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Self-Referenced Memory, Social Cognition, and Symptom Presentation in Autism

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Abstract

Background—We examined performance on a self-referenced memory (SRM) task for higher functioning children with autism (HFA) and a matched comparison group. SRM performance was examined in relation to symptom severity and social cognitive tests of mentalizing.

Method—Sixty-two children (31 HFA, 31 comparison; 8–16 years) completed a SRM task in which they read a list of words and decided whether the word described something about them, something

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- Self-awareness is essential for social communication and competence
- Self-referenced memory (SRM) effect documented in typically developing populations in which self-relevant information is preferentially encoded and recalled over other types of information
- Current study documents
  - SRM effect shown by typically-developing children but higher functioning children with autism (HFA) failed to preferentially process self-relevant versus other-relevant information
  - extent of preferential self processing associated with symptom severity; associations not accounted for by performance on mentalizing tasks
- Atypical processing of self-relevant information may impact ability to detect and internalize information from and about others
- Interventions targeting self awareness and monitoring may impact social functioning

about Harry Potter, or contained a certain number of letters. They then identified words that were familiar from a longer list. Dependent measures were memory performance (d′) in each of the three encoding conditions as well as a self-memory bias score (d′ self-d′ other). Children completed The Strange Stories Task and The Children's Eyes Test as measures of social cognition. Parents completed the SCQ and ASSQ as measures of symptom severity.

Results—Children in the comparison sample showed the standard SRM effect in which they recognized significantly more self-referenced words relative to words in the other-referenced and letter conditions. In contrast, HFA children showed comparable rates of recognition for self- and other-referenced words. For all children, SRM performance improved with age and enhanced SRM performance was related to lower levels of social problems. These associations were not accounted for by performance on the mentalizing tasks.

Conclusions—Children with HFA did not show the standard enhanced processing of self- vs. other-relevant information. Individual differences in the tendency to preferentially process self-relevant information may be associated with social cognitive processes that serve to modify the expression of social symptoms in children with autism.

Atypical self-awareness may be fundamental to social impairments in autism (Frith & Happe, 1999; Hobson, Chidambi, Lee, & Meyer, 2006; Mundy, 2003; Russell, 1997). Disturbances in self-related memory processes may be one manifestation of this atypicality (Millward et al., 2000; Toichi et al., 2002; Yamamoto et al., 2004). Many studies have documented that self-referenced processing enhances word memory relative to other semantic forms of word processing (Symons & Johnson, 1997). Theory on this self-referenced memory (SRM) effect suggests that self-related information is processed within an extensive frontal network of associations and is encoded more deeply and efficiently than other types of information (Craik et al., 1999). However, unlike typically developing adults, Lombardo, Barnes, Wheelwright, and Baron-Cohen (2007) reported that adults with autism showed attenuated SRM effects and Toichi et al. (2002) reported that adults with autism failed to show a recognition memory advantage for words studied in a self-referenced versus general semantic condition.

This literature suggests that SRM paradigms may be useful in examining the role of self-awareness in autism. However, most of the research on self-referenced word memory has been conducted with adults. Therefore, it is not clear if this paradigm is valid with children, or whether age impacts the development of SRM similarly in typically developing children and children with autism. It is also not clear whether SRM difficulties in autism reflect specific deficits in self-awareness or more general mentalizing deficits. Frith and Happe (1999) suggest that, just as people with autism have difficulty mentalizing the knowledge of other people, they may also have difficulty mentalizing self-knowledge. This perspective suggests that attenuated SRM may be an epiphenomenon of the social cognitive mentalizing deficits associated with autism. Alternatively, others suggest that while self-monitoring and self-awareness may be a component of social cognition, its impairment in autism may be distinct from mentalizing about others (Hobson et al., 2006; Mundy, 2003). These fundamental impairments in self-awareness and knowledge may, in turn, diminish one's ability to integrate what is known about the self with what one observes in others, which is essential for social cognitive development (Mundy & Newell, 2007; Oberman & Ramachandran, 2007).

To examine these issues, self-referenced memory, social cognition and social symptoms were assessed in a sample of children with higher functioning autism (HFA) and a matched comparison sample of children without autism. SRM was measured in a three-condition recognition memory task that required children to study words while thinking about whether the words: (1) described themselves, (2) described another person (Harry Potter), or (3) contained a specific number of letters. The following hypotheses were tested.

Children with autism, like adults with autism, were expected to display an attenuated self-referenced memory effect. If this was specific to atypical *self*-related processes rather than more general mentalizing functions, then children with autism would perform less well than comparison children only in the self-referent condition. Similarly, any associations between memory performance and autism symptoms would be specific to the self-related processing condition and associations between self-related processing and symptoms would not be mediated by performance on social cognitive mentalizing tasks.

If SRM deficits among children with autism are a result of general problems in person-related processing, or a mentalizing deficit (MD), HFA children would be expected to display poorer recognition memory for words in both the self and other conditions but not the letter counting condition compared to children in the comparison sample. In this case, memory performance in both the self- and other- processing conditions would be expected to relate to measures of social cognition and autism symptoms in the HFA group.

Methods

Participants

Thirty-one (28 boys) 8- to 16-year-old HFA children (IQ > 70) with community diagnoses of autism spectrum disorders were recruited from the University of Miami Center for Autism and Related Disabilities. All diagnoses were made prior to the study by community mental health professionals using DSM criteria. Symptoms were confirmed upon entry to the study using the Autism Spectrum Screening Questionnaire (ASSQ; Ehlers et al., 1999) and the Social Communication Questionnaire (SCQ; Berument et al., 1999). All children in the HFA sample met clinical cutoffs on the ASSQ and 27/31 also met criteria on the SCQ. None of the HFA children were affected by a neurological disorder, syndromes other than autism (e.g., Tourette's disorder), or psychotic symptoms (auditory hallucinations or delusions). The Comparison Group included 31 (22 boys) typically developing (n=28) or learning disabled children (n=3) who did not have a community diagnosis of autism. No child in the comparison sample met criteria on the SCQ and one child had a score of 13 on the ASSQ but no other indicators of autism and was therefore retained in the comparison sample.

Procedures and Measures

All measures were completed during two separate visits to the laboratory. Parental informed consent and child assent were collected at the beginning of each visit.

Intelligence—To minimize the assessment burden an abbreviated version of the Wechsler Intelligence Scale for Children-IV (Williams, Weiss & Rolfhus 2003) was used to assess children's cognitive status. This yielded standardized Verbal Comprehension Index (VCI) and Perceptual Reasoning Index (PRI) estimates. Two subscales of the VCI (Vocabulary and the Similarities Scales) and two subscales of the PRI were administered (Block Design and Matrix Reasoning Scales). These scales have the highest loadings on the respective VCI and PRI factors, strong test-retest reliabilities,internal consistencies and the narrowest standard errors of measurement among the WISC-IV scales.

Social Communication Questionnaire—(Berument et al., 1999). The SCQ is a brief instrument for the verification of autism spectrum disorder symptoms in children. Derived from 40 diagnostic algorithm items of the larger Autism Diagnostic Interview, the SCQ has demonstrated validity for the discrimination of ASD from non-ASD conditions. The diagnostic differentiation of the SCQ is valid in all ranges but is strongest in the higher IQ range. A cutoff score of 13 is recommended in order to maximize valid ascertainment of cases of ASD while minimizing errors of omission.

Autism Spectrum Screening Questionnaire—(Ehlers et al., 1999). The ASSQ is a reliable and valid 27-item checklist designed to assess symptoms associated with either Asperger Syndrome (AS) or other high-functioning autism. A cutoff score of 13 is recommended for sensitivity in capturing those individuals who are positive for the disorder, while also identifying children with some degree of social impairment who are not in the autism spectrum.

Self-Referenced Memory—This task was developed and adapted for child participants based on Craik et al. (1999). An incidental word-learning phase was followed by a recognition test phase. In the former, 42 adjectives (3 lists of 14 words each) about personality traits were presented. One of three types of processing condition questions were presented before each word: Letter counting ("Does this word contain seven or more letters ……..?"), other-referent ("Does this word describe something about Harry Potter"?"), and self-referent ("Does this word describe something about you?"). A forced choice "yes" or "no" response was required within 2 seconds of presenting each word. The "Self" and "Other" conditions were designed to induce social semantic processing while the "Letter Counting" condition was designed to induce featural level processing. List order and condition order were counterbalanced across all participants. For two participants who were not familiar with Harry Potter, Spiderman was used in the Other Condition. Immediately after the learning phase, children were presented with a recognition sheet containing all 42 target words randomly interspersed among 84 novel distracter words. The task was to circle 42 words that were judged as "old" during a 5 min period. D-prime (d′) was used as the dependent measure of memory sensitivity in each condition. The d′ measures were computed as the standardized score of correctly remembered words (i.e., old words correctly identified as old) minus the standardized score of false alarms (i.e., new words incorrectly identified as old). The dependent measures used in the analyses were (a) d′ for each processing condition (self, other, letter), and (b) the magnitude of the self versus other bias (d′ self - d′ other), self versus letter bias (d′ self - d′ letter) and other versus letter bias (d′ other - d′ letter). All words were selected from nine lists of 14 words which were equivalent and comparable across the following conditions: Number of words with negative and positive valence (i.e., 7 of each) an d number of syllables per word (i.e., 2 one-syllable words, 8 two-syllable words, and 4 three-syllable words). Sample words include clever, funny, cranky, rude, happy, talkative, noisy. Pilot testing with undergraduate students indicated the three lists with the strongest self-referent effect. These three lists served as the target lists. The words from the remaining six lists served as the distracter words on the recognition test.

Social Cognition & Mentalizing

The Strange Stories Task: (Happe, 1994) consists of 12 short vignettes and was used to assess children's capacity to attribute mental states to others in the context of stories that feature a pretend event, a joke, a lie, a white lie, a figure of speech, and bluffing. After the child's basic understanding of the story was assessed, an open-ended question designed to assess the child's understanding of the mental state of the character was presented. The dependent measure in the current study was the total number of correct mental state responses (out of 12). Strange Stories performance provides a reliable and valid index of social cognition in verbal children with the diagnosis of Autism or Asperger Disorder (Kaland et al., 2002).

The Children's Eyes Test: (Baron-Cohen et al., 2001) is a pictorial measure of social-cognition. Children view 28 photographs of the eye region of the face and are asked to pick which of 4 words best describes what the person in each photo is thinking or feeling. Responses to each photograph are scored as correct or incorrect, thus total scores range from 0 to 28. This is reliable and valid measure for use with HFA children.

Results

Descriptive data by diagnostic group are presented in Table 1. The diagnostic groups did not differ on chronological age, WISC VCI, WISC PRI, or gender distribution. As expected, children in the HFA group had significantly higher scores on the SCQ, $t(59)=11.65$, $p < .001$, d=2.99, and the ASSQ, $t(59)=12.44$, $p < .001$, d=3.20. Children in the HFA group tended to provide fewer correct responses to the Strange Stories vignettes, $t(48)= -1.96$, $p = .055$, d=0.55; however, they did not differ from children in the comparison sample on the Children's Eyes Task, $t(53)= -1.31$, *ns*.

Memory Task Performance

Data were analyzed using a 2 (Diagnostic Group) × 3 (Processing Condition: Self, Other, Letter) mixed ANCOVA with VCI and age as covariates. After controlling for age and VCI, there was a significant interaction between Diagnostic Group and Processing Condition, $F(2, 57)=4.00$, $p = .02$, $\eta_p^2 = .12$ (see Figure 1). In addition, there was an interaction between Age and Processing Condition, $F(2, 57)=4.66$, $p = .013$, $\eta_p^2 = .14$.

In order to examine the interaction between Diagnostic Group and Processing Condition, a series of between- and within-group post hoc comparisons were conducted. Between-group comparisons revealed that children with HFA did not differ from children in the comparison group on mean level performance in any condition. Within-group analyses revealed that children in the comparison group displayed the typical SRM effect in that they had increased memory for self- compared to other-referenced words, $t(30)=4.66$, $p < .001$, d=0.65, self- compared to letter-referenced words, $t(30)=9.75$, $p < .001$, d=1.69, and other- compared to letter-referenced words, $t(30)=5.61$, $p < .001$, d=1.04. Alternatively, this pattern of differences was not apparent for children in the HFA group whose performance did not differ in the self- versus other-referenced conditions, $t(30)=0.64$, *ns*. However, children with HFA performed better in the self versus letter condition $t(30)=7.13$, $p < .001$, d=.97 and in the other versus letter condition $t(30)=7.11$, $p < .001$, d=1.02 (see Figure 1).

In order to interpret the Age by Processing Condition interaction, a series of hierarchical regression analyses were conducted to examine the effects of (1) age (as a continuous variable), (2) diagnostic group, and (3) the interaction of age by diagnostic group on memory performance. Separate regression analyses were conducted for each processing condition and for the three difference scores reflecting the magnitude of the advantage for processing in the self- or other-referenced conditions. In this way, developmental changes in memory performance as well as possible differences in developmental trajectories by diagnostic group (i.e., the interaction of age and diagnostic group) were evaluated. Memory performance in the self condition was significantly predicted by age, $F(1, 60)=5.55$, $p = .02$, $\Delta R^2 = .09$, $f^2 = .09$, with increasing age being associated with better performance. After controlling for age, diagnostic group and the interaction of age and diagnostic did not account for significant unique variance in performance in the self-referenced condition. Memory performance in the other and letter counting conditions was not associated with age, diagnostic group, or their interaction.

The magnitude of the self-other bias (d′ self - d′ other) was significantly predicted by age, $F(1, 60)=4.36$, $p=.04$, $\Delta R^2 = .07$, $f^2 = .07$. Again, as children got older, there was a greater difference between performance in the self and other conditions. After controlling for age, diagnostic group accounted for additional unique variance in the magnitude of the self-other bias, $F(1, 59) = 5.78$, $p = .02$, $\Delta R^2 = .08$, $f^2 = .09$, Total $R^2 = .15$, $f^2 = .18$. That is, children with HFA, regardless of age, showed a smaller self-other bias compared to children in the comparison group (see Figure 2). A similar pattern of results emerged for the magnitude of the self-letter bias (d′ self - d′ letter), such that age predicted a larger self-letter bias, $F(1, 60)=10.75$,

p=.002, ΔR^2 = .15, f^2 =.18 and diagnostic status predicted additional unique variance, $F(1, 59)$ = 7.49, p=.008, ΔR^2 = .10, f^2 =.11, Total R^2 = .25, f^2 = .33. The interaction of age and diagnostic group was not significant for either of these analyses, suggesting that all children, regardless of diagnostic group, showed age-related increases in the preferential processing of self-referenced information. The magnitude of the other-letter bias was not associated with age, diagnostic status, or the interaction of age and diagnostic status.

Individual Differences: Self-referenced Memory and Autism Symptom Expression

The degree to which self-referenced memory performance was related to social behavior and autism symptoms on the ASSQ and SCQ was examined in a series of hierarchical regression analyses. In the first two analyses, ASSQ scores and SCQ total scores were regressed on Age, Verbal IQ, Diagnostic Group, memory performance in the self-referent condition (d′ self), and the interaction of diagnostic group and memory performance. In the second two analyses, ASSQ scores and SCQ total scores were regressed on Age, Verbal IQ, Diagnostic Group, self-other bias scores (d′ self- d′ other), and the interaction of diagnostic group and self bias.

Of the four regression models, the only one in which memory performance predicted unique variance over and above the effects of diagnostic group was the one in which ASSQ scores were regressed on the self-other bias score. Specifically, after accounting for diagnostic group differences on the ASSQ, the magnitude of the self-referent bias was significantly associated with ASSQ scores, ΔR^2 = .03, $F(1, 56)$=6.20, p=.016, f^2=.03; Total R^2 = .74, f^2 = 2.85. The lack of an interaction between self-referent bias and diagnostic status suggests that for all children, better memory for words in the self versus other processing condition was related to parent reports of fewer social difficulties on the ASSQ (see Figure 3).

Individual Differences: Self-Referenced Memory, Social Cognitive Mentalizing, and Autism Symptoms

A third set of analyses examined relations between SRM performance (d′ self, d′ other), self-other bias (d′ self- d′ other) and social cognitive mentalizing measures (Eyes Task, Strange Stories). Six regression analyses were run in which social cognitive mentalizing scores (Eyes Task or Strange Stories) were regressed on Age, Verbal IQ, diagnostic group, memory performance (self, other, or self-other), and the interaction of diagnostic group and memory performance. Eyes Task performance was positively associated with Age, $F(1, 48)$=8.02, p=.007, ΔR^2=.14, f^2= .16, and Verbal IQ, $F(1, 47)$=7.30, p=.01, ΔR^2=.12, f^2= .14. Diagnostic group did not account for unique variance in Eyes Task performance, however; additional unique variance was accounted for by memory performance in the self condition, $F(1, 45)$ = 4.82, p =.03, ΔR^2 = .07, f^2 = .07 and a trend for the interaction of diagnostic group and performance in the self condition, $F(1, 44)$ = 3.38, p = .07, ΔR^2 = .05, f^2 =.06; Total R^2 = .39, f^2 = .64. In order to examine the trend, the associations between memory performance in the self condition and Eyes Task performance were examined separately for children in the HFA and comparison samples. For children in the HFA sample, there was a strong positive correlation between memory performance in the self condition and Eyes Task performance, r (25)=.57, p =.003, d=1.39; however, the correlation was not significant for children in the comparison sample, r(30)=.19, *ns,* d=0.39 (see Figure 4). After controlling for Age, Verbal IQ, and Diagnostic Group, Eyes Task performance was not associated with memory performance in the other-referenced condition or the magnitude of the self-other bias.

Performance on the Strange Stories task was positively associated with Age, $F(1, 48)$=4.96, p=.03, ΔR^2=.09, f^2= .10, and Verbal IQ, $F(1, 47)$=12.99, p=.001, ΔR^2=.20, f^2= .25. Diagnostic Group accounted for additional unique variance, $F(1, 46)$=3.89, p=.055, ΔR^2=.06, f^2= .06. However, none of the indices of SRM performance predicted unique variance above and beyond these effects.

A final goal of the study was to assess whether the associations between self-referenced memory and symptom scores were mediated by social-cognitive task performance. Given that the self-other difference score was associated with ASSQ scores across the entire sample, partial correlations were run controlling for Eyes Task and Strange Stories Performance. Controlling for Eyes Task performance, the association between the self-other difference scores and ASSQ scores remained significant across the entire sample, partial $r(51)= -.44$, $p = .001$, d=.98, and within the HFA sample alone $r(22)= -.43$, $p = .04$, d=.95. Controlling for Strange Stories performance, the association between the self-other difference score and ASSQ scores remained significant across the entire sample, partial $r(46)= -.42$, $p = .003$, d=.93, and was slightly reduced within the HFA sample alone $r(20) = -.38$, $p = .08$, d=.82. Thus, it did not appear that social cognitive mentalizing as assessed using the Eyes Task or the Strange Stories task mediated or accounted for the observed associations between SRM performance and symptom expression.

Discussion

Typically developing children clearly demonstrated the SRM effect providing validation for the use of the SRM paradigm in 8- to 16-year-old children. While mean levels of memory performance did not differ between children in the HFA and comparison samples, patterns of differences across the three processing conditions varied based on diagnosis. Specifically, children with HFA displayed a social-semantic processing effect in that they recognized more person referenced words (i.e., self *and* other referenced) compared to words encoded during letter counting. Children with HFA, however, did not preferentially recognize words that were encoded relative to self in the way the comparison children in this sample, or typically developing adults in previous samples, have been shown to do. Thus, while HFA children displayed a pattern of performance that was consistent with enhanced depth of processing for semantic information, they did not show an added advantage of processing *self*-related semantic information in the way comparison children did.

This pattern of differences is similar to the findings reported by Toichi et al. (2002) where adults with HFA recognized words learned in semantic conditions better than words learned in a phonological processing condition. Like the HFA children in our sample, the HFA adults in the Toichi et al. sample did not show preferential recognition of words processed under self-referential conditions. This replicated observation of a failure to differentiate self-related semantic information from other forms of semantic information is also consistent with several observations of children with autism. Yamamoto et al. (2004) reported that children with autism showed enhanced recall for action-based experiences over a verbal task, but failed to preferentially recall self- compared to experimenter-performed actions. Millward et al. (2000) found that children with autism showed poorer memory for self- versus peer-performed events. In contrast, non-autistic children showed facilitated recall for self-performed events. In addition, Lee and Hobson (2006) reported that autistic children showed limited differentiation between drawings of themselves versus others despite the ability to draw distinct pictures of non-human objects when requested to do so.

Together the results of these studies and our own study suggest that autism may not be associated with self-referential deficits per se. Neither the HFA children in our sample nor the HFA adults in the Toichi et al. (2002) sample displayed mean level differences, or deficits, in memory performance in the self-referent condition relative to comparison samples. While Toichi et al. (2002) used a potentially biased performance measure (% of words correctly recognized), our comparable results are based on an unbiased measure of memory sensitivity (d′). However, these findings differ from those of Lombardo et al. (2007) who reported mean level differences in SRM performance for self-referent and close-other referent conditions between adults with ASDs and a comparison group. Instead of demonstrating deficits in self-

processing, we believe our results support the idea that autism is associated with atypical differentiation or depth of processing of self versus other forms of semantic information.

It is not clear why children with autism do not preferentially encode self-relevant information. Among typically developing children, preferential self processing is thought to reflect the natural tendency to incorporate a positive emotional sense of others' perceptions into the self-schema (e.g., Welch-Ross, Fasig, & Farrar, 1999). It may be that children with autism assign less affective salience to self-referent information which in turn leads to a lack of preferential processing of self-relevant versus other types of semantic information. This interpretation is supported by our finding that for HFA children in particular, the ability to accurately detect emotions in others' eyes was associated with better performance specifically in the self-condition of the SRM task.

Another interpretation of the atypical SRM performance of HFA children may relate to altered neural functioning in cortical midline structures including the medial prefrontal cortex and posterior cingulate that are involved in both self-referential processing and mentalizing tasks (Amodio & Frith, 2006; Craik et al., 1999; Decety & Sommerville, 2003). Given that self-relevant information is more efficiently and effectively encoded and organized cognitively, mentalizing about others may be facilitated or scaffolded for typically developing individuals through these shared neural processing pathways. In contrast, there is less specialized neural activation in these cortical midline structures both at rest (Kennedy, Redcay, & Courchesne, 2006) and during mentalizing tasks in individuals with ASDs (e.g., Wang, Lee, Sigman, & Dapretto, 2007; Castelli, Frith, Happe, & Frith, 2002). Consistent with simulation theory (Gordon, 1986), atypical neural and cognitive processes related to preferentially processing and elaborating self information may affect the ability to efficiently and effectively coordinateself and other information which is essential for reciprocal social interactions (Iacoboni, 2006). This interpretationis supported by our finding that for all children, the magnitude of the self-other bias was inversely related to current symptoms and social functioning on the ASSQ.

An alternate interpretation could be that the lack of preferential processing for self-relevant information might be a consequence rather than a cause of more general mentalizing difficulties in autism. However, the HFA group's pattern of memory performance in this study did not fully support a mentalizing deficit (MD) account. There were not robust diagnostic group differences on mentalizing task performance, a finding consistent with past studies of children with autism who have IQs in the average or above average range (e.g., Ozonoff, Rogers, & Pennington, 1991). In addition, the MD account predicted that HFA children would display memory deficits for self-referent and other-referent words, which they didn't as indicated by comparable mean level performance in the self- and other- referenced conditions relative to children in the comparison sample. The MD account also led to the expectation of associations between performance on the social cognitive measures and performance in both the self- and other-referenced conditions on the SRM task which was not supported. Finally, the MD account suggested that associations between SRM performance and social impairments would be mediated by social cognitive task performance, and that was not the case.

Regardless of diagnostic status, age was positively related specifically to performance in the self-referenced condition (d′ self, d′ self-d′ other). This suggests a general developmental change in the specialization and elaboration of self-processing through later childhood and adolescence. Despite these developmental changes, children with HFA were consistently lower in the magnitude of the self-other bias across the age range we studied. Although children with HFA may develop more preferential processing of self-relevant information with age, they may not catch up to their typically-developing peers who continue to improve in self-related

processing at a comparable pace. These diagnostic group differences appear to continue into adulthood as suggested by the findings of Toichi et al. (2002).

The results of this study also indicated that the tendency to process self-relevant information more deeply than other-person relevant information may be an individual difference characteristic that relates to the motivation and ability to competently engage in reciprocal social interactions in the general population as well as among HFA children. This was indicated by the observation that individual differences in the magnitude of the self - other memory bias were inversely associated with social skills and symptom ratings on the ASSQ in both the HFA and comparison samples. Although the effect size was relatively small, this finding suggests that SRM-related processes are fundamental for social development and suggests the need for a deeper understanding of developmental change and individual differences in self processing.

There are several limitations to the current study. First, it was assumed that children processed the words in the self- and other-conditions semantically, but their comprehension of the words was not assessed. Although all children preferentially recognized words in the semantic conditions over the letter counting condition, we do not know for sure that semantic processing did indeed occur. Second, we employed a single condition to assess other-processing in the SRM task using a familiar character (Harry Potter) rather than a familiar family member or friend. In a recent study that employed both familiar character and a close friend conditions to assess SRM for self versus other, the extent of self-bias differed between adults with ASDs and a comparison group in only the fictional character condition (Lombardo et al., 2007). Third, the cross-sectional design of our study does not allow for causal conclusions regarding the directions of effects regarding symptom severity and self-referenced processing. Given that our data demonstrate age-related changes in SRM processes, it will be important to assess change in symptoms and changes in SRM processes within individuals over childhood and adolescence. Highly elaborated self-processing may lead to lower social symptoms or lower social symptoms may permit higher levels of self-processing. Longitudinal research is needed to resolve these possibilities. Finally, after controlling for age and verbal IQ, the majority of our effects were in the small to medium range.

In summary, our data and those of others support the hypothesis that the organization and utilization of self-related information processing and encoding may modify the expression of autism in higher functioning children. We currently don't know why self-related processing is atypical in autism or how that might modify symptom expression. However, we have observed similar relations between differences in self-monitoring processes and variations in social impairments in HFA children (Henderson et al., 2006). The results of this study and our previous work encourage us and others to systematically pursue this area of inquiry.

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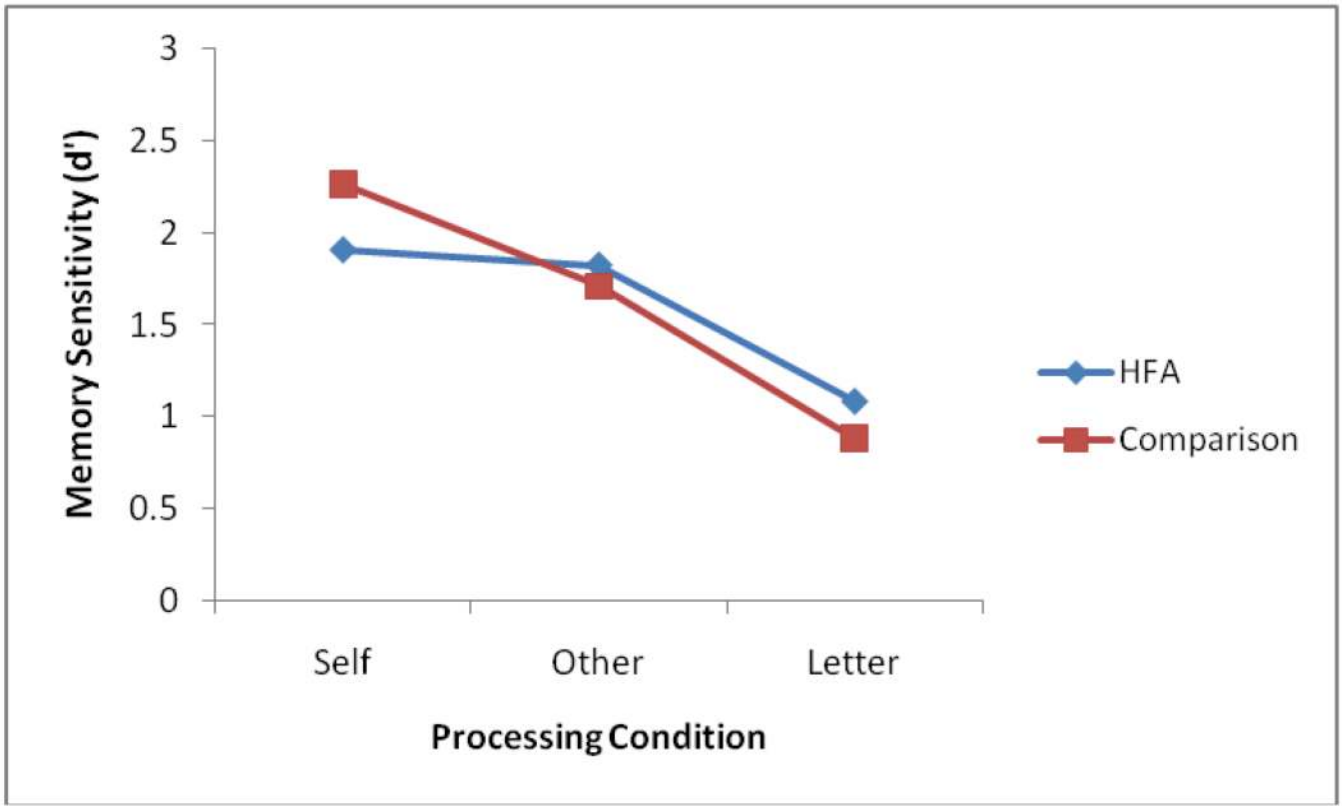

Figure 1.
Memory Sensitivity (d′) by Processing Condition and Diagnostic Group

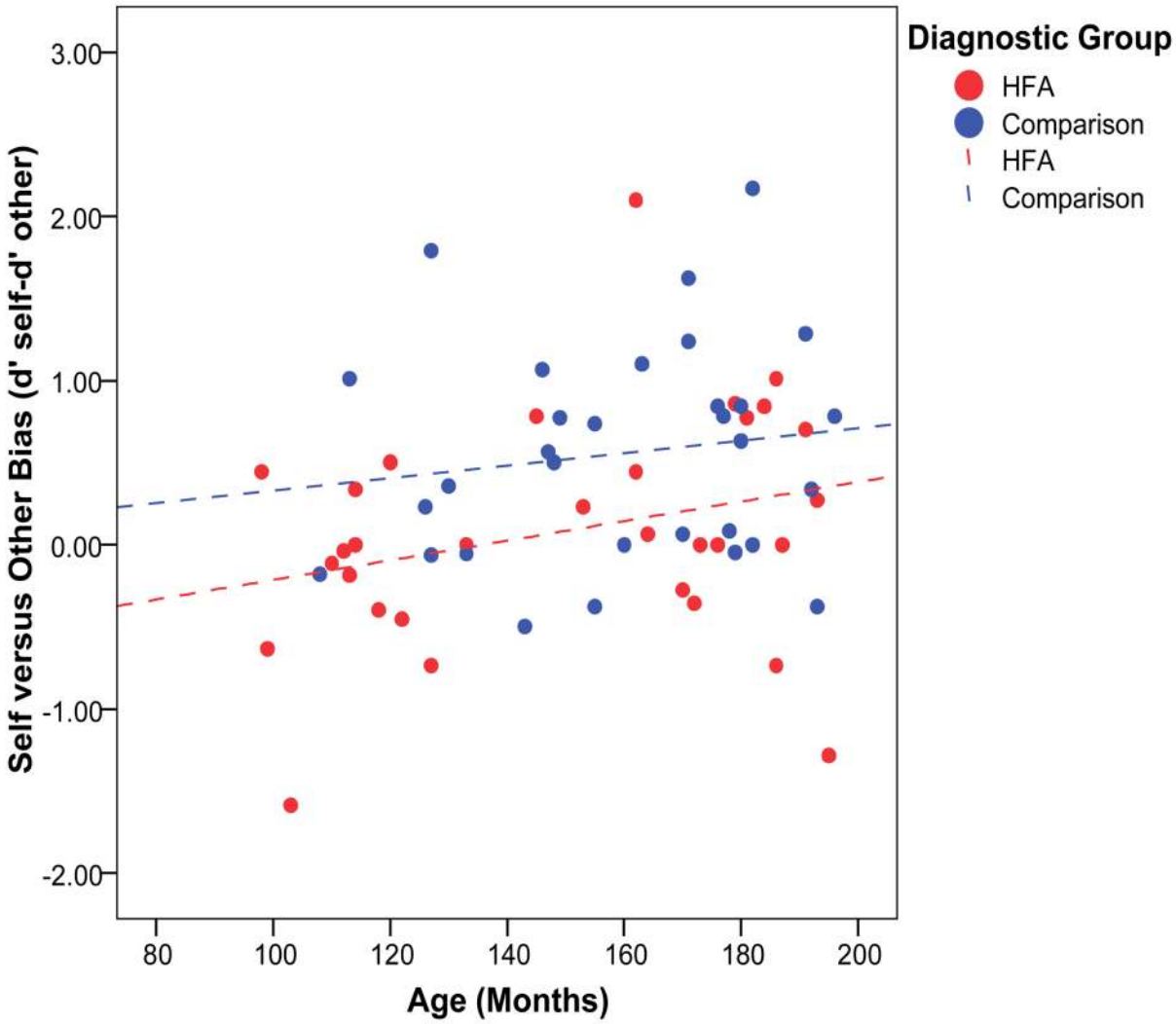

Figure 2.
Age as a Predictor of Self-Other Bias by Diagnostic Group

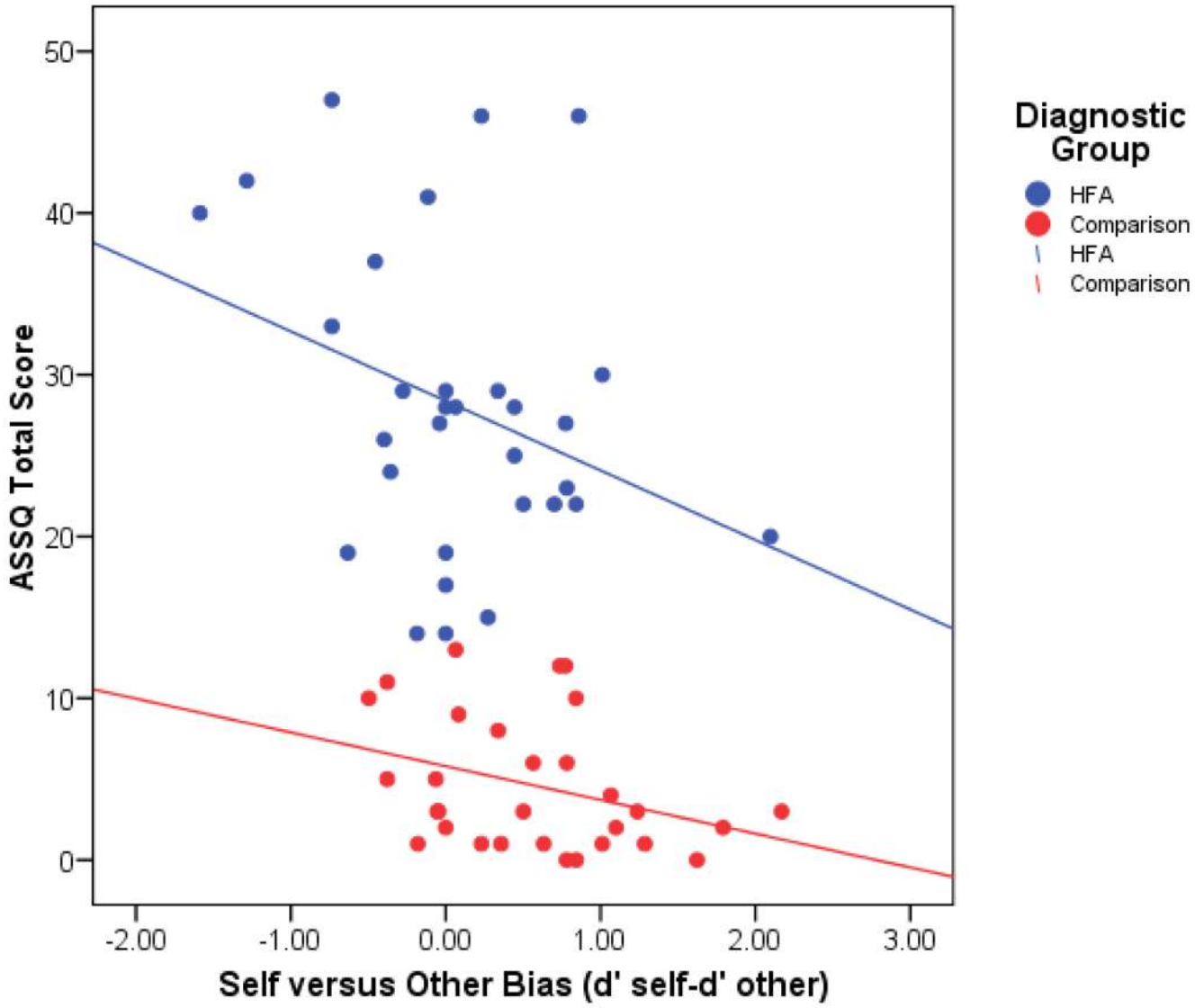

Figure 3.
Self-Other Bias as a Predictor of ASSQ by Diagnostic Group

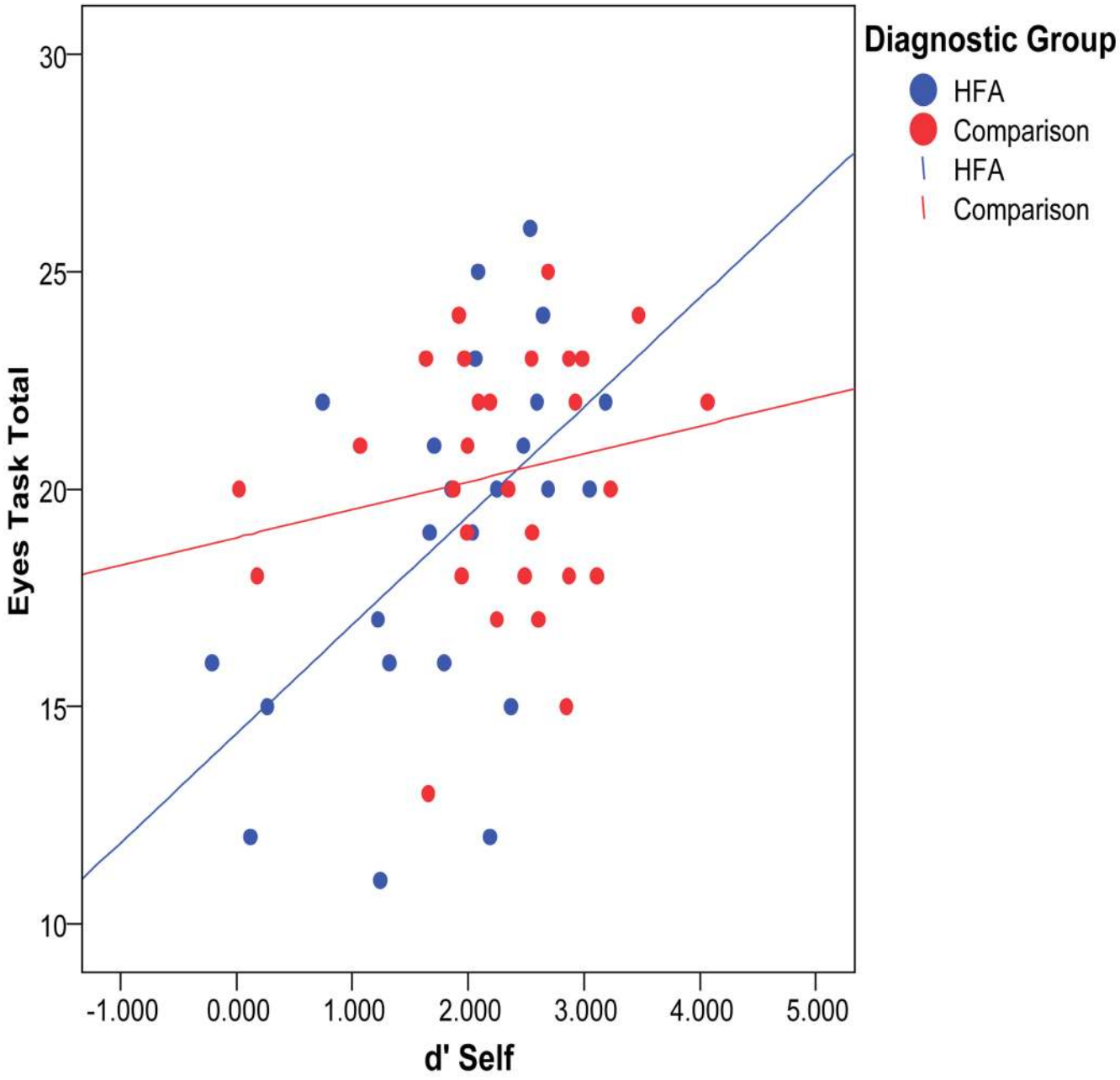

Figure 4.
Self-referenced memory as a Predictor of Eyes Task by Diagnostic Group

Table 1

Sample Characteristics for HFA and Comparison Groups: Mean (SD)

	Diagnostic Group	
	HFA (n=31)	**Comparison (n=31)**
Gender	**28 boys, 3 girls**	**22 boys, 9 girls**
Chronological Age	149.74 (33.23)	159.61 (24.87)
VCI	101.10 (14.79)	104.94 (14.76)
PRI	105.19 (17.83)	99.19 (14.42)
SCQ	21.97 (7.06)	5.50 (3.22, n=30) **
ASSQ	28.03 (9.49)	4.60 (4.12, n=30) **
Eyes Task Total	19.12 (4.16, n=25)	20.37 (2.87, n=30)
Strange Stories	9.91 (1.62, n=23)	10.67 (1.07, n=27) *t*

Diagnostic Group differences

** $p < .001$

t $p = .055$

VCI = WISC IV Verbal Comprehension Index; PRI = WISC IV Perceptual Reasoning Index; SCQ = Social Communication Questionnaire; ASSQ = Autism Symptom Screening Questionnaire