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Cognitive Deficits and Positively Biased Self-Perceptions in Children with ADHD

Julia D. McQuade · Meghan Tomb · Betsy Hoza · Daniel A. Waschbusch · Elizabeth A. Hurt · Aaron J. Vaughn

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Abstract This study examined the relation between cognitive deficits and positive bias in a sample of 272 children with and without Attention Deficit Hyperactivity Disorder (ADHD; 7–12 years old). Results indicated that children with ADHD with and without biased self-perceptions exhibit differences in specific cognitive deficits (executive processes, working memory, broad attention, and cognitive fluency) compared to each other and to control children. Further, specific cognitive deficits emerged as partial mediators of the relation between ADHD diagnostic status and positive bias. Interestingly, some differences in results emerged based on the domain considered (academic, social, behavioral competence). Results lend initial support to the role of cognitive deficits in the positive bias of some children with ADHD. Implications for future research and intervention are discussed.

Keywords ADHD · Positive illusory self-perceptions · Executive functioning · Cognitive deficits

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J. D. McQuade (✉) · M. Tomb · B. Hoza
Department of Psychology, University of Vermont,
2 Colchester Avenue,
Burlington, VT 05405, USA
e-mail: jmcquade@uvm.edu

D. A. Waschbusch
The State University of New York, Department of Pediatrics,
University of Buffalo,
Buffalo, NY, USA

E. A. Hurt
The Ohio State University, Nisonger Center,
Columbus, OH, USA

A. J. Vaughn
Cincinnati Children's Hospital Medical Center, Center for ADHD,
Division of Behavioral Medicine & Clinical Psychology,
Cincinnati, OH, USA

Research documents that overall, children with Attention-Deficit/Hyperactivity Disorder (ADHD) tend to overestimate their competency in several domains (e.g. academic, social, behavioral conduct) relative to external indices such as adult report or actual performance (for a review see Owens et al. 2007). The reason for this overestimation, also termed a "positive illusory bias" (PIB; Hoza et al. 2002), is still unknown. However, research has found that not all children with ADHD demonstrate this bias (Hoza et al. 2002, 2004), suggesting that there may be meaningful differences between those who do and do not overestimate their competency. Importantly, overestimation of competency in children with ADHD has been linked to conduct problems (Kaiser et al. 2008) and aggression over time (Hoza et al. 2010); thus, understanding the mechanisms that lead to this bias is crucial. One explanation, yet to be examined empirically, is that positive bias is the result of cognitive deficits, especially in areas related to executive functioning (Owens et al. 2007). Given these considerations, this study examined whether children with ADHD, with and without an overestimation of domain-specific competency, as compared to control children, differed in cognitive deficits and whether cognitive deficits could explain the relation between ADHD diagnostic status and positive bias.

Given the impairments associated with ADHD (Abikoff et al. 2002; DuPaul et al. 2001; Pelham et al. 2005), it may be expected that children with ADHD would have low self-perceptions of competency and performance. Despite this logic, studies have found that children with ADHD tend to demonstrate a positive bias and report higher than warranted self-perceptions of competence and performance relative to external criteria (Diener and Milich 1997; Hoza et al. 2002, 2004). For instance, when group means of perceived performance during laboratory tasks have been compared to external measures of performance, children with ADHD report perceptions of performance that do not differ from comparison children (Hoza et al. 2001) or are even more positive than comparison children (Hoza et al. 2000). These positive perceptions of performance occur despite the fact that external measures indicate that children with ADHD performed significantly worse than comparison children during the tasks (Hoza et al. 2000, 2001). Other studies have examined the discrepancy between the self-ratings of children with ADHD and indices of competence such as teacher or parent ratings (Hoza et al. 2004) or standardized achievement measures (Owens and Hoza 2003). These studies find that children with ADHD rate themselves as more competent than external indices indicate, whereas children without ADHD approximate or slightly underestimate their competency (Hoza et al. 2002, 2004; Owens and Hoza 2003). Importantly, this overestimation of competence, demonstrated using discrepancy scores, is not fully accounted for by bias in adult ratings, children's impairment, or an ignorance of incompetence (see Owens et al. 2007 for a detailed review of research findings).

Though several explanations for the tendency of some children with ADHD to overestimate their competency have been proposed (Owens et al. 2007), this paper focuses specifically on potential cognitive deficits that may be associated with this bias. Increasing research suggests that children with ADHD demonstrate a variety of cognitive deficits (Nigg 2006), especially in areas related to executive functioning (see Barkley 1997 and Nigg 2006 for reviews). Though there is no agreed upon operational definition of executive functioning, the key components of executive functioning include interference control, response inhibition, set-shifting, planning, and working memory (Martel et al. 2007). A review of test evidence suggests that children with ADHD have specific deficits in spatial working memory, response suppression, set shifting, and activation, with some additional evidence supporting deficits in interference control and verbal working memory as well (Nigg 2006). Barkley's (1997) theory of ADHD suggests that deficits in inhibition and executive functioning lead to a variety of impairments in children with ADHD, including deficits in hindsight and forethought, holding events in mind, social perspective taking, self-reflection, problem solving, and analysis and synthesis of behaviors. These processes also may affect individuals' ability to accurately perceive their competency based on feedback from their environment. Although Barkley (1997) proposes that these impairments are mediated by executive functioning processes, few studies have examined these links directly.

A recent review suggests that cognitive deficits associated with ADHD, such as executive functioning, may relate to biased perceptions of one's own competency (Owens et al. 2007). Though studies have considered differences in self-perceived competence and performance on intelligence tests in other populations of children with attention problems (Barton and North 2006; Geva et al. 2009; Ek et al. 2008), none have examined the relation between executive functioning and overestimation of competency in children diagnosed with ADHD. Evidence supporting the role of executive functioning deficits in overestimation of competency has been taken from studies examining the relation between cognitive deficits and insight in other populations. For instance, a relation between deficits in executive functioning and a lack of insight has been demonstrated in patients with Schizophrenia (Shad et al. 2006) and acquired brain injuries (Owensworth et al. 2002). Further, a lack of insight has been found to relate to specific cognitive impairments rather than general IQ (McGlynn and Schacter 1989; Shad et al. 2006). Despite these findings, the varied etiologies, symptom presentations, and severity levels of these other populations makes it difficult to draw clear conclusions about the role of cognitive deficits in the positive bias of children with ADHD. Thus, examination of differences in cognitive deficits in children with ADHD who demonstrate different levels of biased self-perceptions is necessary.

Another reason it is important to identify mechanisms underlying the development of biased self-perceptions in children with ADHD is that this bias relates to negative adjustment both concurrently and over time (Kaiser et al. 2008; Hoza et al. 2010). Researchers suggest that in normative populations enhanced self-perceptions may allow children to persist on tasks even if they do not have the requisite skill level, which leads to greater mastery of skill over time (Bjorklund 1997). However, children with ADHD tend to exhibit less persistence and poorer performance on laboratory tasks (Hoza et al. 2000, 2001), and greater impairment across domains of competency (Abikoff et al. 2002; DuPaul et al. 2001; McQuade and Hoza 2008; Mrug et al. 2001), despite their positively biased self-perceptions. Given their severe impairments across domains, a lack of awareness of poor competence may limit the ability of children with ADHD to adjust their behavior in accordance with feedback and improve over time. Though yet to be examined empirically, it is possible that the cognitive deficits some children with ADHD experience may limit their ability to incorporate feedback into an understanding of their functioning, thus leading to greater impairment over time.

Although there appear to be negative consequences associated with a positive bias in children with ADHD (Kaiser et al. 2008; Hoza et al. 2010), research also finds that among children with ADHD, a lack of positive bias is associated with greater depressive symptoms (Hoza et al. 2002, 2004). Thus, children with ADHD without a positive bias may be more likely to display depressive symptoms relative to children with ADHD with a positive bias. Interestingly, research also finds that individuals with depression often demonstrate a specific pattern of executive functioning deficits (see Rogers et al. 2005 for a review). Thus, it may be important for studies examining differences in cognitive deficits in children with and without a positive bias to also consider depressive symptoms as a unique predictor.

Given this backdrop, this study had two goals. First, we examined differences in executive functioning deficits in control children and children with ADHD who were subdivided based on level of positive bias in their self-perceptions. Specifically, children with ADHD were subdivided into two groups; children with self-perceptions that were not exceedingly positive relative to their teacher's report (ADHD) and children who overestimated their competence relative to teacher report (ADHD+PIB). Given that self-perceptions of competency are best assessed in a domain specific manner (Harter 1985), we examined differences in cognitive functioning relative to three different competence domains (academic, social, and behavioral conduct). We hypothesized that, consistent with previous research, all children with ADHD would demonstrate greater cognitive deficits relative to control children. However, we expected that the ADHD+PIB group would demonstrate greater cognitive deficits relative to the ADHD group, given research finding an association between cognitive deficits and poor insight of competency in other clinical populations (Owensworth et al. 2002; Starkstein et al. 2006; Shad et al. 2006). The second goal of this study was to examine the mediating role of cognitive deficits in the relation between ADHD diagnostic status and positive bias. This relation was examined when considering positive bias in the academic, social, and behavioral competency domains. It was hypothesized that deficits in cognitive abilities would partially explain the relation between ADHD status and positively biased self-perceptions. Additionally, given the relation of depressive symptoms to positive bias (Hoza et al. 2002, 2004) and cognitive deficits (Rogers et al. 2005), we examined depressive symptoms as an additional predictor in all analyses.

Method

Participants Participants were 184 children with combined or hyperactive/impulsive type ADHD and 88 control children between the ages of 7.7 and 11.4 years (M=9.2, SD=0.91), 77% male. Children were recruited from three locations, two in the Northeast (n=82 and n=116) and one in the Midwest (n=74), using identical procedures for eligibility determination and diagnosis. Participants were recruited from multiple sources including referrals from local pediatricians, child psychologists and psychiatrists, local schools, ADHD specialty clinics, summer treatment programs, and media advertisements.

All participants with ADHD met criteria for a DSM-IV (American Psychological Association 2000) diagnosis of combined or predominantly hyperactive/impulsive type ADHD; they could also have secondary diagnoses of oppositional defiant disorder (ODD; n=90), conduct disorder (CD; n=28), or elevated symptoms of anxiety or depression. Children with predominantly inattentive type ADHD were excluded from this study as positively biased self-perceptions appear not to be associated with the inattentive subtype of ADHD (Owens and Hoza 2003; Tomb et al. 2010). Approximately one third of the participants recruited were children who did not meet criteria for ADHD. These control participants were evaluated using the same measures as the children with ADHD and could not currently nor in the past have met criteria for ADHD. To the extent possible, controls were selected to have the same sex and ethnic composition as the children with ADHD.

Exclusionary criteria, regardless of ADHD status, included: an IQ below 77 (i.e. 1.5 SD below the mean); a history of seizures or other neurological problems and/or taking medications to prevent seizures; currently being treated for ADHD with medications that could not be withdrawn for testing such as anti-depressants; history or concurrent diagnosis of pervasive developmental disorder, schizophrenia or other psychotic disorders, sexual disorder, organic mental disorder, or eating disorder. To maximize the generalizability of the comparison sample to the general population, control children were not excluded on the basis of ODD (n=0), CD (n=1), or internalizing problems such as anxiety or depression. The ADHD and comparison samples did not differ in regards to age, sex ratio, or demographic characteristics (See Table 1). However, as would be expected, on the Woodcock-Johnson Tests of Cognitive Abilities, Third Edition, children with ADHD had significantly lower scores in Brief Intellectual Ability (M=98, SD=14) relative to comparison children (M=107, SD=14).

ADHD diagnostic status ADHD diagnoses were made at each site through agreement by two independent doctoral-level (Ph.D.) diagnosticians, after considering all information gathered. Primary diagnostic measures included the DISC-IV (Shaffer et al. 2000) administered to the primary

Table 1 Demographic characteristics of children with ADHD and control children

Variable	Children with ADHD	Control children	p
Age, *M (SD)*	9.2 (.94)	9.2 (.86)	ns
Male, *N (%)*	147 (80%)	63 (72%)	ns
Ethnicity, *N (%)*			ns
White	152 (84%)	68 (78%)	
African-american	17 (9%)	10 (12%)	
Other	15 (7%)	10 (10%)	
Family composition			ns
Percent two parents	72.8%	83.0%	
Mother's education, N (%)			ns
High school or less	41 (23%)	16 (18%)	
Some college (< 4 year)	56 (31%)	40 (46%)	
4-year college degree	44 (25%)	16 (18%)	
Postgraduate degree	38 (21%)	16 (18%)	
Father's education, N (%)			ns
High school or less	51 (38%)	15 (22%)	
Some college (< 4 year)	35 (26%)	17 (24%)	
4-year college degree	30 (22%)	24 (34%)	
Postgraduate degree	30 (15%)	14 (20%)	
Mother's Income, N (%)			ns
Not working	31 (18%)	17 (19%)	
< 20,000	39 (23%)	20 (24%)	
20,001–50,000	81 (47%)	48 (49%)	
> 50,001	21 (12%)	5 (6%)	
Father's Income N(%)			ns
Not working	6 (5%)	3 (4%)	
< 20,000	12 (9%)	2 (3%)	
20,001–50,000	62 (47%)	32 (47%)	
> 50,001	51 (39%)	31 (46%)	

ns = nonsignificant

caretaker/s, parent and teacher ratings on the DSM-IV version of the Disruptive Behavior Disorders (DBD) Rating Scale (Pelham et al. 1992), and the parent Child Behavior Checklist (CBCL) and Teacher Report Form (TRF; Achenbach and Rescorla 2001). ADHD diagnostic status was defined as the presence of a diagnosis of either combined type or predominantly hyperactive/impulsive type ADHD and was based on the consensus diagnosis.

Medication status of ADHD participants All children with ADHD were unmedicated at the time of on-site testing and parents and teachers were asked to rate the children's behavior off medication. This is consistent with standard practice in ADHD research that is not directly examining medication effects. Permission to rate and test children off medication was obtained from parent/s and prescribing physicians prior to testing. Children were off-medication only for the minimum amount of time necessary or as recommended by the child's prescribing physician. For a subset of children with ADHD (n=45), teachers rated children's competence regarding medicated behavior or did not report whether their ratings were on or off medication.

Measures

Self- and teacher-reported competence Each child and their teacher completed the respective child or teacher versions of the Self-Perception Profile for Children (SPPC; Harter 1985). The child report version of the SPPC is a 36-item questionnaire comprising six subscales designed to measure global self-worth and domain-specific self-perceptions of scholastic competence, social acceptance, athletic competence, physical appearance, and behavioral conduct. Each of the six domains is comprised of 6 items which are rated on a 1 to 4 scale, with higher scores indicating greater perceived competence. In the present study, only the scholastic, social, and behavioral conduct subscales were used because these domains represent the three most common areas of impairment for children with ADHD (DuPaul et al. 2001; Mrug et al. 2001; Pelham et al. 2005).

In this study, the teacher versions of the relevant SPPC subscales were expanded from 3 items (Harter 1985) to include all six items from the child version in order to keep the two versions as comparable as possible. Per Harter (1985), teachers were instructed to indicate "what you feel to be the [child's] actual competence on each question." Reliability of the SPPC subscales is well-documented (Harter 1985). In the present sample the alphas ranged from 0.73 to 0.83 on the subscales for the child version and from 0.91 to 0.97 on the subscales for the teacher version. For children with multiple teachers, the teacher most familiar with the child was selected to provide ratings.

Children's Depression Inventory (CDI; Kovacs 1992) The CDI is a well-regarded and commonly used brief child self-report measure assessing cognitive, affective, and behavioral symptoms of depression in children. The CDI is a 27-item scale with three statements to choose from for each item. Each item is scored on a zero to two response scale with higher scores indicating higher levels of depressive symptoms. The rater selects the statement for each item that best describes his/her feelings for the past 2 weeks. This scale produces T-scores normed by age and sex, and has well-documented reliability and validity data (see Kovacs 1992). For the present sample the coefficient alpha for the total score was 0.88.

Woodcock-Johnson Tests of Cognitive Abilities, Third Edition (WJ-III COG; Woodcock et al. 2001) The WJ-III COG is a standardized assessment tool that provides an index of general intellectual ability as well as specific cognitive abilities. Though a range of cognitive abilities can be assessed, in the present study only the Executive Processes, Cognitive Fluency, Broad Attention and Working Memory cluster scores were used. These cognitive abilities were examined because the cluster score or individual subtests that comprise the cluster score have been found to differentiate children with and without ADHD (Ford et al. 2003; Schrank and Flanagan 2003). The Executive Processes, Broad Attention, and Working Memory clusters all tap aspects of executive functioning and the Cognitive Fluency score assesses fluency and speed of performance (Mather and Woodcock 2001). The WJ-III includes factors that represent specific cognitive abilities (Schrank et al. 2002) and previous research supports the use of these factors as separate constructs (Penny et al. 2005). The Working Memory cluster is comprised of two subtests, Numbers Reversed and Auditory Working Memory, and assesses the ability to hold and manipulate information held in immediate memory. The Broad Attention cluster includes four subtests, Attentional Capacity, Sustained Attention, Selective Attention, and Auditory Working Memory and assesses the ability to focus attentional resources and hold and manipulate information. The Cognitive Fluency cluster is comprised of three subtests, Retrieval Fluency, Decision Speed, and Rapid Picture Naming and measures fluency and speed in performing simple and complex cognitive tasks. The Executive Processes cluster is comprised of three subtests, Concept Formation, Planning, and Pair Cancellation and assesses strategic planning, proactive interference control, and the ability to shift mental set repeatedly.[1] Standard scores for each cluster were computed based on an age-equivalent normative sample.

Results

Preliminary Analyses

Computation of bias scores Teacher and child reports on the SPPC (Harter 1985) were used to compute separate discrepancy scores for each domain (academic, social, and behavioral conduct) that reflected how the child versus the teacher assessed the child's competence. Specifically, in each domain, the teacher's rating of the child's competence was subtracted from the child's self-perception score. Higher positive scores indicated greater overestimation of competence or positive bias whereas higher negative scores indicated greater underestimation of competence or negative bias.

Definition of subgroups In the first set of analyses, three groups were compared. Children with ADHD were categorized based on their level of positive bias. Given the known domain-specific nature of self-perceptions (Harter 1985), the two ADHD groups were defined separately using discrepancy scores in each of the three domains (academic, social, behavioral). Children with a positive bias score greater than or equal to 1 were categorized as high positive bias (ADHD+PIB), and those with a bias score less than 1 were categorized as not high on positive bias (ADHD). A cutoff score of 1 or greater was selected because in the overall sample, across domains, a positive bias score of 1 or greater corresponded to a score that was approximately one standard deviation above the mean. Thus, children with ADHD were subgrouped in three ways: 1) based on positive bias in the academic domain; 2) based on positive

[1] Readers should be aware that although researchers argue that the clusters of the WJ-III are conceptually independent constructs, the Broad Attention and Working Memory clusters are highly correlated in this sample (0.92) and in the WJ-III normative sample (0.89 to 0.90). Given this correlation, readers may want to interpret results of only one of the two clusters. However we report all four clinical cluster scores implicated in the impairments of children with ADHD (Ford et al. 2003) so that those interested in the WJ-III clusters can examine all results.

bias in the social domain; and 3) based on positive bias in the behavioral conduct domain. All children without ADHD were classified in the control group (Control) given that only a small subset demonstrated a positive bias greater than one in the academic ($n=5$), social ($n=10$), or behavioral conduct ($n=10$) domain.

Subgroup comparisons Three ANOVAs were run to compare the discrepancy scores of children in each group. As expected, across all three domains, the ADHD+PIB group demonstrated significantly higher discrepancy scores relative to both the ADHD group and the control group. In contrast, children in the ADHD group and control group did not differ in discrepancy scores (see Table 2).

Examination of depressive symptoms Given the negative relation between depressive symptoms and positive bias (Hoza et al. 2004) and the relation between depressive symptoms and cognitive deficits (Rogers et al. 2005), groups (ADHD+PIB, ADHD, and Control) were compared on the CDI total score: ANOVAs were run separately for subgroupings based on bias in each of the three domains. Across all sets of analyses, group comparisons indicated that the ADHD group demonstrated significantly higher CDI total scores relative to both the control group and the ADHD+PIB group. In contrast, the ADHD+PIB group and the control group were not significantly different from one another.

Additionally, the correlation of the CDI total score with the cognitive variables and with the discrepancy scores in each domain were examined. The CDI total score was significantly negatively correlated with Broad Attention, Cognitive Fluency, Working Memory, and with positive bias in all three domains. As a result, the CDI total score was included as an additional predictor in all analyses.

Primary Analyses: Cognitive Deficit Comparisons by Group

Differences in cognitive deficits between the three groups (ADHD, ADHD+PIB, and Control) were examined using univariate analyses of variance (ANOVAs), following recommendations by Huberty and Morris (1989) to use univariate tests when examining variables that are conceptually independent. Previous research using the WJ-III cluster scores supports the use of a univariate approach to examining group differences (Penny et al. 2005; Ford et al. 2003). A total of 12 ANOVAs were run, four for each subgrouping domain, with separate analyses comparing groups on each of the four cognitive variables. Additionally, the CDI total score was included as an additional predictor.[2] Significant univariate group effects were clarified through pairwise comparisons (see Table 2).

Academic Domain Results indicated significant group differences in Broad Attention ($F(3, 185)=6.64$, $p<0.01$), Cognitive Fluency ($F(3, 271)=10.96$, $p<0.001$), and Executive Processes ($F(3,262)=11.80$, $p<0.001$) but no significant group difference in Working Memory ($F(3, 186)=3.02$, $p>0.05$). Post hoc comparisons indicated that the control group demonstrated greater ability in Broad Attention, Cognitive Fluency, and Executive Processes relative to the ADHD (Cohen's $d=0.61$, 0.69, 0.42, respectively) and ADHD+PIB (Cohen's $d=0.74$, 0.79, and 0.93, respectively) groups. Additionally, the ADHD group demonstrated greater ability in Executive Processes compared to the ADHD+PIB group (Cohen's $d=0.49$) but were not significantly different in regards to Broad Attention or Cognitive Fluency (Cohen's $d=0.09$ and 0.06 respectively). The CDI total score was significantly negatively related to Cognitive Fluency ($F(1, 271)=10.97$, $p<0.01$) and Executive Processes abilities ($F(1,262)=4.55$, $p<0.05$) but not to Working Memory ($F(1,186)=1.08$, $p>0.10$) and Broad Attention ($F(1,185)=1.28$, $p>0.10$).

Social Domain Significant group differences were found on Working Memory ($F(3,186)=5.30$, $p<0.01$), Broad Attention ($F(3,185)=9.51$, $p<0.001$), Cognitive Fluency ($F(3,270)=13.04$, $p<0.001$), and Executive Processes ($F(3,261)=8.75$, $p<0.001$). Post hoc comparisons indicated that controls demonstrated greater ability in Broad Attention, Cognitive Fluency, and Executive Processes relative to the ADHD (Cohen's $d=0.53$, 0.66, 0.47, respectively) and ADHD+PIB (Cohen's $d=0.89$, 0.78, 0.66, respectively) groups. Further, the control group demonstrated greater ability in Working Memory relative to the ADHD+PIB group (Cohen's $d=0.67$), but not relative to the ADHD group (Cohen's $d=0.29$). In addition, the ADHD group demonstrated greater Working Memory, Broad Attention, Cognitive Fluency, and Executive Processes relative to the ADHD+PIB group (Cohen's $d=0.36$, 0.36, 0.20, 0.25, respectively). The CDI total score was significantly negatively related to Cognitive Fluency ($F(1,270)=12.82$, $p<0.001$) and Executive Processes ($F(1,261)=4.00$, $p<0.05$) but not to Working Memory ($F(1,186)=2.06$, $p>0.10$) and Broad Attention ($F(1,185)=2.65$, $p>0.10$).

Behavioral Conduct Domain Results indicated significant group differences in Broad Attention ($F(3,185)=6.37$, $p<0.01$), Cognitive Fluency ($F(3,271)=10.34$, $p<0.001$), and

[2] In group comparison analyses, the interaction of the CDI total score and group also was examined. Across all analyses, there were no significant interactions of the CDI total score with group. Thus the interaction term was not included in the final model.

Table 2 Group means and standard deviations for cognitive cluster scores, depressive symptoms, self- and teacher-rated competence, and bias scores separately reported for each of the three domain subgroupings

	Control		ADHD		ADHD+PIB	
	M	*SD*	*M*	*SD*	*M*	*SD*
Academic domain	N range=60–88		N range=91–138		N range=34–46	
Working memory	104.3	10.6	99.7	14.8	97.4	13.5
Broad attention	106.8 [a]	10.4	99.6 [b]	13.2	98.5 [b]	12.1
Cognitive fluency	99.5 [a]	13.9	89.5 [b]	15.1	88.6 [b]	13.9
Executive processes	108.0 [a]	12.4	102.7 [b]	12.8	96.6 [c]	11.9
CDI total score	43.95 [a]	7.76	50.96 [b]	11.40	44.98 [a]	8.72
Self-perceived competency	3.21 [a]	0.59	2.72 [b]	0.76	3.42 [ab]	0.48
Teacher-rated competency	3.47 [a]	0.59	2.79 [b]	0.72	1.89 [c]	0.55
Child-teacher discrepancy	–0.24 [a]	0.72	–0.06 [a]	0.68	1.53 [b]	0.47
Social domain	N range=60–88		N range=85–113		N range=34–70	
Working memory	104.3 [a]	10.6	100.8 [a]	13.9	95.6 [b]	15.2
Broad attention	106.8 [a]	10.4	100.8 [b]	12.3	96.1 [c]	13.6
Cognitive fluency	99.5 [a]	13.9	90.5 [b]	13.3	87.5 [c]	16.9
Executive processes	108.0 [a]	12.4	102.3 [b]	11.8	99.1 [c]	14.3
CDI total score	43.95 [a]	7.76	51.71 [b]	12.12	45.44 [a]	7.17
Self-perceived competency	3.18 [a]	0.63	2.48 [b]	0.79	3.32 [a]	0.53
Teacher-rated competency	3.29 [a]	0.67	2.60 [b]	0.82	1.72 [c]	0.54
Child-teacher discrepancy	−0.09 [a]	0.86	−0.12 [a]	0.66	1.61 [b]	0.51
Behavioral domain	N range=60–88		N range=63–86		N range=62–98	
Working memory	104.3	10.6	99.1	15.0	99.1	13.9
Broad attention	106.8 [a]	10.4	99.1 [b]	13.1	99.5 [b]	12.8
Cognitive fluency	99.5 [a]	13.9	88.3 [b]	14.1	90.1 [b]	15.4
Executive processes	108.0 [a]	12.4	102.3 [b]	12.5	100.1 [b]	13.1
CDI total score	43.95 [a]	7.76	53.48 [b]	12.55	45.94 [a]	8.16
Self-perceived competency	3.31 [a]	0.64	2.53 [b]	0.79	3.29 [a]	0.56
Teacher-rated competency	3.51 [a]	0.65	2.51 [b]	0.92	1.59 [c]	0.55
Child-teacher discrepancy	−0.19 [a]	0.82	0.01 [a]	0.70	1.70 [b]	0.55

Post hoc comparisons were interpreted for significant group effects. Significant post hoc comparisons are identified by superscripts a, b, and c. Means that do differ significantly between groups are identified by different superscripts; means that do not differ between groups are identified by the same superscript; CDI= Children's Depression Inventory Total T-score

Executive Processes ($F(3,262)=7.96$, $p<0.001$) but not in Working Memory ($F(3,186)=2.47$, $p>0.05$). Post hoc comparisons indicated that controls demonstrated greater ability in Broad Attention, Cognitive Fluency, and Executive Processes relative to the ADHD (Cohen's d=0.65, 0.80, 0.46, respectively) and ADHD+PIB (Cohen's d=0.63, 0.64, 0.62, respectively) groups. The ADHD and ADHD+PIB groups did not demonstrate significant differences in Broad Attention, Cognitive Fluency, or Executive Processes (Cohen's d=0.03, 0.12, 0.17, respectively). The CDI total score was significantly negatively related to Cognitive Fluency ($F(1,271)=9.20$, $p<0.01$) but not to Executive Processes ($F(1,262)=3.69$, $p>0.05$), Working Memory ($F(1,186)=0.72$, $p>0.10$) or Broad Attention ($F(1,185)=0.97$, $p>0.10$).[3]

[3] Given that a small subset of children in the comparison group demonstrated a positive bias greater than 1 in the academic (n=5), social (n=10), or behavioral conduct (n=10) domain, group comparison analyses also were conducted excluding comparison children with a positive bias. Across all analyses, results were consistent when control children with a positive bias were excluded.

Follow-up analyses In order to rule-out the possibility that differences in cognitive deficits between the ADHD and ADHD+PIB group are merely a reflection of differences in symptom severity level between the two groups, follow-up analyses compared groups on parent-rated total problems, externalizing problems, and internalizing problems from the CBCL. Separate ANOVAs were run with children with ADHD subgrouped based on PIB in each of the three domains. Across all analyses, there were no significant differences in parent-rated total problems, externalizing problems, or internalizing problems for the ADHD and ADHD+PIB groups. However, as expected, both ADHD groups had significantly higher total problems, externalizing problem scores, and internalizing problem scores relative to the control group.

Additionally, group differences in self-perceived competency and teacher-rated competency on the SPPC also were compared to examine if the ADHD+PIB group differed in both teacher and child-rated competency relative to the control and ADHD group. A series of ANOVAs were run comparing teacher-rated competency or self-perceived competency in each of the three domains. In each ANOVA, children with ADHD were subgrouped based on bias in the domain of competency examined. Results indicated that the three groups were significantly different in teacher-rated competency in each of the three domains, with the ADHD +PIB group demonstrating significantly poorer teacher-rated competency than both the ADHD and control groups. Additionally the ADHD group also demonstrated significantly poorer teacher-rated competency than the control group across all three domains. However, results also indicated that the ADHD+PIB demonstrated significantly higher social and behavioral conduct self-perceptions and marginally significantly higher academic self-perceptions relative to the ADHD group. Children in the control group also demonstrated significantly higher self-perceived competency relative to the ADHD group across all three domains (see Table 2).

Primary Analyses: Cognitive Deficits as a Mediator of the Relation Between ADHD and Bias

For the second set of analyses, we examined the extent to which each cognitive variable (Executive Processes, Cognitive Fluency, Broad Attention, and Working Memory) mediated the relation between ADHD diagnostic status and positively biased self-perceptions. Mediation was assessed using bootstrapping techniques with bias-corrected confidence estimates and 1,000 bootstrap resamples (see Preacher and Hayes 2008 for a description). Preacher and Hayes (2004) note that bootstrapping techniques are beneficial because they do not assume normality of the distribution of indirect effects and are more reliable with smaller sample sizes. A bootstrapping approach allows for the examination of the direct and indirect effects of the dependent variable on the independent variable. The total effect of an independent variable (IV) on a dependent variable (DV) is composed of the direct effect of the IV on the DV and an indirect effect of the IV on the DV through a proposed mediator. The indirect effect takes into account the effects of the IV on the mediator and the effect of the mediator on the DV, after taking out the effect of the IV; thus each bootstrapping mediation model examined the direct and indirect effects of ADHD diagnostic status, mediated through cognitive deficits, on biased self-perceptions. Biases in the academic, social, and behavioral conduct domains were considered as separate DV's. The mediating roles of each of the cognitive variables were considered in separate models. In each mediation model, the CDI total score was entered as an additional predictor.

Academic Domain Table 3 provides a summary of results predicting bias in the academic domain. Results indicated a significant direct path between ADHD diagnostic status and bias in the academic domain in all four analyses. However results also suggested that Working Memory, Broad Attention, Cognitive Fluency, and Executive Processes are significant predictors of bias in the academic domain. Further, the significant indirect effects indicated that Working Memory, Broad Attention, Cognitive Fluency, and Executive Processes all were partial mediators of positive bias in the academic domain. Additionally, a greater CDI total score was a significant predictor of less positive bias in all analyses (all ps<0.001)

Social Domain Table 4 summarizes the results predicting bias in the social domain. In each of the four analyses, results suggested a significant direct path between ADHD diagnostic status and bias in the social domain. Additionally, Working Memory, Broad Attention, Cognitive Fluency, and Executive Processes significantly predicted bias in the social domain. Significant partial mediating effects were found for Working Memory, Broad Attention, Cognitive Fluency, and Executive Processes, as shown by the significant indirect effects for each. The CDI total score also significantly predicted less positive bias in each model (all ps<0.001).

Behavioral Conduct Domain Table 5 presents the results of analyses predicting bias in the behavioral conduct domain. In each of the four models, the direct effect of ADHD status on bias in the behavioral conduct domain was significant. Further, Executive Processes also was a significant predictor of bias in the behavioral conduct domain and emerged as a partial mediator, as shown by the significant indirect effect. Working Memory, Broad Attention, and Cognitive Fluency did not emerge as significant mediators of bias in the behavioral conduct domain. Again, the CDI total score also was a significant predictor across all analyses (all ps<0.001).

Discussion

To our knowledge, this study is the first to examine the role of cognitive deficits in the positively biased self-perceptions of children with ADHD. Consistent with hypotheses, meaningful differences in cognitive deficits were found between control children and children with ADHD both with and without biased self-perceptions. Not only did results show that children with ADHD and a positive bias have greater cognitive deficits than those without a positive bias, but specific cognitive deficits were

Table 3 Summary of point estimates for mediation of ADHD diagnostic status predicting biased self-perceptions in the academic domain

Mediating variable (M)	Effect of IV on M (a)	Effect of M on DV (b)	Direct effects (c')	Total effects of IV on DV (c)	Indirect effects (a x b)	BCa 95% CI	
						Lower	Upper
Working memory	−4.581*	−0.015**	0.653***	0.722***	0.069 [a]	0.0141	0.1716
Broad attention	−6.815***	−0.016**	0.615***	0.724***	0.109 [a]	0.0364	0.2374
Cognitive fluency	−9.118***	−0.015***	0.610***	0.744***	0.134 [a]	0.0664	0.2322
Executive processes	−6.381***	−0.018***	0.638***	0.752***	0.115 [a]	0.0523	0.2105

IV = independent variable (ADHD diagnostic status); DV = dependent variable (bias in the academic domain); M = mediating variable (cognitive score); BCa CI = Bias Corrected and Accelerated 95% Confidence Interval. For the indirect effects, confidence intervals that include zero are interpreted as nonsignificant; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; superscript [a] signifies significant indirect effect; 1,000 bootstrap samples

found to partially mediate the relation between ADHD and biased self-perceptions. Interestingly, different relations between cognitive deficits and positive bias emerged depending on the domain of competency assessed. Thus, this study found that cognitive deficits may be a potential mechanism that underlies the domain specific overestimation of competency in children with ADHD.

Our first goal was to examine differences in Executive Processes, Working Memory, Broad Attention, and Cognitive Fluency deficits among control children and children with ADHD subdivided based on the presence of positively biased self-perceptions in the academic, social, or behavioral conduct domains. Consistent with previous research (see Barkley 1997), children in the control group demonstrated greater abilities in Broad Attention, Cognitive Fluency, and Executive Processes relative to all children with ADHD, regardless of their levels of bias. However, in regards to Working Memory, only children with ADHD and positively biased social self-perceptions demonstrated deficits relative to control children, suggesting that working memory may be more likely to be impaired in children with ADHD who overestimate their social competency (see Table 2).

Differences between children with ADHD subgrouped based on the presence of domain specific bias also emerged. Specifically, children with high positive bias in the academic or social domain demonstrated greater deficits in Executive Processes relative to children without such a bias. Further, children with ADHD and a positive bias in the social domain also demonstrated greater deficits in Cognitive Fluency, Working Memory, and Broad Attention relative to children with ADHD without this bias. Thus, children with both ADHD and positively biased self-perceptions in the academic or social domain appear to demonstrate specific cognitive deficits relative to control children *and* relative to children with ADHD without high levels of positive bias (see Table 2). These results extend existing literature that has found greater cognitive deficits in individuals with low insight regarding their impairments in other clinical populations (Owensworth et al. 2002; Starkstein et al. 2006; Shad et al. 2006).

Further, follow-up analyses indicated that although children with ADHD with and without a positive bias differ in cognitive deficits, they do not differ in overall internalizing, externalizing or total symptom severity as rated by parents. Additionally, a common criticism of discrepancy scores as a measure of bias is that children with ADHD, due to poor competency, are more likely to demonstrate a positive bias (Owens et al. 2007). However, follow-up analyses comparing children subgrouped based on the presence of a positive bias suggested that children with ADHD and a positive bias demonstrated poorer

Table 4 Summary of point estimates for mediation of ADHD diagnostic status predicting biased self-perceptions in the social domain

Mediating variable (M)	Effect of IV on M (a)	Effect of M on DV (b)	Direct effects (c')	Total effects of IV on DV (c)	Indirect effects (a x b)	BCa 95% CI	
						Lower	Upper
Working memory	−4.581*	−0.016**	0.609***	0.683***	0.073 [a]	.0050	0.1804
Broad attention	−6.815***	−0.020***	0.552***	0.686***	0.134 [a]	0.0439	0.2757
Cognitive fluency	−9.118***	−0.010*	0.685***	0.773***	0.088 [a]	0.0229	0.1926
Executive processes	−6.381***	−0.010*	0.680***	0.744***	0.064 [a]	0.0131	0.1532

IV = independent variable (ADHD diagnostic status); DV = dependent variable (bias in the social domain); M = mediating variable (cognitive score); BCa CI = Bias Corrected and Accelerated 95% Confidence Interval. For the indirect effects, confidence intervals that include zero are interpreted as nonsignificant; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; superscript [a] signifies significant indirect effect; 1,000 bootstrap samples

Table 5 Summary of point estimates for mediation of ADHD diagnostic status predicting biased self-perceptions in the behavioral domain

Mediating variable (M)	Effect of IV on M (a)	Effect of M on DV (b)	Direct effects (c')	Total effects of IV on DV (c)	Indirect effects (a x b)	BCa 95% CI	
						Lower	Upper
Working memory	−4.581*	−0.005	1.143***	1.168***	0.024	−0.0128	0.0941
Broad attention	−6.815***	−0.005	1.147***	1.183***	0.037	−0.0260	0.1347
Cognitive fluency	−9.118***	−0.001	1.293***	1.298***	0.005	−0.0748	0.0751
Executive processes	−6.381***	−0.010*	1.215***	1.278***	0.063 [a]	0.0121	0.429

IV = independent variable (ADHD diagnostic status); DV = dependent variable (bias in the behavioral domain); M = mediating variable (cognitive score); BCa CI = Bias Corrected and Accelerated 95% Confidence Interval. For the indirect effects, confidence intervals that include zero are interpreted as nonsignificant; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; superscript [a] signifies significant indirect effect; 1,000 bootstrap samples

teacher-rated competency but also greater self-perceived competency relative to children with ADHD without a positive bias. This suggests that the presence of a positive bias in children with ADHD is a function of both poor competency as well as high self-perceived competency. Thus, the differences in cognitive functioning between children with ADHD with and without a positive bias are not merely a reflection of symptom severity or poor teacher-rated competency.

Interestingly, results comparing the cognitive deficits of children with ADHD subgrouped based on high levels of positive bias in three different domains of competency were not entirely consistent, suggesting that different mechanisms may be at play depending on the domain of competency examined. Our results suggest that a greater range of cognitive deficits may be implicated in positively biased self-perceptions in the social domain. Considering that social information may be more nuanced and may require a greater range of cognitive skills to process, these results make intuitive sense. In fact, some research does suggest that executive functioning may relate to various social abilities (Bellanti and Bierman 2000; Clark et al. 2002), including the ability to define the problem and recognize feelings of others in hypothetical social vignettes of conflict (Zadeh et al. 2007). One study also found that executive functioning fully mediated the relation between ADHD diagnostic status and difficulty detecting subtle verbal cues and remembering the conversation during a computer simulated chat-room task (Huang-Pollock et al. 2009), suggesting that executive functioning may impair the ability of children with ADHD to process social information. Thus, the cognitive abilities assessed in the present study, such as planning, fluency, and retaining and manipulating information, may be particularly important prerequisites in order for children to perceive and incorporate social feedback from others.

In addition to examining differences in cognitive deficits among children subgrouped by their level of positive bias, this study also examined whether specific cognitive deficits mediated the relation among ADHD status and positively biased self-perceptions. Importantly, results indicated that across all three domains, Executive Processes partially mediated the relation among ADHD status and positively biased self-perceptions even when considering depressive symptoms as an additional predictor. Additionally, when considering bias in the academic and social domains, Working Memory, Broad Attention, and Cognitive Fluency were all significant partial mediators of the relation among ADHD status and positively biased self-perceptions. Though directionality cannot be inferred from cross-sectional analyses, our results suggest that cognitive deficits may be one mechanism that can partially explain why some children with ADHD demonstrate greater positive bias.

These results are particularly significant given the potential negative implications associated with positive bias in children with ADHD. For instance, not only is positive bias associated with greater aggression over time (Hoza et al. 2010), but positive bias also may lead children to be less capable of adjusting their behavior in accordance with feedback (McQuade and Hoza 2008; Owens et al. 2007). Although some research from normative populations suggests that there may be benefits to overly positive self-perceptions (Bjorklund 1997; Taylor and Brown 1988), these benefits may not hold for children with ADHD. Given the impairments of children with ADHD, the ability to alter behavior in response to environmental cues may be especially important for improved functioning over time.

If part of the overestimation of competency in children with ADHD is the result of cognitive deficits, it may be possible to increase the insight of children with ADHD by improving cognitive functioning. Studies have demonstrated that executive functioning ability can be improved with short-term cognitive retraining interventions (Bell et al. 2001) and it has been suggested that these improvements may generalize to other areas of functioning (Stablum et al. 2000). Social psychologists also have suggested that improving competence may increase self-awareness (Kruger and Dunning 1999); however this possibility has not been examined in children with ADHD. Despite the potential for these interventions to reduce biased self-perceptions in children with ADHD, it is important to note that in our study, as well as other studies, more accurate self-perceptions relate to greater depressive symptoms concurrently (Hoza et al. 2002) as well as over time (Hoza et al. 2010). Thus, it will be important for future research to examine not only whether different interventions can reduce bias in self-perceptions but also its impact on depressive symptoms in children with ADHD. This will help determine whether it is clinically advantageous to alter the self-perceptions of children with ADHD. Nevertheless, our results do suggest that children with ADHD and positively biased self-perceptions may have specific impairments that include cognitive deficits. Thus, assessment of self-perceived competency in conjunction with actual functioning may prove to be clinically useful in identifying children with ADHD that may be more likely to have cognitive impairments and associated adjustment risks.

Additional research also may wish to consider other cognitive skills such as perspective taking, self-reflection, and information processing that may relate to positive bias or explain the relation between cognitive deficits and positive bias. Although yet to be examined empirically, it is possible that executive functioning deficits limit children's ability to process information and reflect, which in turn leads to difficulty accurately perceiving competency. Additionally, some researchers have proposed models that suggest that the combination of certain cognitive deficits may predict impairments for children with ADHD (Denny and Rapport 2000). Thus, additional research may want to explore whether certain cognitive deficits interact in predicting positive bias. Further, given that cognitive deficits were found to partially mediate, rather than fully mediate, the relation between ADHD status and positive bias, future research also should consider other factors that may play a role, such as self-protection or cognitive immaturity (see Owens et al. 2007 for a review of other potential mechanisms).

Though results from this study are promising and open up new avenues of research, several caveats must be noted in interpreting these findings. First, children with the inattentive subtype of ADHD were not included in this study; thus our results are only applicable to children with the combined or hyperactive/impulsive subtype of ADHD. Previous research has shown that children with the inattentive subtype of ADHD tend to exhibit negatively biased self-perceptions (Owens and Hoza 2003), and research has yet to examine how cognitive deficits may be implicated in the negative bias of children with the inattentive subtype of ADHD. Second, though we used a measure of cognitive deficits that is well validated and has been found to differentiate children with ADHD from children without ADHD (Schrank and Flanagan 2003; Woodcock et al. 2001), results should be replicated using other measures of cognitive functioning. Third, our data are cross sectional. Although we would expect that ADHD is present prior to the development of positively biased self-perceptions, causal inferences cannot be made from our analyses; thus additional longitudinal studies are needed. Fourth, because only a small number of control children demonstrated a positive bias, we were unable to examine whether cognitive deficits also are observed in non-ADHD children with a positive bias. Finally, although previous research has demonstrated similar patterns of positive bias using parent reports (Hoza et al. 2004) or achievement testing (Owens and Hoza 2003), it is possible that teacher reports, used to create bias scores, may be negatively biased for children with behavior problems. Thus, additional studies may want to consider other measures of competency (e.g. academic achievement) as criterion measures.

In sum, this study demonstrated differences in cognitive deficits among children with ADHD who do and do not demonstrate positively biased self-perceptions. Though the cause of positively biased self-perceptions in children with ADHD is unknown (Owens et al. 2007), this study suggests that cognitive deficits may be one factor that contributes to positively biased self-perceptions in children with ADHD. Importantly, these results may inform future research on interventions designed to improve accuracy of self-perceptions and to reduce risk for adjustment problems in children with ADHD. Future research also may consider whether other cognitive deficits are implicated in positively biased self-perceptions and whether interventions can change cognitive functioning and alter the levels of bias in self-perceptions of children with ADHD.

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