperactivity disorder: problematic peer entry, host responses, and evaluations. *Journal of Abnormal Child Psychology*, *39*, 829–840. doi:10.1007/s10802-011-9497-3.

Scahill, L., & Schwab-Stone, M. (2000). Epidemiology of ADHD in school-age children. *Child and Adolescent Psychiatric Clinics of North America*, *9*, 541–555.

Shaffer, D., Fisher, P., Lucas, C. P., Dulcan, M. K., & Schwab-Stone, M. E. (2000). NIMH diagnostic interview schedule for children version IV (NIMH DISC-IV): description, differences from previous versions, and reliability of some common diagnoses. *Journal of the American Academy of Child and Adolescent Psychiatry*, *39*, 28–38. doi:10.1097/00004583-200001000-00014.

Sheridan, S. M., & Dee, C. C. (1996). A multimethod intervention for social skills deficits in children with ADHD and their parents. *School Psychology Review*, *25*, 57.

Singh, S. D., Ellis, C. R., Winton, A. S. W., Singh, N. N., Leung, J. P., & Oswald, D. P. (1998). Recognition of facial expressions of emotion by children with attention-deficit hyperactivity disorder. *Behavior Modification*, *22*, 128–142. doi:10.1177/01454455980222002.

Soliva, J. C., Carmona, S., Fauquet, J., Hoekzema, E., Bulbena, A., Hilferty, J., & Vilarroya, O. (2009). Neurobiological substrates of social cognition impairment in attention-deficit hyperactivity disorder: gathering insights from seven structural and functional magnetic resonance imaging studies. *Values, Empathy, and Fairness across Social Barriers*, *1167*, 212–220. doi:10.1111/j.1749-6632.2009.04604.x.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., et al. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, *168*, 242–249. doi:10.1016/j.psychres.2008.05.006.

Tseng, W.-L., Kawabata, Y., Gau, S. S.-F., & Crick, N. R. (2014). Symptoms of attention-deficit/hyperactivity disorder and peer functioning: a transactional model of development. *Journal of Abnormal Child Psychology*, *42*, 1353–1365. doi:10.1007/s10802-014-9883-8.

Tung, I., Brammer, W. A., Li, J. J., & Lee, S. S. (2014). Parenting behavior mediates the intergenerational association of parent and child offspring ADHD symptoms. *Journal of Clinical Child and Adolescent Psychology*. doi:10.1080/15374416.2014.913250.

Waschbusch, D. A., Andrade, B. F., & King, S. (2006). Attention-deficit/hyperactivity disorder. In C. A. Essau (Ed.), *Child and adolescent psychopathology: Theoretical and clinical implications* (pp. 52–77). New York: Routledge.

Wellman, H. M. (1992). *The child's theory of mind. The MIT Press series in learning, development, and conceptual change*. Cambridge, MA: The MIT Press.

Whalen, C. K., Henker, B., Collins, B. E., Finck, D., & Dotemoto, S. (1979). A social ecology of hyperactive boys: medication effects in structured classroom environments. *Journal of Applied Behavior Analysis*, *12*, 65–81. doi:10.1901/jaba.1979.12-65.

Whalen, C. K., Henker, B., & Granger, D. A. (1990). Social judgment processes in hyperactive boys: effects of methylphenidate and comparisons with normal peers. *Journal of Abnormal Child Psychology*, *18*, 297–316. doi:10.1007/BF00916567.

Williams, L. M., Hermens, D. F., Palmer, D., Kohn, M., Clarke, S., Keage, H., et al. (2008). Misinterpreting emotional expressions in attention-deficit/hyperactivity disorder: evidence for a neural marker and stimulant effects. *Biological Psychiatry*, *63*, 917–926. doi:10.1016/j.biopsych.2007.11.022.

Youngstrom, E., Izard, C., & Ackerman, B. (1999). Dysphoria-related bias in maternal ratings of children. *Journal of Consulting and Clinical Psychology*, *67*, 905–916. doi:10.1037/0022-006X.67.6.905.

Zoromski, A. K., Owens, J. S., Evans, S. W., & Brady, C. E. (2015). Identifying ADHD symptoms most associated with impairment in early childhood, middle childhood, and adolescence using teacher report. *Journal of Abnormal Child Psychology*, 1–13. doi:10.1007/s10802-015-0017-8.