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Review

Assessment of joint attention in school-age children and adolescents☆

Jessica L. Bean, Inge-Marie Eigsti *

Department of Psychology, University of Connecticut, Storrs, CT, United States

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ABSTRACT

Joint attention (JA), the ability to share attention to an object or event with another person, is one of the earliest identified deficits in autism spectrum disorders (ASD) and directly influences language and social development. There are several effective assessments of JA for young children (e.g., Mundy et al., 2003), but none are appropriate for school-age or adolescence. We developed a measure of response to JA and assessed individuals with ASD ($n = 18$) and typical development ($n = 24$), ages 7 to 17. Six naturalistic prompts were interleaved throughout a testing session. Discriminative validity was high: there was a broad range for both groups, though scores were lower for children with ASD. Scores in the ASD group were associated with receptive language, symptomatology, and theory of mind. Reliability across examiners was high ($\kappa = .875$). This measure, which requires no special equipment and minimal training, was useful in capturing JA skills in older individuals with and without ASD. Further, scores were associated with theoretically related skills, indicating high external validity. Given the powerful developmental sequelae and numerous interventions for JA, this measure offers a longitudinal assessment opportunity.

Contents

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* Corresponding author at: University of Connecticut, Department of Psychology, 406 Babbidge Rd, Unit 1020, Storrs, CT 06269, United States. Tel.: +1 860 486 6021; fax: +1 860 486 2760.
E-mail address: inge-marie.eigsti@uconn.edu (I.-M. Eigsti).

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1. Introduction

Joint attention is a social process that involves sharing focus with another person on an object or event (Moore & Dunham, 1995). Joint attention emerges during the first months of life, follows a well-documented trajectory through toddlerhood (Kaplan & Hafner, 2006), and continues as children acquire more sophisticated social (e.g., theory of mind, TOM) and linguistic abilities (Carpenter, Nagell, & Tomasello, 1998; Kaplan & Hafner, 2006). Despite its central importance in development, there is limited empirical literature on joint attention skills in later childhood and adolescence. A major limiting factor is the lack of appropriate measurement tools.

Joint attention deficits reliably distinguish autism spectrum disorders (ASD) from other developmental disorders. Young children with ASD demonstrate fewer responses to and initiations of joint attention than their peers (MacDonald et al., 2006). Deficits are thought to shape later development (Ventola et al., 2007), including expressive and receptive language abilities (Mundy & Gomes, 1998), social cognition (Barton & Tomasello, 1991), and self-regulatory behaviors (Raver, 1996).

Theoretical models of joint attention hint at a developmental trajectory that continues into adolescence. The *multiple processes model* suggests that joint attention is strongly associated with executive functions, specifically inhibition and shifting (Mundy, Card, & Fox, 2000), and it has been linked to networks in frontal and parietal cortices (Mundy & Thorp, 2006). Neural and behavioral studies document that these regions undergo structural and functional changes into adolescence (Giedd et al., 2009), raising the possibility that joint attention skills may also continue to develop and modulate later stages of development. Studies focusing on "social brain" areas also document maturation and reorganization into early adulthood (Burnett, Sebastian, Cohen Kadosh, & Blakemore, 2011; Nelson & Guyer, 2011). Because neurodevelopmental maturation in ASD likely follows a different trajectory (Cheng, Chou, Fan, & Lin, 2011), tracking behavioral manifestations of social cognitive abilities is critical for measuring the efficacy of earlier interventions and characterizing the developmental trajectories of diagnostic subtypes.

Currently, joint attention skills are effectively assessed in *young* children using the Early Social Communication Scales (ESCS; Mundy et al., 2003; Seibert, Hogan, & Mundy, 1982) and Modules 1–2 of the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, & DiLavore, 1999). These measures evaluate a child's response to semi-structured prompts requiring triadic gaze between the experimenter and an object or event (e.g., saying "Look!" and pointing at a toy). These measures are appropriate for children up to 30 months (ESCS) and those with two-word phrase speech (ADOS), but are less useful for characterizing deficits in older children.

Researchers have explored joint attention in older children (e.g., Hobson & Hobson, 2007; Hobson & Lee, 1998; Hobson, Lee, & Hobson, 2010) by examining "shared looks" to an object or activity partner along with other markers of engagement (i.e., personal pronoun use, gestural imitation, and greetings); in each study, researchers used one type of prompt or one situation during which they observed and coded joint attention (e.g., looks to a second examiner when referred to by the primary examiner in the context of a game, Hobson et al., 2010). Participants with ASD and intellectual disabilities had fewer shared looks or "relatedness triangles" than their intellectually disabled, non-ASD peers (Hobson & Lee, 1998). Although these single-item studies provide a useful assessment of joint attention, a more comprehensive and subtle measure is needed for high functioning, older individuals on the spectrum, many of whom have participated in interventions specifically addressing joint attention. Such a measure could yield a more continuous, graded measure of joint attention skills.

Given the theoretical impact of joint attention in later development and the lack of age-appropriate, comprehensive tools for older children, a measure is needed to track joint attention development, illuminate the nature of the relationship between cortical and behavioral trajectories, monitor its influence on associated skills, and longitudinally evaluate intervention outcomes. The ADOS and ESCS achieve these goals effectively, but their utility is limited once children age out of

Table 1
Origins of prompts used in the joint attention measure.

Source of prompt	Current name	Action designed to measure	Current form
ESCS (Mundy et al., 2003)/ADOS Module 1 (Lord et al., 1999)			
Social imitation/anticipated routine	Handshake	Response to examiner modeling a predictable social routine	Routine changed from a longer routine (e.g., following a birthday party script) to a more age-appropriate handshake
Social imitation/anticipated routine	Give pen	Response to examiner modeling a predictable social routine	Interaction involving use of pen rather t han a toy
Gaze following	Personal object	Ability to follow examiner's gaze to an item of interest	Gaze to an object of the child's interest, rather than a novel toy
Respond to name	Call name	Child's ability to disengage from his/her current focus	Prompt occurs when child is otherwise engaged with an interesting activity
Bacon et al. (1998)			
Lost pen out of examiner's view	Lost pen	Child's ability to recognize the object of examiner's interest	Prompt occurs during the testing situation
Hobson and Lee (1998)			
Greetings	Introduction	Child's response to a greeting opportunity	Age-appropriate prompt occurs when child would naturally be introduced to a new person

toddlerhood. For example, it is not feasible to assess shared attention to a bubble machine or to a mechanically activated toy with for school-age individuals, who are less intrinsically interested in these activities and objects. Single-prompt scales, such as the greeting and tower studies designed by Hobson and colleagues, are ideal for establishing the straightforward presence or absence of triadic attentional abilities, but do not measure more subtle variability. The current study extends these established measures (see Table 1), providing a set of modified and novel prompts that are developmentally appropriate for older children and which elicit a wider set of skills. This measure is useful in both clinical and research efforts, providing a characterization of joint attention skills that are often the target of early intervention and a marker of developmental progress. This measure is sufficiently subtle to characterize abilities in typically developing adolescents and is, therefore, useful for assessing joint attention in individuals with ASD who experience ‘‘optimal outcomes’’ (Helt et al., 2008; Sutera et al., 2007).

In this study, we describe a brief naturalistic measure of response to joint attention utilizing examiner-led prompts, designed to mirror established tools (i.e., ADOS Modules 1–2, ESCS), and that is appropriate for ages 7–17 years. There were two primary goals. First, differences in performance of individuals with ASD and with typical development (TD) were used to index the measure's sensitivity to joint attention skills. Second, the measure's external validity was evaluated using standardized assessments of social and communicative skills. We predicted that the joint attention task would differentiate between groups and would correlate with measures of theoretically-linked skills (e.g., receptive language, TOM), but not with more general measures (e.g., cognitive abilities).

2. Methods

2.1. Participants

Participants were 42 individuals (27 males) ages 7–17 years; the sample was predominantly Caucasian ($n = 39$). Participants were diagnosed with an ASD ($n = 18$) or were TD ($n = 24$). Individuals in the ASD group met DSM-IV-TR criteria for Autistic disorder, Asperger's Syndrome, or Pervasive Developmental Disorder-Not Otherwise Specified; experienced clinicians confirmed diagnoses using the ADOS, the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994), and clinical judgment. Autism was diagnosed when a participant received an ADOS Social Communication score above 10 and there was a language delay reported on the ADI-R; PPD-NOS was diagnosed when a participant received an ADOS score between 7 and 10 and there was a language delay reported on the ADI-R; Asperger's was diagnosed when a participant received an ADOS score above 7 and there was no language delay reported on the ADI-R. Participant details are given in Table 2. Participants were excluded if they had a history of seizures or a full-scale IQ below 85, to limit the confounding factor of intellectual disability. TD participants were excluded if they had a diagnosed learning disability or a first-degree relative with ASD. Seven children were excluded from the initial sample on the basis of low IQ ($n = 2$), a previous learning disability ($n = 2$), unconfirmed ASD diagnoses ($n = 2$), and a history of seizures ($n = 1$). All procedures were reviewed and approved by the University's Institutional Review Board.

2.2. Experimental joint attention measure

The joint attention scale consisted of six naturalistic examiner-initiated prompts designed to elicit a response to joint attention.[1] The child sat across from the experimenter, on the other side of a small table. Prompts were embedded in between other tasks in the testing session (i.e., during casual conversations, in between standardized assessments), at times when the participant was visually engaged with another task or object (e.g., looking at objects on the table or playing with personal items). The experimenter did not administer prompts when the child was visually engaged on the examiner, as this situation would not allow for a disengagement from the current focus. Based on prior research (e.g., Hobson & Lee, 1998), prompts required participants to engage in triadic gaze (i.e., ‘‘correct response’’); refer to Table 1 for a history of the prompts design. For example, in the ‘‘*give pen*’’ prompt, the correct response required that participants shift gaze from the experimenter to the pen, and take the pen after it was offered by the experimenter. Responses were scored such that higher scores marked more social responses, with points awarded for each of the following: (1) engaging in triadic attention; (2) looking at the examiner's face; (3) making eye contact; and (4) offering a spontaneous, relevant verbalization (e.g., ‘‘Did you need something?’’). Based on prior research, prompts were subdivided into two types: (1) whether the experimenter's prompt was verbal (verbal, $n = 4$, or nonverbal, $n = 2$) and (2) the number of attentional shifts required for a ‘‘correct response’’ (single-shift, $n = 4$, or dual-shift, $n = 2$). All responses were scored in vivo by a graduate clinician and video-recorded for later analysis and reliability scoring.

Finally, in order to assess the ‘‘naturalness’’ of the joint attention prompts, and to assess whether participants were responding out of an explicit perception of experimenter demands, all children answered four questions about the joint attention interaction. A first question asked, ‘‘Did you notice any special about what we did today?’’ Sixteen children (38 percent) said ‘‘yes’’, but none mentioned the joint attention prompts (e.g., they said, ‘‘Yes, the memory games were fun!’’). A second question asked, ‘‘Did you notice anything special about our conversation?’’ In response, eight children (21 percent)

[1] Detailed descriptions of the six prompts and a transcription of an ASD participant responding to the prompts are available upon request.

Table 2
Participant demographics.

	ASD ($n = 18$)	TD ($n = 24$)	F	p	η_p^2
Age (years)	12.8 (3.0); 7.7–17.2	13.0 (2.7); 8.1–17.8	.07	.80	.002
ADOS, Social Communication[a]	9.9 (3.9); 4–20[b]	N/A			
SCQ Total[a,**]	20.7 (6.5); 9–33	1.3 (1.0); 0–4	213.01	<.001	.852
Modified SCQ[c,**]	20.9 (4.2); 13–26	13.0 (4.0); 6–20	34.53	<.001	.483
NEPSY-II TOM Verbal Raw Score[d,*]	18.6 (3.16); 12–22	20.3 (1.8); 14–22	4.84	.03	.116
FSIQ[e]	104.2 (11.2); 85–127	105.4 (11.5); 88–139	.12	.73	.003
PPVT-III[f]	110.4 (13.2); 83–131	115.9 (10.8); 100–147	2.18	.15	.052
CELF-4, Core Language[g,*]	102.3 (14.6); 78–126	111.8 (8.3); 97–130	7.00	.01	.152

Note: Data are presented as *M (SD); Range*. IQ, PPVT-III, and CELF-4 measures are standard scores with $M = 100$ and $SD = 15$.
[a] Social Communication Questionnaire (SCQ) scales and ADOS are presented as sum scores; higher scores indicate greater symptom severity.
[b] The participant with a score of 4 was included on the basis of ADI-R, SCQ, and clinical judgment data. Analyses were run with and without this participant and findings were unchanged.
[c] Modified SCQ score has a possible range of 6–30; scores are based on ratings of 1–5 for the six joint attention items on the SCQ. Higher scores represent more significant impairments.
[d] NEPSY-II TOM Verbal has a possible range of 0 to 22; higher scores represent more correct responses.
[e] FSIQ: Stanford-Binet Abbreviated IQ.
[f] PPVT-III: Peabody Picture Vocabulary Test-III.
[g] CELF-4: Clinical Evaluation of Language Fundamentals-4.
[*] $p < .05$
[**] $p < .001$

said "yes"; only one 17-year-old TD participant noted "I could tell after awhile that you were trying to see my reaction." A third question asked, "Did anything about our conversation seem rehearsed or practiced?" In response, 13 children (33 percent) said "yes," and then mentioned the standardized assessment instructions; none mentioned a joint attention prompt. Responses were recorded and coded for any direct or indirect mention of the joint attention prompts.

2.3. Inter-rater reliability

A trained research assistant, naïve to diagnosis, coded 20% of participant videos ($n = 10$). Eye contact scores were excluded from reliability coding due to the difficulty of accurately determining gaze fixation from video. Inter-rater reliability was very high (agreement = 94.2%) and Cohen's kappa, accounting for chance agreement, was in the highly reliable range ($\kappa = .875$).

2.4. General cognitive and language functioning

Participants completed the Stanford–Binet Abbreviated IQ (FSIQ; Roid, 2003) as a measure of cognitive ability, and the Clinical Evaluation of Language Fundamentals (CELF-4; Semel, Wiig, & Secord, 2003) and Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997) as measures of language functioning. The ASD and TD groups did not differ in chronological age, FSIQ, or PPVT-III, all p's > .15, as shown in Table 2. The TD group had significantly higher language scores (CELF-4), $p = .01$, and, as expected, no ASD symptomatology (Social Communication Questionnaire, SCQ; Rutter, Bailey, & Lord, 2003), $p < .001$.

2.5. Social ability/cognition

Participants in the ASD group completed the ADOS and all children completed the NEPSY-II TOM subtest (Korkman, Kirk, & Kemp, 2007) as measures of social functioning and knowledge. The TOM task provides a verbal raw score, as well as a total raw score, which includes items testing facial expression perception. The verbal items are most analogous to commonly used TOM tasks; as such, the verbal scale items were used for all analyses. The NEPSY-II task yields noncontinuous percentile ranges rather than standard scores, so raw scores were converted into residualized scores, covarying for mental age; these scores were used in subsequent analyses.

2.6. Parent report measures

Parents completed the SCQ and the Social Responsiveness Scale (SRS; Constantino, 2005). The SCQ is a yes/no questionnaire assessing symptoms of ASD; higher scores indicate more severe symptomatology. Following standard administration, parents were asked to rate six SCQ items from 1 to 5 (1, "multiple times per day" to 5, "never") to provide a continuous measure of joint attention. The SRS measures social reciprocity; higher scores indicate more significant difficulties.

3. Results

3.1. Joint attention measure and discriminative validity

One-way ANOVAs assessed whether joint attention scores discriminated between groups with and without ASD. Total joint attention scores differed significantly for ASD and TD groups, $p < .001$, and demonstrated excellent variability within each group, as shown in Table 3. Item scales (i.e., verbal/nonverbal and single/dual-shift) further differentiated between the ASD and TD groups, p's $< .01$.

3.2. External validity

Nonparametric correlations evaluated associations between joint attention total and subscale scores, and standardized social and language measures. Scatterplots were visually inspected for artifacts. Correlations are presented in Table 4.

Within the ASD group, joint attention total, $r = .48$, $p = .04$, and single-shift prompt, $r = .49$, $p = .04$, scores were significantly correlated with receptive vocabulary (PPVT-III score), indicating that better joint attention was associated with better receptive language. Joint attention performance was also correlated with age for the ASD group, $r = .50$, $p = .03$, but not the TD group, $r = -.01$, $p = .97$, consistent with the possibility that triadic gaze continues to develop for the ASD group, whereas children with TD have already mastered this developmental milestone. Within the TD group, joint attention was not associated with any standardized assessments of general cognition (FSIQ) $r = -.10$, $p = .63$, and language abilities (PPVT-III) $r = -.36$, $p = .09$ and (CELF-4) $r = -.31$, $p = .15$.

Because some participants had better language abilities than others (i.e., CELF-4), we assessed responses to verbal and nonverbal cues separately. For the ASD group, social abilities were associated with joint attention. Specifically, response to verbal joint attention prompts was significantly correlated with SCQ Social, $r = -.53$, $p = .04$, and SCQ Communication, $r = -.61$, $p = .02$, such that greater symptom severity was associated with lower scores on our joint attention measure. Verbal TOM was correlated with joint attention for verbal, $r = .53$, $p = .04$, and single-shift, $r = .57$, $p = .02$, prompts; participants with better insight had better joint attention. Nonverbal prompts were not significantly correlated with *any* of the social measures, p's $> .14$. Importantly, the joint attention measure was not correlated with ADOS Social Communication, $r = -.30$, $p = .25$, highlighting that our measure is not simply tapping general social relatedness. For individuals with TD, again, there were no significant correlations (with the joint attention total, verbal items, and nonverbal items scores), with all p's $> .15$.

Table 3
Joint attention total and subscale scores.

	ASD ($n = 18$)	TD ($n = 24$)	F	p	η_p^2
Total (possible range)					
6-Item Total (0–24)***	11.4 (2.8); 7–18	18.4 (2.2); 14–22	83.33	<.001	.673
Subscales					
Verbal Items (0–16)***	7.9 (2.5); 3–13	11.7 (1.7); 3–13	44.24	<.001	.525
Nonverbal Items (0–8)***	3.1 (1.4); 1–7	5.7 (1.0); 4–7	47.05	<.001	.541
Dual-shift Items (0–4)**	2.4 (.77); 1.3–3.7	2.9 (.47); 2–3.7	6.55	.01	.141
Single-shift Items (0–4)***	1.8 (.44); .8–2.8	3.0 (.40); 2–3.6	83.21	<.001	.675

Note: Data are presented as *M (SD); Range* of observed scores. Higher scores represent better joint attention. The maximum possible range for each item is listed in parentheses next to the item name.
** $p < .01$
*** $p < .001$

Table 4
Correlations between joint attention measure scores and standardized assessments.

	Age (years)	FSIQ	PPVT-III	CELF-4, Core Language	SCQ, Total	NEPSY-II	Joint Attention Total
Age (years)		**−.64****	−.29	−.26	.10	.28	.01
FSIQ[a]	.05		**.64****	**.46***	−.19	−.07	−.10
PPVT-III[b]	.26	.41		**.42***	−.03	−.14	−.43
CELF-4, Core Language[c]	.07	**.54***	**.88****		−.08	.24	−.31
SCQ, Total[d]	−.26	−.01	.19	.15		.18	.09
NEPSY-II Theory of Mind-Verbal	**.51***	−.02	.44	.47	−.09		−.31
Joint Attention Total[e]	**.50***	−.07	**.48***	.17	−.17	.41	

Note: Participants with ASD are *below* the diagonal; participants with typical development are *above* the diagonal. Significant correlations are in **bold font**.
[a] FSIQ: Stanford-Binet Abbreviated Fullscale IQ.
[b] PPVT-III: Peabody Picture Vocabulary Test-III.
[c] CELF-4: Clinical Evaluation of Language Fundamentals-4.
[d] SCQ: Social Communication Questionnaire.
[e] Joint Attention Scores were non-normally distributed, so correlations were evaluated using nonparametric statistics (e.g., Spearman's rho).
* $p < .05$
** $p < .001$

In summary, for individuals with ASD, better performance on the experimental joint attention measure was related to better performance on measures of receptive language, parent-report joint attention, and TOM, but not general measures of cognition (i.e., FSIQ) or social relatedness (i.e., ADOS Social Communication). Further, scores on verbal prompts were associated with symptom severity and TOM while nonverbal prompts were not, possibly reflecting the limited variability within the two nonverbal prompts and/or a ceiling effect on these prompts. For the TD group, no associations reached the level of significance.

4. Discussion

The goal of this study was to describe a measure of joint attention appropriate for school-age children and adolescents. First, we reported that joint attention skills differed strikingly for individuals with ASD and TD. Additionally, even TD participants showed a range of scores (14–22), suggesting that joint attention skills vary even in adolescence and that this measure may be sensitive enough to detect subtle differences. Second, this study explored the external validity of this tool through standardized and parent-report measures of associated skills. Within the ASD group, overall joint attention and single-shift prompt scores were correlated with receptive language, consistent with prior studies (Mundy & Gomes, 1998; Tomasello & Farrar, 1986). Joint attention to verbal prompts was also correlated with TOM, social communication, and parent report of joint attention. Within the TD group, correlations were not significant, likely reflecting the generally high scores on both the joint attention and the social, language, and TOM measures. The measure had excellent inter-rater reliability, suggesting it can be administered by individuals after brief training and yield reliable scores.

While a strength of this study, the novelty of this type of measure for older children means that there are no known assessments of joint attention with which to compare this measure for concurrent validity. Although measures of theoretically-related skills were included in this project, future studies comparing this measure to independently developed assessments of joint attention in older children will be important. Also limiting the generalizability of findings, the data were drawn from a sample of relatively homogeneous participants, in reference to language and cognitive skills. The inclusion of multiple diagnoses in the ASD group may increase generalizability to children with social difficulties; however, the inability to compare subgroups of children with ASD is a limitation of this study. Additionally, the measures of social cognition (e.g., SCQ), as well as standardized assessments of language, cognition, and TOM, had reduced variability in the TD group, decreasing our sensitivity to individual differences. Furthermore, examiner and individual effects are inherent to an interactive assessment; we limited such effects by using multiple administrators and coders, but replication is needed. Finally, we attempted to assess the naturalistic quality of this assessment through debriefing questions; however, observations and coding outside of the clinical setting should be explored (e.g., in the waiting room prior to testing), to limit the ‘‘contrived,’’ and potentially confounding factor of only measuring children’s responses in the formal setting of an examination.

Results suggest the utility of this brief, naturalistic measure of joint attention in older children and adolescents. This measure, which requires no special equipment, assesses subtle individual differences; as such, it will facilitate the empirical investigation of the developmental trajectory of joint attention through adolescence.

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