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Triadic Gaze Intervention for Young Children with Physical Disabilities

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Abstract

Purpose—This randomized controlled study investigated whether a supplemental treatment designed to teach triadic gaze (TG) as a signal of coordinated joint attention (CJA) would yield a significantly greater increase in TG in the experimental versus control group.

Method—Eighteen 10- to 24-month-old children with severe motor impairments were randomly assigned to an experimental (n=9) or control group (n=9). For approximately 29 sessions over 17 weeks, experimental participants received TG treatment twice weekly with a speech-language pathologist (SLP) in addition to standard practice. Controls received only standard practice from birth-to-three therapists. Coders masked to group assignment coded TG productions with an unfamiliar SLP at baseline, every three weeks during the experimental phase, and at the final measurement session.

Results—TG increased across groups from baseline to final measurement, with the experimental group showing slightly greater change. Performance trends were examined using experimental phase moving averages. Comparisons revealed significant differences between groups at two time points (at 12 weeks, $r = .30$, a medium effect and at the end of the phase $r = .50$, large effect).

Conclusion—Results suggest the promise of a short-term, focused treatment to teach TG as a behavioral manifestation of CJA to children with severe physical disabilities.

Young children with severe physical disabilities are at high risk for delayed development of early signals of communication. Complicated developmental profiles can profoundly disrupt production of conventional gaze, gestures and vocalizations in the context of social interactions. This, in turn, interrupts critical teaching and learning opportunities during the first months of life (Halle, Brady, & Drasgow, 2004; Iacono, Carter, & Hook, 1998; Olswang, Pinder, & Hanson, 2006; Paparella & Kasari, 2004; Pinder & Olswang, 1995;

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Pinder, Olswang, & Coggins, 1993). Early intervention for this population is crucial to teach behaviors that facilitate social engagement and joint attention (Arens, Cress, & Marvin, 2005; Goossens' & Crain, 1987; Paparella & Kasari, 2004; Pinder et al., 1993; Pinder & Olswang, 1995; Reinhartsen, 2000; Wetherby, Yonclas, & Bryan, 1989; Woods & Wetherby, 2003). While the need for treatment may appear obvious, the challenges in working with this population are substantial because of the severity and heterogeneity of their impairments. The purpose of this research was to examine the efficacy of a treatment designed to teach children with physical disabilities to use gaze behaviors as signals of intentional communication.

Children with Physical Disabilities

Young children with severe physical disabilities (e.g., cerebral palsy, congenital conditions, genetic syndromes) constitute a diverse clinical group who can be affected by impairments across sensory, motor, cognitive, and social domains. These children often exhibit unstable health, with accompanying seizure disorders and feeding difficulties threatening survival. Such problems can result in day-to-day performance variability that impairs interactions and greatly impacts overall development (Dowden & Cook, 2012). Some children demonstrate poor head and trunk control, which limits their use of gestures, gaze, vocalizations, and even facial expressions unless supportive positioning is provided. When these behaviors are absent, children with physical disabilities may begin to produce idiosyncratic signals in an attempt to engage caregivers (Sigafos & Mirenda, 2002). Some children may have concomitant sensory impairments, including hearing and vision deficits, or hyper/hypo-sensitivity to auditory, visual, and/or tactile stimulation. Lastly, additional challenges may arise from cognitive delays (e.g., knowledge of objects, object relations such as means/end), which are difficult to assess in this population but can further interfere with the development of early communication skills.

Such deficits are particularly problematic because, during the first months of life, children typically produce gaze, gestural, and vocal behaviors to share attention with caregivers about objects, events, and emotions. A critical milestone that occurs around nine months of age involves the child learning to shift his/her gaze back-and-forth between an adult and an object or event of interest, a behavior termed **triadic gaze (TG)** (Bakeman & Adamson, 1984; Bates, Camaioni, & Volterra, 1975; Trevarthen & Hubley, 1978). TG is a critical achievement, demonstrating the child's ability to use coordinated joint attention (CJA). Several research groups have argued that the appearance of TG to coordinate attention between objects and persons marks the transition from preintentional to intentional communication, which is associated with significant neurological change and is highly predictive of later language development (Beuker, Rommelse, Donders, & Buitelaar, 2013; McCathern & Warren, 1996; Mundy & Newell, 2007; Mundy, Sigman, & Kasari, 1990). Thus, as a signal of CJA, TG reflects the child's growing ability to monitor, relate, and integrate the behavior of self and others (Mundy & Acra, 2006), which supports the development of contingent communication between child and caregiver (Dunst, Trivette, Raab, & Masiello, 2008). Because children with severe physical disabilities have difficulty producing conventional behaviors that are recognized by others, they are less able to participate successfully in natural communication interactions. As a result, these children are

at extreme risk for delays in language acquisition (Arens et al., 2005; Halle, et al., 2004; Iacono et al., 1998; Paparella & Kasari, 2004; Pinder et al., 1993; Pinder & Olswang, 1995; Reinhartsen, 2000).

Early Intervention

While the need to target communication in early intervention for children with physical disabilities seems apparent, research has revealed the paucity of such focus in practice (Cress, 2004; Pennington, Goldbart, & Marshall, 2005). Since the passage of Part C of the Individuals with Disabilities Education Act in 1997 (IDEA, 2004), early intervention has been characterized by transdisciplinary, caregiver-directed treatment. Typically, services are delivered under a primary service provider model, in which one professional consults with the caregiver on child goals, based on family-identified priorities (American Speech Language Hearing Association, 2013; Hanft, Rush, & Sheldon, 2004). Although communication can be included as an important part of early intervention (Warren et al., 2008; Yoder & Warren, 2002), motor-related needs frequently dominate services for children with physical disabilities. The challenge is to develop effective and efficient service delivery models to meet child and family needs, while maximizing outcomes across developmental domains. Unfortunately, this approach sometimes ends up prioritizing developmentally appropriate behaviors in a few easily identifiable domains (e.g., mobility, feeding) over other critical milestones such as intentional communication.

Efforts to document the efficacy of interventions for teaching intentional communication to this population of young children have been limited (Pennington et al., 2005). However, preliminary research has demonstrated the value of focused, short term, SLP-delivered intervention specifically for this purpose (Pinder & Olswang, 1995; Pinder, et al., 1993). The treatment included providing communication opportunities, waiting for the child's response, recognizing the child's attempt, and guiding or shaping performance toward TG. Findings showed that children can learn to use TG to request the continuation of a discontinued action and to make a choice between desired objects under structured, familiar conditions after twice weekly treatment for 12–16 weeks. Further, the research documented that children with motor impairments can progress from gazing at an object or an adult (dyadic gaze) to shifting their gaze between an object and adult (triadic gaze) with SLP shaping and reinforcement. The heterogeneity of the population was reflected in differences in success among participants; some children rapidly increased TG productions, while others learned more slowly, requiring practice with earlier developing behaviors. This research program also documented two changes that coincided with the introduction of participation in TG treatment: an increase in the variety of object play and improvement in caregiver report of child exploration and interaction with toys (Olswang & Pinder, 1995).

Another study suggested the value of teaching this same protocol to caregivers of three children with physical disabilities (Olswang, Pinder, Hanson, 2006). After six sessions, caregivers demonstrated the ability to provide opportunities for communication and recognize gaze attempts, although they were minimally able to shape TG. In contrast to previous results, these children's TG productions increased only slightly during the study period, perhaps indicating the importance of shaping. All of this research has shown the

promise of a treatment designed to teach gaze behaviors associated with CJA. The research has helped define critical elements of the treatment protocol for maximizing outcomes, namely intense, short-term treatment provided by an SLP who is eliciting, shaping and reinforcing TG productions. Further exploration of this treatment will have important implications for designing more efficacious services for young children who are at risk for long-term therapeutic needs.

Research Focus

The purpose of this research was to examine the value of this treatment for teaching TG as a manifestation of CJA to young children with severe physical disabilities as a supplement to their ongoing early intervention services (hereafter referred to as “standard practice”). The unique aspects of the current research included the following: a) randomized assignment of children to either an experimental group receiving TG + standard practice or a control group receiving only standard practice, b) multiple SLPs trained to provide the TG treatment, c) different SLPs masked to group assignment conducting measurement sessions, and d) numerous coders also masked to group assignment. Both between group and individual time series analyses were employed to answer the following four research questions:

1. Will young children (ages 10–24 months) with physical disabilities produce TG as a signal of CJA to a greater degree with TG treatment than a control group without that treatment at the final measurement session?
2. Will the two groups of children demonstrate differences in change in TG production from baseline to final measurement session?
3. Will trends in level of TG production differ over time for individuals within each group?
4. Will the level of TG production differ between groups at 12 weeks into the experimental phase and at the end of the experimental phase?

Method

General Procedures

This research employed a randomized, controlled design, in which children with severe physical disabilities between 10–24 months of age were randomly assigned to one of two groups: an experimental treatment group (n=9) or a control group (n=9). All participants were considered good candidates for learning TG as a conventional and reliable communication signal (see *Recruitment* below for detailed characteristics). Children were referred by birth-to-three centers in the Seattle area, and recruited with the approval of the University of Washington’s Institutional Review Board (IRB) and parental consent. In accordance with IRB requirements, caregivers were informed at the time of consent that participation in this research would not affect their current birth-to-three services in any way. Children in the experimental group received direct treatment for TG delivered by a research SLP in addition to standard practice (treatment provided by their birth-to-three center service providers). Children in the control group received only standard practice sessions. Children

in both groups were observed in a play activity with an examiner approximately every three weeks to monitor TG learning.

Participants

Recruitment and enrollment—Forty-six children were recruited from seven birth-to-three centers in the Seattle area (see Figure 1 for a CONSORT flow diagram, following Schultz, Altman, Moher, for the CONSORT group, 2010). Twenty-two children qualified for enrollment based on the following criteria: a) age between 10 and 24 months at time of consent, b) severe motor delay as measured by a score of ≥ 2 standard deviations below the mean on either the *Fine Motor* or *Gross Motor Subscales* of the *Bayley Scales of Infant and Toddler Development, Third Edition (BSID-3)* (Bayley, 2006), c) adequate vision measured by passing 5 of the first 7 items on the *Visual Reception Subtest* from the *Mullen Scales of Early Learning (MSEL)* (Mullen, 1995), d) adequate hearing judged by passing 4 of the first 6 items on the *Receptive Language Subtest* from the *MSEL*, coupled with behavioral observation consistent with functional hearing, e) interest in toys and people, as revealed through change in muscle tone, facial expression, vocalization, and/or direction of gaze, and f) demonstrating $>80\%$ dyadic gaze (sustained gaze to adult or object), $<20\%$ TG, and no manifestations of symbolic communication (e.g., words, signs) during the baseline measurement session. Three participants withdrew following consent and completion of eligibility assessments. The remaining children who met enrollment criteria were randomly assigned to the experimental ($n=10$) or control ($n=9$) group. One participant allocated to the experimental group was dropped from the study due to frequent cancellations. Thus, final groups consisted of nine experimental and nine control participants.

Participant characteristics—The previously described eligibility criteria were used to ensure homogeneity among the participants on the basis of static assessment. Table 1 provides child/family characteristics, including age at consent, racial-ethnic background, maternal education and household income, language(s) spoken in the home, diagnosis, complications, and hearing/vision status. There were no differences between the experimental and control groups in the distribution of racial-ethnic groups, highest level of maternal education, or average annual household income. All primary caregivers had sufficient English proficiency to read and sign the consent form and engage with SLPs during measurement and treatment sessions. As described in Table 1, five children came from households that spoke two or more languages including English; an additional three participants came from households that reportedly only spoke a language other than English. In accordance with the American Speech-Language-Hearing Association's position statement for "Clinical Management of Communicatively Handicapped Populations," the research team queried these families about language use and preferences in the home and with their birth-to-three service providers prior to enrollment (American Speech-Language-Hearing Association, 1985). Interpreter services were offered to all families who reported one or more household languages other than English, although no caregivers accepted this offer. All caregivers reporting other household languages spoke English to the SLPs and in the presence of their children during research sessions.

Table 2 provides a summary of baseline performance for participants in the experimental and control groups. A nonparametric Mann-Whitney *U*-test revealed non-significant differences in TG production at baseline between the experimental (mean rank 9.17) and control (mean rank 9.83) groups, $U=37.50$, $z=-.27$, $p=.79$, $r=-.06$. Furthermore, there were no statistically significant between-group differences in the mean ranks of any the following: mean age, mean scores on the Fine Motor subscales of the *BSID-3*, and *MSEL* subscale scores. Significance levels (*p*-values) ranged from .11 to .46. However, non-significant differences in mean ranks of standardized test scores had small to medium effect sizes with experimental participants demonstrating higher mean ranks in all cases. Moreover, mean ranks on the Gross Motor subscale of the *BSID-3* were significantly different between the experimental (11.50) and control (7.50) groups, $U=22.50$, $z=1.46$, $p=.03$, $r=.51$, with a large effect size in favor of the experimental group. While group differences in motor scores were obtained, children's performances differed by only one or two items on the *BSID-3*.

Despite the effect sizes favoring the experimental group participants on the motor subscales of the *BSID-3*, all children had significant delays in motor development. Most displayed abnormal muscle tone, either hypo- or hyper-tonicity. Most of the children were not sitting independently, and none were walking independently. With the exception of one child, all had fine motor delays, leading to difficulty with manipulating toys independently. In addition, all of the children demonstrated sensory challenges, such as hyper- or hyposensitivity to sensory input (e.g. sounds, textures, light).

Eligibility criteria also ensured homogeneous expressive communication development. Despite the heterogeneity of diagnoses, all participants displayed intentional behaviors (e.g., looking at an object or adult) but did not use TG or symbolic communication as a means to an end. Combined, the children's motor, sensory, and communication characteristics indicated that it would be appropriate to teach TG as a communicative signal for CJA.

Session Procedures

TG treatment—The treatment sessions were designed to teach TG as an exemplar of CJA to the nine children in the experimental group. These sessions occurred in the children's homes for approximately 30 minutes twice per week in an attempt to reach 32 sessions within approximately 16 weeks. This phase of the study was called the "experimental phase". We use this term to refer to the ~16 week window of time following baseline and prior to the final measurement session (described below). On average, children in the experimental group received 28.78 sessions ($SD=3.77$) across the experimental phase. The number of weeks spent in the experimental phase was not significantly different between the experimental (mean rank 11.39) and control (mean rank 7.61) groups, $U=23.50$, $z=-1.50$, $p=.13$, although a large effect size was found in favor of the experimental group, $r=.50$. Treatment was conducted by one of three ASHA certified and Washington State licensed SLPs who had two to eight years of experience working with children with severe disabilities and were trained in the delivery of the TG treatment. None of the treatment SLPs participated in eligibility assessments or measurement sessions (described below). Each treatment session consisted of structured opportunities for the child to communicate a request or a choice for a preferred toy or play routine as described below. Twenty

opportunities per treatment session were targeted ($M=22.08$, $SD=6.09$) to provide the child with robust experience in learning to use gaze as an intentionally communicative signal. Developmentally appropriate toys were used to support object exploration, cause-effect experiences, and early symbolic play. A consistent set of toys was brought to each session, although specific toys used within a session varied with child interest. Examples of toys included: touch-and-feel books, a pop-up busy box, nesting cups, stacking blocks, sensory toys, and objects for thematic play such as doll play.

The treatment SLP began by positioning the child as specified by the birth-to-three team. This included an appropriate seat (e.g., high back chair, modified booster seat) with supports as needed to help the child maintain an upright position (e.g., foam inserts). Once the child was positioned, the SLP initiated TG treatment with the following core elements: provide opportunity, wait, recognize and respond to child's behavior, and shape TG. During each session, the SLP provided two different types of opportunities in the context of play: *request* and *choice*. For "request opportunities," the SLP briefly played with a toy, paused with the toy out of the child's reach, looked expectantly, and provided a verbal stimulus (e.g., "Do you want more?"). For "choice opportunities," the SLP held up two toys, made sure the child saw each toy, and provided a verbal stimulus (e.g., "Which one do you want?"). Each opportunity was followed by a *wait* time of up to 15 seconds, giving the child sufficient time to respond. If the child produced a TG, the SLP immediately reinforced that behavior by responding with the desired toy. If the child produced a behavior other than TG, the SLP verbally *recognized* the child's communicative effort (e.g., "You're looking at the ball") and *shaped* the child's behavior to TG.

Shaping consisted of verbal, visual, and tactile cues that were designed to scaffold each child's potentially communicative behaviors to TG. Specifically, the SLP used cues to move the child's performance from looking at the object or adult alone, to looking between two objects or between the object and adult, ultimately prompting a full triadic or three-point gaze shift (*object-adult-object* or *adult-object-adult*). The treatment procedures did not specify the type, sequence or hierarchy of cues, but rather permitted the SLP to match cues to each child's needs. For example, a child who responds less to verbal cues could be given visual cues (e.g. moving the object) or tactile cues (e.g. touching the object to her hand.) These cues are described in detail in Olswang, Feuerstein, Pinder, and Dowden (2013). Once the child's gaze behavior was successfully shaped to TG, the clinician delivered the desired toy and engaged the child in play for several minutes before presenting the next opportunity. Play was an important aspect of treatment, as it was designed to reinforce the child's communicative attempts and to facilitate development of underlying cognitive concepts, particularly means-end relations.

Caregiver Involvement: Once a child was assigned to either group, caregivers were given an education manual with information about early communication, including the importance of gaze, gestures, and vocalizations as early signals. Because the caregivers of children in the experimental group were permitted to observe intervention, their manual included general information about the treatment and suggestions for object play. These caregivers were not provided any further instruction, nor were they encouraged to implement treatment strategies. This approach insured that the TG treatment primarily remained a child-

directed focused, SLP-administered intervention. Because children in the control group experienced standard practice only, their manual had no information about TG treatment.

Standard practice treatment—Participants in both the experimental and control groups continued with standard practice sessions provided by their birth-to-three centers. This permitted families to maintain services they deemed appropriate for their children, which was an ethical consideration required by the University of Washington IRB. Each of the centers operated under a primary service provider model. Intervention was delivered in the home by a primary professional (e.g., occupational therapist (OT), physical therapist (PT), SLP, educational specialist) with consultation from other clinicians as needed. The primary provider carried out the treatment objectives prescribed in the Individual Family Service Plan by working directly with the children and/or coaching the caregivers.

According to clinician notes, assessment summaries, and attendance records, the children enrolled in our study received, on average, 3.46 standard practice sessions per month ($SD=2.11$). Session length was not recorded by all centers, but the sessions were typically scheduled for 60 minutes. There was no significant between group difference in the mean rank for number of standard practice sessions received per month by children in the experimental (*mean rank*: 8.88) and control (*mean rank*: 7.00) groups, $U=21.00$, $Z=.81$, $p=.42$. Accounting for both treatment and co-treatment sessions, children were seen most often by OTs and PTs (34% and 46% of sessions, respectively) and comparatively less often by SLPs (22% of the sessions). According to therapists' notes, early signals of communication were rarely addressed during these sessions, even by SLPs, perhaps because they typically saw these children only for feeding therapy. Accordingly, session goals focused almost exclusively on gross and fine motor development with some limited goals in sensory-motor aspects of feeding. Importantly, TG was mentioned only once for one child. This close look at standard practice sessions makes it clear that the birth-to-three practitioners did not teach TG during this study.

Measurement—To monitor children's progress in learning to produce TG, measurement sessions were conducted at: a) baseline, b) approximately every three weeks during the experimental phase, and c) at final measurement, approximately four weeks following the end of the experimental phase. As outlined above, the baseline measurement was part of the static assessment and was used to determine TG production for eligibility. Measurement sessions were conducted primarily in the child's home by an SLP who did not administer treatment and was masked to group assignment. During these sessions, the measurement SLP engaged the child in play and mimicked the core elements of the treatment protocol (i.e., providing communication opportunities, waiting, and responding to the child's behaviors), with the exception of shaping. Toys were different from those used in treatment, although similar in nature, and child preferences were always considered when toys were introduced. These sessions were designed to sample child behaviors without adult assistance, yet provide a structured context to support performance. Each session sampled a variety of communicative intentions, including approximately 10 choice and 10 request opportunities, as described above, plus five opportunities to comment. During "comment opportunities," the SLP introduced an object to elicit an acknowledgement from the child

(e.g., introduction of a novel toy or an unexpected sound). The variety of opportunities was included for breadth of sampling, even though previous research with the same population had demonstrated no difference in production of TG across request and choice contexts (Pinder & Olswang, 1995). The number of measurement sessions across the entire study period (including baseline and the final measurement session) was not significantly different between the experimental (mean rank 11.22) and control (mean rank 7.78) groups, $U = 25.00$, $z = -1.42$, $p = .16$. Despite these non-significant differences, a medium effect size was found in favor of the experimental group, $r = .47$.

Data Collection and Reduction

Measurement—All TG measurement sessions were videotaped for later review. Each video was coded by a primary and reliability coder, both graduate students in communication sciences and disorders. Over the course of the study, a total of six such students were trained to code videos using The Observer XT ® 7.0 event logging software (Noldus Information Technologies, 2011). TG productions served as the primary dependent variable; however, videos were coded for all gaze behaviors with and without gestures, signs, vocalizations, and/or verbalizations. Interobserver agreement, discussed below, was examined on the full set of behaviors. *Percent TG* was calculated for each measurement session only for engaged opportunities, defined as those in which a child produced at least one codable behavior. Engaged opportunities were used versus all opportunities because we were interested in measuring TG productions when children were engaged in the task rather than crying or protesting. Within engaged opportunities, only one occurrence of TG was counted. For each measurement session, percent TG was then calculated by dividing the number of opportunities in which at least one TG production occurred by the total number of engaged opportunities.

Procedural and Measurement Reliability

Procedural reliability was examined for fidelity of delivery of both measurement and treatment protocols. Following Billingsley, White, and Munson (1980), templates were created to identify the core elements for each session type. In all cases, these elements included providing opportunities, waiting, and recognizing and responding to the child's signals; in the case of the treatment, shaping TG was also included. Fidelity to the measurement protocol was examined for 30% (30/100) of all such sessions across 14 children (six experimental, eight control) selected randomly from the 18 total participants. Delivery of these core elements was shown to be between 92–100% accurate. Fidelity of treatment delivery was examined for 20% (51/258) of all TG treatment sessions across the nine children in the experimental group. Ten opportunities (five each for request and choice) in each of five sessions were examined per child. Delivery of core treatment elements was shown to be 91% – 100% accurate ($M = .98$, $SD = .02$).

Measurement reliability consisted of examining interobserver agreement in coding gaze, with and without gestures and vocalizations, for all children during measurement sessions. Two independent observers coded 93% (122/131) of all measurement sessions for the 18 children in this study. Cohen's kappa (1960) was calculated for each of the sessions and values were found to range from .60–.96. In accordance with guidelines by Cicchetti &

Sparrow (1981), kappa values of .60–.74 are judged as good agreement, and .75 as excellent. Only 16 of the 122 sessions (13%) yielded a kappa between .60 and .74. These videos were re-examined in their entirety by the two coders and the first author of this manuscript. Some disagreements were found to be errors in the entry of codes or interpretation of coding guidelines; these were corrected by consensus. Actual disagreements were left unchanged. Following correction, all kappa values were over .75, with the exception of one session ($k=.72$).

Data Analysis

Recall this research posed four questions. The first two examined differences between the experimental group and control group based on single points in time: baseline and final measurement. These comprised the primary analyses. Two post-hoc questions were posed based on the amount of variability in performance that was observed among the children in both groups. Children with severe physical disabilities are known to have considerable fluctuations in health and performance day-to-day (Siegel & Cress, 2002). Therefore, analyses that reveal trends in TG productions over time were deemed important for a better understanding of individual as well as group differences.

Final measurement session—To address the first research question, we began by examining the distribution of percent TG at each of two time points: baseline and final measurement session. Percent TG for all participants at baseline was quite low with limited variance and positive skew. At the final measurement session, a large amount of variance in the experimental group and limited variance in the control group led to a discrepancy in the between group variance. Because of the limited sample sizes and distributional characteristics of the data, a nonparametric Mann-Whitney U -test was run. An effect size (r) was calculated by dividing z by the square root of the total sample size across both groups (Cohen, 1992). Cohen's guidelines indicate $r=.10$ is a small effect; $r=.30$ is a medium effect; and $r=.50$ is large effect.

Change from baseline to final measurement session—To address the second research question, a difference score from baseline to final measurement was calculated for each participant. Again, a Mann-Whitney U -test was used to examine the difference in mean ranks between experimental and control groups, and an effect size was calculated.

Individual child change using moving average—To address the third research question, we examined trends in learning TG for individual children within groups during the experimental phase of the study (i.e., excluding baseline and final measurement sessions). To reduce the impact of day-to-day performance variability commonly observed in this population, we calculated moving averages over three consecutive data points. The moving average procedure smoothes the data and enables examination of trends in performance over time, which can be a valuable analysis for highly variable data (Krus & Ceurvorst, 1978). In this procedure, percent TG for the first three measurement sessions in the experimental phase (i.e., sessions 2, 3, 4, which immediately followed baseline) were averaged. The second moving average data point included measurements 3, 4, and 5. This averaging continued through the end of the experimental phase, excluding the final

measurement session. Moving average data points were graphed based on the amount of time that had passed since baseline, and were centered at the second of the set of three measurements. For example, if measurement sessions 2, 3, and 4 occurred at weeks 2, 5, and 9, this moving average would be plotted at week 5. TG performance was examined over time by visual analysis and in comparison to baseline entry criteria (<20%).

Differences between groups using moving average at two time points—The final research question was addressed by using the moving average data points to compare differences in the level of TG production between experimental and control groups at two time points: a) at the moving average point plotted at 12 weeks, and b) at the end of the experimental phase. The former reflects the time point furthest out from baseline at which a moving average could be calculated for the majority of children in both groups (exceptions are #125 and #145 in the control group). Recall, the study was designed to provide 32 treatment sessions to children in the experimental group. Because some children missed sessions due to illness, the experimental phase for these participants was lengthened to ensure completion of the targeted number of treatment sessions. This resulted in longer periods of enrollment and continued measurement sessions for this group. The total number of weeks spent in the study (calculated as time from baseline to final measurement session) was significantly different between the experimental (mean rank 11.94) and control (mean rank 7.06) groups, $U=18.5$, $z=-1.95$, $p=.05$, with a large effect size in favor of the experimental group, $r=.65$. The 12-week comparison point allowed us to examine differences in performance with time held constant, thus permitting a preliminary look at change due to treatment versus maturation. In contrast, examining performance at the end of the experimental phase provides a comparison following maximum exposure to treatment for the experimental group. Nonparametric Mann-Whitney U -tests were used to examine between-group differences in the moving average data points at: a) 12 weeks into the experimental phase and b) the end of the experimental phase. Combined, these analyses provided a comprehensive picture of TG performance and learning within and between groups.

Results

Final measurement session

Mean rank for percent TG produced by the experimental group (10.39) was greater than the mean rank for percent TG produced by the control group (8.61) at final measurement session. This difference was not statistically significant, $U=32.50$, $z=.71$, $p=.48$. However, this represents a small effect size, $r=.17$ in favor of the experimental group. Figure 2 presents these data.

Change from baseline to final measurement session

The mean rank for change in percent TG from baseline to final measurement session for the experimental group was 10.67, while the corresponding mean rank for change in percent TG for the control group was 8.33. This difference was not statistically significant, $U=30.00$, $z=.93$, $p=.39$. However, this result represents a small effect size, $r=.22$ in favor of the experimental group.

Individual child change using moving average

Moving averages over three data points to smooth the data and enable examination of trends in learning are plotted in Figure 3 for the experimental (top) and control (bottom) participants. The x-axes display the number of weeks into the experimental phase, and the y-axes display percent TG averaged over three consecutive data points. Recall, moving average data points are plotted at the time (number of weeks into the experimental phase) at which the second of the three measurements occurred. As can be seen in the figure, three of the children in the experimental group (#102, #106, and #122) were followed over a longer period of time due to interruptions in their treatment schedule, which extended the time required to provide all of the treatment and measurement sessions. Also note, one child in the experimental group (#127) and two children in the control group (#125 and #145) had relatively fewer measurement sessions due to frequent illness.

Overall, children in the experimental group demonstrated more variable performance than children in the control group. Six children in the experimental group demonstrated moderate gains (over 20% of the opportunities-recall < 20% served as enrollment criteria) in percent TG. Three of the children demonstrated rapid gains (#123, #136, and #153), while another child (#106) showed gradual learning across the treatment phase. Three children (#122, #124, and #127) in the experimental group showed flat or decreasing trends (less than 20% of the opportunities) in TG production. Trends in the control group were relatively flat (consistently observed in less than 20% of opportunities) TG production. However, five of the children (#121, #135, #146, #148, and #152) in the control group had slightly rising performance, approaching the 20% level.

Differences between groups using moving average at two time points

To determine if there were significant differences in TG productions between experimental and control groups at about 12 weeks into the experimental phase and at the end of the experimental phase, Mann-Whitney *U*-tests were conducted using a) the moving average data point closest to 12 weeks and b) the last moving average data point. At 12 weeks, the mean rank of experimental participants (12.11) was significantly greater than the mean rank of control participants (6.89), $U=17.00$, $z=2.08$, $p=.038$, $r=.49$. This represented a medium effect size favoring the experimental group. At the end of the experimental phase, the mean rank of experimental participants (12.00) was significantly greater than the mean rank of control participants (7.00), $U=18.00$, $z=1.99$, $p=.047$, $r=.47$). This represented a medium effect size, favoring the experimental group.

Discussion

Summary of Findings

While the results of this randomized, controlled study do not provide conclusive evidence of the efficacy of TG treatment, they contribute to earlier research suggesting its promise for teaching TG as a signal of intentional communication to young children with severe physical disabilities. The current study examined the effects of this treatment when added to standard practice provided by birth-to-three centers. Results suggested that there were no significant differences between groups at the final measurement session, approximately four weeks

after the end of the experimental phase, when a single data point was used to measure change. However, significant between-groups differences were found when comparing moving averages of %TG produced by children *within* the experimental phase. Specifically, results suggested that children in the experimental group produced more TG behaviors and were more variable in their performance during this phase than children in the control group. Recall that eligibility criteria required that children produce < 20% TG at baseline measurement. Comparing performance during the experimental phase, as captured by moving average data, to this baseline criteria revealed the following: six of the children in the experimental group produced TG in more than 20% of the opportunities in more sessions than children in the control group. Three of the children in the experimental group did not improve in production of TG over baseline. None of the children in the control group produced TG in over 20% of the opportunities during measurement sessions; however, five of the children approached the 20% level. The improved performance for six of the nine children in the experimental group suggests the benefits of the treatment, even though significant differences between groups were not observed at final measurement. Perhaps the differences between groups during the experimental phase reflect the active learning of TG, with stability or maintenance not yet having been accomplished. These results provide preliminary data regarding the promise of the TG treatment in increasing production of TG as a clear and conventional behavior to signal CJA and suggest that the treatment be further explored.

This research examined TG treatment as a supplement to standard practice sessions provided by the children's birth-to-three centers. Therefore, children in the experimental group received more overall intervention than children in the control group, and more measurement sessions. This difference in exposure prevents us from attributing TG change solely to the TG treatment. However, the value of the TG treatment can be argued. Recall that standard practice documentation showed TG was not taught to any participants in our study and intervention focused on feeding and/or fine and gross motor objectives. This means that only children in the experimental group received intervention that targeted this signal of communication, so the gains in performance can be more confidently attributed to the administration of TG treatment.

Children with Physical Disabilities: Heterogeneity and Variability

This research revealed two particularly interesting aspects of performance among the children: the heterogeneity in the sample in regards to both responsiveness to treatment (experimental group) and maturation (control group), and the session-to-session performance variability. While all children enrolled in this study appeared similar on standardized tests and in TG production at baseline, the data revealed heterogeneity among the children in their change over time. Three of the children in the experimental group did not appear to benefit from treatment, while some children in the control group demonstrated improvements approaching 20% TG. The cause of change in this latter group is unknown; it could have been due to maturation, exposure to the measurement task or natural interactions with caregivers who observed the measurement sessions. Heterogeneity in this population is not a surprise, with some children not changing even with individual treatment, and some children showing the emergence of TG without treatment. Differences among children who

appeared similar at baseline have been documented in our own research. In an earlier single-subject study designed to teach TG to similar participants, Pinder and Olswang (1995) demonstrated that while two children responded immediately to treatment, a third child required treatment for earlier developing behaviors prior to TG. Olswang and colleagues (Olswang, et al., 2013) later demonstrated differential performance among six children who appeared similar on standardized measures and rate of TG productions at baseline. Five children demonstrated change during the treatment period, though to different degrees, and one child showed no change. We argued that differences in responsiveness to the treatment reflected different degrees of readiness for learning TG. Further, the study suggested that readiness could be predicted by dynamic assessment procedures, which sampled the children's baseline responsiveness to a variety of prompts designed to support the production of TG (Olswang et al., 2013). No doubt a number of factors could account for heterogeneity in this population, including chronic health problems or underlying cognitive impairments. Determining readiness to learn a particular behavior for children with such severe disabilities and complicated developmental profiles requires better tools to identify appropriate treatment objectives and teaching strategies. Dynamic assessment appears to be useful for untangling individual child characteristics leading to tailored treatment. Also of interest was the session-to-session performance variability observed across children. Visual inspection of TG productions over time, using smoothed data from a moving average procedure, revealed the experimental group had higher overall production of TG and greater fluctuations in performance. We interpreted this increased variability as an indication of emerging acquisition of TG, and perhaps the child's gradual understanding of intentional communication. Emerging behaviors are often characterized by inconsistent performance, particularly for children with physical disabilities who are known to show less persistence in challenging tasks, with an inverse relationship between persistence and degree of motor impairment (Jennings, Connors, Stegman, Sankaranarayan, & Mendelschn, 1985; Smidt & Cress, 2004). This may be due in part to challenges with mastery motivation, or "...the independent and persistent task-directed behavior in problem-posing situations" (Hauser-Cram, 1996, p. 236). Cress and colleagues have suggested that children with disabilities may not persist in a task because the cost of struggling to produce difficult behaviors may not be worth the effort (Cress et al., 2000; Cress, Reynolds, & Andrews, 1998; Smidt & Cress, 2004). Perhaps the children in the experimental group were discovering the importance of TG, but the effort required to produce this behavior at times outweighed the benefit. As a result, variable performance in TG productions might reflect the children's challenges in consistently demonstrating an emerging behavior.

Implications for Early Intervention

The focused, SLP-delivered treatment described in this research expands options for early communication intervention for children with severe disabilities. In the current climate of birth-to-three intervention, a primary provider typically coordinates and delivers services. Under this model, the caregiver identifies priorities and the service provider coaches the caregiver on strategies to address particular objectives within daily activities in the natural environment (American Speech Language Hearing Association, 2013). This approach has many strengths, including capitalizing on caregivers' knowledge of their children. However, as shown in our documentation of standard practice in this population, a primary service

provider model may result in neglect of some objectives, notably communication. In addition, the emphasis on coaching may de-emphasize the value of intensive, targeted treatment by a specialist in one discipline or another. Some behaviors and skills are notably harder to teach caregivers and may require the expertise of a trained professional. Olswang et al. (2006), for example, demonstrated that scaffolding children's performance to TG is difficult for caregivers to learn, even when given direct instruction. Because no single approach can serve all needs, birth-to-three providers must select the most appropriate treatment and service delivery model to match a child's current and emerging developmental profile, as well as family needs and preferences (Brady, Warren, & Sterling, 2009; Prelock, 2013). The results of the current research provide preliminary evidence to support consideration of a targeted treatment for teaching a behavior to signal CJA. Further, our earlier work investigating dynamic assessment suggests that it is possible to determine which children might immediately benefit from such treatment. These results may assist with decision-making when considering different service delivery models as a way to maximize change in children who may need ongoing intervention.

Limitations and Future Directions

While this study provides promising evidence in support of TG treatment, several limitations must be acknowledged. First, the design does not allow us to identify the TG treatment as the sole mechanism for change in the experimental group. As discussed above, the question of exposure to more treatment cannot be ruled out as a confounding factor in the change experienced by experimental participants. Second, the small number of participants in this research is also a limiting factor. The heterogeneity of the children and the variability in their performance restricts our conclusions about the population.

Future research is necessary to explore ways to attain greater treatment effects and improved generalization and maintenance in TG production. Questions remain about the optimum timing and dosage of treatment, as well as the best approach to tailoring procedures to individual child characteristics. These questions, however, require consideration of a larger view of birth-to-three practice. As we move forward to explore how to best facilitate intentional communication in young children with physical disabilities, we acknowledge the importance of situating research in the context of those early intervention services.

Conclusions

Achieving the milestone of coordinated joint attention and social engagement with others is undeniably important for children with physical disabilities. It not only allows children to interact more fully and successfully with others, but also provides them with the means to achieve future cognitive, social, and communicative skills. By teaching children to produce specific, conventional and recognizable behaviors to coordinate action and attention with others, we begin to assemble the foundation on which future learning is built. The results of this research move us closer to designing such a treatment and contributing to our understanding of how to improve services for children with a potential lifetime of therapeutic needs.

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Figure 1.
CONSORT flow diagram of study progression from recruitment through data analysis.

Figure 2. Mean rank for Percent TG produced at baseline and final measurement sessions by the experimental (n=9) and control (n=9) groups.

Figure 3.

Moving averages over three data points for individual participants in the experimental ($n=9$, top) and control ($n=9$, bottom) groups.

Child and Family Demographic Information

Table 1

Gender	Age* (mos.)	Race, Ethnicity	Language(s) in Home	Household Income	Caregiver Education	Etiology	Complications	Hearing, Vision	
Experimental subjects									
1	Male	10	Multi-racial, Hispanic	Spanish	\$20,000–\$29,999	High school	Down syndrome	None	Adequate
2	Male	11	Caucasian, Not Hispanic	English, Spanish, Norwegian	\$100,000+	High school	Down syndrome	Plagiocephaly, feeding	Adequate
3	Female	14	Caucasian, Not Hispanic	English	\$50,000–\$59,999	2-year college	Microcephaly	Feeding, respiratory	Adequate
4	Female	18	Caucasian, Not Hispanic	English	No data reported	4-year college	Unknown syndrome	Seizures, orthopedic differences	Adequate, HA, glasses
5	Female	19	Caucasian, Not Hispanic	English, Russian	No data reported	2-year college	CP due to Anoxia	Seizures	Adequate
6	Male	20	Caucasian, Not Hispanic	English	\$100,000+	4-year college	Osteogenesis Imperfecta, ASD	None	Adequate
7	Female	22	Hispanic, Race not reported	English, Spanish	\$50,000–\$59,999	High school	CP due to TBI	None	Adequate
8	Male	23	Hispanic, Race not reported	English, Spanish	\$70,000–\$79,999	2-year college	CP due to Kernicterus	Dysphagia, reflux	Adequate, HA
9	Male	23	Pacific islander, Not Hispanic	English	No data reported	Graduate school	Chromosomal abnormality	Seizures	Adequate
Control Subjects									
1	Male	9	Hispanic, Race not reported	Spanish	Less than \$9,999	Some high school	Unknown	Developmental delay	Adequate
2	Male	10	Caucasian, Hispanic	English	No data reported	4-year college	Unknown	Developmental delay, seizures (epilepsy)	Adequate
3	Male	13	Caucasian, Not Hispanic	English	\$80,000–\$89,999	Graduate school	Chromosomal abnormality	Acid reflux, PE tubes, dysphagia	Adequate
4	Male	14	African American, Not Hispanic	English	Less than \$9,999	High school	Hydrocephalus, CP due to brain bleed	Tube fed, respiratory	Adequate, glasses
5	Female	17	Hispanic, Race not reported	English	\$60,000–\$69,999	2-year college	Down syndrome	Hypothyroidism, unilateral PE tube	Adequate
6	Female	17	Asian, Not Hispanic	Tagalog	\$50,000–\$59,999	High school	Unknown	None	Adequate
7	Male	18	Caucasian, Not Hispanic	English	\$100,000+	4-year-college	Unknown	Dysphagia, PE tubes, acid reflux	Adequate
8	Male	23	Caucasian, Not Hispanic	English	No data reported	2-year college	Unknown	Developmental delay, Seizures	Adequate
9	Male	24	Caucasian, Not Hispanic	English, Spanish	No data reported	4-year college	Hypoxia at birth	None	Adequate

Note:

* Age at consent, which did not differ significantly between groups, p=0.50.

CP=cerebral palsy; TBI=traumatic brain injury; HA=hearing aids, PE tubes=pressure equalization tubes; ASD=autism spectrum disorder

Table 2

Baseline Performance

	Group				Significance		
	Experimental (n=9)		Control (n=9)		<i>U</i>	<i>z</i>	<i>P</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Age at baseline (mos.)	19.00 (5.36)		17.33 (5.36)		31.50	0.80	0.43
% TG ^a at baseline	0.04 (0.04)		0.05 (0.06)		37.50	-0.27	0.79
<i>BSD-3^b</i> : Fine Motor	3.00 (3.50)		1.11 (0.33)		30.00	1.27	0.20
<i>BSD-3^b</i> : Gross Motor	1.89 (1.36)		1.00 (0.00)		22.50	1.46	0.03
<i>MSEL^c</i> : Receptive	22.89 (5.82)		20.44 (1.33)		35.00	0.75	0.46
Language							
<i>MSEL^c</i> : Expressive	24.78 (7.14)		20.89 (2.67)		26.00	1.62	0.11
Language							
<i>MSEL^c</i> : Visual	23.00 (6.08)		20.11 (0.33)		35.00	0.75	0.46
Reception							
<i>MSEL^c</i> : Fine Motor	25.33 (10.23)		20.22 (0.67)		30.50	1.21	0.23
<i>MSEL^c</i> : Gross Motor	21.78 (4.06)		20.00 (0.00)		31.50	1.46	0.15

Note:

^a triadic gaze;^b Bayley Scales of Infant and Toddler Development - Third Edition (Bayley, 2005; Mean=100, SD=15);^c Mullen Scales of Early Learning (Mullen, 1995; Mean=50, SD=10);[†] small/^{††} medium/^{†††} large effect favoring experimental group;^{*} small effect favoring control group based on Cohen (1992), where $r=.10$ is a small effect, $r=.30$ is a medium effect and $r=.50$ is large effect.