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Delayed Self Recognition in Autism: A Unique Difficulty?

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Abstract

Achieving a sense of self is a crucial task of ordinary development. With which aspects of self do children with autism have particular difficulty? Two prior studies concluded that children with autism are unimpaired in delayed self-recognition; we confirm and clarify this conclusion by examining it in conjunction with another key aspect of self understanding, including several needed controls and contrasts. Three groups of children were tested in a delayed self-recognition paradigm as well as a self-other action memory card game in which they took turns placing pictures with an adult: 3-year-olds ($n = 25$), 5-year-olds ($n = 27$), and children with autism spectrum disorder ($n = 20$). Children with autism spectrum disorder (ASD) demonstrated impaired performance on self-other recall compared to both typical 5-year-olds and typical 3-year-olds, but were not significantly different on delayed self-recognition. Results are discussed with regard to the unique profile of self-related performance in autism.

Keywords

autism; self-recognition; autobiographical memory

1. Introduction

By the middle of the second year of life, typically developing children are engaging in a suite of activities that reveal their abilities to consciously represent the self. Reaching to one's own forehead in response to a marked mirror image has traditionally been conceptualized as an important, initial measure of self awareness (the mirror self recognition test, or MSR, e.g. Gallup, 1970) and it typically emerges between the ages of 18 and 24 months (Bertenthal and Fischer, 1978). MSR is a developmental accomplishment that emerges in synchrony with other indications of emerging self-representation such as personal pronoun use (Courage, Edison and Howe, 2004; Hay, 2006). At the same time children begin to pass level-1 perspective taking tasks (e.g., Moll and Tomasello, 2006), in which they realize that a single object can be simultaneously visible to one person but not visible to another. Relatedly, children engage in other-directed pretend play (e.g., Lewis and Ramsay, 2004), and demonstrate increasingly sophisticated attention to gaze (Dunphy-Lelii

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and Wellman, 2004; Moll and Tomasello, 2004), all of which indicate conscious differentiation between themselves and others.

While impressive, these self-representational accomplishments are limited. In particular, young children find it challenging to conceptualize and speak of themselves at time points other than the present (e.g., Busby and Suddendorf, 2005). Thus, even once a typically developing 2-year-old is able to pass the MSR test, her self-concept is tethered to the here-and-now. It does not reflect the older child's more mature concept of the self-through-time', that is, a linking of past, present, and future experiences into a single self with consistent and causal properties (Povinelli, 1995). One task in particular has been used to investigate the temporal properties of self recognition: the delayed self recognition test (DSR). When given a DSR task that amounts to the MSR task but with the difference that the video image they see of themselves is slightly delayed, young children do not consistently demonstrate full self-recognition until the fifth year (Povinelli, Landau, and Perilloux, 1996; Suddendorf, 1999). In this scenario, all the visual cues that a child could normally use to identify herself are the same as in the standard MSR test *with the exception of* the perfect here-and-now temporal contingency produced by a mirror image. 3-year-olds, while frequently able to verbally identify themselves in slightly delayed video footage by answering the question "Who is that?" correctly, are much less likely to reach to their own heads to remove a mark than older children. Those 3-year-olds that do reach to their own heads often do so regardless of the length of time that has passed – be it 5 minutes or a full week. Older children reach for the mark when several minutes (but not a week) have passed, demonstrating understanding of the rigors of the passage of time on their person as well as the causal relationship between the past and present physical self (Povinelli and Simon, 1998).

Self-recognition, however, is just one way to investigate the development of the temporal self. The ability to successfully pass the DSR task likely emerges coincidentally with children's ability to situate the self in the past. Memory of the self, in particular, must play a vital role in accumulation and integration of self states into a temporally coherent self-representation. Indeed, beyond improved performance on DSR tasks, the years between three and five are crucial to developments of autobiographical, episodic memory as it is traditionally tested in children, through verbalized recall of past episodes in their own lives. Children are frequently characterized as developing this kind of memory only well into their fourth year, when a combination of sociocognitive, linguistic, and brain maturational factors come together to provide support for this achievement (Bauer, 2002). It is not until about age 4, for example, that children demonstrate the emerging ability to accurately recount novel, episodic memories from more than several months ago (e.g., Fivush and Hammond, 1990). Children younger than 3 years may be quite capable of both semantic and episodic memories (Bauer, 1996; Howe et al., 2003) yet not be capable of "autonoetic memory" in the sense of attaching these memories to a continuous self. Moreover, 3-year-olds are less able than older children and adults to consistently distinguish memories that are derived from personal experience from those they have simply been told about (Gopnik and Graf, 1988; O'Neill and Gopnik, 1991). Four-year-olds can similarly find it quite difficult to remember which of two speakers was the source of an utterance (Lindsay, Johnson, and Kwon, 1991), abilities that develop by 5 and 6 years of age (e.g., Foley and Johnson, 1985). These developments do not just co-occur; for typically developing children, success on the DSR test is correlated with children's verbal elaborations and recall of past events in their lives (Welch-Ross, 2001) as well as future-oriented prudence (Lemmon and Moore, 2001), in which children make decisions based on their own future benefit.

1.1 Atypical developmental trajectories

Children with autism provide a special avenue for better understanding the self and in particular the self-through-time; likewise, examining the self through time provides an informative avenue for understanding social cognition in children with autism. While early research demonstrated that most children with autism achieve MSR (e.g., Neuman & Hill, 1978; Spiker & Ricks, 1984), self-recognition performance may have been confounded by mental age (MA), which was not carefully controlled or reported. In the above studies, children's ages ranged from 3 years to 12 years, and in Neuman and Hill (1978) only 7 children were tested. In Dawson & McKissick (1984), 15 children between 4 and 7 years of age were tested, all of whom scored below average on IQ measures; nonetheless, 11 of these children showed MSR. In both this study and Neuman and Hill (1978), the authors noted that those children who succeed typically fail to show the self-conscious and shy behaviors that mark typical children's reaction to their marked image. Despite the record of relative MSR achievement, the lack of self-conscious behaviors during the MSR task itself, together with a general lack of self-consciousness in front of others, language abnormalities relevant to perspective (such as pronoun reversal; Lee, Hobson, and Chiat, 1994), difficulty with protodeclarative pointing, and poor performance on standard theory-of-mind tasks, suggests that children with autism may be specially impaired in self-awareness.

We may distinguish between *psychological* and *physical* self-awareness, as did Lind (2010); self-recognition reflects the latter, and irregularities in pronoun use, perspective-taking, and protodeclarative gestures reflect the former. Relatively unimpaired visual self-recognition supports the idea that individuals with ASD have intact *physical* self-awareness, as do findings demonstrating no impairment in detecting contingency between their own actions and movement on a screen (Russell and Hill, 2001; Williams and Happe, 2009). In contrast, there is evidence of impairment in *psychological* self-awareness in autism. For example, individuals with autism fare worse than matched controls when asked to provide rich narrative descriptions of past autobiographical events, despite unimpaired narrative skill (Losh and Capps, 2003). Indeed, individuals with autism demonstrate irregularities in episodic autobiographical memory despite displaying very good rote memory (Jordan and Powell, 1995). That is, these individuals often have relatively unimpaired working memory (Ozonoff and Strayer, 2001) and semantic memory (Mottron, Morasse, and Belleville, 2001). Klein, Chan and Loftus (1999) report, in a very interesting case study, that a high-functioning 21-year old man with autism performed accurately when attributing personality traits to himself while simultaneously demonstrating serious impairment in accessing the *episodic* autobiographical memories on which this trait knowledge ordinarily relies (see also Crane and Goddard, 2008; Goddard et al., 2007). Since this man's difficulties are developmental in origin (as opposed to traumatic amnesia, for example), it suggests that the acquisition of trait self-knowledge may proceed independently of episodic memory. In addition, individuals with ASD struggle to accurately identify their own emotions and cognition on-line (Silani et al., 2008; Williams and Happe, 2010).

With an uneven pattern of self-development, constructing a rich temporally extended self may be particularly problematic even for those individuals with autism who achieve self-recognition. Such difficulty might reveal itself when attempting to distinguish self from other in memory tasks. Millward and colleagues (2000) paired children with autism with typical children and took them on a walk during which a number of memorable activities and sights were experienced. Children with autism (compared to typically developing children) were able to recall significantly fewer of the activities they themselves had performed, and were able to recall fewer of their own actions than those of their partner. Additionally, in a picture recall task children with autism were less able than MA-matched peers to recall which cards they themselves had placed and which had been placed by an experimenter (Russell and Jarrold, 1999). Finally, children with ASD in Lind and Bowler's

(2009) study showed reduced ability to distinguish self from other in their memories of a card naming game compared to matched controls. However, Williams and Happe (2009) failed to replicate Russell and Jarrold's (1999) findings using similar methodology, and Farrant, Blades and Boucher (1998) showed that children with autism performed no worse than matched controls in recalling which words had been spoken by themselves versus another person. The picture for adults with autism is similarly complex: Hare and colleagues (2007) showed that adults with autism failed to show the developmentally-typical pattern of improved performance for self-experienced events over observed events, and a different group of adults with autism failed to demonstrate the self-reference effect in recall of word lists (Toichi et al., 2002). Nonetheless, adults in the Hare et al. (2007) study did demonstrate better *cued* recall for self-experienced events than observed events, and in the Toichi et al. (2007) study there were no significant differences between adults with ASD and matched controls.

Given these irregularities in reference to and recall of the self (as well as the relative scarcity of research on explicit self-other distinction in autism), even children with autism who achieve MSR may nonetheless show special impairment on self-concept tasks that require normal understanding of the self over time and use of autobiographically connected episodic memory. Such a compelling possibility prompted two recent reports using the DSR paradigm; both of which, somewhat surprisingly, conclude disconfirmation of such a hypothesis. Lind and Bowler (2009) reported a comparison between 30 children with ASD (average verbal mental age 6+ years) and 30 other children in a composite group half of whom had developmental delay and half of whom did not. When compared to this mixed group, children with ASD performed similarly on the DSR task – 83% showed evidence of mark-directed behavior vs 100% of the comparison group. Dissanayake and colleagues (2010) conducted two studies presenting the DSR paradigm to children with ASD. For example, in their Study 1 including 24 high-functioning children with high functioning autism and Asperger's Disorder (AD): 91.6% of their ASD sample and 100% of their 14 MA-matched controls passed. Their ASD sample ranged from 5 to 9 years ($M = 7.4$ years) chronological age (CA) and averaged 7.5 years MA. The sample of children with ASD in their second study was somewhat younger, ranging from 4.5 to 7 years ($M = 5.75$ years), but also performed well on DSR.

These two reports are remarkably similar in their findings and in their conclusion that ASD children do not differ on DSR tasks from comparison groups including typically developing children. Arguably, however, the key hypothesis concerning developmental delay in DSR (and relatedly in achieving a self-through-time) remains unconfirmed in the strongest senses for at least three reasons. *First*, in typical development DSR develops consistently between the third and fifth years. Tests of children with autism at substantially older mental ages, as in these two prior studies, leave open the possibility that these children *were* in fact significantly delayed-- achieving DSR only substantially later in comparison to the MA trajectories of typically developing children. This possibility is all the more plausible because in both of these reports the comparison groups of typically developing children had clear limitations; for example, Lind and Bowler (2009) provide the largest comparison group, but one that combined typically developing along with delayed children. Including other delayed children importantly addresses whether any impairment is specific to autism as a subgroup of developmental delay. But including them along with typically developing children in one overall contrast group makes it difficult to establish delay or lack of delay in comparison to typical development. *Second*, not only did neither study include precisely targeted 5-year-old (or younger) ASD children, neither included a comparison group of younger typically developing children for example 3-year-olds who typically do poorly at DSR. If indeed MA-matched children with ASD are delayed in comparison to typical 5-year-olds, do they closely resemble still younger children (arguing for straightforward

delay), or follow a unique developmental trajectory? Ideal data requires testing children using the identical methodology, rather than relying on comparisons with existing 3-year-old data from other studies and tasks. *Third*, neither study moved beyond DSR to examine companion aspects of the typically developing child's self-awareness, such as performance on explicit memory tasks involving recall of self and others' actions. It is possible that children, and especially children with autism, may pass the DSR task but be delayed on other crucial aspects of achieving temporal self-relevant understandings. DSR provides an important but also arguably a limited picture by focusing so exclusively on physical self-concept (see Lind 2010) and on physical-visual information. Given that focus, it is even possible that children with ASD use some alternative mechanisms (for example, a perceptual rather than a conceptual one, see Povinelli and Simon, 1998) to solve this task. In this day of ubiquitous family videos, children with autism might indeed achieve some adequacy at video perceptual self-recognition. Convergent and discriminate information for the same individuals on DSR and an additional self-relevant task is desirable and needed.

1.2. The Present Study

With this focus, the current study tested three groups of children -- typically developing 3-year-olds, typically developing 5-year-olds, and children with ASD of 5 years MA-- on the delayed self-recognition paradigm, as well as a self-other memory task in which children were asked whether they themselves or another person placed particular cards in a recently played game. With regard to DSR, these precise matchings can clarify if children with ASD are delayed at the key developmental phase of 5 years mental age. Including both DSR and another key task can clarify a larger picture as to development of self-through-time in children with autism. We chose self-other action memory because it arguably requires more than visual recognition or perceptual displays. If children with autism did indeed perform similarly to typical 5-year-olds on the DSR task (as suggested by Lind & Bowler, 2009 and Dissanayake et al.) and simultaneously demonstrated equal competence with this related self-other memory task, this would suggest a broad competence at developing a self-through-time. Alternatively, if they were simultaneously poor at this other task that would suggest that this task is tapping importantly different self-relevant skills, and additionally provide data for a clearer albeit more uneven profile of understandings. If on either of these tasks children with ASD perform worse than MA-matched typically developing children, then comparison to children of a younger chronological age, notably 3-year-olds, can help clarify the nature of their delay. If children with autism perform similarly to typical 5-year olds on the DSR task but simultaneously demonstrate difficulty with a related self-other memory task, this would suggest that this task is tapping importantly different self-relevant skills, and empirically confirm the contention that this task goes beyond an assessment of solely physical self-awareness.

Performance on these two focal tests was also compared with performance on standardized cognitive assessments including memory and general cognitive performance. This should help to rule out (or to support) the possibility that focal differences in performance might merely reflect differences in more general cognitive-memorial competences across these groups.

2. Study Method

2.1 Measures

2.1.1 Peabody Picture Vocabulary Test (PPVT)—All participating children were administered the *PPVT*. The *PPVT* is highly correlated with other measures of verbal performance for children with autism (Condouris et al., 2003) and is also highly correlated with *WISC-III IQ* scores for children with mental retardation (Slate, 1995).

2.1.2 Social Communication Questionnaire (SCQ)—Parents of all participating children completed a *Social Communication Questionnaire (SCQ)* Current version, a 40-item questionnaire based on the Autism Diagnostic Interview - Revised (ADI-R). The SCQ has been shown to have good discriminative validity for screening individuals with pervasive developmental disorder (PDD) from those without (see Berument, Rutter, Lord, Pickles, and Bailey, 1999) when a cutoff score of 15 is used.

2.1.3 Standardized Assessment of Cognitive Functioning—All participating children were administered the Bead Memory subtest of the *Stanford Binet (IV)* as a measure of their visual memory. For the two typically-developing groups of children, these scores were calculated based on the child's chronological age (CA). For children with autism, these scores were calculated based on verbal mental age, (MA) as indicated by their PPVT scores. Children with autism were administered the Picture Similarities subtest of the *Differential Ability Scales (DAS)* as an assessment of their nonverbal cognitive performance. In this subtest, children view a group of drawings and select the one that "matches" their card in some thematic way (e.g. their snowman card might match with the wintry weather drawing). The DAS has been shown to correlate highly with other standardized measures of nonverbal cognitive performance, such as the *Wechsler Preschool and Primary Scale of Intelligence-Revised* and the *McCarthy Scales of Children's Abilities* (e.g., DiCerbo and Barona, 2000).

2.2 Participants

2.2.1 Typically developing children—As shown in Table A, 25 3-year-old children (15 girls, ranging from 3 years, 1 month to 3 years, 9 months) and 27 5-year-old children (8 girls, ranging from 4 years, 8 months to 5 years, 10 months) participated. Families were recruited from existing participant databases of a behavioral research laboratory at a large Midwestern university. None of these typically developing children scored higher than 10 on the SCQ ($M = 5.00$, ranging from 0 to 10).

2.2.2 Children with Autism Spectrum Disorders (ASD)—Thirty-seven children (three girls) with current diagnoses of an ASD were included. These children had received diagnoses, by a trained pediatrician or neuropsychologist, of autism ($n = 21$), Asperger's Disorder ($n = 5$), and PDD NOS ($n = 11$) according to established psychiatric criteria (American Psychiatric Association, 2000). Candidate participants in this group were recruited by announcement through a variety of support groups, parent groups, and local resource centers in the southeastern Michigan area or via participation in an ongoing research project at a university's autism center.

If a child's PPVT score placed them between 54 and 76 months mental age with regard to receptive language, the child proceeded through the rest of the protocol. Thirteen children did not continue past the PPVT. Of the resulting sample of 24 children, four were excluded because their SCQ score fell below a 12. Excluding these children ensured that those who remained averaged well above the risk cutoff for ASD, and that there was no overlap between our typical children and those with ASD. The final sample of 20 children with ASD had an average SCQ score of 17.53, and an average PPVT score (Table A) equivalent to a receptive vocabulary age of 63.95 months, or essentially 5 years mental age. Diagnoses of these remaining 20 children (two girls) were: ASD ($n = 15$), Asperger's Disorder ($n = 2$) and PDD NOS ($n = 3$). These children's chronological ages ranged from 5 years, 1 month to 13 years, 7 months ($M = 7;3$).

2.3 Tasks and Procedure

The Self-Other Action Memory task and the delayed self-recognition (DSR) test were administered to all participants in that order. Additional tasks targeting general cognitive or memory functioning are described at the end of this section, though these took place throughout the session in a standardized order (with several exceptions for individual children who required play breaks).

2.3.1 Self-Other Action Memory—Before this task began, a videocamera was focused so that the child's face and the gameboard (described below) were clearly visible. The child was seated at a table next to the experimenter. A brightly colored game board (30in × 18in) with 18 small pictures (3in × 5in each) of simple objects and animals (e.g., monkey, car, apple) placed face-up in rows and attached securely to the board's surface was used. The game board was half yellow and half blue, with half of the pictures falling into the blue zone and half falling into the yellow zone. The experimenter announced, "We're gonna play a matching game with pictures!"

On the table was a stack of 16 cards, facedown. On each card was a picture identical to one of the pictures on the board (two of the pictures on the board did not have a matching card, in order to prevent the last few cards from being placed simply by process of elimination). The experimenter said "So look at our game board here, see how this side is yellow and this side is blue? See how there are all these pictures, and then this pile of cards? We're gonna play a game where we turn over these cards and match them to the pictures on the board. First I'll take a turn, and then you'll take a turn." The experimenter then took the top card and placed it face-up on top of the corresponding picture, saying: "Here's a zebra! The zebra goes here, on the blue!" Then it was the child's turn, and so on with alternating turns until the stack was gone. During this game, the experimenter touched the child's head twice in congratulations when the child placed his or her card; this was a "sham-marking procedure, to normalize the experimenter's touching of the child's head in order for the actual sticker-marking to go unnoticed. Near the end of the stack, the experimenter again did this, but this time surreptitiously placed a sticker on the child's hair, near the forehead.

Once the stack was gone, the experimenter and the child collected the cards from the board in random order and put the gameboard away. The experimenter then said to the child, "Remember how you did some of the cards and I did some of the cards? I remember that I did the zebra, so let's put the zebra here in front of me. I remember that you did the queen, so let's put the queen here in front of you. Okay, now *you* put all the cards that *you* did here in front of you, and put all the cards that *I* did here in front of me." The child then made two piles, one in front of the experimenter and one in front of him/herself. If necessary, the experimenter prompted the child by holding up a card and asking as she pointed to herself and the child "Who did this one, you or me?" (for one child with autism who appeared confused by pronouns, the experimenter used proper names instead – e.g., "Who did this one, Jenny or Gabe?"). When the game was over, the sticker remained on the child's head.

This task yielded three scores. *Self* and *Other* subscores were calculated as the number of cards children placed correctly in each of these two categories minus those that the child placed incorrectly in this category. For example, if the child placed into the "self" category six cards that he had in fact placed on the board and two cards that the experimenter had placed, the child would receive a score for self-memory of four. If the child placed cards into a category exactly at chance, the child would receive a score of 0 (with correct and incorrect placements canceling each other out). *Overall Actor* scores were calculated by adding Self and Other scores together and could potentially range from –16 to 16 (actual scores ranged from –3 to 16, $M = 9.45$).

2.3.2 Delayed Self-Recognition (DSR)—Once one minute had passed since the end of the Self-Other Action Memory task, the experimenter said to the child, “I want to show you something.” The experimenter then played footage of the child, beginning just after the sticker was placed on the child’s head. This was done to standardize presentation, and because evidence from Povinelli et al., (1996) showed that viewing the marking event itself provided negligible benefit to children. This footage was viewed on the LCD panel of the video camera itself, measuring 3in × 2.5in (this was done to permit home-visit testing of children with autism). Footage centrally showed the head and upper body of the child, some of the game board, and some of the head/upper body of the experimenter. Depending on how long the child took to play the matching and sorting card game, the time elapsed between when the earliest footage on the screen actually occurred and the point at which the child began to watch the video ranged from 3 to 5 minutes.

When watching the footage, child and experimenter sat side by side and if the child made no verbal response after approximately 30 seconds, the experimenter asked, “Who is that?”, pointing to the child’s image on the screen. The experimenter then went through several subsequent prompts (waiting 30 seconds between each and repeating each once if necessary), which continued as long as the child had not removed the sticker from his or her own head. After “Who is that?”, the next prompt was, “What is that?” (while pointing to the sticker in the image), and finally, “Can you get that for me?” If the child did not respond by reaching to his or her own head, a handheld mirror (10 inches × 10 inches) was turned to face the child and the same prompts were asked again. Thus, children who did not demonstrate DSR (by reaching to investigate the sticker after viewing video footage) were administered something quite similar to the standard MSR test.

Children’s scores on the DSR test were calculated on a five-point scale, with self recognition defined as the child reaching to his or her own head upon seeing their own video image, in an effort to explore or remove the sticker: 5 = sticker removal without any prompt, 4 = sticker removal after “Who is that?” prompt, 3 = sticker removal after “What is that?” prompt, 2 = sticker removal after “Can you get that?” prompt, 1 = no DSR. Children in this last category include those that removed the sticker once shown a mirror and children who never removed the sticker. Scores overall on this test ranged from one to five, with a mean of 2.39 across groups.

Children were also given a self-reference score on this test, by coding their answer to the experimenter’s question, “Who is that?” while pointing to the child’s image on the screen. Self-reference was scored in five categories: 1 = “me” or “I”, 2 = a possessive pronoun (e.g., “that’s on my head”), 3 = a point to themselves without verbalization, 4 = their own proper name (e.g., “that’s Gabe”) or 5 = third person reference (e.g., “She’s playing a card game”). In all cases except the self-point, the child’s first response to the question was the one coded. In the case of the self-point, the experimenter asked, “Can you tell me in words who that is?” and, if the child gave a verbal answer, this was coded instead.

Children’s responses to the DSR test were coded from videotape by the first author and an additional coder who coded a randomly chosen 25% of children from each group, plus an additional 6 children randomly selected from each of the typically-developing groups (for purposes of sufficient sampling). The additional coder was not told of children’s group membership before coding, though these were in some cases obvious (age for example, or children with ASD engaging in stereotyped behavior). This coder was blind to hypotheses. For self-recognition score, $\kappa = .89$ (90% agreement) and for self-reference, $\kappa = .86$ (92% agreement). The few disagreements were resolved through discussion.

3. Results

3.1 Cognitive Performance Indicators

3.1.1. Social Communication Questionnaire—As shown in Table A, an overall difference existed between groups on the *SCQ*, $F(2,68) = 121.54$, $p < .001$, helping corroborate the focal diagnostic groupings based on pediatric, neuropsychological diagnosis and confirming *SCQs* of 10 or below for the typical groups. As expected comparisons (t-tests) indicated that children with ASD scored significantly higher (i.e., demonstrated more autistic traits) on the *SCQ* than typical 3-year-old children, $t(42) = 11.81$, $p < .001$, *Cohen's d* = 3.57, and typical 5-year-old children, $t(44) = 13.39$, $p < .001$, *d* = 3.87. (Effect sizes in terms of *d* can range from 0 to infinity and those that are 0.8 or higher are considered large; Cohen, 1988).

3.1.2. Peabody Picture Vocabulary Test III—With regard to verbal MA, as measured by receptive vocabulary, typical 3-year-old children scored significantly lower than both typical 5-year-olds, $t(50) = 6.34$, $p < .001$ and children with ASD, $t(43) = 5.31$, $p < .001$, *d* = 1.63 (see Table A). Typical 5-year-olds and children with autism performed equivalently, $t(45) = .852$, $p = .40$, *d* = .25. (*ds* that are 0.2 to 0.3 are considered small, and help substantiate the near equivalence of two groups on a measure.)

3.1.3. Stanford Binet Bead Memory and Differential Abilities Scales—The Bead Memory subtest yields a standardized score so that children of different ages (and different absolute performance levels) can be directly compared. Scores for children with ASD did not differ from those of typical 3-year-olds, $t(41) = 1.20$, $p = .24$ or those of typical 5-year-olds, $t(43) = .18$, $p = .86$. Neither did typical 3-year-olds differ from typical 5-year-olds, $t(50) = 1.4$, $p = .17$. Thus, these 3 groups were well-matched with regard to age-appropriate visual memory competence. On the Picture Similarities subscale of the *Differential Abilities Scales*, raw scores of children with ASD averaged 15.32. This is equivalent to a mental age of 66.42 months, placing them within the typical 5-year old range. These data also show that these children with ASD evidenced similar scores with regard to verbal MA and performance MA.

3.2. Delayed Self Recognition (DSR)

During testing, a few children became aware of the sticker on their heads before they were shown the video, as a result of noticing the experimenter place it there, randomly touching their own head during the course of the study, or being told that it was there by a parent (though parents were asked not to mention this): typical 3-year-olds ($n=3$) and typical 5-year-olds ($n=2$). For some additional 3-year-olds ($n=2$), 5-year-olds ($n=3$), and children with ASD ($n=4$), DSR data were not collected due to experimenter error or child non-compliance. This resulted in a total of five 3-year-olds, five 5-year-olds, and four children with ASD being excluded from DSR analysis.

A one-way ANOVA indicated no significant difference in response to the DSR test overall between diagnostic groups, $F(2,55) = 1.30$, $p = .283$, as shown graphically in Figure A. Typical 5-year-olds ($M=2.68$, $SD=1.32$) scored marginally higher than typical 3-year-olds ($M=2$, $SD=1.21$) -- $t(40) = 1.73$, $p = .08$, *d* = .54. Focally, DSR scores of children with ASD ($M=2.50$, $SD=1.71$) did not differ from typical 5-year-olds', $t(36) = .37$, $p = .71$, *d* = .12. They also did not differ from typical 3-year-olds', $t(34) = 1.02$, $p = .313$, *d* = .34.

Beyond comparisons of overall DSR scores, Table B presents percentages of children in each group who persisted in not passing after each additional prompt. To summarize in terms of a key percentage, 11 of 21 (50%) typical 3-year-olds exhibited DSR, that is, they

removed the sticker with only video prompting, before any use of the mirror. Almost equally, 9 of 16 (56%) of children with ASD did this. Of typically developing 5-year-olds, 16 of 22 (73%) exhibited DSR in this fashion. Just as with the parametric data, typical 5-year-olds and children with ASD did not differ in DSR when coded in this alternative, categorical manner, $\chi^2(1, N=38) = .51, p = .48$

3.2.1. Children's self-reference during DSR test—For these analyses, a child's first *verbal* self-reference was used – recall that those children who first answered with a self-point were prompted to answer verbally. Several children never produced a verbal self-reference during this task: one 3-year-old, two 5-year-olds, and one child with ASD. These children were set aside for these analyses. See Table C for percentages of answer type by participant group. Of typical 5-year-olds, 18 of 20 (90%) gave as a first verbal self reference either a first person pronoun (“I” or “me”) or the possessive pronoun “my”. Sixteen of 20 (75%) typical 3-year-olds answered in this way, whereas only 7 of 15 (46%) children with ASD did so. Children in the two typically developing groups typically answered in the first person -- they answered in the first person more often than any other response -- and these two groups did not differ from one another, $\chi^2(1, N=40) = .2, ns$. When the combined typically developing children were compared to those with ASD, the latter group were significantly less likely to answer in the first person, $\chi^2(1, N=55) = 6.55, p < .05$

3.3. Self–Other Action Memory

It remains possible that self memory reflects key challenges for children on the autism spectrum, and that sorting by Actor on the self-other action task might reveal this. Indeed, an ANOVA revealed overall differences in Overall Actor sort scores between groups, $F(2,66) = 8.02, p < .01$. Independent samples t-tests showed that typical 3-year-olds were worse than typical 5-year-olds on Overall Actor sort, $t(48) = 2.13, p < .05, d = .61$. Children with ASD scored significantly worse than typical 5-year-olds, $t(42) = 4.16, p < .001, d = 1.25$, and also considerably worse than typical 3-year-olds, $t(42) = 1.95, p = .05, d = .58$, on Overall Actor sort. With regard to Self subscore, these children with ASD (with average VMA of 5 and chronological age higher still) averaged a score of 3.53 (of a possible 8), compared to a score of 6.44 for typical 5-year-olds and 5.04 for typical 3-year-olds. See Figure B for Overall Actor sort performance by group

3.4. Supplemental Analyses

Because comparisons between typically developing children and those with ASD are focal, we confirmed the above findings with additional analyses on several key subgroups of our ASD sample. A similar pattern of results is apparent using (a) our original sample of 24 children with ASD, including those that scored lower than 12 on the *SCQ*, (b) a restricted sample of only those 15 children with ASD scoring a 15 or higher on the *SCQ* and (c) a restricted sample of only those 14 children with ASD for whom the gap between their CA and VMA is less than 20 months (which might arguably make such a subgroup still more similar to their typically developing peers). For sample (a) children with ASD performed similarly to typical 5-year-olds on DSR, $t(40) = .15, p = .89, d = .24$ and significantly worse on Overall Actor sort, $t(46) = 4.32, p < .01, d = 1.25$. For sample (b) children with ASD performed similarly to typical 5-year-olds on DSR, $t(34) = 1.13, p = .267, d = .38$ and significantly worse on Overall Actor sort than both typical 5-year-olds, $t(39) = 4.62, p < .01, d = 1.45$ and typical 3-year-olds, $t(39) = 2.38, p < .05, d = .76$. For sample (c) children with ASD performed similarly to typical 5-year-olds on DSR, $t(31) = .603, p = .551, d = .22$ and significantly worse on Overall Actor sort, $t(37) = 4.19, p < .01, d = 1.38$.

3.5. Self-Other Action Memory, Bead Memory, Picture Similarities, and DSR

If delayed self-recognition captures something more specific to self-conception, and is not merely a proxy for overall cognitive level, scores on the DSR test should not correlate strongly with general cognitive performance. Correlations were calculated within the three groups between DSR score and performance on the PPVT and Bead Memory tasks and, for the ASD group, DAS Picture Similarities. DSR score was not correlated with PPVT score for typical 3-year-olds, $r(20) = .275$, *ns*, typical 5-year-olds, $r(22) = .217$, *ns* or children with ASD, $r(20) = .305$, *ns*. For no group of children was DSR score correlated with Bead Memory score, and for children with ASD, DSR was not correlated with Picture Similarity performance.

Because the Self – Other Action task evidences considerable delay for ASD children, Actor sort scores might well correlate with DSR, on the hypothesis that these very different measures nonetheless tap some overlapping capacities for representations of the self through time. For children with ASD, Overall Actor sort score was substantially, positively correlated with DSR, $r(15) = .53$, $p < .015$. If we consider DSR performance categorically as a yes/no, the Overall Actor sort scores of those children with ASD who *did* pass the DSR task are significantly higher than those who did *not*, $t(13) = 3.04$, $p < .01$. For typically developing children, however, it seemed less likely that Actor sort scores could correlate with DSR scores, because adequate and high levels of self memory seemed already well established in the younger children--even 3-year-old typically developing children were already substantially correct on this score. Indeed, for typically developing 3-year-olds, $r(20) = .09$, *ns* and 5-year-olds, $r(21) = .29$, *ns*. Overall Actor sort score did not correlate with DSR. For none of these three groups did Overall Actor sort score correlate with scores on Bead memory or PPVT.

4. Discussion

Our results confirm that children with autism spectrum disorders perform like verbal MA-matched typical 5-year-olds with regard to delayed self-recognition. Previous research drew similar conclusions (Dissanayake et al., 2010; Lind and Bowler, 2009), but our inclusion of ASD children with verbal MA equivalent to typical 5-year-olds, as well as a precisely matched group of typical 5-year-olds, provide substantial additional support for this claim. With this comparison we provide a clearer evaluation of children with ASD at the mental age at which DSR is newly passed in typical groups. This more precise comparison further indicates that children with ASD appear remarkably unimpaired in DSR. Our results also revealed, however, that while children with ASD are not significantly different than typical 5-year-olds on the DSR task, neither are they different from typical 3-year-olds. This may reflect some inherent limitations to the DSR task, discussed further below, in that even 3-year-olds are often about 50% correct on this measure.

On a separate self-other memory task in which children were asked to recall whether they or another actor placed a series of cards, the same children with ASD who performed at VMA-appropriate levels on the DSR task had a difficult time – performing worse than both 5- and 3-year-olds. Prior experimental and anecdotal work with ASD children revealed irregularities in several abilities arguably related to self-through-time cognition. This included provocative (albeit equivocal) support for difficulties in remembering self-relevant actions and activities (e.g., Millward et al., 2000; Phillips et al., 1998; Russell and Jarrold, 1999). Such findings encouraged the initial hypotheses that children with ASD would struggle with DSR. The accumulating data that DSR is unimpaired in ASD children, at least those with 5 years of MA, then raises the possibility that by this MA they are on standard timetables for achieving a self-through-time more broadly. Alternatively, it is possible that children with autism may pass the DSR task but be delayed on other crucial aspects of

achieving temporal self-relevant understandings. Lind (2010) argues just this in reviewing findings across various studies. In confirmation of this second possibility, we found that the same children with ASD who are unimpaired in DSR were impaired with regard to several other facets of self memory – distinguishing self from other, in particular, as well as autobiographical self reference. This pattern of competencies, though foreshadowed in the uneven patterns in prior research, provides particularly convincing evidence for such a conclusion because it is not based on comparisons across studies with different samples of children of unknown or incomparable make up. This pattern of results now deserves interpretation.

One aspect of fuller interpretation concerns clarifying what DSR, and competence on that task, tells us. While the DSR paradigm can be quite revealing there are reasons to be cautious and precise in its interpretation. First, the DSR task requires children to deal with physical representations. In fact, children with ASD are typically quite good with physical representations such as photographs, drawings, and maps (e.g. Caron, Mottron, Rainville, and Chouinard, 2004, in which children with autism show superior performance using maps) and notably better with such representations of the physical world in comparison to mental representations (Leekham and Perner, 1992; Leslie and Thaiss, 1992). With this in mind, it is worth noting that more children with ASD passed our DSR task with the best possible score than did typically-developing children of either age (see Table 2). In part these ASD performances may reflect and help explain that physical self-concept is relatively unimpaired in children with autism. Further, the data may show limitations in the DSR task itself. For example, passing is possible by some young children (in the present study 50% of typically developing 3-year-olds) potentially without the recognition of the causal link between past and present selves that older children possess. Povinelli and Simon (1998) discuss this possibility with regard to their substantial subgroup of 3-year-olds that also passed by reaching to their own heads during their implementation of the DSR task, a percentage quite similar to our typical 3-year-olds and our children with ASD (see also Skouteris et al., 2006 and Zelazo et al., 1999 for the effect of cueing on 3-year-olds' performance). Povinelli and Simon suggest that such young children approach the DSR test as they would the MSR task, by simply disregarding information related to movement contingency. This interpretation could be addressed in future research with children with ASD by using alternate versions of the DSR test, as has been done with typically developing children. For example, children could be tested with delays of several weeks in comparison to just moments (Povinelli and Simon, 1998). Typically developing 5-year-olds (but not 3-year-olds) appropriately refrain from reaching to their own heads if viewing these older, outdated video depictions of themselves from several weeks earlier.

A related, but mostly unaddressed hypothesis, would be that contemporary children with ASD, especially those whose MA is 5 years or higher, may be particularly competent with understanding video. They are, after all, older chronologically than their MA-matched peers, and they are likely to have seen themselves often on family videos. The ubiquitous presence of family videos has indeed led to several important studies of the social behaviors at one year of age of children who later go on to be diagnosed with autism (e.g., Colgan et al., 2006; Maestro et al., 2005). Thus, these children have had substantial time to familiarize themselves with video presentations of the self and to cultivate "lower-level" visual strategies which could enable them to pass DSR tasks. This is not just a methodological issue, but a theoretical issue (related to their understanding of dynamic social representations in general, as in the self-through-time), as well as a topic of interest in its own right (e.g., the comprehension and miscomprehension of ubiquitous video presentations by children with ASD).

It might even be argued that our data could underestimate understanding of the physical self-through-time of children with ASD. Past studies implementing the DSR paradigm (e.g., Povinelli et al., 1996) utilized a full screen in which children's image appeared approximately life-size (and was therefore more analogous to a mirror image). But in order to facilitate and standardize testing children with developmental delays in their homes, for our research it was preferable to show children footage on an LCD panel screen of a handheld camera that could be the same across all home testings. If children with ASD have particular difficulty with grasping the relevance of self-footage on a small screen, perhaps due to decreased sensitivity to movement or context cues or difficulty in recognizing the physical features of the self in a smaller presentation, this procedure might have been problematic. However, we found good DSR results with our children with ASD, and results quite similar to those reported in the two prior studies, so there is little to suggest that these children were negatively impacted by this methodological choice.

It is worth addressing several potential weaknesses in the current research in more detail: (a) the possibility that parents influenced their children's responses, and that typically-developing children may have benefited from this, (b) potential limitations of using the PPVT as our measure of MA, and (c) the prevalence of boys in both the typically-developing 5-year-old and the ASD groups. Regarding (a), it is indeed likely that typically-developing children would be better able to utilize subtle social cues than children with ASD. However, except for obvious cases in which parents pointed out the sticker (and which were excluded from analysis), we had no reason to believe they were employing such cues in the present study. In all cases, parents were seated at least two feet behind the child. This offered the benefit of being *out* of the child's line of sight, while being directly *in* the experimenters'. As for (b), any single measure of MA has limitations, but as noted earlier the PPVT correlates with full-scale measures of IQ like the *WPPSI*. Moreover, we sought additional assessment of children's overall cognitive functioning via Bead Memory and Picture Similarities. Because of the frequent disparity between verbal and performance MA in children with ASD, a measure of verbal MA was the more conservative choice of the two. With regard to (c), we recruited a comparison group of typically-developing 5-year-olds that matched the overwhelming overrepresentation of boys in our ASD group (which reflected the typical gender imbalance in ASD). If, for example, girls outperform boys on DSR, then children with ASD may compare less favorably to typically developing children simply through lacking girls. That said, research to date (Dissanayake et. al., 2010; Povinelli et. al, 1996) has not found that girls outperform boys on DSR and, while the current sample showed no differences on DSR, there were significant differences on memory for self.

We included several measures of cognitive performance in the present study, which served two purposes. First, it allowed us to select a group of children with ASD who matched our older typical group on several key performance measures. Second, it provided a way to evaluate if children' performance on the target measures was simply capturing domain-general competence. For none of our three groups did self-other action memory or DSR correlate with any of our other measures of cognitive performance (Bead Memory, Picture Similarities, or *PPVT*). This pattern of results suggests that our two self tasks are tapping something unique, and are not solely the product of developing basic skills.

Several factors likely contribute to an impaired sense of a self-through-time in children with autism. Our specific finding concerns significant difficulties for children with ASD on self-other action memory. Children with ASD were, as noted, significantly worse even than typically developing 3-year-olds on this task. Imagine a child who is especially challenged in sorting memories of their own actions from those of the other people around them. He or she may be able to recognize previously learned features of the self-relevant environment (e.g. via video and pictures), but tagging certain features as uniquely relevant to oneself and

building a coherent causal identity would be hard in the extreme. Children with ASD may manifest just this difficulty in achieving the sort of self-through-time that characterizes typical development by 5 or 6 years of age. As noted in the Introduction, prior research presents a somewhat contradictory picture regarding self-other memory performance in children with ASD. Some of this may be due to different ages tested and different age-related comparisons. Again, our use of ASD children of relatively young MA and use of several typically developing comparison groups, may have aided in providing more sensitive findings. One possibility our findings support is that the primary difficulty for children with ASD is not so much in tracking the self but in tracking the self *versus another*. Our self-other action memory task required not just remembering one's own actions, but doing so when those were intertwined with someone else's actions. Although this is an easy task for young normally developing children, it was notably difficult for children with ASD. Our data underscore the value of further research on the development of self-other memory processes in children with ASD.

Another topic for future research concerns how children with ASD would conceive of future selves and states as part of an extended conception of the self through-time. As one example, how would they perform on a task requiring they weigh benefits to their future self? Work with typically developing children suggests that future-oriented prudence (or being able to delay immediate gratification for future benefit) is correlated with passing the DSR paradigm, which would now suggest that children with ASD would perform just fine. However, temporal order recall (of card placement) and recall of contextual information about past games is related to future-oriented prudence (Lemmon and Moore, 2001) for typically developing children, and so our self-action memory results would suggest that children with ASD would struggle. When children with ASD develop an initial sense of self-through-time -- in coming to an understanding of the link between images of the past self and the physical state of the present self, albeit at an older CA than typical children -- they may very well still find it quite difficult to simulate and distinguish a future, as yet nonexistent, self and make decisions and predictions accordingly (what Suddendorf and Corbalis, 2007 call *foresight*). We predict that making decisions based on the future *physical* self would be easier than those based on the future *psychological* self.

Continued research of this sort is important because of the conceptual centrality to human self-conception of the linkage of distinctly self events to a temporally organized autobiographical memory. Difficulties with such self representations, as seem evident in children with autism, are theoretically informative, but moreover they represent social and identity challenges for the children involved. Both factors inherent to autism and factors that follow from the social-communicative impairments of autism could contribute to this irregular sense of self through time. Continued research in this area is thus needed to illuminate the nature of these children's difficulties, build upon their existing strengths in decoding the physical world, and to offer support as they face the crucial task of establishing a coherent sense of self and their personal memory-based identity.

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Research highlights

- Children with ASD were compared to typical 3- and 5- year-olds on two tasks.
- Children with ASD performed worse than both groups on sorting cards by actor.
- These children performed similarly to both groups on delayed self-recognition.
- These results confirm and extend previous work.

Figure 1.
Delayed Self-Recognition Score, by Group

Figure 2.

Overall Actor Sort, by Group

Note: * means significant at $p < .05$; ** means significant at $p < .01$

Table A

Means (and SD) for Cognitive Performance Variables, by Group

	n	CA	VMA	Picture Similarities	Bead Memory	SCQ
Typical 3	25	41.80 (1.80)	49.12 (10.71)	—	54.02 (4.82)	5.72 (2.42)
Typical 5	27	62.67 (4.09)	65.93 (8.34)	—	51.67 (7.74)	4.33 (2.69)
ASD	20	87.20 (26.29)	63.95 (7.15)	69.31 (9.66)	51.17 (11.28)	17.53 (4.00)

* Both chronological age (CA) and verbal mental age (VMA) are reported in month-equivalents. Bead Memory scores are standardized and can be directly compared across age groups. Picture Similarities scores are reported in month-equivalents. The Social Communication Questionnaire (SCQ) yields scores indicating more autism-like behaviors (generally accepted at-risk for autism score is a 15 or higher).

** Ultimately, only 16 children with ASD were included in DSR analyses. For this group, mean scores were as follows: CA (85.25), VMA (62.31), Picture Similarities (71.25), Bead Memory (51.60), and SCQ (17.53).

Percentages of children in each category who passed the delayed self-recognition task with each consecutive prompt.

Table B

	No prompt	“Who’s that” prompt	“What’s that” prompt	“Get that” prompt	No DSR
Typical 3	5	5	23	18	50
Typical 5	14	5	45	9	27
ASD	25	5	15	15	45

Table C

Percentages of children first utilizing each self-reference, by group (second self-reference recorded if first was a self-point).

	“I” or “me”	Possessive pronoun	Proper name	3rd person pronoun
Typical 3	70	5	10	15
Typical 5	85	5	5	5
ASD	33	13	0	53