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ORIGINAL ARTICLE

Social-Communication Intervention for Toddlers with Autism Spectrum Disorder: Eye Gaze in the Context of Requesting and Joint Attention

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Abstract Beginning in infancy, before a diagnosis is made, children with Autism Spectrum Disorder (ASD) show significant impairments in the foundation for social-communication interactions including eye gaze in the contexts of both requesting and joint attention (JA). Addressing these early impairments as early as possible in toddlers who receive the diagnosis of ASD provides them with a foundational social-communication repertoire necessary for learning. In this study we examined the effects of a social-communication intervention involving prompting and reinforcement to teach gaze shift (GS; shifting gaze from an object to the interventionist's eyes) in the context of responding to a request and initiating JA to four toddlers with ASD. Intervention lasted 3–9 weeks with all toddlers demonstrating GS to mastery across both contexts. Toddlers also showed generalization to a repertoire of social-communication behavior, including initiating requests and increases in smiling. Some improvements in symptoms of ASD and overall functioning were observed. Results suggest a promising brief intervention to address the earliest form of social communication that remains a part of successful social-communication interactions throughout life.

Keywords Autism spectrum disorders · Toddlers · Eye gaze · Gaze shift · Requesting · Joint attention

The identification of early risk markers in infants who later receive a diagnosis of Autism Spectrum Disorder (ASD) reveals how the foundation for competent social-

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communication interactions is already significantly impaired at this young age (Zwaigenbaum et al. 2005). Perhaps one of the most striking characteristics of children with ASD is the impairment in eye gaze or gaze shift (GS; shifting gaze from an object to the social partner's eyes) during social-communication interactions. Infants later diagnosed with ASD show a decline in fixation on the social partner's eyes from 2 to 6 months of age (Jones and Klin 2013).

Eye gaze occurs within a social-communication context. During the first year of life in children with ASD, impairment in eye gaze is already evident in the social-communication contexts of requesting (to obtain a specific reinforcer such as food, toys, etc.) and joint attention (JA) (to obtain social interaction and attention, a generalized social reinforcer) (Ibañez et al. 2013; Rozga et al. 2011; Zwaigenbaum et al. 2005). JA continues to be impaired in preschoolers and older children with ASD (Paparella et al. 2011), though requesting is perhaps less so (Mundy et al. 1986). However, requesting may take unconventional forms (e.g., autistic leading, grabbing; Drasgow et al. 1998). In both of these contexts, the absence of eye gaze is most pronounced when the child with ASD initiates interaction (Barbaro and Dissanayake 2013), that is, when the child begins the interaction in the absence of another person's prompts. The impairment in eye gaze across social-communication contexts, and especially when initiating interaction, continues to be a hallmark characteristic of ASD throughout life (American Psychiatric Association 2013).

Atypical eye gaze from early in life means that children with ASD miss out on numerous interactions. When children do not respond to caregiver requests, the interaction with the caregiver may easily break down. For example, simply looking at the caregiver following her request for the child's book acknowledges the caregiver's request and continues the interaction; not looking at the caregiver would clearly end the interaction, and, in this case, likely ends the opportunity for the child and caregiver to read together. When children do not initiate requests, their needs may not be met and they may resort to problem behavior (Carr and Durand 1985). The absence of eye gaze during JA interactions also means children miss the opportunity to observe a caregiver's expressions of affect and gestures and engage in conversation and interaction with the caregiver and object that is part of JA. Eye gaze is a critical form of both requesting and JA from early in life. Not only is eye gaze in children with ASD correlated with a degree of social disability (Jones et al. 2008), but the contexts in which eye gaze is so apparently impaired, both JA and requesting, are also linked to developmental outcomes, both language and social (Charman et al. 2003; Jones et al. 2008; Kasari et al. 2008; Loveland and Landry 1986; Mundy et al. 1990; Paparella et al. 2011; Tomasello 1995).

Impairment in eye gaze resulted in some early studies to increase eye gaze primarily as a form of compliance when responding to an adult's request; for example, teaching children to look in response to the spoken instruction, "Look at me" (Foxx 1977; Hamlet et al. 1984; Lovaas 1987). A number of studies used prompting and reinforcement to teach children to initiate requests (also referred to as mands) (e.g., Ben Chabane et al. 2009; Carbone et al. 2010; Jennett et al. 2008; Williams et al. 2000), though only a few specifically included eye gaze as part of the response form. For example, Thomas et al. (2010) demonstrated the effectiveness of prompting and differential reinforcement to teach looking, pointing, and vocal approximations to request to three children with ASD (3.2 to 3.6 years old).

Eye gaze has also been successfully improved through intervention within the context of JA. Intervention involves prompting and reinforcement to increase eye gaze to both respond to and initiate JA in children with ASD (e.g., Jones et al. 2006; Kasari et al. 2008; Whalen and Schreibman 2003). For example, Krstovska-Guerrero and Jones (2013) taught three 2- to 4-year-old children with ASD to smile and shift gaze in response to an interventionist's JA instructions. Jones (2009) used prompting and reinforcement to teach two 3- and 4-year old children with ASD to initiate JA by shifting gaze and then also pointing and commenting.

Careful examination of the expectations for eye gaze in requesting and JA intervention studies reveals inconsistencies. In some studies of JA intervention, eye gaze is defined as looking at the partner's eyes (e.g., Jones et al. 2006; Krstovska-Guerrero and Jones 2013; Naoi et al. 2008; Taylor and Hoch 2008), but, in others, eye gaze means looking anywhere at the partner's face (e.g., Schertz et al. 2013; Vernon et al. 2012). Similarly, in requesting intervention studies, when eye gaze is part of the response form, it is sometimes defined as looking at the partner's eyes, face, or mouth (Thomas et al. 2010). Looking at a social partner's eyes is what becomes so strikingly different beginning early in infancy (Jones and Klin 2013), indicating the need for early interventions to focus on eye gaze.

In the studies just described, eye gaze was addressed, although not consistently requiring GS to the interventionist's eyes, within only one social communicative context. But impairment in eye gaze is evident across social-communication contexts. Only a few studies have specifically addressed eye gaze across social-communication contexts including both requesting and JA functions (Dawson et al. 2010; Yoder and Stone 2006). Yoder and Stone (2006) compared Responsive Education and Prelinguistic Milieu Teaching (RPMT) and Picture Exchange Communication System over the course of 6 months (PECS; Bondy and Frost 1994) in 36 children with ASD (18 to 60 months of age). Dawson et al. (2010) examined the Early Start Denver Model (ESDM) with 48 children with ASD between 18 and 30 months of age in a 2-year randomized controlled trial. Part of each of these interventions involved eye gaze, requesting, and JA. Children showed improvements following intervention. However, in both studies multiple responses were taught and, in Dawson et al. (2010), a whole curriculum was taught, so it is difficult to draw conclusions about eye gaze in the social-communication contexts of requesting and JA specifically.

In this study we examined the effect of intervention to address eye gaze in social-communication contexts of responding to a request (RR) and initiating JA (IJA), in toddlers recently diagnosed with ASD. Intervention focused on just two social-communication contexts; we began teaching GS to respond to the interventionist's request and then proceeded to GS to engage in IJA. Addressing the earliest of social impairments may provide a foundation of social-communication competence for improved outcomes. A number of studies of JA intervention show collateral changes in language (Jones et al. 2006; Kasari et al. 2008), expression of positive affect (Lawton and Kasari 2012), and generalization, to natural settings and interactions with the child's mother (Kasari et al. 2006; Whalen et al. 2006). To examine broader effects of intervention we examined generalization to other social-communication contexts, especially those in which the child is initiating interaction and to other responses (smiling) as well as changes in measures of social-communication skills, symptoms of ASD, and overall functioning.

Method

Participants

This study was approved by the Queens College IRB and parents provided informed consent for their toddlers to participate.

Toddlers with ASD

Four boys with ASD participated. Ian was 25 months, John 20 months, Jeff 23 months, and Robert 29 months old at the beginning of the study. Criteria for participation included being under 3 years of age, signed parental informed consent, a diagnosis of Autistic Disorder using the Diagnostic and Statistical Manual of Mental Disorders criteria (4th ed., text rev.; DSM-IV-TR; American Psychiatric Association 2000) by a psychologist or physician not associated with this study, and engagement in basic attending skills as assessed by the interventionist. During a brief play session the interventionist examined whether toddlers with ASD demonstrated basic attending skills necessary for intervention. Attending behaviors included sitting upon request, visually tracking moving objects, responding to auditory stimuli by looking in the direction from which the sound was coming, and reaching for preferred objects while looking at the objects. Toddlers with ASD were able to turn their heads up and down and left and right (motor movements necessary for GS). During the play session the interventionist presented five opportunities for the toddler to demonstrate each response. For example, to determine if the toddler visually tracked moving objects, the interventionist held a toy that had been identified as preferred by the parent and moved it slowly in front of the toddler in all directions. The interventionist held a toy in front of the toddlers and out of reach. The interventionist also activated a toy to see if the toddler looked in the direction of the toy. Toddlers demonstrated 80 to 100 % correct responding on each area assessed. During the play session, the interventionist also presented five requesting and five IJA opportunities; toddlers demonstrated limited (0 to 20 % correct responding) GS during requesting and IJA.

All toddlers had received evaluations as part of their participation in early intervention services. These evaluations were conducted by professionals not associated with this study and included the *Bayley Scales of Infant and Toddler Development* (3rd edition; Bayley 2005), *Vineland Adaptive Behavior Scales* (2nd edition; Sparrow et al. 2005), *Hawaii Early Learning Profile* (Parks 2007), *Childhood Autism Rating Scale* (CARS; Schopler et al. 1999), and *Autism Diagnostic Observation Schedule* (ADOS; Lord et al. 2000). All toddlers came from bilingual, English and Spanish, households, with English as the dominant language only in John's home. Therefore, bilingual evaluations were conducted with the other three toddlers, Ian, Jeff, and Robert. Consistent with recommendations for evaluating bilingual children (Mindt et al. 2008), only percentages of delay and percentiles were reported for Ian, Jeff, and Robert. The total score on the *Childhood Autism Rating Scale* (CARS; Schopler et al. 1999) was reported for all toddlers. Additionally, the total score on the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2000) was reported only for John. Table 1 shows toddlers' characteristics from these existing assessments. A trained graduate student also administered the ADOS (Lord et al. 2000) to assess the toddlers' diagnostic classification and to evaluate changes associated with intervention.

Table 1 Toddlers' characteristics from their existing early intervention evaluations

	Ian	John	Jeff	Robert
Age in months	25	20	23	29
BSIDD-III	>25% delay	na	>33% delay	>33% delay
Social/Emotional scales				
VABS-II				
Socialization Subdomain SS (percentile)	na	68 (2^{nd} percentile)	na	na
Communication Skills Subdomain SS (percentile)	na	60 (1^{st} percentile)	na	na
HELP	na	na	>33% delay	>33% delay
Autism Severity				
CARS	37	31	46	46
ADOS	na	15	na	na
Diagnosis	Autism	Autism	Autism	Autism

Assessments conducted as part of early intervention services by professionals not associated with this study. *Na* not assessed, *BSID-III* The Bayley Scales of Infant and Toddler Development, 3rd edition (Bayley 2005) *VABS-II* Vineland Adaptive Behavior Scales, 2nd edition (Sparrow et al. 2005) *HELP* The Hawaii Early Learning Profile (Parks 2007). Range on autism severity on the CARS (Childhood Autism Rating Scale; Schople et al. 1999): 15–29 = non autistic, 30–36 = mildly autistic, 37–60 = severely autistic. Communication and Social cut-off score on the ADOS (Autism Diagnostic Observation Schedule; Lord et al. 2000) =12, *SS* = standard score

All four toddlers had just begun receiving early intervention services. Their intervention focused on manipulating toys in a functional manner, increasing in-seat behavior, decreasing behavioral issues, and teaching basic cognitive skills. Requesting using signs and responding to name were being addressed, but GS in requesting and JA contexts were not yet being addressed for any of the toddlers. Toddlers received 10 to 20 h of home-based Applied Behavior Analysis (ABA) special instruction per week. John received 10 h at home and an additional 10 h in school. At the beginning of this study, Jeff received 20 h of ABA at home. Before the end of intervention (session 86), he started to attend a therapeutic nursery 10 h per week and his home-based ABA decreased to 10 h per week. Toddlers also received speech and language therapy, physical therapy, and occupational therapy two to four times per week in 30-min sessions. John suffered from frequent ear infections and underwent two surgeries to insert tubes in both of his ears to help with draining the fluid behind his eardrums. The first surgery occurred after the first session of the partially prompted phase of *requesting* intervention (Fig. 2, session 47); the second surgery occurred 8 days before John's 1-month follow-up session.

Typically Developing Toddlers

Three typically developing (TD) toddlers participated before the beginning of baseline for the toddlers with ASD to provide comparative data to determine response criteria for the latency and duration of GS in the contexts targeted for intervention and generalization. TD toddlers' responding was assessed following the same baseline procedures used for toddlers with ASD (described shortly). Two girls (18 and 25 months old) and one boy (25 months old) participated. Criteria for participation included a signed parental consent. The interventionist administered the *Developmental Assessment of Young Children* (DAYC; Voress and Maddox 1998) to assess cognitive,

language, social-emotional, adaptive, and physical functioning. Results confirmed functioning in the average range in all five areas of development assessed for each toddler (standard scores [SS] ranging from 100 to 102).

Setting and Interventionists

All sessions occurred at the toddlers' homes in rooms usually used for intervention (approximately 6×6 m). The interventionist conducted the intervention sessions. She is a special education teacher who provides early intervention services to toddlers with ASD and was a doctoral student in the behavior analysis program in the psychology department.

Materials

Thirty toys were identified for intervention and generalization. Twenty-four toys were used for intervention and six toys for generalization. Toys were multiple piece puzzles, blocks, books, or wind-up objects. Most were small (e.g., pieces of a puzzle, small blocks, etc.) selected so they did not block the interventionist's eyes when prompting GS by moving the toy in front of the interventionist's eyes. The ADOS (Lord et al. 2000), the DAYC (Voress and Maddox 1998), and the *Early Social Communication Scale* (ESCS; Mundy et al. 2003) were administered to participants. Materials for the ESCS included 5 wind-up toys, 3 hand-held mechanical toys (e.g., jack-in-the-box), a car, a ball, a picture book, a hat, a comb, glasses, and a clear plastic jar with a screw-on lid. The interventionist recorded data on data sheets and used a video camera to record sessions.

Dependent Variables

Gaze Shift (GS)

The dependent variable was GS. The interventionist measured latency (time elapsed from the interventionist's instruction to looking at the toy and from shifting gaze from the toy to the interventionist's eyes) and duration (of looking at the toy and looking at the interventionist's eyes) of responding of the three TD toddlers. The average across toddlers and responses provided information to help define response latency and duration for GS for toddlers with ASD.

GS was defined as looking at the toy for 1 s and shifting gaze from the toy to the interventionist's eyes (the interventionist must at the same time look at the toddler's eyes for 1 s). For all generalization contexts (described later), except responding to name (RR name) and IJA (toy in hand), toddlers started with their gaze not directed at the toy with the criteria that the toddler look at the toy within 2 s of the instruction and shift gaze within 2 s of looking at the toy. For IJA (toy in hand), toddlers started with looking at the toy in their hand; the GS from the toy to the interventionist's eyes must have occurred within 12 s of having the toy in hand, the latency observed in the TD toddlers' sample. For RR (name), the toddler was again already looking at the toy; GS must have occurred within 2 s of the interventionist saying the toddler's name.

The interventionist recorded GS as either correct (independent or prompted) or incorrect on each opportunity. Performance data are reported as the percentage of correct (prompted) responses during the first two phases of intervention (i.e., full

prompt [FP] and partial prompt [PP] phases) and correct (independent, unprompted) responses during baseline, time delay (TD), and follow-up phases.

Collateral Change Measures and Generalization Probes

The ADOS (Lord et al. 2000), DAYC (Voress and Maddox 1998), and ESCS (Mundy et al. 2003) were administered pre- and post- intervention to evaluate changes associated with this intervention. The ADOS is a 30 to 60 min semi-structured assessment used as part of a diagnostic assessment of ASD across developmental levels, ages, and language skills. The ADOS includes an assessment of requesting skills, preverbal gestures, JA interactions, responding to name, and other areas of social communication that are part of the ASD diagnosis and also targeted in this intervention. Based on each toddler's language and developmental level, Module 1, which is for children who are largely nonverbal and demonstrate little or no phrase speech, was used with all toddlers. The ADOS was used to evaluate changes in specific symptoms and ASD diagnosis from pre- to post-intervention (Dawson et al. 2010). The ADOS yields scores in each of five areas (i.e., Language and Communication, Reciprocal Social Interaction, Communication and Social Interaction, Play, and Stereotyped Behaviors and Restricted Interests). Higher scores indicate more severe impairment. Reciprocal Social Interaction is the area most related to this intervention because it includes items related to eye gaze and gaze coordination with other behaviors (social smiling, response to name, requesting, and JA). We also calculated the ADOS standardized severity score (Gotham et al. 2009).

The DAYC (Voress and Maddox 1998) evaluates five developmental domains (cognitive, communication, social-emotional, physical development, and adaptive behavior) in young children from birth through 5 years 11 months. It is used as part of early intervention services to evaluate changes over time (e.g., it is re-administered every 6 months), to identify children's strengths and weaknesses, and to assist with the development of individual goals and objectives for each child. Each subtest requires 10 to 20 min to administer. We report standard scores for each domain and the general developmental quotient score.

The ESCS (Mundy et al. 2003) is a videotaped semi-structured assessment of nonverbal social communication (e.g., gesture and eye gaze during requesting, JA, and social communication contexts) used with children of verbal ages under 30 months. This assessment requires 15 to 25 min to administer and is often used to examine differences in social communication in children with ASD. During the ESCS, the interventionist provided opportunities for the toddler to both respond to the interventionist's communicative bids and to initiate interaction with her. The interventionist then coded the toddlers' behavior from the video recorded session for requesting (i.e., initiation of a behavioral request [IBR] and responding to a behavioral request [RBR]), JA (i.e., initiation of joint attention [IJA] and responding to joint attention bids [RJA]), and social interaction contexts (i.e., initiation of social interaction [ISI] and responding to social interaction [RSI]). IJA, IBR, ISI and RSI are reported as a frequency count and RJA and RBR as a percentage of correct responses.

Generalization probes were also conducted during baseline and are described in the section on Generalization.

Experimental Design

A multiple baseline probe design across four toddlers with ASD was used to evaluate intervention involving prompting and reinforcement to teach GS in the context of requesting and JA. After demonstrating steady responding in baseline, intervention began with teaching GS during responding to a request (RR). Baseline probes of initiating JA (IJA) continued and, once RR was mastered, intervention was applied to teach IJA if the toddler did not demonstrate GS to IJA. To avoid unnecessarily delaying intervention for the fourth toddler, intervention began at the same time for the third and fourth toddlers. Generalization was examined during baseline, intervention, and 1- and 3-month post-intervention follow up. Collateral changes were examined with measures administered pre- (i.e., at the same time as baseline) and post-intervention (i.e., within 1 month of mastery of IJA).

Procedure

Pre-Assessments

To describe each toddler's ASD symptoms and severity, a trained doctoral student administered the ADOS (Lord et al. 2000) before intervention. The interventionist administered the DAYC (Voress and Maddox 1998) to evaluate developmental functioning of the toddlers with ASD across communication, cognitive, social-emotional, adaptive behavior, and physical development domains. The interventionist also administered the ESCS (Mundy et al. 2003) to evaluate social-communication skills.

Preference Assessment

Before baseline and intervention began, the interventionist identified 24 toys based on parent/teacher report of preference. Sixteen toys were used to teach responding to a request and eight remote control toys were used to teach IJA. At the beginning of each session, the interventionist randomly selected five toys out of the 24 toys identified previously for intervention and allowed the toddler to choose three (without replacement) for use during that specific session (MSWO; DeLeon and Iwata 1996). The interventionist then selected one of the three toys to begin the session and replaced it with the second toy if the toddler lost interest (e.g., did not reach, looked away for 2 s) in the first toy during the session and replaced the second toy with the third if the toddler lost interest in the second toy. If the toddlers did not show interest in the three toys offered, the interventionist presented five different toys and allowed the toddler to select another three toys. Toys used in one session were presented again after all other toys had been used. This way the interventionist presented and rotated all preferred toys during baseline, intervention, and follow-up.

Baseline

The interventionist sat on the floor facing the toddler who was seated on the floor or in a booster seat. Baseline sessions began with the preference assessment just described. An opportunity began with the presentation of an instruction.

To assess GS in the *RR* context, the interventionist requested the toddler take a toy by holding it in front of the toddler, but out of reach below the toddler's eye level (no other gestures or vocalizations were used). If the toddler did not look and reach for the toy, the interventionist presented this opportunity one more time before replacing the preferred toy. This occurred only a few times for each toddler.

To assess GS in the *IJA* context, the interventionist engaged the toddler in play for a short time (10–15 s) (e.g., building a tower with blocks, stringing beads, etc.). When the toddler was not looking, the interventionist placed a remote control toy, selected by the toddler, on the floor out of reach, but within the toddler's line of sight (i.e., the toy was positioned to the right of the child and interventionist, but closer to the interventionist). The interventionist hid the remote control behind her back so that the toddler could not see it and then used the remote control to make the toy on the floor produce a sound and move for 2 s (no gestures or vocalizations were used). If the toddler did not look at the activated toy, the interventionist presented this opportunity one more time before replacing the preferred toy.

No prompts or error correction procedures were presented during baseline sessions. Natural consequences were provided for GS. For example, if the toddler reached for the object and shifted his gaze to the interventionist's eyes during an *RR* opportunity, the interventionist provided the toddler with the object. If the toddler looked at the remote control toy and shifted his gaze to the interventionist's eyes during an *IJA* opportunity, the interventionist smiled and commented (e.g., saying, "That's a funny toy!"). Regardless of the toddler's response (i.e., correct, incorrect, or no response), the interventionist terminated the opportunity after 2 s and presented another opportunity. Baseline sessions lasted approximately 5 min and consisted of 5 opportunities each.

Each toddler completed a minimum of five baseline sessions and demonstrated steady responding during baseline before proceeding to intervention. Baseline probe sessions for toddlers and responses remaining on baseline occurred approximately every fifth intervention session of the response for which intervention had been introduced (i.e., approximately once a week for each toddler).

Intervention

Intervention involved the presentation of 10 repeated opportunities during one session, in close proximity, with prompting and reinforcement. The number of sessions varied between 1 and 3 per day, 2–4 times per week, depending on each toddler's availability. Mastery criterion was at least 80 % correct independent responses across two consecutive sessions during 2 days of intervention. Consistent with previous JA research (e.g., Jones et al. 2006), the prompting procedure involved most-to-least prompting combined with a time delay (i.e., prompts were initially presented immediately following the instruction [0 s time delay] and then faded to a 2 s time delay). Details about the intervention procedures for RR and IJA are described next and in Fig. 1. Criteria for GS (latency and duration) were obtained from typically developing toddlers. Fifty percent of the sessions were video recorded for the purpose of interobserver agreement and intervention integrity.

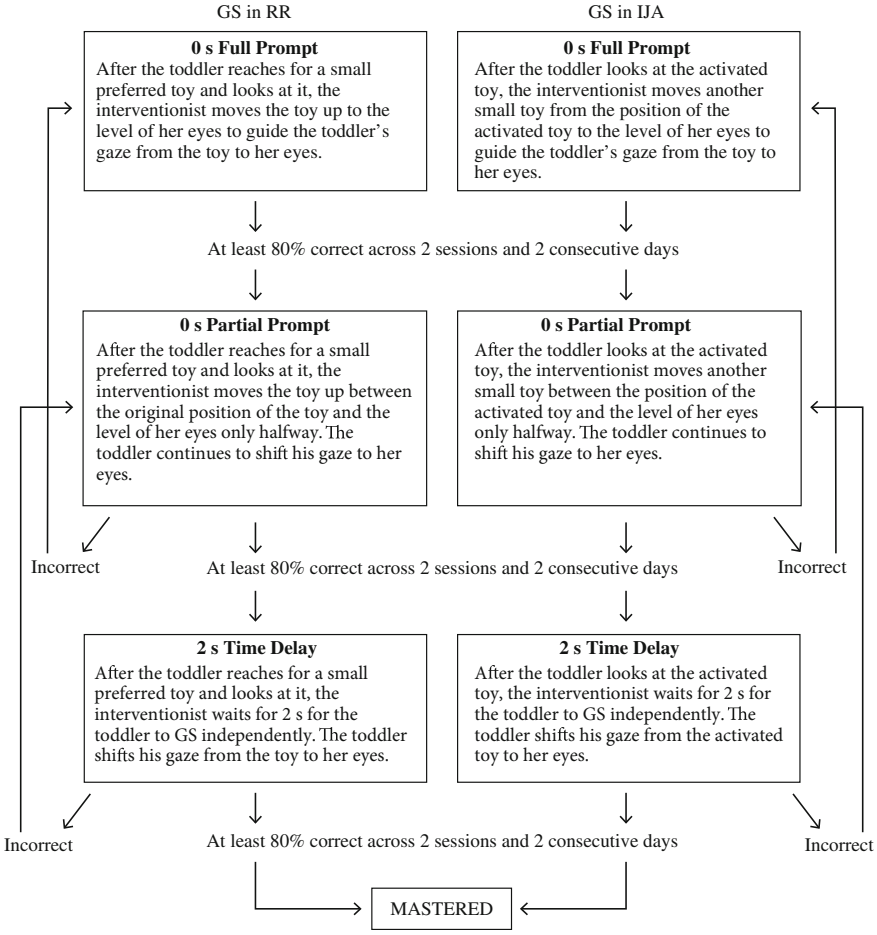

Fig. 1 Prompting and prompt fading procedure to teach GS in RR and IJA contexts

Responding to a Request (RR) Intervention began in the same manner as baseline. The interventionist taught the toddler to shift his gaze from the toy she held in front of the toddler (out of his reach) to her eyes (no verbal instruction was used).

Once the toy was presented and the toddler looked at it and reached for it for 1 s (per screening criteria all toddlers looked at and reached for preferred toys), the interventionist slowly brought the toy up to the level of her eyes in the full prompt (FP) phase of intervention. The toddler visually tracked the toy and looked in the interventionist's eyes for 1 s, demonstrating GS. The left side of Fig. 1 outlines the prompting, most-to-least prompt fading, and time delay procedures. Fading prompt levels occurred when a toddler showed 80 % or better performance across 2 consecutive sessions and 2 days of intervention. In addition, if, during an opportunity, the toddler did not respond to a prompt, the interventionist used a more intrusive (previous level) prompt so the toddler always practiced the correct response (e.g., if the toddler did not GS when the interventionist used a partial prompt [PP], she then used a FP).

Once the toddler shifted gaze following a prompt or independently, the interventionist immediately provided natural consequences by saying something such as, "Here you go," while handing the toy to the toddler. The natural consequences of access to the toy were provided with a continuous schedule of reinforcement (i.e., every correct response was reinforced).

Initiating Joint Attention (IJA) This intervention step differed from the previous intervention step in two important ways. First, the function of the behavior changed from requesting to JA. During requesting, the toddler obtained the preferred toy as a consequence; during JA, the toddler received social consequences only. Second, we specifically devised this context so that the interventionist did not give a direction to the toddler to do something, rather, the toddler *initiated* interaction.

As in baseline, the interventionist hid the remote control behind her back so that the toddler could not see it and then used the remote control to make the toy on the floor produce a sound and move for 2 s (she did not provide any verbal instruction). After the toddler turned his head toward the toy on the floor and briefly looked at it (e.g., 1 s) (all toddlers looked per screening criteria), the interventionist used the prompts and prompt fading procedures described in Fig. 1. In contrast to RR in which the interventionist used the same toy she offered to the toddler to prompt the toddler's GS, in IJA, she used another preferred toy (not selected by the toddler for this particular session) to slowly trace the visual path from the toy to the level of her eyes. If the toddler did not look at the IJA toy after it made a sound and moved, the interventionist activated the toy again. If the toddler still did not respond, the interventionist replaced that remote control toy with another toy selected for this session. This occurred only a few times during IJA intervention.

When the toddler shifted gaze, the interventionist immediately smiled and provided a social comment (e.g., saying, "Yes, I see that!"). During the FP and PP phases, she also gave the child the toy she was holding (the toy used to prompt, not the IJA toy). Consequences were provided on a continuous schedule (i.e., every response was reinforced) during the FP level of teaching GS to IJA. When toddlers reached the first session of 80 % correct responding at the PP level, toys were provided on an FR-2 schedule (i.e., every second response was reinforced by a toy and social praise remained continuous). During the time delay phase of intervention, toys were no longer used as reinforcers, but the interventionist provided social praise and natural JA consequence on a continuous schedule.

Post-Assessment

The ADOS (Lord et al. 2000), DAYC (Voress and Maddox 1998), and ESCS (Mundy et al. 2003) assessments were re-administered post-intervention (within 1 month) to evaluate changes associated with this intervention.

Generalization and Maintenance

Five opportunities were provided during a generalization session to assess each type of generalization. Generalization sessions occurred during initial baseline sessions, when responding reached mastery level for GS to RR and IJA, and during 1- and 3-month follow-ups. As in baseline the interventionist did not provide prompts or error

correction procedures during generalization probes. She only provided natural consequences for correct responses.

Generalization Across Partners Generalization with each toddler's mother was examined for GS in both RR and IJA contexts with the same toys that were used during baseline and intervention.

Generalization Across Contexts The interventionist assessed GS across six social-communication contexts not targeted in intervention with preferred toys only used during generalization probes (not used for intervention). These contexts reflected a repertoire of social-communication behaviors that are often part of assessments of social communication (e.g., ESCS; Mundy et al. 2003 and behavioral assessment of JA; MacDonald et al. 2006) and symptoms of ASD (e.g., ADOS; Lord et al. 2000) and have been shown to be impaired in children with ASD (Klein et al. 2009; Paparella et al. 2011; Zwaigenbaum et al. 2013).

Responding to a Request (RR [Clean up]) The purpose of this generalization probe was to examine GS for responding to a different request than that taught in intervention, but one often presented to young children. In this case, the interventionist requested that the toddler clean up his toys. The interventionist engaged the toddler in play (e.g., with blocks or puzzles), said, "Let's clean up now," and moved a plastic bag/box in front of the toddler holding it slightly out of reach. All toddlers looked at the bag/box for 1 s and extended their hands with toys toward the bag/box (as per screening criteria). The interventionist recorded if the toddler shifted gaze from the toy to the interventionist's eyes within 2 s. If the toddler did, the interventionist provided natural consequences, moving the plastic bag/box within the toddler's reach to allow the toddler to complete the response to the interventionist's request.

Responding to Name (RR [Name]) The purpose of this probe was to examine responding to name (a request), something children with ASD often do not demonstrate (Zwaigenbaum et al. 2005). The interventionist engaged the toddler in play and called the toddler's name when he was looking at a toy. If the toddler shifted his gaze from the toy to the interventionist's eyes within 2 s, she provided natural consequences, commenting on the toy with which the toddler was playing (e.g., "Yes, this block is red," or, "Do you want another block?").

Initiate a Request (IR [Toy out of Reach]) The purpose of this probe was to examine GS in a situation that reflects initiating a request, something we did not directly teach, and that children with ASD are less likely to show compared to their typically developing peers (Winder et al. 2013). When the toddler was not looking, the interventionist placed a preferred toy (e.g., a piece of a puzzle with which the toddler was playing) in front of the toddler and out of reach (in this way the toy was not directly offered by the interventionist). If the toddler shifted his gaze from the toy to the interventionist's eyes, the interventionist provided natural consequences by handing the toy to the toddler to play with for several seconds.

Respond to JA (RJA [Head Turn]) The purpose of this probe was to assess responding to JA, which is also impaired in children with ASD (Charman et al. 1998; Mundy et al. 1986). RJA involves adult bids for JA that can take several forms, one of which is the adult partner shifting her gaze and turning her head to look at an object (e.g., a mother turns her head and shifts her gaze toward the family cat playing with a toy). The interventionist placed a toy on the floor on her right side and out of the toddler's reach and turned her head to look at the toy. No additional gestures (pointing) or vocalizations were provided. If the toddler looked at the toy within 2 s and shifted his gaze back to the interventionist's eyes within 2 s of looking at the toy, she provided natural consequences by smiling and commenting about the toy (e.g., "Wow, it's Elmo!").

Respond to JA (RJA [Head Turn, Point, Vocalization]) Another form of adult bid for RJA is when the adult turns her head, points, and vocalizes. This probe was conducted exactly the same as RJA (head turn) except the interventionist turned her head to look at the toy while also pointing at the toy and making a comment (e.g., "Wow, it's Elmo!").

Initiate JA (IJA [Toy in Hand]) The purpose of this probe was to examine GS in a different IJA context from the one taught during intervention. Unlike the IJA context in intervention in which the remote control toy was placed on the floor out of the toddler's reach, during this generalization probe the interventionist placed a preferred toy in front of the toddler and within his reach for the toddler to play with it. If the toddler shifted his gaze to the interventionist's eyes for at least 1 s while manipulating the inactive toy within 12 s of obtaining it, the interventionist provided natural JA consequences.

Response Generalization The purpose of this measure of generalization was to examine changes in a related response form that is often part of social-communication interactions. Smiling is often coordinated with GS, especially in the context of JA (Kasari et al. 1990). Smiling was coded from the video recorded sessions during baseline and time delay phases of intervention for RR and IJA. Smiling was defined as the corners of the toddler's mouth turned up. Performance is reported as percentage of RR and IJA opportunities in which toddlers smiled at the toys, but did not shift his gaze to her eyes and smiled at the toys and also the interventionist when shifting gaze.

Maintenance One- and three-month post-intervention follow-up sessions were conducted to assess maintenance of GS across all contexts. The interventionist conducted all follow-up sessions in the same way as baseline sessions. If toddlers responded correctly, the interventionist provided natural consequences. She did not provide any prompts or correction procedures.

Social Validity

Each toddler's mother completed two questionnaires. On one she reported her perceptions of her toddler's social-communication skills at pre- and post-intervention.

Questions included: 1) Does your child respond to requests in an age-appropriate manner? 2) Does your child initiate requests in an age-appropriate manner? 3) Does your child respond to joint attention direction in an age-appropriate manner?, and, 4) Does your child initiate joint attention in an age-appropriate manner? On the second she evaluated the appropriateness of the intervention procedures post-intervention. Questions included: 1) Was this intervention appropriate to address gaze behavior, especially eye contact during social interactions? 2) Are you satisfied with the type of intervention used to address gaze behavior and eye contact? 3) Are you satisfied with the results of the intervention?, and, 4) Will you continue to implement intervention to maintain your child's requesting and joint attention skills?

Interobserver Agreement

To examine interobserver agreement (IOA), a trained undergraduate research assistant and the interventionist independently scored each toddler's performance for 30 to 40 % of baseline session, 34 to 40 % of intervention sessions, 50 % of the follow-up sessions, and 34 to 50 % of the generalization sessions. The student and interventionist independently recorded the toddler's response to each opportunity as independent correct or prompted. The same data sheet used for intervention was used to record IOA. Mean percentage agreement was calculated by dividing the number of agreements by the total number of agreements plus disagreements and multiplying by 100 %. For all toddlers, overall IOA for GS during baseline, intervention, follow-up, and generalization probes was 100 %.

The same trained undergraduate student and the interventionist also scored smiling from the video recorded sessions. Percentage agreement was calculated by dividing the number of agreements by the total number of agreements plus disagreements and multiplying by 100 %. For Ian, John, Jeff, and Robert, overall IOA for GS coordinated with smiling during baseline and time delay phases of intervention for RR and IJA was 100 %.

A trained doctoral student scored 50 % of the ESCS video assessments for IOA. IOA for IJA (lower level, higher level, and the total), IBR (lower level, higher level, and the total), total ISI and total RSI was calculated by dividing the smaller count by the larger count multiplied by 100. IOA for RJA lower and higher level and RBR passes was calculated by dividing the number of agreements by the total number of agreements plus disagreements multiplied by 100. Mean agreement across toddlers for IJA lower level was 94 % (range 86–100 %), IJA higher level 96 % (range 86–100 %), IJA total 95 % (range 87–100 %), RJA lower level and higher level was 100 %. Mean agreement across toddlers for IBR lower level was 96 % (range 92–100 %), IBR higher level 94 % (range 80–100 %), IBR total 94 % (89–100 %), and RBR passes was 100%. Mean agreement for total ISI was 100 % and for total RSI 98 % (range 92–100 %).

Intervention Integrity

At the same time that the trained undergraduate research assistant recorded a toddler's performance for IOA, she also assessed intervention integrity. To determine the

percentage of correctly implemented intervention components (i.e., presentation of instructions, prompts, and consequences), the number of correctly implemented components was divided by the total number of correct plus incorrect presentations, multiplied by 100 %. For all toddlers, overall intervention integrity for the presentation of instructions, prompts, and consequences was 100 %.

Results

RR and IJA Intervention

Figure 2 shows toddlers' performance during baseline, intervention, 1- and 3-month follow-up with the interventionist as well as generalization with each toddler's mother. With the interventionist, each toddler showed 0 % independent responses during baseline of GS across both RR and IJA contexts with the exception of one session of IJA each for Ian and Jeff.

After intervention for RR began for Ian, he reached mastery criterion in 13 sessions. During intervention for RR, performance of IJA varied between 0 and 60 %. After intervention began for IJA, Ian reached mastery criterion in six sessions. After intervention for RR began for John, he reached mastery criterion in 10 sessions. John's performance of IJA increased from 0 to 80 % during the first prompted phase of

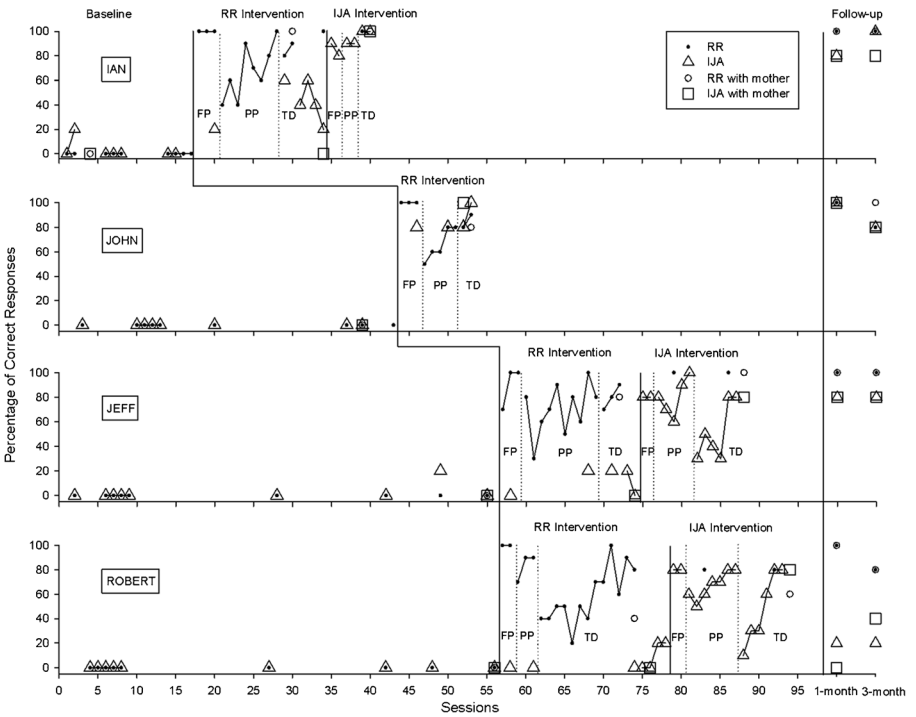

Fig. 2 Participants' performance during baseline, intervention, 1-month and 3-month follow-up with the interventionist as well as generalization with each participant's mother

intervention for RR and remained within mastery level through the end of intervention for RR, therefore it was not necessary to introduce intervention to teach IJA. After intervention for RR began for Jeff, he reached mastery criterion in 16 sessions. Jeff's performance of IJA fluctuated between 0 and 20 % during the intervention phase for RR. Once intervention began for IJA, he reached mastery criterion in 13 sessions. After intervention for RR began for Robert, he reached mastery criterion in 18 sessions. Robert's baseline performance of IJA increased slightly from 0 to 20 % after the end of intervention for RR. Once intervention began for IJA, he reached mastery criterion in 15 sessions.

Table 2 shows the average performance of GS of the three typically developing toddlers in both RR and IJA contexts (generalization contexts will be discussed shortly). In Table 2 the percentages reflect opportunities during which the toddlers shifted gaze meeting the latency criterion we used for the toddlers with ASD (2 s for all contexts except 12 s for IJA). Toddlers with ASD who met our 80 % mastery criteria, met or exceeded the performance of the typically developing toddlers sample for RR and IJA.

Table 3 shows time between diagnosis and intervention and duration of intervention. Ian, John, Jeff, and Robert completed intervention in 13, 6, 18, and 19 days, respectively, reflecting 3–9 weeks of intervention.

Generalization and Maintenance

Generalization Across Partners

Figure 2 also shows performance for GS in RR and IJA contexts during generalization probe sessions with each toddler's mother. Each toddler's performance with his mother was at 0 % for RR and IJA during baseline sessions. Ian's, John's, and Jeff's performance with their mothers increased to between 80 and 100 % during the last intervention sessions. Robert's generalization performance with his mother increased at the end of intervention to 60 % for RR and 80 % for IJA, matching the performance of his typical peers (Table 2).

Table 2 Typically developing toddlers' performance

	Average performance of typically developing toddlers (%)
RR	60
IJA	80
RR (clean up)	93
RR (name)	73
IR (Toy out of reach)	93
RJA (head turn)	7
RJA (head turn, point, vocalization)	33
IJA (Toy in hand)	73

Percentage of opportunities during which GS occurred within 2 s for all contexts except 12 s for IJA (toy in hand). The 2 s and 12 s latencies reflect the average for the typically developing toddlers and were used as the criterion used for the toddlers with ASD

Table 3 Time between diagnosis and intervention and duration of intervention for all toddlers

	Ian	John	Jeff	Robert
Months between diagnosis and intervention	2.5	2.5	3	1.5
Number of weeks of intervention	5	3	8	9
Number of days of intervention	13	6	18	19
Number of sessions to mastery	19	10	29	33

Baseline sessions are not included in the number of weeks and days of intervention

Generalization Across Contexts

Figures 3 and 4 show the toddler's performance during intervention and generalization across social-communication contexts. The first and third panels of Fig. 3 show Ian's and John's performance during baseline, intervention, and 1- and 3-month follow-up, respectively, as shown in Fig. 2. The second and fourth panels show Ian's and John's performance during probes of generalization across contexts, respectively. The first and third panels of Fig. 4 show Jeff's and Robert's performance during baseline, intervention, and 1- and 3-month follow-up, respectively as in Fig. 2. The second and fourth panels show Jeff's and Robert's performance during probes of generalization across contexts, respectively.

During baseline, across all generalization contexts, participants showed 0 % independent correct responding with the exception of one instance of RR (name) (20 %) for Ian, and one instance of IJA (toy in hand) (20 %) each for Jeff and Robert. For Ian (Fig. 3), generalization probes at the end of IJA intervention

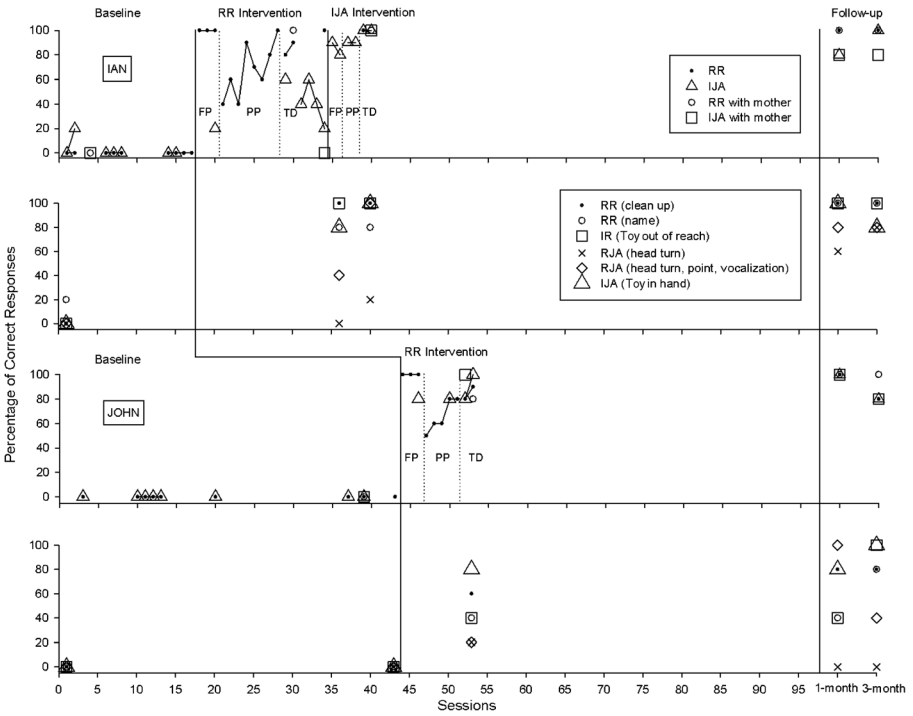

Fig. 3 Ian's and John's performance during intervention and generalization probes to different social-communication contexts during baseline, intervention, and 1-month and 3-month follow-up

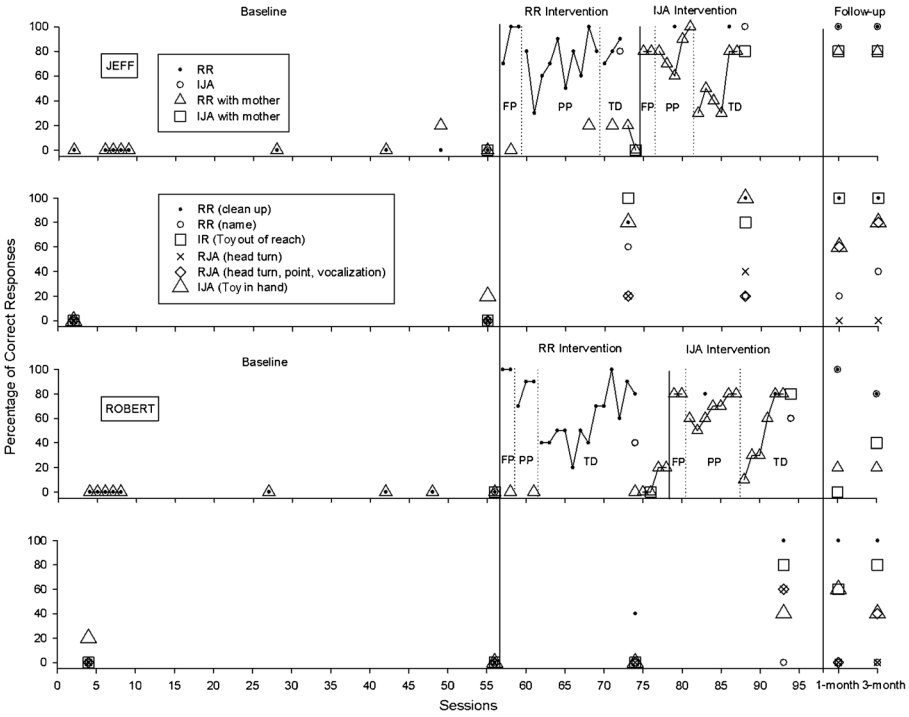

Fig. 4 Jeff's and Robert's performance during intervention and generalization probes to different social-communication contexts during baseline, intervention, and 1-month and 3-month follow-up

showed increases in performance at or above 80 % for all probes except for RJA (head turn) that remained at 20 %. For John (Fig. 3), generalization probes recorded during the last session of intervention for RR (John did not receive IJA intervention because his performance increased to mastery at the end of RR intervention) showed an increase in performance above baseline levels, but only IJA (toy in hand) increased to 80 %. For Jeff (Fig. 4), generalization probes recorded at the end of IJA intervention showed increases in performance above baseline levels with RR (clean up), IR (toy out of reach), and IJA (toy in hand) increasing to or above 80 %. For Robert (Fig. 4), generalization probes recorded at the end of IJA intervention showed increases in performance above baseline levels with RR (clean up) and IR (toy out of reach) increasing to or above 80 %.

Table 4 shows a summary of performance across generalization contexts reflecting contexts in which toddlers showed at least one probe with performance at or above 80 % and contexts in which toddlers showed no probe with performance at or above 80 % at the end of intervention and during follow-up (to be discussed shortly). At the end of intervention, three of four toddlers showed generalization to RR (clean up) and IJA (toy in hand). Ian and Jeff showed generalization to IR (toy out of reach). Only Ian showed generalization to RR (name) and RJA (head turn, point, and vocalization).

Tables 2 and 4 and Figs. 3 and 4 allow for a comparison of the performance of the toddlers with ASD in the generalization contexts to that of the typically developing toddlers. In general, the pattern of performance of toddlers with ASD is similar in comparison to the performance of TD toddlers in this study with a few exceptions. For

Table 4 Summary of performance across generalization contexts

	Ian		John		Jeff		Robert	
	Intervention	Follow-up	Intervention	Follow-up	Intervention	Follow-up	Intervention	Follow-up
RR (clean up)	✓	✓	×	✓	✓	✓	✓	✓
RR (name)	✓	✓	×	✓	×	×	×	×
IR (Toy out of reach)	✓	✓	×	✓	✓	✓	×	✓
RJA (head turn)	×	✓	×	×	×	×	×	×
RJA (head turn, point, vocalization)	✓	✓	×	✓	×	✓	×	×
IJA (Toy in hand)	✓	✓	✓	✓	✓	✓	×	×

✓ = contexts in which toddler showed one probe with performance at or above 80% during intervention and one of the follow-up probe sessions, × = contexts in which toddler showed no probe with performance at or above 80% at the end of intervention and during one of the follow-up probe sessions

example, Table 4 shows that none of the toddlers with ASD reached 80 % RJA (head turn) by the end of intervention. But Table 2 shows that the typically developing toddlers only responded correctly to 7 % of RJA (head turn) opportunities. In fact, Figs. 3 and 4 show that all four toddlers with ASD exceeded this level of performance of their typically developing peers on RJA (head turn) by the end of intervention. Similarly, Table 4 shows that Robert did not meet our performance criteria of 80 % or higher during RJA (head turn, point, and vocalization) during follow-up. Again, though, his performance (in Fig. 4) exceeded that of the TD toddlers shown in Table 2 who shifted gaze on only 33 % of opportunities.

Response Generalization

Table 5 shows the percentage of RR and IJA opportunities in which the toddlers shifted gaze and smiled during baseline and time delay phases of intervention for each toddler with ASD, averages across the four toddlers with ASD, and averages across the three typically developing toddlers.

While smiling at the toy without shifting gaze to RR did not occur at all in the typically developing toddlers, three toddlers with ASD showed some smiles without GS during baseline and intervention. Smiling coordinated with GS occurred during 13 % of opportunities for typically developmental toddlers. Toddlers with ASD did not smile while shifting gaze during RR opportunities at all during baseline, but

Table 5 Percentage of RR and JA opportunities coordinated with smiling

	Ian		John		Jeff		Robert		Average across toddlers with ASD		Average across typical toddlers
	BL	INT	BL	INT	BL	INT	BL	INT	BL	INT	
RR											
Smile at toys	2 (0-20)	5 (0-10)	0	0	20 (0-80)	17 (0-40)	16 (0-80)	10 (0-40)	10 (0-80)	8 (0-40)	0
GS with smile	0	15 (0-30)	0	80 (60-100)	0	3 (0-10)	0	24 (0-60)	0	31 (0-100)	13 (0-20)
IJA											
Smile at toys	3 (0-20)	0	0	5 (0-10)	0	0	9 (0-60)	10 (0-20)	3 (0-60)	4 (0-20)	7 (0-20)
GS with smile	0	5 (0-10)	0	90 (80-100)	2 (0-20)	7 (0-10)	0	33 (0-60)	1 (0-20)	34 (0-100)	40 (20-80)

Mean percentage of opportunities (range in parentheses) during which the toddler smiled at the toy and smiled during gaze shift (smiled at the toy and at the interventionist) during responding to a request (RR) and initiating joint attention (IJA) at baseline (BL) and the time delay phase of intervention (INT). BL includes all baseline sessions before INT for RR began; INT includes all sessions in time delay

Table 6 ADOS and DAYC

	Ian		John		Jeff		Robert	
	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
ADOS[a]								
Language and Communication	5	2	4	8	4	5	7	8
Reciprocal Social Interaction	8	1	9	4	13	8	10	8
Communication and Social Interaction	13	3	13	12	17	13	17	16
Play	2	3	4	4	4	4	4	4
Stereotyped Behaviors and Restricted Interests	1	1	0	0	1	0	0	2
Standardized Severity Score	6	2	4	4	7	6	7	7
Classification based on Standardized Scores	autism	non-spectrum	autism spectrum	autism spectrum	autism	autism	autism	autism
Decrease in Classification Severity	YES		NO		NO		NO	
DAYC[b]								
Cognitive	85	105	80	90	80	81	66	72
Communication	72	92	63	64	52	52	52	63
Social-Emotional	89	93	74	89	74	82	68	70
Physical Development	90	90	90	91	78	83	78	79
Adaptive Behavior	84	89	70	71	72	75	72	81
General Developmental Quotient	82	92	72	78	67	71	61	69

[a] Language and Communication Total: autism cut off = 4, autism spectrum cut off = 2; Social Interaction Total: autism cut off = 7, autism spectrum cut off = 4; Communication and Social Interaction Total: autism cut off = 12, autism spectrum cut off = 7. [b] Standard scores across five areas of development and general developmental quotient

performance increased for each toddler during intervention to a level exceeding their typically developing peers for three of the toddlers.

Smiling at the toy without shifting gaze to IJA occurred during 7 % of opportunities for typically developing toddlers. Two of the toddlers with ASD did not smile at the toys at all during baseline; the other two showed a similar low level of smiling at the toys as compared to their typically developing peers. Typically developing toddlers smiled and shifted gaze during 40 % of the opportunities for IJA. Three toddlers with ASD did not smile and GS at all during baseline. All toddlers improved over their baseline performance, though only one toddler's performance exceeded that of the typically developing toddlers and a second approached the level of performance of the typically developing toddlers.

Maintenance

One- and three-month follow-up sessions were conducted after intervention ended with each toddler to assess response maintenance with the interventionist and participant's mother, as well as generalization across contexts.

Figure 2 shows follow-up performance with the interventionist and toddler's mother. Ian, John, and Jeff demonstrated performance at or above 80 % for GS in both RR and IJA contexts with the interventionist and the toddler's mother during both follow-up sessions. Robert demonstrated performance at or above 80 % for RR with the interventionist and his mother during both follow-up sessions. Robert's performance of IJA with the interventionist decreased to 20 % at a 1- and 3-month follow-up. Robert's performance of IJA with his mother decreased to 0 % at a 1-month follow-up with a slight improvement to 40 % at 3-month follow-up.

Figures 3 and 4 and Table 4 show generalization probes across contexts during intervention and follow-up sessions. By the time of the 1- or 3-month follow-up session, toddlers' performance improved compared to their performance at the end of intervention as shown by higher percentage of correct responses and, for some toddlers, performance at mastery level in a larger number of generalization contexts.

Characteristics of ASD and Overall Development

ADOS Table 6 shows pre- and post-intervention scores on each section of Module 1 of the ADOS assessment along with standardized severity scores and severity classifications for the toddlers with ASD. The ADOS yields scores in Language and Communication, Reciprocal Social Interaction, Language and Communication and Social Interaction, Play, and Stereotyped Behaviors and Restricted Interests. The Reciprocal Social Interaction section is most related to this study because it assesses eye gaze and gaze coordination with other behaviors (social smiling, response to name, requesting and JA). Results from the post-intervention ADOS assessment reflect decreases in scores on the Reciprocal Social Interaction section for all toddlers. Examination of severity scores (Gotham et al. 2009) at post-intervention shows that Ian's standardized severity score decreased and his ADOS diagnostic classification changed from autism to non-spectrum. The other three toddlers' classifications remained the same. The average severity score also decreased from 6 and 4.7, though two toddlers' scores remained the same.

DAYC Table 6 also shows pre- and post-intervention standard scores on the DAYC assessment across the cognitive, communication, social-emotional, physical development, and adaptive behavior domains. The Communication and Social emotional domains include items most directly related to the scope of this study. All toddlers showed improvements from pre- to post-intervention in those domains, with the exception of Jeff whose score in the Communication domain remained unchanged. The General Developmental Quotient also improved for all toddlers.

ESCS Table 7 shows toddlers' performance on the ESCS pre- and post-intervention for Initiating Joint Attention (IJA), Responding to Joint Attention bids (RJA), Initiating Behavioral Requests (IBR), Responding to Behavioral Requests (RBR), Initiating Social Interaction (ISI), and Responding to Social Interaction (RSI). We taught GS within two of these social-communication contexts, RR (RBR on the ESCS) and IJA. From pre- to post-

Table 7 ESCS assessment pre- and post-intervention

	Ian		John		Jeff		Robert	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
IJA (frequency)								
Lower Level	2	7	11	8	4	8	2	8
Higher Level	3	8	1	5	0	0	0	0
Total IJA	5	15	12	13	4	8	2	8
RJA (percentage)								
Lower level	100	100	100	100	63	67	100	60
Higher level	71	75	0	38	25	50	0	75
IBR (frequency)								
Lower level	18	25	12	25	10	4	10	10
Higher level	6	21	3	18	2	5	1	3
Total IBR	24	46	15	43	12	9	11	13
RBR (percentage)	100	100	75	71	11	38	0	22
Total ISI (frequency)	1	0	2	2	1	1	0	1
Total RSI (frequency)	3	5	11	7	1	3	3	4

IJA initiation of joint attention, *RJA* responding to joint attention, *IBR* initiation of behavioral requests, *RBR* responding to behavioral requests, *ISI* initiation of social interactions, *RSI* responding to social interactions

intervention, three of the four toddlers showed increases in the percentage of correct RBR. All toddlers showed improvements in total IJA. This reflected increases in higher-level IJA for Ian and John and lower level IJA for John, Jeff, and Robert. The other contexts on the ESCS are similar to our generalization contexts. Lower level RJA (i.e., following proximal point) remained unchanged for three of the toddlers, but higher-level RJA (i.e., following line of regard) increased for all four toddlers. Three toddlers showed improvement in total IBR, reflecting increases in higher level IBR as well as lower level IBR for two of the toddlers. RSI improved for three toddlers, but ISI improved for only one toddler. Overall initiation of interaction increased as reflected in IBR and IJA, but not ISI.

Social Validity

On the questionnaire about perceived changes from pre- to post-intervention, all mothers indicated improvement in their toddler's social-communication skills with ratings between 5 and 7 (i.e., 7 being the highest score). On the questionnaire about the outcome and appropriateness of this intervention, caregivers rated their satisfaction as 7 (i.e., 7 being the highest score).

Discussion

The present study demonstrated the effectiveness of a social-communication intervention with toddlers with ASD targeting eye gaze in the contexts of requesting and JA. Toddlers were taught eye gaze within two social-communication contexts and showed generalization across partners, time, other social-communication contexts including, importantly, when they initiate interaction, and smiling. Toddlers also showed some improvements on standardized measures of social-communication development, characteristics of ASD, and overall functioning.

We targeted eye gaze because it is notably different in individuals with ASD from early in life (American Psychiatric Association 2013; Zwaigenbaum et al. 2005). This difference in eye gaze persists throughout life and is a part of all social-communication interactions. GS was taught across both requesting and JA contexts to a level comparable to that of our sample of TD toddlers. Intervention began with GS in an RR context for several reasons. In this context the interventionist requested the toddler take a toy by offering it to him. This allowed the interventionist to easily prompt GS by simply moving the toy to the level of her eyes. Eye gaze resulted in immediate access to a preferred toy, which functioned as a reinforcer, and that was paired with the interventionist's eyes and social praise. Perhaps this resulted in the social partner's eyes becoming a conditioned social reinforcer, something that would enhance eye gaze across social-communication contexts (Dube et al. 2004), especially JA contexts that involve only social reinforcers. In fact, GS in JA contexts began to increase as toddlers mastered RR with one toddler showing generalization from RR to IJA functions.

Intervention targeted just two social-communication contexts. A repertoire of social-communication behavior involves many more contexts. The focus on one common response form (i.e., GS) that is relevant across multiple social-communication contexts (with different antecedents and consequences for eye gaze) may also be one reason that

toddlers demonstrated generalization to a number of other social-communication contexts. Toddlers showed increases in performance. Although their performance within generalization contexts was not necessarily to mastery level, in comparison to the average performance of the three TD toddlers in our study, the performance of the toddlers with ASD generally matched that of the TD toddlers. Increases above baseline levels mean that toddlers are engaging in different social-communication interactions and have the opportunity to access reinforcement and to further improve performance. This is evident when examining changes in responding between the end of intervention and the 3-month follow-up. Overall toddlers showed maintenance or increases in responding from the end of intervention to the 3-month follow-up (except for Robert whose performance of GS across two contexts decreased). Continued follow-up is warranted to assess if early gains in the social-communication repertoire maintain over longer periods of time (Landa and Kalb 2012).

Some toddlers showed more improvement in some contexts than in others. Only two toddlers demonstrated responding to name. Jeff and Robert did not; their mothers reported some disturbance in their toddler's responding to auditory stimuli. It may be that other environmental auditory stimuli interfered with the auditory antecedent (i.e., the interventionist calling the toddler's name) in the RR (name) context. Toddlers also showed very limited generalization to RJA (head turn). Even the TD toddlers in our study responded to the interventionist's head turn on only a small percentage of opportunities. Paparella et al. (2011) found that RJA (head turn) emerged around 18 months of age in TD toddlers. Ian, the only toddler who showed RJA (head turn), showed higher overall performance on the DAYC post-intervention.

These findings suggest that RJA (head turn) and RR (name) may warrant direct intervention. Whether it is necessary to teach RR and IJA as well as RJA (head turn) and RR (name) remains for future investigation. Exploration of different samples of contexts to target for intervention may reveal greater generalization.

Across intervention and generalization contexts, toddlers showed improvement in initiating behavior, both requesting and JA. The initiation of social interaction has been identified as significantly impaired from a young age (Barbaro and Dissanayake 2013; Mundy et al. 1986; Winder et al. 2013). Developing interventions that directly or indirectly result in an improvement of initiating behavior across requesting and JA is critical to successful social interactions.

Up to this point, we have discussed the toddlers' performance with the interventionist. Not only did toddlers acquire gaze shift across requesting and JA contexts, but they demonstrated generalization to interactions with natural social-communication partners for young children, their mothers. All mothers were very satisfied with the intervention and outcomes. After intervention ended, each mother received instructions about the intervention procedures to help maintain GS. Three out of four toddlers showed maintenance with their mothers. Additional guidance (e.g., parent training) may have supported generalization and maintenance for Robert.

Although we examined generalization across natural partners (mothers), the situation was still relatively structured. It will be important to examine performance in even more natural interactions (e.g., mother and toddler playing in the living room, visiting the zoo, etc.) where toddlers should be engaging in such social-communication interactions. Ensuring such generalization may also help with maintenance of changes.

Without direct intervention, toddlers also showed increases in smiling. Social-communication interactions, especially JA, are characterized by the expression of positive affect, such as smiling (Kasari et al. 1990). Children with ASD show impairment in the expression of affect (Clifford and Dissanayake 2008; Zwaigenbaum et al. 2005) and may require direct intervention to address it (DeQuinzio et al. 2007; Krstovska-Guerrero and Jones 2013). Toddlers with ASD in the present study did not just smile at the toys, but shared that smile with the interventionist by shifting gaze and smiling while looking at the interventionist. Even small increases in smiling, as seen for Ian and Jeff, mean caregivers now have some smiling responses to reinforce and build upon.

The increase in smiling may be a result of imitation. When the toddler looked at the interventionist as a result of learning to shift gaze, he observed the interventionist's smile and then began to imitate the expression. If toddlers began smiling as a result of imitation, not only have we observed changes in the expression of affect that is often impaired in learners with ASD, but these results perhaps suggest improvements in imitation, another area of impairment (Rogers 1999). Future research may assess imitation as another outcome.

Improvements in GS across social-communication contexts and in smiling were measured during intervention sessions and also observed on the ESCS, a semi-structured assessment of early social-communication skills. Jeff and Robert showed less improvement on the ESCS, which is consistent with their performance in GS across generalization contexts. Overall initiation of interaction increased during IBR and IJA, but not ISI. It may be because there were many opportunities throughout the assessment for the toddlers to engage in IBR and IJA, but limited number of opportunities to engage in ISI. As additional collateral change measures, we examined performance on the ADOS and DAYC. On the ADOS and DAYC, changes occurred within the specific sections directly relevant to the behaviors taught in this study, but overall change was minimal. Ian's ADOS standardized severity score improved. The limited change on the ADOS is comparable to others who have used the ADOS as a pre-post-intervention measure (e.g., Dawson et al. 2010), but the continued use of such measures is particularly relevant to examine the broader effects of intervention.

Results from the ADOS, DAYC, and the ESCS must be interpreted with caution due to repeated administration and possible practice effects. The ADOS evaluator was not otherwise involved in this study, but was aware of the type of intervention the toddlers were receiving. The interventionist administered the DAYC and ESCS. Use of blind evaluators is warranted in future research.

We must also note that toddlers all received other intervention and may have improved in these collateral change measures as a result of the passage of time, though intervention was relatively brief lasting only 3 to 9 weeks. Further exploration of collateral changes associated with this intervention would be bolstered by use of a between groups design to control for changes associated with other intervention.

Although intervention was relatively brief, some differences in time to acquisition of target responses occurred. Ian and John required fewer weeks of intervention than Jeff and Robert, with John being the only toddler who demonstrated generalization of GS across RR and IJA contexts. Intervention for Jeff and Robert began in the summer and may have been prolonged because of several missed sessions due to family and interventionist vacations. It may be

that these missed sessions decreased the intensity of intervention enough to impact acquisition. Future research may examine how varying intervention intensity such as the frequency of sessions affects time to acquisition.

This is one of only a few studies focusing on toddlers with ASD (e.g., Dawson et al. 2010; Schertz et al. 2013) and with intervention occurring within the first few months of diagnosis. Not only was this one of the first interventions the toddlers received, but it was associated with some broader changes. Intervention impacted the majority of atypical social-communication behavior identified as early signs of autism (Zwaigenbaum et al. 2009). We did not control for duration of intervention, but intervention was relatively brief, lasting 3 to 9 weeks. Recent interventions to address only JA have lasted for similar durations (e.g., Kasari et al. 2006) and longer (e.g., Landa et al. 2011). Such rapid acquisition of eye gaze across RR and IJA with generalization to a repertoire of social-communication behavior suggests a promising efficient and effective intervention to address the most profound impairments evident in toddlers with ASD soon after they receive the diagnosis.

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Compliance with Ethical Standards

Ethical Approval All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest The authors declare that they have no conflict of interest.

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