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Fostering a Social Child with Autism: A Moment-By-Moment Sequential Analysis of an Early Social Engagement Intervention

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Abstract Young children with autism often experience limited social motivation and responsiveness that restricts establishment of crucial social momentum. These characteristics can lead to decreased opportunities for parental engagement and the social learning associated with these moments. Early social interventions that capitalize on pre-existing interests may be able to re-establish this developmentally critical feedback loop, in which both child and parent social behaviors simultaneously increase and influence one another. This investigation examined the moment-by-moment, micro-transactional relationship between parent and child social behavior gains observed in an early intervention study. Time-window sequential analyses revealed the presence of clinically and statistically significant sequential associations between parent and child social behaviors during an embedded social interaction intervention, but not in a comparable motivational intervention that utilized highly preferred toys and objects. Specifically, the onset of parent eye contact, directed positive affect, or offer of a reinforcing incentive predicted the immediate occurrence of child eye contact and positive affect in the experimental social intervention condition. Additionally, child verbal initiations, positive affect, and eye contact immediately predicted the onset of parent positive affect during this social intervention paradigm. Theoretical implications for the social developmental trajectory of autism are discussed.

Keywords Autism · Sequential Analysis · Early Social Intervention · Naturalistic Developmental Behavioral Intervention · Pivotal Response Treatment

Introduction

There is a growing research literature supporting the notion of malleability in the social development of young children with autism (e.g. Dawson & Zanolli 2003; Mahoney & Perales 2003; Schertz & Odom 2007; Trivette & Dunst 2011; Walton & Ingersoll 2012; Wilson 2013; Wimpory et al. 2007; Wong 2013). Professionals and organizations have recognized that the social developmental trajectory of autism becomes more deviant as a function of time, and as a result, they have strongly advocated for early identification and intervention (Osterling & Dawson 1994; Osterling et al. 2002; Kasari 2002; National Research Council 2001). The recognition that early intervention has a large effect on child outcome has important implications. This finding suggests that, when applied early, intervention can serve in a preventative capacity, in that therapy can help the recipient learn core skills to serve as the platform for acquiring more complex skills and staving off later difficulties. Parents, in particular, may be in a position to significantly contribute to these intervention efforts.

Parents often play a pivotal role in treatment delivery and significantly contribute to their child's skill acquisition and subsequent development (e.g. Koegel et al. 1996). However, children with autism, by the very diagnostic criteria of their disorder, can be difficult to engage in social interaction (APA 2013). Without proper education in effective autism intervention strategies, parents' unsuccessful attempts to engage their children in playful social exchanges may impact their motivation and lead to a

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learned helpless-like state (i.e. a reduction in continued attempts to capture their child's attention). On the other hand, if easy-to-implement, effective intervention strategies can be taught to parents, they are likely to experience increased motivation to engage with their child over time (e.g. Schreibman et al. 1991). Using appropriate strategies, a parent may be able to create the appropriate transactional context to successfully elicit reciprocal social responses.

A promising method for improving social responding may lie in capitalizing on the pre-existing interests of children with autism (Baker et al. 1998; Boyd et al. 2007; Trivette & Dunst 2011; Vismara & Lyons 2007). Using socially analogous versions of existing preferences may be particularly important for eliciting significant social gains in young children with autism (Koegel et al. 2009; Vernon et al. 2012). These previous investigations have demonstrated that using social activities derived from pre-existing (but previously non-social) interests greatly increased the participants' collateral levels of eye contact, positive affect, and overall engagement directed towards their social partner. In these studies, children were also found to verbally initiate language more frequently, while parents were observed to increase their use of positive facial expressions (affect) directed towards their children.

Several scholars hold that pairing reinforcing activities with the presence of other people may encourage children with autism to perceive subsequent social encounters as more reinforcing (Halle et al. 1995; Yoder & McDuffie 2006). Recent studies build on this concept by integrating (in lieu of merely pairing) social interaction with functional reinforcement (Koegel et al. 2009; Vernon et al. 2012). Embedding social versions of existing reinforcement appears to motivate children to initiate and sustain reciprocal social exchanges. The next step in this line of research would be closely analyze the components of this intervention in order to determine the possible causal mechanisms behind the observed social gains.

Evidence that is highly indicative of a causal link between variables can be obtained through time-window sequential analysis procedures (Bakeman & Quera 1995; Chorney et al. 2010; Yoder & Tapp 2004). In a time-window sequential analysis, the behaviors of two parties (e.g. parent and child) are defined and micro-coded on a moment-by-moment basis. Next, these behaviors are examined for the presence of predictable temporal relationships. Specifically, a short time window immediately following each antecedent behavior of one person (e.g. parent verbalization) is examined for the presence of a target behavior from another person (e.g. child eye contact). Evidence for a causal relationship is based on overall probability in which a target behavior of interest is more likely to occur within a short time-window immediately

following a specified antecedent behavior then outside of that window. If the observed ratio of behavior sequences significantly exceeds the predicted ratio based on base rate occurrences of these behaviors, there is strong evidence for a purported causal relationship (Yoder & Tapp 2004).

The purpose of this empirical investigation was to use time-window sequential analysis procedures to evaluate the relationship between successive parent and child social behaviors in a caregiver-implemented early social engagement intervention. These methods were employed to augment traditional observational coding techniques by assessing for evidence of possible causal, cyclical relationships between parent and child social behaviors. The ultimate objective of this investigation is to better understand the contextual variables in which parent and child social attunement is maximized.

Method

Participants

Intervention data from three young children diagnosed with autism spectrum disorder and their parents were used for the time-window sequential analyses. All children received diagnoses by outside agencies, which were then confirmed using the Autism Diagnostic Observation Schedule (Lord et al. 2000), Autism Diagnostic Interview-Revised (Lord et al. 1994), informal parent interviews, and direct child observations. Inclusion criteria consisted of (a) a chronological age falling between 2:0 and 4:11 years (b) behavioral signs of significant social impairment (limited eye contact and joint attention, occurring <5 % of the time across social contexts), (c) use of first words for requesting purposes (defined as at least five functional words) and (d) evidence of adaptive social deficits on the Vineland Adaptive Behavior Scales, 2nd Edition (Vineland-II; Sparrow et al. 2005). Specifically, their socialization age equivalents were required to be at least half the child's chronological age and no >18 months.

Child One was a 4-year, 3-month old Hispanic-American male and his mother was a married 30-year-old Hispanic-American female (Family One). Child Two was a 2-year, 4-month old biracial (Hispanic- and European-American) male and his mother (Parent Two) was a married 33-year-old Hispanic-American female (Family Two). Child Three was a 2-year, 11-month old European-American and his father (Parent Three) was a married 35-year-old European-American male (Family Three). Additional information about the participants can be found in a summary table in Vernon et al. (2012).

Research Design

A multiple-baseline across participants design (Barlow & Hersen 1984) was used to evaluate the transactional effects of an experimental social intervention. Time spent in the initial baseline intervention was systematically varied (i.e. 4, 8 and 12 sessions) to control for developmental maturation and changes that could be due to mere exposure to the training clinician or accumulative effects of any clinical exposure/intervention. Each child then received 20 sessions of the experimental social intervention.

Setting and Materials

Sessions took place in the participants' homes and community settings (parks, school playgrounds, etc.). Materials used during the study included motivating toys and other household items readily available in the participants' homes to elicit social-communication from the participants.

Procedure

The following is a summary of the investigation procedures used to obtain the social data used in the current time-window sequential analyses.

Across both baseline and experimental phases, parent education sessions used a language intervention based on the delivery format of Pivotal Response Treatment (PRT) to target language acquisition with the participant children. The specific motivational strategies of PRT used are described in detail in Koegel et al. (1989) and included using child choice in the selection of intervention items and activities, obtaining child attention prior to eliciting a language opportunity, reinforcing reasonable attempts at child responding, providing immediate and contingent delivery of reinforcement following a verbal utterance, and using incentives logically related to a child's verbal request.

Parent-education sessions were provided across all baseline and intervention phases. All sessions were approximately 1 h in length and occurred 3–5 times a week depending on family availability. 10-min video probes of the parents implementing intervention were collected during each session for behavioral coding purposes, with the video angle continually adjusted to ensure consistent view of parent and child faces.

Baseline Phase

During the baseline phase, a traditional PRT intervention format was used. Learning opportunities took place in the following three-step format: (a) the parent set up a language learning opportunity by signaling to their child that

he needs to make a language attempt (e.g., modeling a target word while enticing him with an object of interest), (b) the parent waited for the child to respond by making a verbal request attempt, and (c) the parent reinforced their child's verbal attempt with access to the *motivating object*. Following adequate time for the child to enjoy the motivating incentive, another opportunity was created. Spontaneous child requests were also reinforced with the desired stimulus. The activities and items used were systematically altered to match the children's evolving interests during and across sessions. While a formal reinforcement assessment was not conducted, parents were encouraged to use any available stimulus identified as highly reinforcing to their child. Because of the multiple baseline design, participants received a varying number of baseline intervention sessions (i.e. Family 1 received 4 one-hour sessions, Family 2 received 8 sessions, and Family 3 received 12 sessions).

Intervention Phase: Embedded Social Interaction

When families transitioned to the embedded social interaction condition, the investigators initially discussed these methods with each caregiver. Parents were taught to modify the existing three-step intervention format by modifying the incentives used to reinforce child language attempts. Specifically, parents were taught to embed socially analogues of their child's existing interests into the learning sequence: (a) the parent again provided a verbal prompt and/or enticed the child with the motivating stimulus, (b) they waited for a verbal response for their child, and (c) the parent immediately reinforced their child's language attempts with a *motivating social interaction*.

Social versions of reinforcing stimuli were developed by evaluating the core elements of existing interests, extracting the specific components likely to be attracting the child's attention, and determining methods for embedding these into a form of social reinforcement. Prior to beginning the embedded social interaction condition, a thorough investigation of the child's preferences and interests was conducted. These methods included parent interviews, naturalistic observations of the child's play, and systematic introduction of different toys and objects during the initial evaluation. After a comprehensive interest survey was developed, the items and activities were analyzed for specific sensory characteristics that attracted and engaged each child participant. Finally, these characteristics were integrated into a number of comparable social analogues. These interests varied by child and some were visual (e.g., animating an inanimate toy), auditory (e.g., singing a favorite song from a favorite cartoon), tactile (e.g. tickling a child that enjoys physical contact), or proprioceptive (e.g. swinging the child in the air). As additional examples, if a

child derived reinforcement from a musical toy, a possible social reinforcer might involve having a parent mimic those sounds following their child's request. As another example, if the child was observed to enjoy playing with water, a social analogue might involve a social splashing game. The general intervention concept required transforming an engaging but nonsocial interest into an equivalent social activity that promotes engagement with a social partner. Development of additional social activities continued throughout the social intervention condition. All participants received 20 one-hour sessions of the experimental embedded social intervention.

Fidelity of Implementation

To ensure accurate implementation of the interventions, systematic fidelity procedures were followed for approximately 50 % of all sessions. All parents scored above the established 80 % cutoff (Koegel et al. 1989) across the basic PRT fidelity components in both baseline and intervention conditions (group mean of 97.7 %). Additionally, parents were noted to adhere to near-exclusive use of non-social reinforcement during the baseline condition (94.6 % of opportunities) and social reinforcement during the embedded social intervention condition (86.7 % of opportunities).

Time-Window Sequential Analysis

Established procedures for conducting time-window sequential analyses were implemented (Chorney et al. 2010; Yoder & Tapp 2004). All behavioral coding and time-window analyses were conducted with the assistance of Noldus Observer software (Noldus et al. 2000). Within each intervention condition, all 10-minute video probes for each participant family for all baseline and intervention sessions were examined using a 1-second unit of analysis. Specifically, 4 baseline intervention condition videos were coded for Family Dyad One, 8 were coded for Dyad Two, and 12 were coded for Dyad Three. 20 social intervention condition videos were also coded for each family dyad. 43,200 s of total video were analyzed.

A maximum time window of 5 s was used for the analysis (i.e. the onset of the antecedent social behavior of one party must be followed by the onset of the target social behavior of the other party within 5 s to be included in the sequential calculations). This brief time window selection was selected to ensure that behaviors that *did not* happen in quick succession were excluded. Sequences were limited to the *onset* of parent antecedent social behaviors and *successive onset* of child target social behaviors, in addition to sequences consisting of the *onset* of child antecedent social behaviors and *successive onset* of parent target social behaviors. Following the procedural recommendations of

Yoder and Tapp (2004), duration of the antecedent and target social behaviors were not considered in these analyses due to the relatively brief nature of both the antecedent and target social behaviors of interest (i.e. mean duration of or <5 s across social behaviors).

The specific social behaviors used in the time-window sequential analyses were originally defined in an earlier investigation (Vernon et al. 2012) and are summarized here: *Child Eye Contact* was defined as the child looking at the facial region of his parent's face. *Child Verbal Initiations* was defined as any unprompted, functional verbal utterance towards a parent for requesting purposes. Self-stimulatory and other nonfunctional vocalizations were not coded. *Child Positive Affect* was defined as visible and/or audible indications of happiness and enjoyment, including smiling, laughing, and physical affection (hugging and kissing). *Parent Positive Affect* was defined as visible and/or audible indicators of happiness and enjoyment, including smiling, laughing, using an elevated and playful vocal tone (i.e. motherese), clapping, and physical affection (i.e. hugging, kissing). *Parent Initiated Language Opportunity* is a parent verbalization (verbal cue) intended to elicit a child verbal response to obtain reinforcement. All variables were coded on a continuous basis.

Inter-observer reliability for all variables ranged from 0.84 to 0.92 (mean of 0.88) with kappa scores ranging from 0.50 to 0.77 (mean of 0.63). The following sequences were examined within a time-window sequential analysis:

- Parent language opportunity* (antecedent) → *child positive affect* (target).
- Parent positive affect* → *child positive affect*.
- Parent language opportunity* → *child eye contact*.
- Parent positive affect* → *child eye contact*.
- Child verbal initiations* → *parent positive affect*.
- Child eye contact* → *parent positive affect*.
- Child positive affect* → *parent positive affect*.

Transitional Sequences

In each experimental condition, the mean frequency of transitional sequences that occurred per 10-min probe was calculated. A transitional sequence was defined as the presence of a specified antecedent social behavior (e.g. child eye contact) accompanied by the designated target social behavior (e.g. parent positive affect) within the 5-second time window. The mean number of sequences and effect sizes were calculated between baseline and experimental intervention conditions.

Effect size calculations were also conducted to gauge the magnitude of any observed mean sequence increases between baseline and experimental intervention conditions. Effect sizes were calculated by subtracting mean baseline

sequences from mean experimental sequences for each participant and dividing by the weighted standard deviation derived from the pooled variance of both conditions (following procedures outlined by Busk & Serlin 1992).

Transitional Probability

The mean percentage of antecedent social behaviors followed by the specified target behavior was also calculated. This transitional probability was determined by dividing the number of antecedent-to-target social behavior sequences by the total number of times the antecedent behavior occurred. Mean transitional probabilities were calculated for each intervention condition.

Odds Ratio Calculation

An odds ratio is a measure of sequential association that controls for base rates of the behaviors of interest and the duration of the time probes (Bakeman & Gottman; 1997; Bakeman et al. 1996; Yoder & Tapp 2004). It is calculated using the following equation: $(A/B)/(C/D)$. *A* represents the number of seconds in which the target behavior occurred within the time windows following the antecedent behavior. *B* represents the (remaining) number of seconds within the time-window in which the onset of the target behavior did not occur. *C* represents the number of discrete onsets of the target behavior outside of the time window. *D* represents the number of seconds in which neither the onset of antecedent or target behaviors occurred.

A/B yields a ratio of occurrences versus non-occurrences of the target social behavior within the time-windows. C/D yields the ratio of occurrences versus non-occurrences of the target behavior in general (excluding data within the time-windows). The final odds ratio calculation yields a measure of effect size, with a number <1 indicating that the target behavior is less likely to occur immediately following the antecedent behavior. An odds ratio of 1 would indicate no association between behaviors, and a number >1 would indicate the magnitude in which that target behavior is more likely occur within the time window of the antecedent event than outside of it. Odds Ratios were calculated for each sequence for both experimental conditions.

Yule's Q

Yule's *Q* was also calculated as an additional measure of sequential association (Reynolds 1984) with a minimum value of -1.0 and a maximum value of 1.0 . A negative Yule's *Q* indicates that the onset of the target behavior occurs less within the antecedent time-window than outside of it, a result of 0 indicating no sequential relationship between behaviors, and a positive Yule's *Q* indicating that

a specific target behavior is more likely to occur within the time-window of a specified antecedent behavior.

Test of Statistical Significance of Sequential Associations

In order to confirm that differences between observed and expected sequences between antecedent and target behaviors were not merely due to chance, z-scores were calculated by subtracting the expected frequency of antecedent-target behavior sequences from the observed sequential frequency and dividing the result by the standard deviation of this difference (Bakeman & Gottman 1997; Yoder & Tapp 2004).

Results

Transitional Sequences

During the baseline intervention condition, sequences between parent-to-child social behaviors occurred on a very infrequent basis (overall mean of 0.32 per 10-min video probe across sequences, or *each type* of parent-to-child sequence occurring approximately once every 31 min). On average, 1.28 cumulative parent-to-child sequences (all types) occurred per probe. Child-to-parent social behaviors occurred at an overall mean of 0.24 per 10-min probe, or approximately once every 42 min. On average, 0.72 child-to-parent sequences (cumulative) occurred per probe. The data for individual transitional sequence across all three family dyads is summarized in Table 1.

During the embedded social intervention condition, the number of parent-to-child social behavior sequences significantly increased to a mean of 6.00 per 10-minute probe, or each type of sequence occurring approximately once every 100 s). On average, 24 total parent-to-child sequences (cumulative of all types) occurred per 10-min video probe. The number of child-to-parent social sequences increased to a mean of 5.80 per 10-min probe, or each type of sequence occurring once every 103 s. On average, 17.40 total child-to-parent sequences (cumulative) occurred per 10-min video probe.

Effect size calculations consistently yielded evidence of large effects between the baseline and social intervention conditions across all three family dyads, except for the *Child Positive Affect* → *Parent Positive Affect* sequence for Family Dyad 3, which was indicative of a moderate effect ($d = 0.56$). These data are listed in Table 1.

Transitional Probability

During the baseline intervention, the onset of an antecedent parent social behavior was followed by a target child social

Table 1 Time-window sequential analyses for all social behavior sequences

Antecedent social behavior → target social behavior transitional sequence	Family dyad	Treatment condition	Mean trans. sequences/ 10 min (SD)	Effect size (d) for trans sequence Δ	Transitional probability (%)	Odds ratio	Yule's Q	z-score
Parent language opportunity → child positive affect	1	Baseline	0.50 (1.00)		3.91	18.32	0.90	2.38*
		Social	5.75 (3.70)	1.50	38.85	19.85	0.90	6.95**
	2	Baseline	1.00 (1.31)		5.55	7.90	0.78	2.15*
		Social	7.13 (4.16)	1.70	35.63	27.18	0.93	8.51**
	3	Baseline	0.25 (0.45)		1.95	5.98	0.71	0.95
		Social	5.50 (4.29)	1.55	28.95	29.56	0.93	8.01**
Parent positive affect → child positive affect	1	Baseline	0.00 (0.00)		0	0	-1.00	-0.12
		Social	8.06 (3.70)	2.31	20.72	8.90	0.80	5.52**
	2	Baseline	0.25 (0.71)		5.43	6.72	0.74	1.05
		Social	4.31 (2.52)	1.86	17.45	8.24	0.78	4.19**
	3	Baseline	0.00 (0.00)		0	0	-1.00	-0.06
		Social	2.00 (2.07)	1.23	17.09	10.43	0.83	3.47**
Parent language opportunity → child eye contact	1	Baseline	0.00 (0.00)		0	0	-1.00	-0.20
		Social	6.06 (3.38)	1.90	40.95	16.99	0.89	6.56**
	2	Baseline	1.38 (2.26)		7.67	18.36	0.90	3.71**
		Social	9.19 (5.19)	1.70	45.95	27.31	0.92	9.15**
	3	Baseline	0.17 (0.39)		1.33	6.98	0.75	0.86
		Social	4.69 (3.55)	1.62	24.68	15.27	0.88	5.85**
Parent positive affect → child eye contact	1	Baseline	0.00 (0.00)		0	0	-1.00	-0.12
		Social	11.13 (7.14)	1.65	28.60	12.17	0.85	7.15**
	2	Baseline	0.25 (0.71)		5.43	9.06	0.80	1.26
		Social	5.38 (3.67)	1.63	21.78	7.24	0.76	4.27**
	3	Baseline	0.00 (0.00)		0	0	-1.00	-0.05
		Social	2.75 (2.29)	1.53	23.5	12.47	0.85	4.32**
Child verbal initiations → parent positive affect	1	Baseline	0.25 (0.50)		6.25	8.30	0.78	1.20
		Social	4.88 (2.92)	1.68	45.61	13.69	0.86	5.24**
	2	Baseline	0.00 (0.00)		–	–	–	–
		Social	1.69 (1.78)	1.11	54.52	29.89	0.93	4.48**
	3	Baseline	0.00 (0.00)		0	0	-1.00	-0.03
		Social	1.19 (1.72)	0.88	25.32	18.86	0.90	3.67**
Child eye contact → parent positive affect	1	Baseline	0.25 (0.50)		13.89	20.15	0.91	1.93
		Social	12.13 (7.89)	1.60	41.83	14.62	0.87	7.92**
	2	Baseline	0.38 (0.74)		9.5	14.72	0.87	2.01*
		Social	7.00 (4.27)	1.81	26.21	11.15	0.84	5.88**
	3	Baseline	0.08 (0.29)		6.15	38.42	0.95	1.58
		Social	3.50 (3.16)	1.38	20.71	18.31	0.90	5.66**
Child positive affect → parent positive affect	1	Baseline	0.00 (0.00)		0	0	-1.00	-0.12
		Social	12.44 (6.00)	2.20	52.05	22.55	0.92	9.23**
	2	Baseline	1.13 (1.24)		21.32	46.17	0.96	5.45**
		Social	6.38 (4.57)	1.33	34.12	15.91	0.88	6.63**
	3	Baseline	0.00 (0.00)		0	0	-1.00	-0.06
		Social	3.00 (1.97)	0.56	22.39	19.16	0.90	5.47**

Family Dyad Two's *Child verbal initiations* → *Parent positive affect* data could be not calculated due to an absence of antecedent social behavior occurrences (i.e. no child verbal initiations during any baseline sessions)

* $p < 0.05$, ** $p < 0.001$; two-tailed

behavior (within the time window) an overall mean of 3.58 % of the time across dyads. The onset of a child antecedent social behavior was immediately followed by a parent target behavior a mean of 9.28 % of the time across dyads.

During the embedded social intervention condition, the parent-to-child social behavior transitional probability increased to a mean of 28.96 % of the time. Similarly, the child-to-parent social behavioral transitional probability increased to a mean of 37.36 %. The mean percentage of each sequence's transitional probability for each individual dyad is displayed in Table 1.

Odds Ratio and Yule's Q

During the baseline intervention condition, parent-to-child social behavior sequences occurred at a relative frequency that was 7.71 times that of the target child behavior outside of the antecedent time-window (Yule's Q of 0.80). The child-to-parent sequences occurred at a relative frequency 19.48 times greater than that target parent behavior outside of the time-window (Yule's Q of 0.90).

During the social intervention condition, a parent-to-child sequence was 15.37 times more likely to occur than the target child behavior outside of the antecedent time-window (Yule's Q of 0.87). A child-to-parent sequence occurred at a relative frequency 17.70 times greater than the target parent behavior outside of the time-window (Yule's Q of 0.88). The odds ratio and Yule's Q for each individual transitional sequence for each family dyad are displayed in Table 1.

Test of Statistical Significance

For Family Dyad One, one transitional sequence (*Parent language opportunity* → *Child positive affect*) was found to occur at an observed frequency significantly exceeding the expected sequential frequency at baseline (at a level greater than what could be accounted for by chance alone: z-score 2.38, $p < 0.05$). For Dyad Two, four of the seven sequences occurred at a statistically significant frequency in baseline (see Table 1). Finally, baseline data for Dyad Three did not yield any statistically significant occurrences of observed sequences.

For each family dyad in the social intervention condition, all seven social behavior sequences were found to occur at an observed frequency significantly higher than the base rate predictions for expected frequency (z-scores ranging from 3.47 to 9.23, $p < 0.001$). The z-scores for individual transitional sequences are displayed in Table 1.

Discussion

The results of this investigation suggest that teaching parents to embed social interaction into their intervention strategies may have a notable effect on both child and parent responding. Specifically, the time-window sequential analysis data are indicative of a reciprocal, causal relationship between parent and child social exchanges.

The increase in both the number of transitional sequences and overall transitional probabilities during the social intervention paradigm provide promising evidence of improvements to parent-child synchrony. Parent social behaviors (i.e. offer of an reinforcing incentive, directed positive affect, eye contact) appear to be directly driving the improvements to child social responding (i.e. eye contact, directed positive affect) in the embedded social intervention condition. In turn, child social behaviors seem to immediately elicit in-kind social responses from their parents. These reciprocal exchanges provide evidence of accruing social momentum in the form of a positive feedback loop.

An examination of the odds ratio and Yule's Q calculations further clarify the factors underlying the parent-child exchanges. Because these values control for the difference in the base rates of the antecedent and target behaviors (Yoder & Tapp 2004), they can allow for a more accurate comparison between experimental conditions. For some of the sequences, comparable odds ratios across both conditions suggest that the parents and children remained equivalent in their relative responsiveness to social behaviors, regardless of the intervention condition. The difference in the actual number of observed social sequences can be attributed to the limited occurrences of antecedent social behaviors in the baseline PRT intervention condition. That is, there were long periods of time in which there were no "trigger" social behaviors to activate a response from the other member of the family dyad. Such findings support the rationale that intervention context is of utmost importance. The nature of the exchange in the embedded social intervention condition naturally elicited the onset of numerous social behaviors, which in turn caused in-kind responses from both parent and child.

In the baseline condition, Family Dyad Three did not appear to engage in any transitional sequences at a rate exceeding those expected to randomly occur due to the relative base rates of the examined parent and child social behaviors. There were, however, indications of four such sequences in the baseline condition for Family Two and one sequence for Family One. Analyzing these findings through the lens of clinical significance, however, these transitions (although likely not chance occurrences) transpired with such a relative infrequency that they were highly unlikely to foster meaningful changes to generalized

social engagement patterns. Specifically, the total number of such social transitional sequences averaged about 2 per 10-min period, suggesting that long periods of time elapsed without a meaningful parent–child synchronous exchange.

In contrast, all social behavior sequences were found to occur at a rate exceeding chance in the social intervention condition. These data, paired with the increase in actual mean levels of transitional sequences, provide both statistical and clinical evidence for the utility of the intervention paradigm. Many of the examined sequences began to occur at a rate likely to be clinically meaningful (i.e. approximately 40 cumulative parent–child and child–parent sequences per 10-min period). Calculated effect sizes provide further indication that clinically relevant increases to social exchanges appeared to occur.

It is important to note that the social behaviors assessed in this investigation were not explicitly targeted in intervention, nor were parents informed of the social measures that would be collected. That is, eye contact and directed positive affect were not directly shaped, encouraged, or targeted through parent instruction. Rather, these social behaviors were observed to improve “naturally” as the motivation of the child increased.

Typically developing young children are not explicitly taught social relatedness skills. This skill acquisition is believed to occur as a natural accumulation of skills precipitated by finding inherent value in social exchanges (e.g., Dawson et al. 2005; Schultz 1998). By extension, it is logical that we should promote social initiations and responses in children with autism in a similar manner. It may be more difficult to encourage fundamental social referencing behaviors in children with autism through explicit instruction, shaping, and arbitrary reinforcement paradigms. Instead, identification of core motivating stimuli may be paramount to altering their underlying social profiles (Vernon et al. 2012). A child who is required to make eye contact in order to receive a desired incentive is using this social behavior only as a means to a nonsocial end, whereas a child who is making eye contact to convey true enjoyment to a parent is using this same act as their *primary objective*.

The participant children were also noted to become more active agents within their social environment. Namely, they did not remain passive responders to their parent’s interactive bids; rather, they exhibited increased agency with regards to being able to initiate a desired social exchange. Through the increased use of verbal and non-verbal initiation strategies, these children appear to be better equipped to influence the actions of others and obtain desired environmental outcomes in the future. There is existing evidence that supports the fundamental importance of self-initiations in children with autism (Buggey et al. 2011; Koegel et al. 1999, 2003; Shabani et al. 2002; Taylor

et al. 2005). This empowerment is crucial, given that learned helplessness responding often threatens the well-being of individuals with significant disabilities (Basil 1992; Koegel & Egel 1979).

It is important to also consider the social changes of the parent participants. The current investigation yielded evidence of a powerful parent-driven intervention effect with a high degree of social validity. Within the context of the embedded social intervention, parents were naturally inclined to direct positive affect towards their children, without being instructed or encouraged to do so. On a moment-by-moment basis, experiencing their child’s social responses appears to be the driving force behind parents’ own displays of positive affect. The parents’ relatively high degree of enjoyment directly reflect their emotional response to using motivating interventions to potentially alter their children’s social outcome. This is not a minor consideration, as parent empowerment appears to be an extremely powerful factor in treatment efficacy (Kaiser et al. 2000; Koegel et al. 1984). Parents are in a position to provide substantially more frequent, more consistent, and more individualized treatment than their clinician counterparts over the lifespan. Parents are present during hours that are not economically or logistically feasible for professionals. If they can be made to feel efficacious in their efforts, they are arguably the most influential change-agents in their children’s lives. Equipping parents with treatment strategies that are both highly effective and personally rewarding also appears to significantly reduce stress (e.g. Estes et al. 2014).

Strength-based approaches are a growing consideration in the field of autism (e.g. Cosden et al. 2006). Assessing for and utilizing child preferences is an explicitly recommended strength-based approach that has powerful implications for treatment. The strategy of incorporating a child’s interests and preferences into intervention has been increasingly common among empirically validated treatments (e.g., Koegel & Koegel 2006; McGee et al. 1999; Prizant et al. 2006; Rogers & Dawson 2010; Yoder & Warren 2002). In the current investigation, parents were encouraged to build upon these interests to specifically promote social engagement.

Children with autism are not devoid of engagement. Rather, they tend to engage with non-social, versus social, aspects of their environment (Klin et al. 2009; Shic et al. 2011; Shultz et al. 2011; Sasson et al. 2008). Thus, a promising avenue for forging a social connection with these individuals appears to be taking advantage of these pre-existing interests. Specifically, if one can identify the salient characteristics of their non-social interests and then embed identical traits into a reciprocal social activity, it appears possible to extend this pre-existing motivation into the social realm. This paradigm was the basis of the

experimental intervention model. This treatment has promising implications for immediate quality of life, as well as for long-term outcome. If children with autism are exposed to social activities that they find pleasurable, then they may be able to expand their collective sources of reinforcement beyond their initial, restricted set of preferred objects. Concurrently, if intervention improves attraction to social stimuli, rate of verbal initiations, and level of social engagement, these children seem to have acquired tools to extract key knowledge and information from their social environment. Increased access to sources of pleasure and attention to critical social information both have obvious implications for their overall quality of life. Namely, a child's ability to extract crucial information from his/her social environment may generalize beyond the designated treatment sessions (i.e. to everyday ecological settings), possibly creating permanent changes to social functioning.

While encouraging, the presented data only provides preliminary evidence to support the described social engagement paradigm. The small number of participants limits the generalizability of the reported findings, as the described paradigm may have varying levels of effectiveness on other children given the broad heterogeneity of autism. A randomized controlled trial is currently being conducted to provide additional understanding of the specific merits and limitations of this particular naturalistic developmental behavioral intervention.

In summary, this study aimed to reveal the effectiveness of targeting social motivation to create a promising interactive effect in both young children with autism and their parents. Increasing motivation may serve as an appropriate treatment target rather than directly teaching rote behaviors that only outwardly resemble their social counterparts, such as manually prompting a child to alternate eye gaze with a parent. The rapid rate of social skill acquisition appears to increase motivation for both parent and child to continue treatment. Increased parent motivation is likely to translate to increases in future embedded social-communicative learning opportunities, creating the positive feedback loop with the potential to alter their child's social developmental trajectory. The social success of children with autism may be influenced by building upon the foundation of their preexisting motivation to engage. Overall, this study assessed the implications of targeting social motivation within an interactive parent-child framework, which appears to be an especially promising avenue for improving the social trajectories of young children with autism.

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