Research Article

Communicative Use of Triadic Eye Gaze in Children With Down Syndrome, Autism Spectrum Disorder, and Other Intellectual and Developmental Disabilities

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Purpose: This study examines differences in the communicative use of triadic eye gaze (TEG) during a communicative interaction in 2 neurodevelopmental disorders: Down syndrome (DS) and autism spectrum disorders (ASD), and a 3rd group of varying disabilities associated with intellectual and developmental disabilities (IDDs). Also, the relationship between TEG use and language abilities was explored.

Method: Participants were 45 children, 15 in each group. The frequency of TEG was coded during a scripted communication assessment when children were between 3 and 6 years of age (37–73 months). Receptive and expressive language was measured using raw scores from the Mullen Scales of Early Learning concurrently between 3 and 6 years and again 2 years later when children were between 5 and 8 years (59–92 months).

Results: Descriptively, children with DS had a higher frequency of TEG than children with ASD and IDD, but significant differences were only observed between children with DS and ASD. More TEG at Time 1 in children with DS was associated with higher receptive language at Time 1 and higher expressive language at Time 2. For children with ASD, a trend for a positive association between TEG at Time 1 and language abilities at Time 2 was observed. No significant associations were observed for children with IDD.

Conclusion: Children with DS used TEG significantly more than children with ASD in this sample. Identifying strengths and weaknesses in TEG use is important because providing caregiver training to facilitate TEG can result in increased opportunities to respond with language models and promote language development.

In early development, children communicate with prelinguistic behaviors such as eye gaze, gestures, and nonspeech vocalizations (Bates & Dick, 2002). Although, typically developing children transition into linguistic communication during their second year, children with neurodevelopmental disorders associated with intellectual disability, including those with Down syndrome (DS), autism spectrum disorders (ASDs), and other intellectual and developmental disabilities (IDDs) may remain in the prelinguistic period of communication for several years (Roberts, Price, & Malkin, 2007). This prolonged prelinguistic

period is due in part to the presence of intellectual disability coupled with difficulties in expressive language (Fidler, Philofsky, & Hepburn, 2007; Luyster, Seery, Talbott, & Tager-Flusberg, 2011). Examining the presence, absence, or relative use of specific prelinguistic behaviors in children with neurodevelopmental disorders provides useful information about likely developmental trajectories of these skills (Bopp & Mirenda, 2011; Brady, Marquis, Fleming, & McLean, 2004). Triadic eye gaze (TEG) is an example of such a prelinguistic behavior (Clifford & Dissanayake, 2009; Paparella & Kasari, 2004).

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Prelinguistic Communication

Prelinguistic communication is the intentional coordination of nonverbal communication behaviors such as eye gaze, facial expressions, vocalizations, and gestures to convey a message (i.e., needs or wants) prior to the acquisition of spoken language (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Calandrella & Wilcox, 2000; Volterra,

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Caselli, Capirci, & Pizzuto, 2005). In typical development, these prelinguistic communication skills emerge between 6 and 12 months and continue to become more complex with age (Bates et al., 1979). While vocalizations emerge before 6 months, they begin to be more directed and intentional around this time (Nathani, Ertmer, & Stark, 2006). Importantly, infants begin to coordinate prelinguistic behaviors to express needs and wants and engage in social interactions prior to the emergence of spoken language (Bates & Dick, 2002; Trevarthen & Aitken, 2001). Prelinguistic communication skills also predict future expressive language outcomes in both typically and atypically developing children indicating that these skills serve as the foundation for linguistic communication (Brady et al., 2004; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Fenson et al., 1994; Yoder & Warren, 2004; Zampini & D'Odorico, 2011).

In addition to these foundational values, prelinguistic or nonverbal behaviors, such as gestures and eye gaze, are active additions to communication throughout the life course for individuals with and without language impairments, including individuals with neurodevelopmental disorders (Knapp, Hall, & Horgan, 2013). Individuals with expressive language difficulties may consistently rely on nonverbal communication to augment spoken words when interacting with others (Mainela-Arnold, Alibali, Hostetter, & Evans, 2014; Stefanini, Caselli, & Volterra, 2007). Directed eye gaze indicates that the individual intends to communicate with the partner and is jointly engaged (Iverson & Thal, 1998). Recent research is focusing on how one form of directed eye gaze—TEG—may be used as an expressive communication signal (Olswang, Feuerstein, Pinder & Dowden, 2013; Olswang, et al., 2014).

TEG

TEG is looking from an object/event to another person and back or vice versa and, thus, serves as a mechanism for establishing joint attention. This common prelinguistic communication behavior is the most communicative form of eye gaze because it can be used to show intentional communication (Arens, Cress, & Marvin, 2005), serving as the earliest form of joint attention prior to the onset of gestures, vocalizations, or the combination of all three. For example, to comment on a passing fire truck, a child may look from the fire truck to their caregiver and back again. Although TEG is often discussed as a form of joint attention because it is frequently used to share attention and comment on events and objects in the environment, TEG can also be used for requesting and managing the behaviors of communicative partners. For example, to request a drink, a child may look from their caregiver to their cup and then back to their caregiver. In each of these examples, the child is essentially pointing with their eyes instead of their hands. The return of the gaze from to the original spot (the third part of the TEG) helps confirm the intentionality of the behavior. TEG may be used alone or in combination with other prelinguistic behaviors, such as vocalization or gestures. The addition of gestures and vocalizations to TEG can help to

clarify the communicative intention of the behavior (i.e., to share attention or request help).

TEG and language development. The presence of TEG indicates that the individual is communicating about a referent (the object gazed at), but the underlying intention of the communication may not be completely clear (Ames & Jarrold, 2007; Pellicano & Rhodes, 2003). For example, if a child looks at a ball, back to their caregiver, and then back to the ball, it is not clear if they are commenting on the ball, “Look a ball,” or if they are requesting the ball, “I want the ball.” The addition of a gesture, such as a point to comment or a reach to request, provides the communication partner with clarity about the child’s communicative act.

In typically developing children, the use of TEG begins to emerge around 6 months of age, once they have the motor and visual coordination to do so (Moore, 2013). Although initially, the use of eye gaze at this time may be solely a dual orientation (i.e., from an object to the caregiver), TEG emerges soon after (Salley & Brady, 2015). As children develop, TEG is combined with gestures and/or vocalizations to provide clear signals to the communication partner (Bates, Camaioni, & Volterra, 1975; Carpenter et al., 1998; Desrochers, Morissette, & Ricard, 1995). Communication partners frequently respond to (map) communication signals with linguistic input (Tomasello, 2003). Linguistic mapping, in turn, can enhance the child’s communication development by connecting words with meanings (Tomasello, 2003; Tomasello & Farrar, 1986). Triadic social interactions with caregivers, often initiated by a child using TEG, are foundational for children’s acquisitions of first words at about 12 months in typically developing children (Carpenter et al., 1998; Tomasello, 2003). Between 18 and 24 months, typically developing children begin to combine single words into phrases (Fenson et al., 1994). These phrases often verify the focus of attention initially established through triadic social interaction (e.g., “More ball!”; Longard & Moore, 2015; Moore, 2013). Thus, TEG plays a pivotal role in language development.

Recently, Olswang et al. (2014) conducted a randomized control trial to examine if teaching TEG to young children with severe disabilities, in conjunction with their ongoing early intervention, would serve as a signal for joint attention. Results indicated that both the treatment and control participants increased in TEG over the course of the study, but the treatment group changed at a slightly higher rate (Olswang et al., 2014). Specifically, after 12 weeks of TEG intervention, the treatment group had significantly greater TEG use than the control group. In addition, Feuerstein et al. (2017) found that in addition to clinicians having positive attitudes about adopting evidence to support TEG, they could learn to deliver a research-based TEG protocol. Furthermore, the clinicians who were more competent with the TEG protocol—defined as overall quality and quality of delivering the protocol—were more successful at eliciting child productions of TEG (Feuerstein et al., 2017). Thus, there is initial evidence that adding TEG as an intervention target can impact child behavior and, in turn, support the

development of joint attention and intentional communication (Olswang et al., 2014).

Prelinguistic Communication in Neurodevelopmental Disorders

For children who have neurodevelopmental disorders and remain in the prelinguistic period longer than their peers, targeting TEG may improve communication. Use of TEG may help clarify the focus (or referent) of prelinguistic communication and provide the platform for linguistic mapping as discussed previously.

TEG, as well as other aspects of prelinguistic communication, may develop differently across individuals with different etiologies associated with intellectual disability. Identifying and tracking these differences could provide useful information for assessment and intervention planning. Two etiologies of neurodevelopmental disorders that have been characterized as having impairments in expressive language are DS and ASD. However, both DS and ASD appear to have somewhat different patterns of prelinguistic communication from each other and from children with other known or unknown etiologies of IDD. These different patterns may influence their use of TEG and later language development further differentiating children with DS and ASD from each other and from children with other IDDs.

DS

DS is the most common and recognizable chromosomal abnormality with an incidence rate of one in 691 live births (Parker et al., 2010). DS is caused by the presence of an overexpression of genes on chromosome 21, which leads to mild to moderate intellectual disability. Children with DS are characterized as having relative weakness in expressive language skills coupled with relative strengths in receptive language and nonverbal social communication (i.e., eye gaze, gestures for social sharing purposes; for a summary of language abilities in DS, see Fidler et al., 2007; Luyster et al., 2011).

Although children with DS show a delay in the development of spoken language, including prespeech vocalizations (Lynch, Oller, Steffens, & Levine, 1995), they are also motivated to engage with others (Fidler, 2006). One early indicator of this social motivation profile is the tendency of infants with DS to look at their mother longer than their typically developing peers during play interactions (Crown, Feldstein, Jasnow, Beebe, & Jaffe, 1992; Gunn, Berry, & Andrews, 1982). Eye gaze may be an effective way to maintain a social interaction for infants with DS prior to the use of gestures or vocalizations. This social motivation profile may also contribute to the presence of relative strengths in the prelinguistic skill of gesture use, which allows children to share and comment on the world around them to another person (Franco & Wishart, 1995; Mundy, Kasari, Sigman, & Ruskin, 1995; Mundy, Sigman, Kasari, & Yirmiya, 1988; L. Smith & Von Tetzchner, 1986). Specifically, toddlers with DS demonstrate increased gesture use for social purposes

compared to their typically developing peers (Franco & Wishart, 1995; Kasari, Mundy, Yirmiya, & Sigman, 1990; Mundy et al., 1995, 1988). While numerous studies have been conducted on joint attention, gesture use, and vocalizations in DS, a review of the literature suggests TEG remains relatively unstudied.

ASD

Impairments in social communication and social interaction are one of the core features of ASD (American Psychiatric Association [APA], 2013), but the range of communication impairments varies between mild to severe. Due to the wide range of communication abilities observed in ASD, studying prelinguistic communication can provide insight into which behaviors predict later language outcomes (Bopp & Mirenda, 2011; Charman et al., 2003; Luyster et al., 2011; V. Smith, Mirenda, & Zaidman-Zait, 2007). Impairments in prelinguistic communication in children with ASD emerge between 12 and 18 months (Ozonoff et al., 2010; for a full review, see Zwaigenbaum, Bryson, & Garon, 2013), with specific impairments noted in joint attention (Dawson et al., 2004), social orienting (Bhat, Galloway, & Landa, 2010), and gesture use (Lebarton & Iverson, 2016; Talbott, Nelson, & Tager-Flusberg, 2015).

Prelinguistic skills, particularly joint attention, have been examined extensively in children with ASD (see Bottema-Beutel, 2016). TEG, however, has not been extensively studied in isolation. Because TEG is an early occurring prelinguistic behavior that can be used to communicate joint attention, it is important to monitor its development. Poor use of TEG could be an early sign of the social communication impairments observed in ASD.

TEG may be difficult for children with ASD given the tendency to avoid eye contact (APA, 2013). However, several language interventions have successfully improved joint attention in children with ASD (Jones, Carr, & Feeley, 2006; Kasari, Freeman, & Paparella, 2006; Kasari, Paparella, Freeman, & Jahromi, 2008; Stickles Goods, Ishijima, Chang, & Kasari, 2013). Thus, it is likely that TEG can also be targeted during interventions for children with ASD (e.g., Feuerstein et al., 2017; Olswang et al., 2014). TEG could be targeted along with other early communicative behaviors, such as gestures and vocalizations, which will help establish joint attention and intentional social communication.

Other IDDs

Many children have IDD (range: 8.7–36.8 per 1,000 children; National Academies of Sciences, Engineering, and Medicine, 2015) but do not have either ASD or DS. However, there is limited research characterizing TEG in other IDDs. Examining TEG in IDD has both clinical and theoretical importance. Arens et al. (2005) found that children with IDDs between 9 and 25 months produced TEG only 0.2% of the time while playing with their parent—a much lower rate than typically developing children of the same developmental age (Arens et al., 2005; Bakeman & Adamson, 1984). This study takes a next step in examining TEG in

children with IDD by comparing children with IDD to children with DS and ASD, as well as examining the association between TEG and language abilities at two different time points. Clinically, it is just as important to look at TEG in children with IDD as children with an identified etiology. Many of these children will continue to struggle with transitions into advanced presymbolic and symbolic communication (Brady et al., 2004; Brady, Thiemann-Bourque, Fleming, & Matthews, 2013). Identifying relative strengths and weaknesses in TEG could help identify current communication strategies and possible foci for interventions.

Comparisons Across DS, ASD, and Other IDD

There are theoretical reasons to hypothesize differences across children with DS, ASD, and IDD (Dawson et al., 2004; Rogers, Hepburn, Stackhouse, & Wehner, 2003). If TEG is acting primarily as a mechanism of social engagement, one would expect better TEG in children with IDD and DS than in children with ASD because ASD is primarily an impairment of social interaction. In contrast, children with DS are typically described as being social—sometimes overly so (Fidler, 2006). Relatively, high frequencies of TEG in DS could be further indication of high social engagement.

This Study

This study examines differences in the communicative use of TEG during a communicative interaction in children with DS, children with ASD, and children with other IDD between ages 3 and 6 years (37–73 months). Including children with other IDD allows us to examine if there are similar patterns of TEG that may be associated with the presence of intellectual disability broadly, thus serving as a control group. In addition, this study examines the relationship between early TEG use and concurrent and later language ability (~2 years later; 5–8 years). We were interested in how TEG in early childhood was related to language abilities considering that the extant research suggests these skills should support language development. Therefore, we examined TEG as an early predictor of language across etiologies. The following research questions were addressed:

1. Are there differences in the frequencies of TEG use in early childhood by children with DS, children with ASD, or children with IDD?
2. What is the relationship between TEG use in early childhood and language abilities at both Time 1 (37–73 months) and Time 2 (59–92 months)?

Method

Participants

Participants for this study were 15 children with a confirmed diagnosis of DS, 15 children with ASD, and 15 children with IDD (global developmental delay = 4,

unknown etiology = 4, cerebral palsy = 2, spina bifida = 1, traumatic brain injury = 1, Angelman syndrome = 1, C syndrome = 1, paroxysmal tonic upgaze = 1) between 3 and 6 years (37.26–73.86 months) of age at the beginning of this study. This study is a secondary analysis of participants who were recruited as part of a larger study to investigate a model of child and environmental predictors of communication outcomes for a group of young children with developmental disabilities (see Barker, Akaba, Brady, & Thiemann-Bourque, 2013; Brady et al., 2012, 2013, for details). Children were selected for participation in the larger study based on their prelinguistic communication level rather than their chronological age, which is why the age range for this study is very wide. Due to the focus on prelinguistic communication, all children had expressive language T-scores below the floor (i.e., their raw scores were so low that they did not reach the level required for a T-score of 20) and receptive language T-scores at or near the floor on the Mullen Scales of Early Learning (MSEL; Mullen, 1995) at Time 1. All children had normal or corrected vision and hearing. See Table 1 for developmental and demographic information.

For this secondary analysis, we individually matched children with DS, ASD, and IDD from the larger study on chronological age and nonverbal cognitive abilities as measured by the MSEL (i.e., Mullen, 1995). Nonverbal cognitive abilities were estimated by combining the visual reception and fine motor domains (e.g., Barbaro & Dissanayake, 2017; Seager et al., 2018). Because the nonverbal cognitive T-scores ranged from below the floor to at or near the floor (see Table 1), we used nonverbal cognition raw scores for matching. A one-way ANOVA was conducted to examine differences between the three groups on the matching variables. No statistically significant differences were observed—age: $F(2, 42) = 5.15, p = .89$, and nonverbal cognition raw score: $F(2, 42) = 5.15, p = .96$; all p values for matching were greater than .50 per the criteria suggested by Mervis and colleagues (Mervis & Klein-Tasman, 2004; Mervis & Robinson, 2003). Further, there were no statistically significant differences between groups on the T-scores for nonverbal cognition, $F(2, 42) = 1.32, p = .28$, or receptive language, $F(2, 42) = 1.16, p = .32$, at Time 1. For expressive language T-scores, all participants had scores below the floor; therefore, comparisons across groups could not be made because there was no variability in scores.

Procedure

As part of the larger study, each child participated in three assessments over the course of 2 years administered by a trained research assistant at either the child's school or home. In this study, we examined TEG during each child's first assessment. As part of this assessment, all participants were administered a 20- to 30-min scripted communication assessment (described below). Additionally, the MSEL (Mullen, 1995) was administered to each

Table 1. Participant characteristics.

Characteristic	Down syndrome (N = 15)				Autism spectrum disorder (N = 15)				Intellectual and developmental disabilities (N = 15)			
	Time 1		Time 2		Time 1		Time 2		Time 1		Time 2	
	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD	M/%	SD
Age (in months)	52.86	9.27	78.83	11.17	52.34	10.90	78.08	11.27	51.14	8.97	78.19	9.16
MSEL nonverbal cognition raw	22.57	5.82	—	—	22.87	5.93	—	—	22.30	5.15	—	—
MSEL nonverbal cognition T-score	19.36	0.58	—	—	19.30	0.46	—	—	20.00	2.13	—	—
MSEL expressive T-score	19.00	0.00	20.18	3.60	19.00	0.00	19.00	0.00	19.00	0.00	21.67	5.23
MSEL receptive T-score	20.27	2.96	19.73	2.41	19.07	0.26	19.00	0.00	20.00	2.56	23.00	7.09
MSEL expressive raw score	15.93	2.52	25.27	8.68	14.87	4.97	25.57	5.00	12.80	4.26	23.00	12.32
MSEL receptive raw score	20.00	5.75	28.09	7.12	17.53	5.36	25.57	5.91	21.13	7.32	30.07	11.22
Sex (% male)	64.3	—			86.7	—			66.7	—		
Ethnicity (%)												
Caucasian	66.7	—			60	—			73.3	—		
African American	6.7				6.7				13.3	—		
Asian/Pacific Islander	13.3				13.3				—	—		
Hispanic	—	—			6.7	—			—	—		
More than 1 race/other	6.7	—			6.7	—			6.7	—		
Unknown/choose not to respond	6.7	—			6.7	—			6.7	—		

Note. MSEL domains have a mean T-score of 50 and an SD of 10. MSEL = Mullen Scales of Early Learning.

child twice: at the first assessment (Time 1) and 2 years later (Time 2).

Measures

MSEL

The MSEL (Mullen, 1995) is a standardized developmental assessment for children from birth to 68 months. There are five domains of the MSEL: visual reception, fine motor, expressive language, receptive language, and gross motor. T-scores are provided for each domain, and the visual reception, fine motor, expressive language, and receptive language domains can be combined into a composite score (i.e., early learning composite) that provides an estimate of overall development. All domains have a mean domain T-score of 50 with an *SD* of 10. The MSEL has well-established validity and reliability (Mullen, 1995). The administrators were all trained to administer the MSEL to fidelity of administration standard as described in the MSEL manual using a fidelity checklist. A senior investigator reviewed videos of practice administrations, and 100% fidelity was achieved prior to administering the MSEL to any participants.

In this study, receptive and expressive language raw scores from the MSEL at both assessment points were examined. Raw scores instead of T-scores were used because raw scores are sensitive to changes in skills that may not be captured by standard scores. T-scores are bound to relative changes associated with chronological ages in typically developing children. The rate of growth in skills for children in our sample is not consistent with their chronological age due to the presence of intellectual disability. As such, their T-scores may show little or no change even though they have gained skills. All of the children had receptive T-scores at or near the floor and expressive language T-scores below the floor. Both of these issues limit the ability to detect small, yet meaningful, change over time when using T-scores (Kover & Atwood, 2013; Mervis & Klein-Tasman, 2004). Therefore, raw scores were used in analyses.

Scripted Communication Assessment

This assessment was designed by the second author to provide a series of scripted opportunities for communication between the child and a communication partner (Brady et al., 2012). The examiner presented a series of 12 different communication opportunities that were age-appropriate for young children. The 12 communication opportunities were equally divided in the number of items designed to provide an opportunity for a request (i.e., behavior regulation acts) or a comment (i.e., joint attention acts). An example of a task for a request was blowing bubbles. After taking turns blowing bubbles, the child is given a bottle that is difficult to open—thus, creating the motivation to ask for help. For example, to elicit a comment, the child was provided with paper and a box of markers to color with. In the box of markers, there was also a toy hot dog (a novel object to comment on). In

both types of opportunities, the examiner and the child take turns interacting and the examiner waits for the child to either request or comment (Brady et al., 2012). The administrators were all trained to fidelity of administration standards using a fidelity checklist. The fidelity checklist includes seven different items that are assessed for each of the 12 communication opportunities. These items cover appropriate setup of the room and tasks, creating opportunities for communication by waiting, effective prompting strategies (i.e., not asking yes/no questions, saying “what?” during a communication breakdown), and making sure that a participant’s Alternative and Augmentative Communication device is within reach, set up, and modeled properly. The second author reviewed videos, and administrators achieved 100% fidelity before administering to any participants. In addition, videos of administration were reviewed at least once every 3 months to ensure fidelity.

Coding TEG. We coded TEG from the videotapes of the scripted communication assessment described above. Each instance of TEG from the Time 1 assessment was coded from video by two trained coders: (a) a graduate research assistant and (b) an undergraduate research assistant. TEG was defined as a child directing his or her line of sight to an object then to a communication partner and back to the same object (or vice versa—gaze starting with partner, shifting to object then back to the partner) within a 5-s window with the apparent intent of communicating with their communication partner. We inferred communicative intent from the infants’ behavior. For example, if the child engaged in TEG then paused expectantly with a shift in affect (e.g., smile), it would indicate intent. Or, if the infant seemed upset at not obtaining something after initiating TEG, we would infer intent. Acceptable reliability for identifying communication intent of the behaviors coded in this study was reported previously (Brady et al., 2012, 2018).

Reliability. The two independent coders were first trained to a criterion of 80% reliability on at least three consecutive videos previously coded by the second author. Twenty percent of the remaining videos were randomly selected to be coded a second time for reliability. Intra-class correlation coefficients (Shrout & Fleiss, 1979) using absolute values for single measures for TEG frequency was .89, indicating consistent responding across coders.

Results

Group Differences in TEG

Descriptive statistics indicated that, during the scripted communication assessment, children with DS used more TEG ($M = 15.27$, $SD = 10.33$), on average, than children with IDD ($M = 10.20$, $SD = 7.95$) and ASD ($M = 6.00$, $SD = 4.28$; see Figure 1). A one-way ANOVA was conducted to examine if there were statistically significant group differences in TEG. Results indicated significant differences between groups, $F(2, 42) = 5.15$, $p = .01$, $\eta^2 = .20$. Post hoc analyses indicated a significant difference ($p = .01$) between

Figure 1. Mean triadic eye gaze use by group with standard error bars. DS = Down syndrome; ASD = autism spectrum disorders; IDD = intellectual and developmental disabilities.

children with DS and children with ASD, such that children with DS used more TEG than children with ASD. No significant differences were observed between children with ASD and IDD or DS and IDD.

Relationship Between TEG and Language Abilities

Pearson r correlations indicated that for children with DS, TEG use at Time 1 was positively associated with receptive language raw scores at Time 1 ($r = .62$, $p = .01$) and with expressive language raw scores at Time 2 ($r = .67$, $p = .02$; see Table 2 for correlations, Table 1 for language measure descriptive information, and Figure 2 for scatter plots). For children with ASD, a positive trend ($p < .10$) was observed between TEG use at Time 1 and language raw scores at Time 2 (receptive: $p = .06$; expressive: $p = .07$; see Figure 3 for scatter plots). No significant correlations were observed for children with IDD between TEG use at Time 1 and language scores during either Time 1 or Time 2 (see Figure 4 for scatter plots).

Discussion

The purpose of this study was to examine differences in the communicative use of TEG in children with DS, ASD, and IDD, and to examine the relationship between language abilities and TEG at two time points. Comparing TEG across children with different neurodevelopmental disorders associated with intellectual disability can provide insight into the use of this communicative skill and how it relates to language development in these populations. Further, this information may inform interventions to promote language development. As all children in the current study had similar levels of intellectual disability and measured expressive language, our results suggest that TEG use only differed, significantly, between children with DS and ASD.

Our findings suggest that children with DS use TEG more to communicate than children with ASD. It seems, such as other early prelinguistic skills in DS and ASD (e.g., Mundy et al., 1995; Zwaigenbaum et al., 2013), TEG follows a similar phenotypic pattern of prelinguistic and

Table 2. Correlations between triadic eye gaze and language abilities by group.

Group	MSEL receptive raw at Time 1	MSEL expressive raw at Time 1	MSEL receptive raw at Time 2	MSEL expressive raw at Time 2
Down syndrome	.62*	.34	.36	.67*
Autism spectrum disorder	.36	-.23	.52 [^]	.49 [^]
Intellectual and developmental disabilities	.39	.08	.14	.01

Note. MSEL = Mullen Scales of Early Learning.

[^] $p < .10$, * $p < .05$

Figure 2. Scatter plot for the correlation between triadic eye gaze and expressive and receptive language use at Time 1 ($n = 15$) and Time 2 ($n = 11$) for children with Down syndrome.

social strengths in DS (Fidler, 2006) and difficulties in ASD (i.e., core deficits in social functioning; APA, 2013). However, it is important to acknowledge that, for children with ASD, difficulties with visual disengagement may lead to more difficulties in using TEG (Venker, 2016). We also examined differences in TEG between those with IDD and those with DS and ASD. Although, our results did not indicate significant differences between those with IDD and those with either DS or ASD, descriptively, the use of TEG by those with IDD was between those with DS and ASD (see Figure 1). Significant differences may be observed in TEG use across these three groups in a larger sample.

When considered within the broader behavioral phenotype associated with DS, the use of TEG observed in this

study may be one reason why children with DS are often described as “social” (Fidler, 2006) because this skill allows them to more readily engage in social interactions and participate in joint attention. Our findings indicate that more TEG in children with DS was associated with higher receptive language abilities at Time 1 and higher expressive language abilities at Time 2. When examining expressive and receptive language raw scores for participants with DS, most showed a greater increase in expressive than receptive language skills from Time 1 to Time 2 (see Table 1). This pattern of associations is consistent with studies of joint attention and gesture use in DS and other neurodevelopmental disorders (Bottema-Beutel, 2016; Brady et al., 2004; Mundy et al., 1995; Zampini & D’Odorico, 2011). Like gesture use, TEG provides a potential signal for parents to

Figure 3. Scatter plot for the correlation between triadic eye gaze and expressive and receptive language use at Time 1 ($n = 15$) and Time 2 ($n = 14$) for children with autism spectrum disorder.

provide linguistic input that facilitates language development (Kaiser & Hancock, 2003). Therefore, although children with DS may not require intervention for TEG, early language intervention efforts that teach parents to recognize and respond to TEG may help to promote language development in this population.

Children who rarely use TEG, including many children with ASD, may benefit from intervention aimed at increasing their use of TEG (e.g., Olswang et al., 2014). Consistent use of TEG is communicative and thought to be theoretically tied to language development of these children (Feuerstein et al., 2017; Olswang et al., 2014). Facilitating early communication, including prelinguistic communication, is an important goal for early interventions. However, our results suggest that the same positive relationship between TEG and language abilities may not hold across

clinical groups. For all three groups, the variability in expressive and receptive language raw scores was quite large, especially within the IDD group (see Figures 2–4). This variability may have affected our ability to detect associations between TEG and language abilities in IDD and only detect a trend for children with ASD. Future research is needed to examine the benefits and feasibility of teaching TEG to children with ASD, including potential increases in language abilities (Longard & Moore, 2015).

Children with IDD in our study did not differ statistically from the other two groups. Furthermore, TEG use in those with IDD in our sample did not demonstrate the expected positive association between these skills. This may be because this group of children with IDD was too heterogeneous and/or it may have been related to limited power due to the small sample size. More research is needed to

Figure 4. Scatter plot for the correlation between triadic eye gaze and expressive and receptive language use at Time 1 ($n = 15$) and Time 2 ($n = 15$) for children with intellectual and developmental disabilities.

examine TEG and other prelinguistic skills in children with IDD in order to better support their language development.

Clinical Implications

Prelinguistic communication skills, such as TEG, are often the target of clinical practice or early language interventions because they indicate early intentional communication (Braddock & Brady, 2016; Longard & Moore, 2015) and can provide a platform for adding linguistic input to children with DS (Harris, Barrett, Jones, & Brookes, 1988). Many early intervention programs (e.g., Fey et al., 2006; Hanen, responsivity/prelinguistic milieu teaching; Girolametto, & Weitzman, 2006; Olswang, Pinder, & Hanson, 2006; Yoder & Warren, 2002) teach caregivers to linguistically map vocalizations and gestures, and the current data suggest that

providing linguistic mapping during periods of TEG may be a way to provide input even earlier in development. For example, caregivers and clinicians can look for instances of TEG, map probable communicative intent (“Yes, I see a firetruck!”), and continue the scaffolding that promotes language development (Warren & Yoder, 1998).

These periods of TEG in children with DS indicate potential opportunities for interventions to provide additional linguistic input and model communicative responses, which in turn can promote their language development. For example, a parent could note the child’s interest in a ball that is out of reach from the child based on the child’s initiation of TEG. The parent could then say, “Ball?” with an accompanying shrug gesture and wait for the eye gaze of the child to shift to the object and back to the parent with or without an accompanying gesture or vocalization. The parent can

then follow through by retrieving the ball for the child. This event is just one example of how expanding on TEG could potentially promote language development.

Given the low use of TEG in ASD in our study coupled with the extant research indicating a positive relationship between joint attention and language outcomes in ASD (Bottema-Beutel, 2016), targeting or teaching TEG in early interventions may improve early prelinguistic communication. It is important to provide opportunities for training clinicians and caregivers on implementing TEG as part of interventions so that they both feel competent in the techniques (Feuerstein et al., 2017). Further research is needed to see if such intervention benefits later language development.

Limitations and Future Directions

In this study, we examined TEG from videos. Thus, it is possible that we missed some instances of TEG because we were not able to see where the child was looking due to the angles of the camera (we estimate that this happened in less than 5% of item administrations). Also, our study focused on TEG during a scripted interaction with an examiner. Future research is needed to examine the use of TEG during a naturalistic interaction with a caregiver, teachers, and others who frequently interact with participants.

The sample size of this study was small. Thus, these findings warrant replication in a larger sample. In addition, there was an overlap in chronological ages at Time 1 (37–73 months) and Time 2 (59–92 months) in our study. Therefore, we are unable to discern if TEG, at a certain age, was associated with language scores at a specific age. However, each child's second observation was 2 years after their first observation and correlations were performed between each child's initial TEG and their own concurrent and later language outcomes; hence, they reflect changes observed in each child. Future research is needed to explore age-related changes in TEG and its association to language growth. Also, children in this study had limited language abilities at Time 1 (i.e., MSEL language T-score at, near, or below the floor). This allowed us to have additional control to detect differences in TEG between three different neurodevelopmental disorders associated with intellectual disability that were not confounded by their language or non-verbal cognitive abilities (Mervis & Klein-Tasman, 2004; Mervis & Robinson, 1999, 2003).

Due to the low variability in language T-scores in our sample, we examined language raw scores in our analyses. The use of raw scores can limit the ability to interpret skill growth relative to typically developing children; however, in this study, the use of raw scores was necessary due to floor effects of normative scores. It is important to note that all children in this study were in the prelinguistic stage of language development at a chronologically older age. Thus, in comparison to their typically developing peers, these children were demonstrating delays in communication, even those with DS who were using TEG more frequently. Research with larger samples may also help to reduce the

variability in scores, and/or identify subgroups within these etiologies.

In this study, our IDD group was a mixed etiology group. Although this group can provide insight into differences between those with a specific etiology (i.e., DS, ASD) and those with broader developmental delays, these groups are usually made up of several nonspecific etiologies, which may not fully represent those with IDD of unknown etiology. Replication with other samples of those with IDD and typically developing controls is needed. Comparing TEG use between those who are typically developing and those with DS, ASD, and various IDDs can provide insight into the developmental course of TEG and its influence on language. Finally, examining if the use of TEG increases with familiar communication partners has important implications for language development and interventions, as familiarity may lead to more accurate identification of a child's TEG.

Conclusion

Eye gaze, especially TEG, is an early means of social engagement and communication. Our results indicate that there is a wide range of variability in TEG use between children with neurodevelopmental disorders. Not surprisingly, children with ASD had lower rates of TEG compared to children with DS. In addition, more TEG in children with DS was positively related to their current receptive and later expressive language abilities. TEG may serve as a facilitator for further communication development because TEG provides opportunities for communication partners to provide additional linguistic input and model communicative responses during periods of high engagement. More research is needed to explore how to capitalize on TEG and facilitate the development of complex gesture and word productions in children with neurodevelopmental disorders.

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