

Early Childhood Predictors of the Social Competence of Adults with Autism

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Abstract Longitudinal research into adult outcomes in autism remains limited. Unlike previous longitudinal examinations of adult outcome in autism, the twenty participants in this study were evaluated across multiple assessments between early childhood ($M = 3.9$ years) and adulthood ($M = 26.6$ years). In early childhood, responsiveness to joint attention (RJA), language, and intelligence were assessed. In adulthood, the parents of participants responded to interviews assessing the adaptive functioning, autistic symptomology and global functioning of their children. RJA and early childhood language predicted a composite measure of adult social functioning and independence. Early childhood language skills and intelligence predicted adult adaptive behaviors. RJA predicted adult non-verbal communication, social skills and symptoms. Adaptive behaviors changed with development, but symptoms of autism did not. Additional factors associated with adult outcomes are discussed.

Keywords Autism · Longitudinal · Outcome · Adulthood · Social functioning

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Do early childhood intelligence, language, and joint attention predict the independence, adaptive abilities, and symptomatology of adults with autism? Although autism is a developmental disorder, few studies have tracked the same individuals across multiple stages of development into adulthood and none have assessed relationships between childhood joint attention and adult outcomes, or how well individuals can function independently. Joint attention, or the ability to align one's own attention with the attention of another, is important to study as it is foundational for symbolic reference and is commonly impaired in autism (Mundy et al. 2009). The current study is the first to assess whether early childhood joint attention skills predict adult social functioning in autism.

Does RJA Predict Adult Outcomes?

Participants in the current study were assessed at four time points from early childhood to adulthood. Findings from the first three time points have been reported in previous publications (McGovern and Sigman 2005; Sigman and McGovern 2005; Sigman and Ruskin 1999; Siller and Sigman 2002). In early childhood, both responsiveness to joint attention (RJA) and initiation of joint attention (IJA) were assessed. Both RJA and IJA are relevant variables to consider as RJA may index involuntary social orienting while IJA may require more intentional control (Mundy et al. 2007). While both RJA and IJA predicted expressive language gains 1 year after the first assessment, only RJA predicted intelligence quotient (IQ) gains from the first to the second assessment and receptive language at the third assessment (Sigman and McGovern 2005; Sigman and Ruskin 1999). Thus, in the current study we hypothesized that RJA would be associated with adult outcomes.

Previous Longitudinal Research on Adult Outcomes in Autism

While the majority of adolescents and adults with autism achieve limited independence and social relatedness (see Table 1: Billstedt et al. 2005; Cederlund et al. 2008; Eisenberg 1956; Gillberg and Steffenburg 1987; Howlin et al. 2004; Kanner 1971; Larsen and Mouridsen 1997; Lotter 1974; Rutter et al. 1967), exceptions to this pattern have been reported (Eaves and Ho 2008; Kobayashi et al. 1992) particularly for individuals with autism who have higher IQs (Farley et al. 2009; Kanner et al. 1972) or individuals with Asperger syndrome (Cederlund et al. 2008; Engström et al. 2003; Larsen and Mouridsen 1997). However, better outcomes for those with Asperger syndrome relative to those with autism may not be apparent when both groups have comparable IQs (Howlin 2003).

Types of Adult Outcomes

Identifying factors predictive of outcome across longitudinal studies of autism is complicated by variation in diagnostic criteria, IQ, age at initial and follow-up assessments, available early identification and intervention services, and the use of different and often subjective outcome variables (see Table 1: Kobayashi et al. 1992; Lord and Venter 1992; Lotter 1974, 1978; Rutter and Lockyer 1967; Venter et al. 1992). Three common measures of outcome are categorical assessments of independence and social relatedness (social functioning), adaptive behavior skills, and autistic symptoms.

While these outcome measures are often assessed indirectly via caregiver report, each provides unique insights into how individuals with autism develop into adulthood. Social functioning is a global measure of whether adults with autism are employed, have friends, and live independently. Despite variability in means of assessment across studies, social functioning is the most commonly used outcome measure across longitudinal studies of adult outcomes in autism and thus facilitates comparisons across studies. Longitudinal assessment of the adaptive behaviors of individuals with autism may allow educational and vocational opportunities to be tailored to individual needs (Carter et al. 1998; Freeman et al. 1991; Volkmar et al. 1987). Developmental change in the symptoms of autism may provide insights into the natural course of the disorder, as well as supporting service planning (Fecteau et al. 2003; Piven et al. 1996; Seltzer et al. 2003).

Predictors of Adult Social Functioning

Social functioning in adults with autism has been related to speech before age 6 (Eisenberg 1956; Kanner et al. 1972),

early childhood IQ (Eaves and Ho 2008; Farley et al. 2009), or a combination of language skills and IQ (Billstedt et al. 2005; Gillberg and Steffenburg 1987; Howlin et al. 2000; Kobayashi et al. 1992; Lotter 1974; Rutter et al. 1967). While non-verbal IQ (NVIQ) and language ability are only moderately related for individuals who are not intellectually disabled, around 70% of individuals with autism may be at least somewhat cognitively impaired and severe intellectual disability almost always co-occurs with impaired language (Rutter 1970). Despite being related, speech and IQ may explain unique portions of the variance in outcome (Rutter et al. 1967).

Predictors of Adaptive Behaviors and Symptoms

Language abilities (Venter et al. 1992), IQ (Sigman and McGovern 2005), and a combination of the two (Anderson et al. 2009; Szatmari et al. 2009) also predict adaptive behavior skills. While adaptive behaviors and IQ are often correlated in individuals with autism, adaptive behaviors are often lower than would be expected based upon IQ (Freeman et al. 1991; Venter et al. 1992), particularly for non-intellectually disabled individuals (Bölte and Poustka 2002). IQ may (Sigman and McGovern 2005) or may not (Fecteau et al. 2003) predict improvement in symptoms with age.

Relationships between adaptive behaviors and symptoms may vary with IQ. While the social skills and social symptoms of more intellectually disabled children and adolescents are moderately correlated (Anderson et al. 2009), they are less consistently related for higher-functioning individuals (Klin et al. 2006). Participants in the current study had a mean early childhood IQ of 55; therefore, we expected social skills and social symptoms to be correlated across development.

In one of the few studies to assess adaptive behaviors and symptoms at multiple time points, Szatmari et al. (2009) used hierarchical linear modeling to delineate the trajectories of Vineland Adaptive Behavior Scales (VABS; Sparrow et al. 1984) scores and symptoms on the Autism Behavior Checklist (Krug et al. 1980) of high functioning individuals with autism across four assessments from early childhood through adolescence. After verifying that participants were on the autism spectrum, a classification of autism or Asperger syndrome (AS) was conferred based on grammatical impairments between 6 and 8 years of age. While children with AS had better VABS scores across all domains and time points, growth in adaptive behaviors was independent of diagnosis and flattened out in late adolescence. NVIQ assessed at 5.5 years was related to VABS daily living skills and socialization but not communication scores. VABS daily living and socialization skills also improved for participants in the second and third

Table 1 Previous longitudinal studies of adult social functioning in autism

Authors	Final N	Source	Diagnostic criteria	Mean age (range) in years FU ^a	% Male	Mean initial IQ	Outcome criteria	Overall social functioning ^b	Childhood predictor of outcome
Eisenberg (1956)	53	Hospital: before 1956	Behaviors	Intake: 6 FU: 15 (9–25)	79	NA	Vague	5% V/G, 22% F, 73% V/P	Speech by 5
Lotter (1974)	32	Population screening: 1964	Creak	Intake: (8–10) FU: (16–18)	NA	67% <50	Rutter and Lockyer	13% V/G, 23% F, 63% V/P	Speech, IQ
Howlin et al. (2004)	68	Hospital: 1950–1979	Rutter → DSM-IV	Intake: 7 (3–16) FU: 29 (21–49)	90	80	Howlin	22% V/G, 19% F, 58% V/P	PIQ, Speech by 5
Howlin et al. (2000)	19	Hospital schools: before 1971	Rutter	Intake: 7 FU1: 9 FU2: 24 (21–27)	100	NA	Mawhood	16% V/G, 10% F, 74% V/P	Vocabulary, PIQ
Gillberg and Steffenburg (1987)	23	Population screening: born 1961–1968.	DSM-III	Intake: NA FU: (16–23)	74	20% >70	Lotter	59% V/P	IQ > 50, Speech by 6
Billstedt et al. (2005)	78	3 population screenings: born 1962–1984	DSM-III	Intake: <10 FU: 26 (17–40)	70	26% >70	Lotter	8% F, 16% R, 75% V/P, IQ, Speech	
Cederlund et al. (2008)	70 Aut. 70 AS	Clinic: born 1967–1988	Gillberg and DSM-III	Intake: 11 (6–25) FU: AS: 22 (16–34), Aut.: 25 (16–36)	100	AS: 101 Aut.: 83% <70	Lotter	AS: 27% V/G, 47% F, 23% R, 3% V/P, Aut: 7% F, 7 % R, 76% V/P,	NA
Eaves and Ho (2008)	48 Aut. 40 ASD	Clinic: recruited 1974–1984.	Rutter and DSM I–III	Intake: 6 (3–12) FU: 11 (8–17)	75	61% >50	Eaves and Ho	21% V/G, 32% F, 46% V/P	IQ, particularly VIQ
Larsen and Mouridsen (1997)	9 Aut. 9 AS	Child psychiatry departments: 1949–1951	ICD-10	Intake: AS: 9, Aut.: 6 FU: AS: 39 (33–34), Aut.: 37 (32–39)	AS: 78 Aut.: 33	AS: All > 70 Aut.: 4 < 70	Lotter	AS: 33% V/G, 44% F, 22% V/P Aut.: 22% V/G, 11% F, 67% V/P	NA
Farley et al. (2009)	41	Population screening: born 1960–1984	DSM-III	Intake: 7 (3–26) FU: 33 (22–46)	93	NIQ > 70	Howlin	48% V/G, 14% F, 17% V/P	IQ, Change in IQ
Rutter and Lockyer (1967), Rutter (1970)	56	Hospital: 1950–1958	Rutter	Intake: 6 (3–11) FU1: 16 FU2: 22 (15–29)	81	62	Rutter and Lockyer	14% V/G, 25% F, 61% V/P	IQ, Speech by 5, Education, Symptoms
Kobayashi et al. (1992)	197	Therapeutic agencies: born before 1972.	Similar to DSM-III	Intake: 6 (SD = 2.8) FU: 22 (18–33)	84	22.1% > 70	Kobayashi	37% V/G, 27% F, 46% V/P	IQ (all), Speech (males)

Table 1 continued

Authors	Final N	Source	Diagnostic criteria	Mean age (range) in years FU ^a	% Male	Mean initial IQ	Outcome criteria	Overall social functioning ^b	Childhood predictor of outcome
Engström et al. (2003)	32 AS 10 HFA	Population health records 1998	DSM-IV	Intake: AS: 28 (15–41) HFA: 14 (4–20) FU: 31 (18–49)	57	NA	Lotter	12% V/G, 75% F, 12% V/P	NA
Ruble and Dalrymple (1996)	46	Dev. dis. center: before 1996	DSM-III	Intake: 5 FU: 17	72	26% > 70	Vague	100% V/P	NA

^a FU Follow-up

^b V/G Very/good, F Fair, R Restricted but acceptable, P/V Poor/very poor

assessments of our study, particularly those with higher IQs (Sigman and McGovern 2005).

Is Change in Language and Intelligence Predictive of Adult Outcomes?

Do early childhood IQ and language impact adult outcomes simply by remaining consistent across development? Early childhood IQ is predictive of IQ in adolescence and adulthood in autism (Farley et al. 2009; Freeman et al. 1991; Sigman and McGovern 2005). However, lack of change in group-level IQs can obscure substantial variation in the IQ of individuals (Cederlund et al. 2008; Farley et al. 2009; Lockyer and Rutter 1969). While IQ may be less stable for individuals who never develop language (Lord and Schopler 1989; Rutter 1970), higher IQ may differentiate between initially non-verbal children who do and do not develop language after age five (Rutter et al. 1967). Change in IQ from first assessment to follow-up may predict better social functioning approximately 25 years after first assessment (Farley et al. 2009). Language has often been assessed as either present or absent; however, change in a continuous language measure may also be a powerful predictor of social functioning outcomes.

Does RJA Predict Change?

While Szatmari et al. (2009) found that individuals with AS had fewer autistic symptoms than those with autism across all assessments, symptoms decreased for both diagnostic groups with age. Similarly, retrospective comparisons of the current and lifetime symptoms of adolescents and adults on the ADI-R suggest that, for primarily low functioning populations as well as for large samples of individuals with unspecified IQ, all ADI-R symptom domains (e.g., social, verbal and non-verbal communication, and repetitive behaviors) improve with age (McGovern and Sigman 2005; Seltzer et al. 2003), while for higher functioning populations, social and communicative symptoms (as quantified by the ADI-R) may decrease more than repetitive behaviors (Fecteau et al. 2003; Piven et al. 1996). However, prospective comparisons suggest that non-verbal communication may not improve with age (McGovern and Sigman 2005; Shattuck et al. 2007).

Szatmari et al. (2009) suggested that the absence of grammatical impairment, increased VABS scores, and decreased autistic symptoms might all arise from a common developmental precursor such as joint attention. Short-term longitudinal studies of children with autism indicate that more frequent IJA, as indexed by gaze

alternation, predicts reduced social and communicative symptoms (Charman 2003) and both IJA and RJA predict better expressive language (Kasari et al. 2008; Sigman and Ruskin 1999). Thus, IJA might be related to symptoms in adulthood while both types of joint attention may be related to linguistic competence, which in turn might influence adult adaptive abilities and independence.

However, RJA, but not IJA, during the first assessment was related to language at the third assessment in the current set of studies (Sigman and McGovern 2005). Tantam (1992) postulated that the failure of a typically innate tendency to respond to joint attention (RJA) may be a central deficit in autism which makes individuals with autism more apt to focus on idiosyncratic rather than shared attention structures and less likely to learn word-object correspondences (Baldwin 1991). From time point one to time point two of the current set of studies, 26% of the sample moved out of the intellectually disabled range, and those who did so exhibited more RJA during the first assessment than those who remained intellectually disabled (Sigman and Ruskin 1999). Given its effects on language and cognitive development, we expected RJA to predict adult independence and adaptive skills, though we expected its effects to be reduced when changes in language and IQ were also included in analytic models.

Methods

Participants

The current report is based on interviews with the parents of twenty individuals with autism ($M = 26.6$ years, $SD = 3.8$) who were assessed during three prior assessments when participants in the current report had a mean age of: 3.9 years ($SD = 1.2$ years), 11.7 years ($SD = 3.2$), and 18.3 years ($SD = 3.6$). See Table 2 for participant characteristics across time points. While the first three assessments included standardized testing, behavioral observations, interviews and questionnaires, the current assessment consisted solely of tape-recorded parental interviews and questionnaires. As many participants had moved since the last assessment, interviews were conducted over the phone, although one parent elected to do the interviews in person.

Seventy children with autism were first diagnosed in the late 1970s and early 1980s according to DSM-III criteria (Sigman and Ruskin 1999). Fifty one (73% of the original sample) participated in the second assessment when the ADI was used to verify diagnosis for all current participants except one who missed the cut-off for repetitive behaviors by 1 point and one who did not participate in the

second assessment (Sigman and Ruskin 1999). Of those two individuals, one met criteria for autism and one met criteria for PDD-NOS on the ADOS during the third assessment. Forty eight (68% of the original sample) participated in the third assessment (McGovern and Sigman 2005). Relationships between maternal behaviors and the development of a subset of the participants in the current study across the first three assessments were also reported by Siller and Sigman (2002). Twenty participated in the current follow-up study (29% of the original sample). Independent samples *t* tests revealed that participants in the current assessment did not differ from the 50 participants in the first assessment who were lost to follow-up in terms of chronological age ($p = .90$) or mental age ($p = .21$) at first assessment. However, participants assessed during the current assessment had significantly higher developmental quotients (Current Participants: $M = 54.65$; Lost to Follow-Up: $M = 47.18$; $p = .032$) and marginally higher language abilities (Current Participants: $M = 20.13$; Lost to Follow-Up: $M = 14.70$; $p = .054$) at first assessment than participants who did not return for this follow-up assessment.

Twenty-eight participants from the third assessment did not participate in the current study for the following reasons: parents of 3 participants had died, 1 participant had died, 1 parent declined to participate, 20 participants could not be located, and 3 returned the consent form but did not respond to calls. While the previous assessment included 6 females and 42 males, the current sample was composed entirely of males: 13 Caucasian, 4 African American, 2 Asian, and 1 Hispanic.

Two participants did not complete the ESCS during the first assessment. The VABS was not completed during the second assessment for one participant and during the third for three participants. Six participants did not complete language and intelligence testing during the second assessment; therefore, the effects of changes in language and mental age on adult outcome measures were assessed by relating scores at time point one to scores at time point three. The ADI-R was not completed for three participants during the third assessment and for one participant during the current assessment. The latter participant reported that her work schedule was too hectic to complete the ADI-R.

Early Social Communication Scales (ESCS)

Administered during the first assessment, the Early Social Communication Scales (Mundy et al. 1996) is a structured observation of non-verbal communicative abilities including IJA (the frequency with which a child uses eye contact, pointing, and showing to initiate shared attention) and RJA (the proportion of prompts to elicit RJA when the child follows the experimenter's gaze and pointing gestures).

Table 2 Descriptive statistics, N: mean (SD), for final adult sample across time points

	Time point 1	Time point 2	Time point 3	Time point 4
Chronological age	20: 3.9 (1.2)	19: 11.7 (3.2)	20: 18.3 (3.6)	20: 26.6 (3.8)
Mental age	20: 2.2 (1.2)	NA	20: 8.1 (6.4)	NA
Language age	20: 1.7 (0.9)	NA	20: 5.0 (4.4)	NA
DQ	20: 54.7 (15.5)	NA	20: 44.8 (34.6)	NA
<i>ESCS:</i>				
IJA	18: 8.7 ^a (6.4)	NA	NA	NA
RJA	18: .58 ^b (.35)	NA	NA	NA
<i>VABS raw scores</i>				
Socialization	NA	19: 59.5 (30.5)	17: 69.6 (37.9)	20: 67.3 (34.5)
Communication	NA	19: 69.6 (40.9)	17: 79.4 (46.0)	20: 80.0 (45.5)
Daily living skills	NA	19: 89.8 (36.9)	17: 111.5 (43.2)	20: 122.8 (43.6)
<i>ADI-R algorithm</i>				
Social	NA	19: 16.4 (7.5)	16: 11.1 (6.8)	19: 13.3 (5.8)
Non-verbal communication	NA	19: 4.3 (3.1)	16: 3.6 (3.3)	19: 4.0 (3.2)
Restricted and repetitive behaviors	NA	19: 5.2 (2.0)	16: 3.6 (2.1)	19: 4.0 (2.4)

^a Frequency of initiations of joint attention over entire administration of ESCS

^b Proportion of responses to joint attention relative to presses for joint attention

Intelligence Assessments

Based on ability level, either the Cattell Scales of Development (15 participants) or the Stanford-Binet (Terman and Merrill 1973) was given during the first assessment. At time 3, eleven participants were administered the Stanford-Binet 4th edition (Thorndike et al. 1986) and nine received the Mullen Scales of Early Learning (Mullen 1995). All tests yielded mental age equivalents (MA) which were divided by chronological age to yield developmental quotients (DQ).

Language Assessments

Language was measured in early childhood with the Reynell Scales of Language Ability (Reynell 1977). During the third assessment, participants with limited speech were administered the Reynell, while the Clinical Evaluation of Language Fundamentals-Revised (CELF-R; Semel et al. 1987) was used for those with fluent speech. Each test yielded a language age equivalent (LA).

Autism Diagnostic Interview-Revised (ADI-R)

The ADI-R is a standardized, semi-structured caregiver interview that provides a diagnostic algorithm for the DSM-IV (American Psychiatric Association 1980) definition of autism (Lord et al. 1994). The ADI-R was administered by clinicians who had established second-degree reliability with the UMACC ADI-R training site on

training videotapes. ADI-R questions assess the social, verbal, and non-verbal communicative symptoms of autism as well as restricted and repetitive behaviors at both the time of interview (“current”) and between the ages of four and five (“ever”).

Because the ADI-R was administered during the second and third assessments, only current functioning was evaluated during the current (fourth) assessment. Algorithm items which do not yield current ratings were excluded from analysis (Bölte and Poustka 2002; Fecteau et al. 2003; Howlin 2000; Lord et al. 1997; McGovern and Sigman 2005). Seven participants had insufficient speech to assess verbal symptoms, so the verbal domain was not analyzed. As specified in the diagnostic algorithm, all ratings of 3 were transformed into 2 for analysis (Lord et al. 1994). Higher scores indicate greater symptom severity.

Vineland Adaptive Behavior Scales (VABS) Interview Edition

The VABS is a semi-structured caregiver interview assessing self-sufficiency across three domains: communication, socialization, and daily living skills (Sparrow et al. 1984), which was administered during assessments two, three, and four. Domain raw scores can be converted into standard scores or age equivalents. Because age equivalence scores may be misleading due to lack of comparability in range across domains and standard scores may be inappropriate for individuals with autism (Carter et al. 1998), analyses were performed on raw scores.

Overall Social Functioning

For the current study, we used a composite rating on a 5-point scale of overall social functioning based on employment, living situation, and friendships (from Howlin et al. 2004). Parents were asked a set of questions about their child's level of functioning (see "Appendix" for questions asked and coding scheme). This composite rating was chosen as it is similar to outcome measures used in many other studies (See Table 1: Cederlund et al. 2008; Engström et al. 2003; Gillberg and Steffenburg 1987; Larsen and Mouridsen 1997; Lotter 1978; Kobayashi et al. 1992; Billstedt et al. 2005, Rutter et al. 1967). According to this composite, the criteria for a "Very Good" rating included residential and employment independence as well as some friendships. A "Good" outcome signified either paid or voluntary employment with some degree of support in daily living and some friendships or acquaintances. Individuals rated as having a "Fair" outcome had achieved some supported independence and had acquaintances but no close friendships. A "Poor" outcome referred to individuals who required a high level of support and had few social contacts. A "Very Poor" outcome was given if the individual was living in a hospital. The first and second author discussed and reached agreement on all social functioning scores. A research assistant independently coded parent responses and attained 100% agreement with the social functioning scores assigned by the authors.

Results

Due to the small sample size, we regard the following analyses as exploratory and report partial correlation values as well as significance levels. DQ and LA were analyzed separately because separate estimates of DQ based on verbal and non-verbal mental age were not available. Indeed, DQ and LA at first assessment were highly correlated, $r(18) = .68$, $p = .001$. Chronological age at first assessment was entered into, and not significant, in all regressions except those which included DQ. CA was not entered into analyses which included DQ because DQ is defined by dividing MA by CA. Hierarchical linear modeling and regressions revealed similar predictive relationships between skills at first assessment and adult abilities and symptoms, so regressions are reported for ease of comprehension. Adaptive social skills as assessed by the VABS and social symptoms as assessed by the ADI-R were concurrently correlated ($p = .001$) at assessments two $r(17) = -.71$, three $r(14) = .80$ and four $r(17) = -.84$.

Early childhood variables examined in relation to each of the outcome variables included developmental quotient at time 1 (DQ1), language age at time 1 (LA1), and early

childhood RJA and IJA. Change in both LA and DQ from time 1 to time 3 was assessed in relation to each of the outcome variables by adding language (LA3) and developmental quotient (DQ3) from time 3 to models containing time LA1 or DQ1. A difference score indicating change in LA or DQ from time 1 to time 3 was also calculated to examine relationships between changes in abilities and a categorical outcome variable, adult social functioning. To test for possible mediators between RJA and outcome variables, relationships between RJA and change scores were examined: RJA predicted change in language skills from time 1 to time 3 ($\beta = .790$, $t(16) = 3.696$, $pr = .690$, $p = .002$) and change in DQ from time 1 to time 3 ($\beta = .685$, $t(16) = 3.242$, $pr = .642$, $p = .005$). Details of the regression analyses described below are summarized in Table 3.

Social Functioning

The percentage of participants classified into each level of social functioning was as follows: "Very Good" = 20%, "Good" = 10%, "Fair" = 20%, and "Poor" = 50% (see Table 4). Because social functioning is a categorical outcome measure, Spearman correlations were used to examine relationships between predictors and social functioning. Social functioning was related to LA1 ($\rho(18) = -.843$, $p < .001$), RJA ($\rho(16) = -.798$, $p < .001$), LA3-LA1 ($\rho(18) = -.866$, $p < .001$) and DQ3-DQ1 ($\rho(18) = -.825$, $p < .001$). However, social functioning was unrelated to DQ1 ($p = .080$) or IJA ($p = .125$). Thus, both early childhood language and RJA predicted adult social functioning. While change in language and DQ were also predictive of adult social functioning, a direct test to determine if change in skills mediated the relationship between RJA and social functioning was not conducted because of small sample size and because social functioning is a categorical variable.

VABS Scores

Daily living skills improved ($F(2, 30) = 15.442 < .001$) overall and from time three to four ($t(16) = 4.986$, $p < .001$). When entered into simple regression models, LA1 accounted for 40% and DQ1 accounted for 19% of the variance in raw scores on the daily living skills domain at time four. RJA and IJA were unrelated to daily living skills. A model containing LA3 ($\beta = .609$, $t(16) = 3.434$, $pr = .651$, $p = .003$) and LA1 ($p = .127$) explained 63% of the variance in daily living skills. DQ3 ($\beta = .902$, $t(17) = 5.794$, $pr = .815$, $p < .001$) and DQ1 ($p = .654$) explained 71% of the variance in daily living skills. While early childhood LA and DQ (i.e., LA1 and DQ1) predicted adult daily living skills, change in LA and DQ between

Table 3 Beta Values of simple regressions relating early childhood predictors to adult outcomes after controlling for chronological age

Childhood predictor → adult variable↓	IJA T1	RJA T1	DQ T1	LA T1
VABS				
Socialization	.256	.538*	.509*	.857**
Communication	.172	.501	.522*	.914 ***
Daily living skills	.276	.482	.480*	.824**
ADI-R				
Social	-.417	-.603*	-.379	-.721*
Non-verbal communication	-.431	-.797**	-.315	-.569
Restricted/repetitive behaviors	-.302	-.378	-.246	-.327

* $\alpha < .05$ ** $\alpha < .01$ *** $\alpha < .001$

time 1 and time 3 were stronger predictors of daily living skills than baseline measures were.

Improvement in Communication skills ($F(2, 30) = 3.405, p = .047$) was significant across the second, third and fourth assessments. Follow-up t tests indicated significant improvements in communication skills from time two to time four ($t(19) = -2.233, p = .039$), but not from time three to time four ($t(16) = -1.969, p = .067$). LA1 explained 49% and DQ1 explained 23% of the variance in raw scores on the communication domain at time four while RJA and IJA were not related to communication skills. A model containing LA1 ($\beta = .495, t(16) = 2.288, pr = .036$) and LA3 ($\beta = .582, t(16) = 3.638, pr = .002$) explained 70% of the variance in communication skills. DQ3 ($\beta = .887, t(17) = 6.002, pr = .001$) and DQ1 ($p = .899$) predicted 74% of the variance in communication skills. Early childhood language (i.e., LA1) accounted for additional variance in adult communication skills not explained by change in language from the first to the third assessment. However, change in DQ from time 1 to time 3 appeared to mediate the relationship between early childhood DQ and adult communication skills.

Social skills did not differ between the second, third, and fourth assessments ($F(2, 30) = .273, p = .763$). LA1 explained 51%, DQ1 explained 22%, and RJA explained 34% of the variance in raw scores on the socialization domain at time four, while IJA was not significantly related to social skills. When LA1 ($\beta = .687, t(14) = 2.446, pr = .028$) and early childhood RJA ($p = .232$) were simultaneously entered into a regression model, it accounted for 50% of the variance in social skills. A model containing LA3 ($\beta = .588, t(13) = 2.522, pr = .025$), LA1 ($\beta = .508, p = .062$), and RJA ($\beta = -.111, p = .662$) explained 64% of the variance in social

skills. When early childhood RJA ($\beta = .513, t(15) = 2.394, pr = .030$) and DQ1 ($p = .245$) were simultaneously entered into a regression model, the model accounted for 38% of the variance in social skills. A model containing DQ3 ($\beta = .798, t(14) = 3.414, pr = .004$), DQ1 ($\beta = -.018, p = .923$), and RJA ($\beta = .067, p = .755$) explained 63% of the variance in social skills. Thus, all early childhood variables except IJA were related to adult social skills. While relationships between RJA and adult social skills may have been mediated by LA1, associations between LA1 and adult social skills may in turn have been mediated by change in language skills from time one to time three. Additionally, change in DQ from time 1 to time 3 appeared to mediate relationships between RJA and adult social skills. Thus, RJA influenced adult social skills through concurrent relationships with early childhood language and predictive associations with change in DQ.

ADI-R Symptoms

Social interaction algorithm scores changed between the second, third, and fourth assessments ($F(2, 28) = 4.829, p = .016$). T tests indicate that symptoms decreased from time two to time three ($t(14) = 2.94, p = .011$), and then increased from time three to time four ($t(15) = -2.20, p = .044$). Social symptoms did not differ between the second and fourth assessments. RJA explained 33% and LA1 explained 30% of the variance in social symptoms while DQ1 and IJA were unrelated to social symptoms. When early childhood RJA ($p = .135$) and LA1 ($p = .057$) were simultaneously entered into a regression model, the model accounted for 46% of the variance in social functioning. While a model containing LA1, LA3, and RJA explained 42% of the variance in social symptoms, none of

Table 4 Characterization of overall social functioning in adulthood

Participant	Independence	Type of work	Friendship	Overall functioning	Seizures	Medications
1	Family home: can go out alone	Full-time maintenance work at parents' day care	Close friend, shares common interests	Very good	No	For attention
2	Family home: manages own budget	Full-time medical filing clerk	Multiple friends and has dated	Very good	No	For anxiety
3	Own apartment in different state than parents	Full-time manager of small airline	Multiple friends, no dating	Very good	No	No
4	Family home: can go out alone	Full-time work for coca cola and just earned AA	Has friends but they introduced him to a gang and took advantage of him	Very good	No	No
5	Family home: supervised in community	Community college: studying to be history teacher	Extends interest-based friendships outside group situations	Good	No	No
6	Family home: looking for apartment	In college: studying the environmental effects of the workspace	Acquaintances in group situations	Good	No	No
7	Own apartment: weekend staff	Part-time supported employment: art production	No friends	Fair	NA	NA
8	Family home: always supervised	Sheltered employment at community service center: money changing	No friends	Fair	Yes	For blood pressure, cholesterol, stomach pain, epilepsy
9	Family home: supervised in community	Custodial work at program: cleaning pews and shredding paper	No friends	Fair	No	No
10	Own apartment: help with cleaning and taxes	Not employed	No friends	Fair	No	NA
11	Group home: can go out alone	Sheltered workshop part-time	No friends	Poor	No	Mood stabilizer
12	Group home: can go out alone	Sheltered workshop part-time	No friends	Poor	No	Mood stabilizer
13	Group home: always supervised	Not employed	No friends	Poor	Yes	For behaviors, epilepsy
14	Family home: mom and caregiver supervise	Not employed	No friends	Poor	No	For behaviors, anxiety, depression
15	Family home: Weekend caregiver and family supervision	Not employed	No friends	Poor	No	Antipsychotics
16	Group home: always supervised	Sheltered employment: sorting things and loading water bottles	No friends	Poor	No	Multiple antipsychotics, mood stabilizers, anxiolytics
17	Group home: always supervised	Not employed	No friends	Poor	No	For aggression, mood, Tourettes, insomnia
18	Group home: can go out alone	Not employed	No friends	Poor	No	Mood stabilizers
19	Family home: supervised in community	Not employed	No friends	Poor	Yes	For epilepsy
20	Group home: constant supervision	Supported program: food preparation, filing, and paper shredding	No friends	Poor	No	Mood stabilizer

the predictors was significantly related to social symptoms. Thus, RJA and LA1 accounted for overlapping aspects of adult social symptoms and there was no evidence that change in language mediated the relationship between RJA and social symptoms.

Neither non-verbal communication algorithm scores ($F(2, 28) = .408, p = .669$) nor restricted and repetitive behavior algorithm scores ($F(2, 28) = 2.789, p = .079$) changed across the second, third, and fourth assessments. RJA accounted for 47% of the variance in non-verbal symptoms at time four, while DQ1, LA1, and IJA were not related to non-verbal communication. No early childhood scores predicted restricted and repetitive behaviors.

Discussion

The social functioning outcomes of participants in the current study are comparable to those reported by Eaves and Ho (2008) for another population born in the 1970s and 1980s with similar intelligence levels. Both studies suggest that adult social functioning outcomes for individuals with autism may be improving gradually. Additionally, somewhat better outcomes were also noted when comparing longitudinal studies conducted after 1980 to those conducted prior to 1980 (Howlin and Goode 1998). This trend is probably due to the increasing availability of services, particularly as similar outcomes were obtained for individuals born prior to 1972 who participated in intensive community based interventions (Kobayashi et al. 1992).

Selective attrition of particularly low functioning individuals with autism may have inflated the proportion of participants with better outcomes in the current study. While the average intelligence level at first assessment of the twenty participants in the current report was quite low ($M = 54.65$), it was higher than the average intelligence level of the fifty participants who were lost to attrition ($M = 47.18$). Although other studies documenting slight increases in positive outcomes have not lost as many participants to attrition as were lost in the current study, comparisons between participants who were and were not lost were not reported in those studies (Eaves and Ho 2008; Kobayashi et al. 1992). Therefore, as Eaves and Ho also acknowledged, increasingly positive outcomes in more recent longitudinal studies of adult outcomes in autism may be at least partially due to selective attrition of lower functioning participants.

Language skills and RJA, but not intellectual functioning, predicted adult social functioning. Intellectual functioning may have been less prognostic than in other longitudinal studies because the average age of first assessment was quite young in this study (see Table 2), NVIQ was not assessed, and/or intelligence may

discriminate best among those with poor and very poor outcomes (Rutter et al. 1967). Moreover, very poor outcomes are no longer as prevalent due to improvement in services, as well as deinstitutionalization, or the ongoing migration of disabled populations from institutions to community residential arrangements. Some of the predictive potential of language ability (in terms of social functioning) appears to be due to its relationship with RJA, which may have scaffolded changes in DQ and LA. However, it was not possible to determine if predictive relationships between RJA and social functioning were mediated by change in skills with development.

While early childhood LA and DQ were related to all VABS domains, RJA was only related to the social skills domain. Indeed, relationships between RJA and social skills appeared to be mediated by change in intelligence from time one to time three. RJA was also related to social symptoms and non-verbal communication in adulthood. Thus, early childhood RJA may be particularly predictive of social behaviors in adulthood. The lack of a relationship between IJA and any of the outcome measures may demonstrate the prognostic value of more involuntary non-verbal communicative behaviors (Mundy et al. 2007) for adult social outcomes.

Factors other than RJA contributed to relationships between changes in DQ and LA and adult outcomes, as evidenced by the finding that changes in DQ and LA from time one to time three predicted VABS daily living and communication skills in the absence of direct connections between RJA and these skills. Maternal behaviors, such as synchrony, were associated with increases in RJA, IJA, and language for many of the participants in the current study across the first, second and third assessments (Siller and Sigman 2002). Thus, parental behaviors which were not assessed in the current analyses may have also influenced adult outcomes.

The robust relationships between changes in DQ and LA from a mean age of 4 to a mean age of 18 and both VABS scores and social functioning illustrate several important points. First, this finding highlights the importance of skills such as RJA that facilitate learning from others. Second, these results illustrate the potentially powerful impact of early interventions and parental behaviors which promote linguistic and cognitive growth (Kasari et al. 2008; Rogers 1996; Siller and Sigman 2002). Finally, our findings suggest that clinicians should be cautious when counseling parents on what to expect in the future based on early childhood abilities. The latter point is buttressed by the finding that the most consistent predictors of adult outcomes in this study were not early childhood characteristics, but changes in language and mental age between the first and third assessments.

When using VABS raw scores rather than the age equivalents used by McGovern and Sigman (2005), only

daily living skills show strong evidence of improvement across development. Arguably, Daily Living Skills is the VABS domain which is the most amenable to explicit instruction. Increases in VABS socialization scores in younger populations than the one studied here may be due to greater availability of effective interventions for younger cohorts (Anderson et al. 2009). Possibly due to a small sample size and low power, limited evidence of change in ADI-R symptoms with development was evident in the current sample. Our results suggest that, even when symptoms and abilities are correlated, they may develop differently.

Several factors may limit the generalizability of these findings. The small sample size, reliance on telephone interviews, and biased gender ratios are common limitations across longitudinal studies (Eaves and Ho 2008; Larsen and Mouridsen 1997; Mawhood et al. 2000; Szatmari et al. 1989). Reliance on parent report of adult outcomes reduced the depth of information available and may have introduced recall biases particularly about those individuals who were no longer living with family. Direct assessment of the individuals with autism themselves may have allowed for more detailed comparisons between characteristics assessed in early childhood and again in adulthood. However, telephone interviews were selected for practical reasons, as Eaves and Ho (2008) also noted. For example, many participants had moved out of the state. Additionally, while participants from earlier stages of this study did not differ from current participants in terms of age at first assessment, they did differ in terms of DQ and LA in a manner suggestive of selective attrition of lower functioning individuals.

Environmental characteristics, such as socioeconomic status, available services, and parental behaviors, were not assessed and may be related to the outcomes of interest. Furthermore, the generalizability of these results to children who are newly diagnosed may be limited by changes in diagnostic criteria, a primarily low-IQ sample, and changes in the quality and quantity of available interventions. Additional individual characteristics which we did not assess, such as theory of mind and executive function, may also have influenced adult outcomes. However, joint attention reflects emerging social cognition and may be a precursor to theory of mind (Charman et al. 2000). Concurrent relationships between joint attention and executive function in early childhood suggest that difficulties recognizing stimulus-reward contingencies may influence the development of joint attention and executive functions in autism (Dawson et al. 2002). Many aspects of executive functioning are concurrently related to the adaptive behavior skills of children with autism (Gilotty et al. 2002) and thus might be expected to predict changes in adaptive behavior. Future research in this area should assess

relationships between joint attention and executive function longitudinally, particularly in relation to adult outcomes.

While relationships between RJA, language functioning, and adult outcomes illustrate the importance of joint attention interventions, the outcome measures used in this study were based on caregiver perceptions of outcomes. Individuals classified as having a “poor” outcome may experience life as happy and valued members of their communities (Ruble and Dalrymple 1996). Future longitudinal studies of outcome in autism would benefit from multidimensional measures both during initial assessment and follow-up. Measures that we recommend for future studies include early childhood RJA, measures of executive function, detailed information about education and interventions, and multiple outcome measures, including direct interviews that allow the individuals with autism themselves to describe and evaluate their own social and adaptive functioning.

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Appendix: Calculating Social Functioning

Independence Interviewer asked: Where/with whom does your child live?

- 0 = living independently
- 1 = semi-sheltered accommodation (or still at home) but with a high degree of autonomy
- 2 = living with parents, some limited autonomy
- 3 = in residential accommodation with some limited autonomy
- 4 = specialist autistic or other residential accommodation with little or no autonomy
- 5 = in hospital care or at home because nowhere else would accept the individual

Work Interviewer asked the following set of questions from highest to lowest level of employment until one was endorsed.

- 0 = Is your child employed or self employed?
- 1 = Is your child involved in voluntary work or job training?
- 2 = Is your child involved in supported or sheltered employment?

3 = Is your child in a special center or not employed?

Friendship This was calculated from parent response to question 65 of the ADI-3. Interviewer asked: Does your child have any particular friends or a best friend?

0 = One or more friendships defined by mutual reciprocity/responsiveness

1 = One or more relationships outside of prearranged situations but limited in terms of restricted interests or reciprocity

2 = Relationships involving seeking contact but only in group situations

3 = No peer relationships involving selectivity or sharing

Overall Social Functioning Assigned based on summed composite of scores on the above three domains.

0 = Very Good outcome—i.e. achieving a high level of independence, having some friends or a job (total from all 3 areas above 0–2)

1 = Good outcome—generally in work but requiring some degree of support in daily living; some friends and acquaintances (total 3–4)

2 = Fair outcome—has some degree of independence, and although requires support and supervision does not need specialist residential provision; no close friends but some acquaintances (total 5–7)

3 = Poor outcome—requiring special residential provision/high level of support; no friends outside of residence (total 8–10)

4 = Very Poor—needing high-level hospital care, no friends; no autonomy (total 11)

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