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Social responsiveness and language use associated with an enhanced PRT approach for young children with ASD: Results from a pilot RCT of the PRISM model

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ABSTRACT

Background: Vulnerabilities in social motivation among children with ASD constrain attention and responsiveness to parents and other social partners. When this limited social responsiveness remains uncorrected, it is hypothesized to restrict the quality and quantity of social learning opportunities and ultimately yield negative long-term effects on development. Early intervention efforts that target social motivation may hold promise for correcting this detrimental chain of events.

Method: The current pilot RCT examined changes in participant social responsiveness and language use in a trial of 21 young children with ASD who were randomly assigned to treatment or waitlist control groups. Treatment participants received a mean of 6.81 h/week of an enhanced Pivotal Response Intervention for Social Motivation (PRISM) treatment model for six months. Data on social responsiveness to parent bids and expressive language (number of total words, number of different words, mean length of utterance in words) were obtained from behaviorally coding and analyzing video-recorded parent-child play sessions.

Results: Results indicated that young children who participated in the PRISM treatment model demonstrated significant pre-post improvements in social responsiveness and mean length of utterances. Participants in the waitlist condition experienced negligible improvements. Participants who are minimally verbal appear to experience greater gains as a result of the PRISM model. Additionally, initial levels of social responsiveness with parents appear to be predictive of subsequent language use at post-intervention among minimally verbal participants.

Conclusion: This study provides preliminary evidence for the importance of using early intervention paradigms that explicitly target social motivation and responsiveness in young children with ASD. Results also suggest that initial social responsiveness to parents may serve as an important predictor of treatment response.

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1. Introduction

The Social Motivation Theory of Autism (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012) posits that many of the resulting vulnerabilities associated with autism spectrum disorders (ASD) are the consequence of downstream effects of limited interpersonal motivation. Specifically, intertwined neurological and psychological mechanisms influence a child's desire to attend to others (social orientation), respond to and take pleasure in social interactions (social reward), and ultimately foster and maintain social relationships (social maintenance). Research investigating the root etiology of these behaviors has found that individuals with ASD exhibit decreased sensitivity and reactivity to visual and auditory social stimuli in their environments, which in turn reduces opportunities for social engagement and learning from caregivers and other social partners (Čeponienė et al., 2003; Gervais et al., 2004; Klin, 1991; McPartland et al., 2011). These vulnerabilities are suspected to be linked to negative long-term effects on social and communication development in children with ASD (Dawson et al., 2002).

As a prime example of these vulnerabilities, children with ASD place limited attentional resources and diminished reward value on the human voice, as evidenced by reduced sensitivity to their name and other language bids. As social attention to speech is critical to early language learning (Kuhl, Coffey-Corina, Padden, & Dawson, 2005), it is logical why speech delays are a commonly observed diagnostic marker of ASD. In fact, a retrospective analysis of children with ASD who eventually acquired spoken language skills found that measures of social interest and engagement were one of the strongest predictors of language development (Wodka, Mathy, & Kalb, 2013). However, prospective research is needed to investigate if observable indicators of social responsiveness predict later language acquisition in the context of early intervention efforts.

If developmental delays are conceptualized to be downstream effects of limited social attention and responsiveness, it follows that intervention efforts should focus on enhancing motivation to respond as a primary treatment consideration. Naturalistic Developmental Behavioral Interventions (NDBIs) have advanced the field of autism intervention by utilizing naturalistic approaches that prioritize interactive social contexts, child-motivated teaching strategies, and adult-child engagement activities (Schreibman et al., 2015). Treatment modalities such as Early Start Denver Model (ESDM; Dawson et al., 2010), Joint Attention Symbolic Play Engagement and Regulation (JASPER; Kasari, Freeman, & Paparella, 2006) and Pivotal Response Treatment (PRT; Koegel & Koegel, 2006; Koegel, Koegel, Vernon, & Brookman-Frazee, 2017) have shown significant promise for improving social communication for individuals with ASD by directly targeting social motivation through natural reinforcement strategies.

Pivotal Response Treatment (PRT) is a well-validated NDBI that has historically improved communication skills by targeting the core area of motivation through the use of child choice, natural reinforcement, reinforcement of attempts, and a combination of maintenance and acquisition tasks within natural learning contexts (Koegel & Frea, 1993; Koegel, Camarata, Koegel, Ben-Tall, & Smith, 1998; Koegel, Koegel, & Brookman, 2003). PRT has been associated with a variety of favorable outcomes measured using standardized assessments, naturalistic observations, language samples, and brain imaging (Bruinsma, 2005; Duifhuis et al., 2017; Hardan et al., 2015; Mohammadzaheri, Koegel, Rezaee, & Rafiee, 2014; Stock, Mirenda, & Smith, 2013; Ventola et al., 2015; Voos et al., 2013).

Recent investigations have modified PRT to explicitly target *social* motivation through the use of engaging joint activities derived from each child's unique pre-existing but previously nonsocial interests (Koegel, Vernon, & Koegel, 2009; Vernon, Koegel, Dauterman, & Stolen, 2012; Vernon, 2014). Results have consistently found that embedding social interactions into the reinforcement component of PRT results in increased rates of child social orienting to parents and clinicians, self-initiated language use, and positive affect.

Published standardized assessment outcomes from a current RCT of this enhanced PRT approach (the Pivotal Response Intervention for Social Motivation, or PRISM model) have yielded reductions in ASD symptomatology and corresponding increases in developmental functioning (Vernon et al., 2019). While these observed assessment gains are promising, they do not provide information about improvements in the quality of live parent-child dyadic interactions, language use, or the underlying social mechanisms that may be driving these developmental improvements.

While it is recommended that characterization of young children with ASD include both standardized and naturalistic behavioral measures, this practice is not consistently implemented across the field of psychological research. Contemporary reviews of the literature find that most investigations do not regularly utilize sampling and analysis of naturalistic social interactions (Nevill, Lecavalier, & Stratis, 2018; Tager-Flusberg, Rogers, Cooper, Landa, & Lord, 2009; Trembath, Westerveld, & Shellshear, 2016). Such trends are concerning, as such data are necessary for capturing ecologically meaningful samples of communication and language that a child either cannot or is more hesitant to demonstrate in standardized evaluations with unfamiliar evaluators (Bacon, Osuna, Courchesne, & Pierce, 2019; Brady, Marquis, Fleming, & McLean, 2004; Fey et al., 2006; Tager-Flusberg et al., 2009).

There is a pressing need for naturalistic measures that are both (a) sensitive enough to capture incremental social communication improvements and (b) quantify dyadic gains that are not apparent from standardized test results (Bacon et al., 2014; Kasari, Brady, Lord, & Tager-Flusberg, 2013). The creation of new assessments, such as the Brief Observation of Social Communication Change (BOSCC; Grzadzinski et al., 2016) demonstrates adaptations in the field to the need for observation-based measures. In addition, there is an increasing number of recent studies that have investigated the effectiveness of NDBIs using behavioral coding tools as a measure of treatment outcome (Beaudoin, Sébire, & Couture, 2019; Gengoux et al., 2019). Overall, more research is needed to examine the utility of behaviorally coded natural social communication samples as augmentative metrics of treatment response.

The purpose of the current study was to examine changes to social attunement and language use in young children with ASD in the context of a pilot randomized controlled trial. The primary aim of this study hypothesized that individuals assigned to the PRISM group for six months would demonstrate significant improvements in (a) social responsiveness to parent social bids and (b) corresponding language use. A secondary aim examined whether initial rates of social responsiveness could serve as a meaningful predictor of post-trial expressive language abilities.

2. Methods

2.1. Research design

This pilot study utilized a randomized controlled trial (RCT) design. Following the initial assessment, participants were age-matched and randomly assigned to either the PRISM treatment condition (TR) or treatment-as-usual waitlist (WL) condition. Children in the treatment condition began the six-month PRISM treatment immediately after completion of intake assessment. Children in the WL control condition remained on a waitlist for 6-months and continued existing behavioral interventions provided by local community agencies. Following post assessments, the WL group then had the option to enroll in six months of the PRISM treatment.

2.2. Participants

A total of 31 parent-child pairs were recruited over the two-year trial period. Inclusion criteria for the child participants included: (a) being between 1.5 and 4.5 years of age (18–56 months) at intake, (b) exceeding autism classification cut-off scores based on Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012), and (c) meeting DSM-5 ASD diagnostic criteria based on expert clinical judgement by a licensed clinical psychologist. Inclusion criteria for parents included willingness to (a) complete two-day intake and post assessment batteries, (b) participate in a weekly two-hour parent education session, and (c) be at home for up to eight hours a week of clinician-delivered intervention. Participants in this study were recruited from online advertisements, community referrals, and internal referrals. Families were not financially compensated for participation but received two comprehensive developmental assessments with detailed reports and six months of intervention services at no cost. This project was approved by the site's institutional review board (IRB) and all legal guardians provided written informed consent prior to participation.

A CONSORT diagram is provided in Fig. 1. Of the 31 recruited families, 28 were eligible to participate and 23 completed the trial. Complete and codable videos of pre and post parent-child play sessions were available for 21 of these families (12 treatment and 9 waitlist families), with videos unavailable for two waitlist participants due to technical issues.

In addition to a priori hypotheses examining pre-to-post changes in treatment and waitlist groups, we also conducted exploratory post-hoc analyses with a subgroup of minimally verbal children in the pilot trial. We were particularly interested in examining gains in this subgroup because they experienced the greatest vulnerabilities at intake, but also had the greatest potential for developmental growth. Focusing on this group also reduced the tremendous baseline variability associated with the more verbally capable

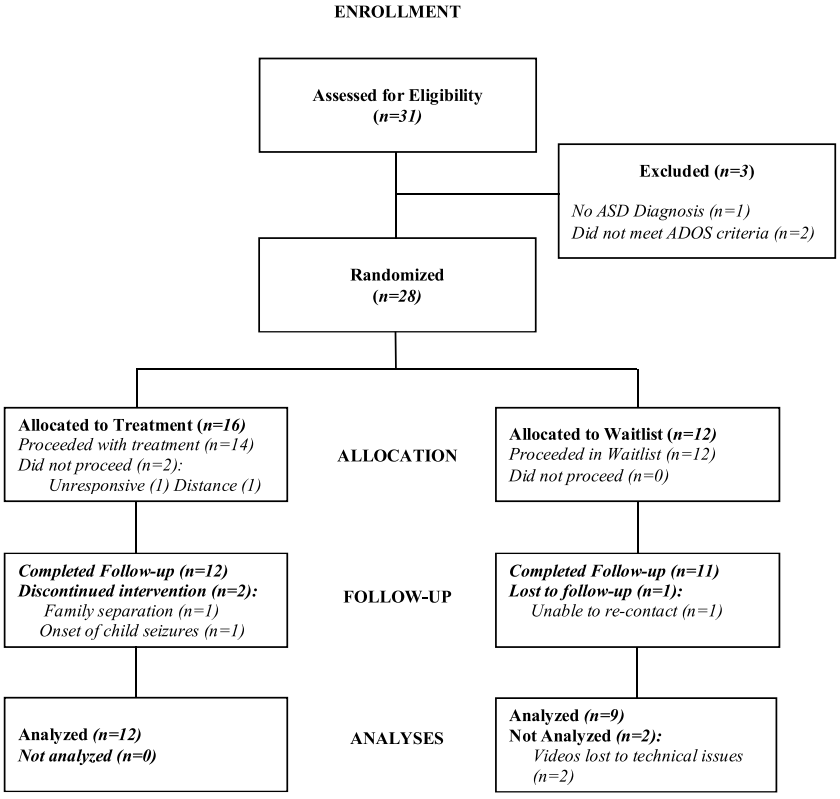

Fig. 1. CONSORT Diagram.

participants. Minimally verbal participants were defined as participants who demonstrated less than 30 functional words in the initial parent-child play session, which is consistent with Kasari et al. (2013) criteria, which defined minimally verbal children as (a) having between 0 and 30 spoken words or phrases (b) being restricted to one or two functions (i.e. to request), (c) using words in limited contexts, and (d) including echolalic, stereotyped, or scripted language. A total of nine participants fell into this category (treatment n = 4, waitlist n = 5).

2.3. Intake procedures

Prior to the intervention or waitlist period, all participants completed a comprehensive intake spanning two half-days. This included a standard battery of developmental, language, and adaptive assessments and a series of video-recorded parent-child interactions. Results of these standardized measures have been previously reported (Vernon et al., 2019). The current investigation focused on systematic coding of recorded parent-child play interactions to obtain measures of social responsiveness and expressive language use.

2.3.1. Parent-child play interaction

A parent-child play interaction was recorded during the intake and post-intervention assessment process. This interaction was 5-minutes in length and took place in a clinic room equipped with a standard set of toys appropriate for young children. Parents were instructed to play with their child as they typically would at home using the toys provided while trying to elicit as much social engagement and communication as they could from their child.

2.4. Intervention procedures

2.4.1. PRISM model

After intake, participants were randomly assigned to either the treatment or waitlist condition by a chance procedure (i.e. coin flip). Participants assigned to the treatment condition received six months of the PRISM intervention (Vernon et al., 2019). Participants were allocated to receive up to 10 h per week of intervention: eight hours of one-on-one clinician-implemented intervention and two hours of parent education and hands-on teaching of the intervention strategies with a graduate student clinician. Families completed a mean of 6.81 h of the 10 h offered weekly, with 25 % of families meeting the threshold of 80 % completion of all possible treatment hours. The treatment model is firmly grounded in an antecedent, behavior, consequence three-term contingency framework (an adult bid or prompt was followed by a child verbal response, which was then followed by adult delivery of the reinforcing stimuli to the child). This behavioral contingency incorporated the PRT components of child choice, task variation, clear opportunities, immediate reinforcement of attempts, use of natural reinforcers, and a blend of maintenance and acquisition tasks. These core components were enhanced with the following PRISM modifications to specifically target child social motivation:

2.4.1.1. Social reinforcement. Parents and clinicians were instructed to exclusively use social activities as reinforcement rather than access to toys or items. Reinforcers could be visual (e.g., blowing and popping bubbles together), auditory (e.g., singing a favorite song), tactile (e.g. tickling a child), or physical (e.g. pushing a child in a swing while facing them). These activities were only possible through the actions of a social partner; thus, the child was unable to access the same quality activity on their own and the adult's presence was required in order for the child to receive reinforcement.

2.4.1.2. Noncontingent exposure. Children were initially granted free exposure to each potentially engaging social activities in order to draw them into the social interaction prior to requiring them to make a verbal request. Through the provision of noncontingent exposure, or "free previews" of these activities, the child's motivation to engage in the activity could be maximized. Once buy-in was achieved, the adult playfully paused the activity and delivered a prompt. Once the child made a successful verbal attempt to respond to the prompt, the activity was enthusiastically continued.

2.4.1.3. High affect bids. Parents and clinicians were instructed to deliver verbal prompts using a playful, high-affect voice and positive facial expressions (i.e. smile or laughter) in order to increase the salience of their bids and to maximize the child's enjoyment and likelihood of response.

2.4.2. Parent education in PRISM

The parent education component of the project ensured that parents were able to learn and implement the PRISM intervention strategies outside of regularly scheduled intervention hours, therefore increasing the overall intensity and generalizability of treatment. During initial treatment sessions, parents were introduced to the treatment components (i.e. child attention, child choice, playful opportunity, natural reinforcement, contingency of reinforcement, reinforcing attempts, social reinforcement), clinicians modeled the techniques, and parents practiced implementation. After the initial month of parent education sessions, the parent educators adopted a session format that primarily emphasized parent implementation of the procedures with ongoing in-vivo feedback. While treatment goals were individualized to meet the needs of each client, global objectives were to increase social engagement, increase expressive language abilities (frequency of language use to engage, breadth of vocabulary, mean length of utterance), and improve the child's ability to use verbal bids to communicate wants and needs and participate in social exchanges through play. Parental fidelity of implementation was coded using 5-minute video recordings of parents implementing the PRISM

intervention with their child. Parents demonstrated a mean of 85.13 % (SD 12.07 %), with ten of 12 families (83.33 %) falling above the established PRT fidelity threshold of 80 % (Vernon et al., 2019).

2.5. Dependent measures

Parent-child play interaction videos were behaviorally coded using Noldus Observer software (Noldus Information Technology, 2010) by two trained research assistants. Raters were masked to the participants' diagnosis, treatment condition, timepoint of the observation, and study hypotheses. Videos were coded using detailed procedures found in Appendix A. The following parent and child behaviors were coded in the video-recorded parent-child interactions:

2.5.1. Parent social bids

Parent social bids were defined as verbal attempts to elicit social engagement or response from their child. Types of Parent Social Bids included calling the child's name (e.g. "Bobby!" or "Bobby, look!"), placing a demand (e.g. "Look at this train!"), asking a question (e.g. "Do you want to feed the baby?"), or prompting for language (e.g. "Car?"). These were recorded using a time-stamped frequency count. It was *not* anticipated that total parent social bids would change from pre to post intervention, but this measure was used for assurance that changes in child social responsiveness were not simply attributable to overall increases or decreases in total number of parent social bids. Nonverbal prompts (e.g. showing an item, giving a toy to the child, putting a toy within a child's line of sight) were coded but were not included in analysis as the current study sought to specifically measure response to verbal social bids.

2.5.2. Child social responsiveness

In this investigation, child social responsiveness to parent bids was also investigated by coding the child's behavior during the 5 s period immediately following the parent social bid. This behavior was coded as either a) *response* or b) *non-response*.

A *response* was defined as a child's intentional social action that occurred in response to a parent social bid and appeared to have communicative intent. Types of child responses included a) direct response b) comment, c) direct parent's attention, d) acknowledge, or e) refuse. Responses could be verbal (i.e. speech) or nonverbal (i.e. gesture, eye contact) in nature as not to discriminate against participants with reduced language abilities. In contrast, a *non-response* was defined as a child's failure to visibly respond or react to a parent social bid. Types of child non-responses included (a) ignoring the request, (b) continuing to follow his/her own agenda without acknowledgement of the parent's social bid, (c) engaging in self-stimulatory behavior without eye contact, and/or (d) using nondirected vocalizations (i.e. babbling to self, humming, self-directed vocalizations, perseverating on an off-topic item). Child initiations (i.e. actions intended to start an interaction with the parent) were coded separately as a measure of spontaneous child interactions not connected to parent social bids.

Using behaviorally coded data on parent social bids, child responses, and child non-responses, total child social responsiveness was calculated by dividing the total number of child responses by the total number of parental social bids to yield a response percentage. For example, if a parent provided 20 social bids across a session to try to the engage their child, and the child demonstrated only 10 responses (with 10 non-responses), the child would have demonstrated social responsiveness 50 % of the time (10/20).

2.5.3. Number of total words

As a measure of total language use, the child's number of total words (NTW) spoken during the parent-child interaction was tallied using a frequency count. Animal sounds (i.e. "moo"), sound effects (i.e. "zoom"), and word approximations (i.e. "balloo" for balloon) that were intelligible were included in the word count. Random, undirected vocalizations that did not appear to be verbal approximation of a word with clear communicative intent (e.g. a request for an unidentifiable action or object) were not included in the word count.

2.5.4. Number of different words

As a measure of vocabulary, the total number of the child's unique or different words (NDW) was also counted. Multiple uses of a same word (e.g. "truck") in a video probe increased the Number of Total Words measured above, but was only be counted as a single item in this category.

2.5.5. Mean length of utterance in words

As a measure of language complexity, the mean length of utterance in words (MLU-w) was calculated by averaging the number of words used in each of the child's language bids and responses. For example, the combined use of the statement "I want the car" (four words) and the statement "Give me" (two words) would yield a mean length of utterance of three words (six total words divided by two statements). If a child did not speak for the entire duration of a parent-child play session, his/her resulting MLU-w would be zero for that probe.

2.6. Data analyses

Inter-observer reliability for all measures was calculated using Kappa coefficients (Landis & Koch, 1977). 50 % of videos were randomly selected and recoded for reliability, yielding a Kappa of .74, which was indicative of substantial agreement. Due to the limited power associated with this pilot investigation, mixed Group x Time ANOVA procedures were not conducted. In order to gain

Table 1
Pre-Trial Between Group Demographic and Measure Comparisons.

	Treatment Group (n = 12)		Waitlist Group (n = 9)		*t*	*p*	Mean	95 CI for Mean *Dif*	
Measure	M	(SD)	M	(SD)			*Dif*	Low	High
Age at Intake (months)	35.75	9.31	38.22	9.78	0.59	0.56	2.47	−6.31	11.25
Female (%)	8.33	28.9	11.1	33.3	0.20	0.84	0.03	−0.26	0.31
White (%)	75.0	45.2	45.0	52.7	−1.43	0.17	−0.31	−0.75	0.14
Latino (%)	17.0	38.9	22.0	45.0	0.31	0.76	0.06	−0.32	0.44
Asian (%)	8.0	28.9	11.0	33.3	0.20	0.84	0.03	−0.26	0.31
Multi-racial (%)	0.0	0.0	22.0	45.0	1.51	0.17	0.22	−0.12	0.56
Child Social Responsiveness (%)	67.0	16.4	61.2	12.9	−0.87	0.40	−5.78	−19.67	8.11
Child Number of Total Words (NTW)	61.83	61.89	46.1	52.46	−0.61	0.55	−15.72	−69.35	37.91
Child Number of Different Words (NDW)	24.33	21.34	21.11	20.82	−0.35	0.73	−3.22	−22.72	16.27
Child Mean Length of Utterance (MLU-w)	1.68	1.14	1.51	0.87	−0.37	0.71	−0.17	−1.12	0.79

preliminary outcome data, paired sample *T*-tests were conducted in order to assess for changes in child engagement and expressive language abilities across time-points in the treatment and waitlist control conditions. Cohen's *d* Effect Size calculations were used to measure the magnitude of change for all dependent variables from pre to post and inform the power calculations of a future, large-scale RCT. Pearson correlations were used to explore the association between initial rates of participant engagement and observable expressive language outcomes after six months.

3. Results

Baseline participant data is summarized in Table 1. There were no significant differences between groups on demographic variables of age, sex, or race. There were no significant differences between groups on baseline measures of child social responsiveness, NTW, NDW, or MLU-w ($p > .05$).

3.1. Parent social bids

Table 2 summarizes the dependent measures data for both the treatment and waitlist groups across both timepoints. As anticipated, frequency in parent social bids showed no significant changes over timepoints for families in treatment [$t(11) = -0.88$, $p = .40$, $d = 0.31$] or waitlist [$t(8) = -0.06$, $p = .96$, $d = 0.02$] conditions. Frequency of parent bids also appeared to have little association with the children's number of total words, novel words, or mean length of utterance at the post timepoint ($r = .21$, $r = .26$ and $r = -.009$, respectively).

Table 2
Dependent Measures.

Treatment Group (n = 12)									
Measure	Pre		Post		*t*	*p*	*d*	95 % CI for *d*	
	M	(SD)	M	(SD)				Low	High
Parent Social Bids	33.08	12.59	29.92	7.14	−0.88	0.40	0.31	−0.20	2.21
Child Social Responsiveness (%)	67.00	16.42	80.92	10.70	2.45	0.03*	1.00	0.01	1.68
Child Total Words	61.83	61.89	70.92	63.94	0.75	0.47	0.14	−0.65	0.95
Child Novel Words	24.33	21.34	34.50	28.43	1.81	0.09	0.40	−0.34	1.29
Child Mean Length of Utterance	1.68	1.14	2.13	0.90	2.52	0.03*	0.44	−0.41	1.20
Waitlist Group (n = 9)									
Measure	Pre		Post		*t*	*p*	*d*	95 % CI for *d*	
	M	(SD)	M	(SD)				Low	High
Parent Social Bids	26.44	11.39	26.22	11.00	−0.06	1.00	0.02	−1.33	1.29
Child Social Responsiveness (%)	61.22	12.93	64.22	17.70	−0.80	0.45	0.19	−0.57	1.04
Child Total Words	46.11	52.46	44.67	45.30	−0.10	0.92	0.03	−0.83	0.77
Child Novel Words	21.11	20.82	25.33	26.89	0.81	0.44	0.18	−0.60	1.01
Child Mean Length of Utterance	1.51	0.87	1.61	0.91	0.60	0.57	0.11	−0.69	0.92

* $p < .05$.

3.2. Child social responsiveness

Results revealed that child participants in the treatment group demonstrated significant changes in social responsiveness associated with a large effect at the post-intervention timepoint [t(11) = 2.45, p = .03, d = 1.00]. Specifically, participants in the treatment condition were responsive to a mean of 80.9 % of opportunities given by caregivers after intervention compared to a mean of 67.0 % of opportunities before intervention (an increase of 13.9 %; see Fig. 2). Social responsiveness among participants in the waitlist condition remained relatively unchanged [t(8) = -0.80, p = .45, d = 0.19].

3.3. Child language use

Data on Language Use can also be found in Table 2. Results indicated that children in the treatment condition demonstrated significantly increased MLU-w with moderate effect size from pre- to post-intervention [t(11) = 2.52, p = .03, d = 0.44], whereas MLU-w among the waitlist condition remained seemingly unchanged [t(9) = 0.60, p = .57, d = 0.11](see Fig. 4). Participants in the treatment condition also demonstrated promising but non-significant increases NDW (d = 0.40) from pre- to post-intervention not seen in the waitlist condition (d = 0.18). Both conditions demonstrated little to no change in NTW spoken during the parent-child interaction from pre- to post (Tx Condition d = 0.14; WL Condition d = 0.03).

3.4. Minimally verbal subgroup data

While the minimally verbal subgroup in each condition was notably small (Tx Condition n = 4; WL Condition n = 5), these exploratory results indicate that treatment effects may be particularly pronounced within this subgroup.

Minimally verbal participants in the treatment group experienced gains associated with large effect sizes for increased social responsiveness with caregivers from pre- to post-intervention (see Fig. 3). Specifically, social responsiveness among minimally verbal participants in the treatment group increased from pre- to post-intervention (TR Condition Pre M = 52.3 % SD = 13.7 %; Post M =

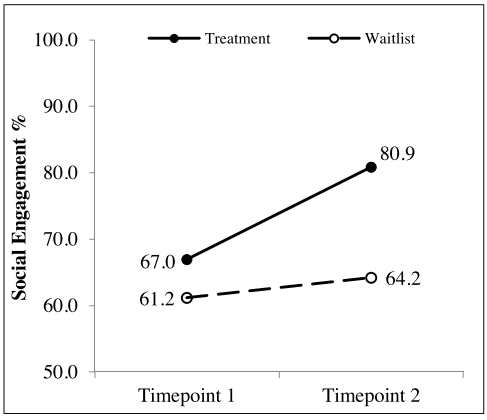

Fig. 2. Changes in Social Engagement in Response to Parent Social Bids among All Participants.

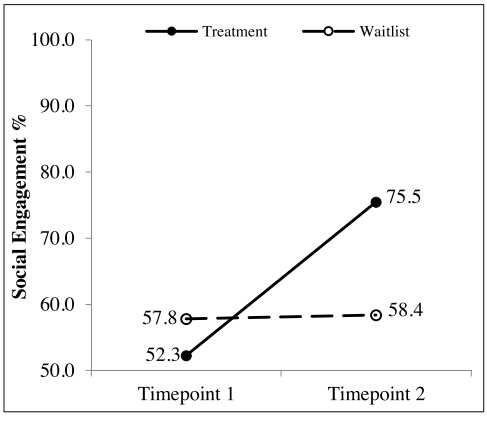

Fig. 3. Changes in Social Engagement in Response to Parent Social Bids among Minimally Verbal Participants.

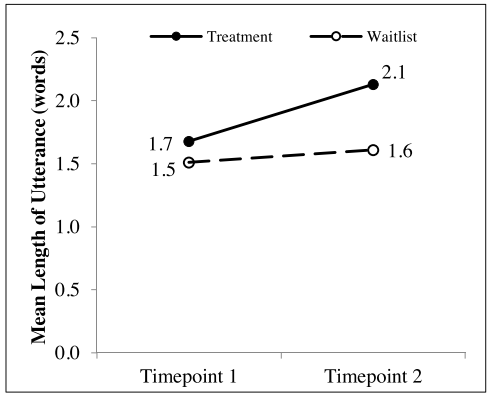

Fig. 4. Changes in Mean Length per Utterance among All Participants.

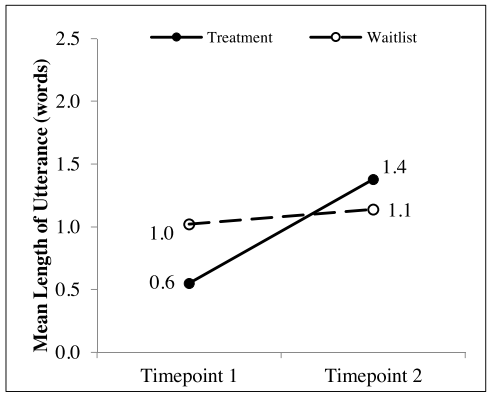

Fig. 5. Changes in Mean Length per Utterance among Minimally Verbal Participants.

75.5 % SD = 14.9; d = 1.62), while levels of social responsiveness among minimally verbal participants in the waitlist group remained unchanged (WL Condition Pre M = 57.8 % SD = 16.5 %; Post M = 58.4 % SD = 18.3 %; d = 0.03).

Similar to the trend witnessed in social responsiveness, we observed increasing trends across word use measures among minimally verbal participants in the treatment condition: Number of Total Words (TR Condition NTW Pre M = 2.25 SD = 2.87; Post M = 15.75 SD = 20.22; d = 0.94), Number of Different Words (TR Condition NDW Pre M = 2.00 SD = 2.83; Post M = 8.00 SD = 8.45; d = 0.95), and Mean Length of Utterance in Words (TR Condition MLU-w Pre M = 0.55 SD = 0.64; Post M = 1.38 SD = 1.38; d = 0.90; see Fig. 5). In contrast, we witnessed negligible effect sizes across word use measures among minimally verbal participants in the waitlist condition: Number of Total Words (WL Condition NTW Pre M = 11.20 SD = 12.07; Post M = 21.00 SD = 32.81; d = 0.40), Number of Different Words (WL Condition NDW Pre M = 7.20 SD = 8.58; Post M = 9.40 SD = 10.24; d = 0.23), and Mean Length of Utterance in Words (WL Condition MLU-w Pre M = 1.02 SD = 0.74; Post M = 1.14 SD = 0.89; d = 0.15). Because these are exploratory analyses with a small subset of the pilot RCT, resulting t-tests were underpowered and did not result in statistically significant changes (p > .05 across social responsiveness and language measures).

3.5. Predictors of outcome

Pearson correlations between initial social responsiveness and gains in language use were conducted for all participants. Mean change scores across (a) total words, (b) different words, and (c) mean length of utterance were used for these analyses.

For all participants, regardless of condition, initial child responsiveness with caregivers showed no association with gains in total words (r = .03, p = n.s.) or gains in mean length of utterance in words (r = .06, p = n.s.) and only weak association with gains in novel words (r = .27, p = n.s.) after six months. However, this was suspected to be due to the minimal changes from pre to post among verbally fluent participants. When analyses focused on the subset of minimally verbal participants, results indicated that initial rates of child responsiveness were strongly associated with gains in total words (r = .67, p = .04) and moderately associated with gains in different words (r = .47, p = n.s.) and mean length of utterance (r = .34, p = n.s.). In other words, for individuals with more limited baseline language use, higher social responsiveness was associated with greater language gains after six months.

4. Discussion

Observational data obtained through interactive parent-child play probes are indicative of potential improvements in child social responsiveness and mean length of utterance in words associated with the PRISM treatment model. As these improvements were not witnessed among waitlist participants, these results suggest that PRISM could be possible means for increasing social responsiveness and mean length of utterance in young children with ASD.

Contrary to expectations, however, participants did not demonstrate improvements in total or different words. Given the variability in baseline participant language complexity (as evidenced by the large standard deviations in Table 1), it is suspected that the more verbally fluent participants (who were already demonstrating a relatively high number of total and novel words) may have experienced a ceiling effect post-intervention (i.e. it was difficult for them to further improve the frequency of word use or vocabulary), which may have clouded the gains obtained by less verbally capable participants. Therefore, we felt it pertinent to examine the subset of minimally verbal participants in post-hoc exploratory analyses.

These results suggest that the minimally verbal participants who participated in the PRISM treatment model may experience more pronounced effects in social responsiveness when compared to their counterparts who started with more advanced language skills. The minimally verbal treatment subgroup also demonstrated encouraging effect sizes for all three word use measures from pre- to post-treatment. While minimally verbal participants in this study presented as more socially detached at intake (i.e. socially responsive to about half of opportunities), they demonstrated the greatest treatment gains in both social responsiveness and language abilities. These results are very preliminary and must absolutely be replicated with significantly increased sample sizes, but they appear to suggest that the PRISM treatment model may be a promising treatment approach for improving both social responsiveness and language use among minimally verbal toddlers with ASD.

In terms of outcome predictors, initial rates of engagement were strongly associated with subsequent language use among minimally verbal participants after six months, suggesting that early social responsiveness may serve as a useful predictor of social word use later in development.

4.1. Predictors of outcome

The findings of this study demonstrate that for young children with ASD, their level of engagement in response to their parent's social bids may be an accurate predictor of social language gains later in development. This interaction may be particularly relevant for individuals with significant language impairments early on. Specifically, children who notice, acknowledge, and respond to their parents' bids in at least half of opportunities are more likely to demonstrate noticeable language gains after six months. These results are consistent with the current research suggesting that less social impairment and greater social attunement during toddlerhood is associated with acquisition of phrase and fluent speech later in development (Wodka et al., 2013).

4.2. Utility of parent-child interaction videos in clinical trials

Recently, greater emphasis has been placed on the need for development of behavioral measures of social communication, particularly for minimally verbal children with ASD (Kasari et al., 2013). In this pilot of young children with ASD, the use of parent-child play sessions successfully measured subtle levels and changes of social responsiveness and engagement among participants. Importantly, these treatment effects could possibly be magnified in minimally verbal participants, a population that is at risk of experiencing floor effects on standardized assessment batteries at pre- and post-intervention (Kasari et al., 2013; Tager-Flusberg et al., 2009). The changes in pre- to post-treatment effects found in this study provide supportive evidence for the utility of parent-child interactions as a measure of ecological gains in natural social encounters. In addition, it is possible that interactions with a parent as their social partner (compared to an unfamiliar researcher or clinician) may capture a child's social engagement skills that are more representative of the his/her everyday social interactions; however, future research would be needed to test this hypothesis. This contributes to the current literature that supports the use of behavioral play-based assessments but highlights the need for structured observation tools and other novel measures of social engagement and communication. As a result, naturalistic assessments that utilize parent-child interactions may serve as a suitable addition to standardized assessment batteries, especially for measuring symptom presentation and treatment progress among minimally verbal populations.

4.3. Limitations and future directions

The sample included in this pilot RCT was relatively small and the trial was intended to inform methodological design and recruitment decision for a future trial. Replicating this study with a fully powered randomized control trial and increased sample size is required to make more definitive claims of treatment efficacy. In addition, it would be advantageous to examine treatment dosage in future studies. Despite families completing in an average of 6.81 of 10 total hours per week offered, the study still found medium to large effect sizes between pre and post. This outcome poses the question of quality versus quantity in regards to the delivery of NDBIs and other autism intervention models.

While there are clear advantages to using coded social interaction probes to diversify trial outcome measures, there are also potential drawbacks. One limitation is the accounting for the natural parent and child behavioral variability inherent across play sessions, regardless of assigned condition. Confounding variables, such as parent and child mood, energy levels, sicknesses, and toy preference, could also explain changes in social responsiveness and language use. Recording multiple play probes at pre and post

timepoints (perhaps across multiple days), and/or collecting probes on regular intervals over the entire course of the trial would allow us to better understand and control for the day-to-day variability of parent and child social behaviors and potentially map the growth curves of social improvements. Furthermore, Kappa coefficient of agreement for behavioral coding raters fell just below the conventional standard of .80, which should be addressed and improved in future studies using this coding scheme.

Another potential limitation with this pilot investigation is the role of different types of parent bids. While the total frequency of parental bids appeared to have little influence on resulting responsiveness or language use, it is possible that the qualitative nature of parental bids (e.g. using a question vs a statement; using a playful versus neutral tone; discussing a child's preferred toy versus a less-preferred toy) may play a role in child responsiveness and language use. Such findings would correspond with the hypothesized mechanisms of change of the PRISM model, in which the qualitative presentation of a parent bid and its link to a social activity of interest are believed to maximize social attunement and responsiveness (Vernon et al., 2012, 2019). Therefore, future analysis of the qualitative aspects of parental bids may provide additional insights into the dynamic nature of parent-child interactions and the transactional influences that a parent's behavior has on their child's social communication behaviors.

4.4. Conclusion

In this pilot randomized control trial, we explored the use of parent-child interactions as a means to obtain naturalistic social communication data from young children with ASD and their parents. This assessment also served as an effective augment to existing standardized assessment outcomes (Vernon et al., 2019), particularly for minimally verbal individuals. These findings further emphasize the need for naturalistic, observation-based assessments that are able to capture nuanced changes in social functioning.

Ultimately, when utilizing a treatment paradigm that directly targets social motivation, we observed encouraging improvements in corresponding responsiveness and language use and a possible associative link between these two social competencies. It appears that children who are more socially attuned and responsive to their parents demonstrated greater expressive language gains within a relatively short period of time. The observed improvements in social responsiveness may illustrate participants' increased association between parent bids and desirable social contingencies as a result of repeated exposure to the PRISM three-step contingency. In the implementation of Pivotal Response Treatment and other NDBI treatment models, teaching parents to offer and contingently deliver a) preferred social activity with high affect and noncontingent initial exposure may be an effective mechanisms for increasing the reward value associated responsiveness to adult bids. Ultimately, this may alter underlying level of social motivation among very young children with ASD. With social motivation heightened, young children with ASD can more efficiently attend to social learning contingencies believed to facilitate language acquisition, build social competencies, and contribute to long-term positive outcomes.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Competing Interest

All authors declare that they have no conflicts of interest.

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