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Examining mechanisms of parent mediated intervention with toddlers on the autism spectrum

By

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DISSERTATION

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DOCTOR OF PHILOSPHY

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DAVIS

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Abstract

Background: Parent participation in early intervention is a leading evidence-based practice in autism, but the strategies parents learn vary by intervention (Ingersoll, 2010; Oono et al., 2013). Two different evidence-based intervention approaches—structured behavioral interventions and naturalistic developmental behavioral interventions (NDBI)—are most frequently utilized. These approaches differ in the methods they emphasize in parent-delivery of the intervention. Both types of interventions rely on adapting adult-child interactions to increase access to learning opportunities for the child, but little attention has been paid to how parent behaviors vary as a function of intervention approach. To our knowledge, no studies have compared parent implementation of structured behavioral and NDBI interventions.

Methods: This study compares the parent-child interactions for 80 parent-child dyads with children with ASD. Parents received coaching in a structured behavioral intervention, Discrete Trial Training (DTT) and the manualized Parent Early Start Denver Model (ESDM) as part of a larger study in which children received intensive, therapist-implement treatment of either DTT or ESDM. Video recordings were collected monthly for 12 months of a toy play activity between the parent and child. We coded 287 videos from months 1, 4, 8, and 12 for: (1) parent sensitivity/responsivity; (2) the variety, frequency, and quality of learning opportunities provided and the use of motivational strategies; and (3) the child's dyadic engagement with the goal of understanding the effects of intervention training on the parent-child interaction.

Results: Parent sensitivity/responsivity started high and did not improve significantly over the intervention. Change in parent sensitivity/responsivity was associated with higher child engagement. Parents in both conditions improved equally in their delivery of all learning

opportunities strategies with motivational strategies most strongly predicting greater child engagement, even when controlling for sensitivity/responsivity.

Conclusions: Parent sensitivity/responsivity is an important component of child dyadic engagement to consider and to examine in initial assessments Focusing solely on parent sensitivity/responsivity as a primary mechanism for child engagement may not be sufficient. Focusing on parent teaching strategies inside learning opportunities, especially child motivation, has a positive impact on increasing child dyadic engagement. As researchers and community practitioners endeavor to support parents of children on the autism spectrum, these findings may help inform coaching programs.

Introduction

Parent–child interaction provides the foundation for a child's psychological development and parent sensitivity/responsivity clearly supports positive early parent-child interactions (Kivijärvi et al., 2001). Initially defined in 1978 by Ainsworth stemming from her attachment theory work with Bowlby (Ainsworth & Bowlby, 1991), sensitivity/responsivity refers to the parent's understanding of child needs and communications, and well-timed and appropriate responses to child cues (Ainsworth et al., 1978). Parents with sensitive responsiveness consistently and appropriately demonstrate a suitable level of control and conflict negotiation, helping children regulate negative states of arousal (Kemppinen et al., 2006; Shin et al., 2008). During sensitive/responsive interactions with their parents, neurotypical children learn that their efforts to attract their parents' attention result in positive emotion, comfort and protection. Over time, these positive dyadic exchanges increase the infant's sense of comfort and engagement while reducing distress (Kemppinen et al., 2006).

The parent-child interaction process is bi-directional, such that the parent's sensitive responses elicit positive child reactions, which inform the parent that their behavior is valued by the child (Kivijärvi et al., 2001). Parental sensitivity/responsivity is associated with numerous child social, emotional, and cognitive outcomes (Shin et al., 2008). For instance, higher ratings of parent sensitivity/responsivity are related to greater social skills (Landry et al., 2001), secure attachment (De Wolff & Van Ijzendoorn, 1997), more exploratory play behavior (Kivijärvi et al., 2001), positive mood (Kivijärvi et al., 2001), greater cognitive development (Landry et al., 2001), and better performance on measures of executive functioning (Pauli-Pott et al., 2018) and self-regulation (Sulik et al., 2015) in children. However, when parents consistently do not respond to their children's cues in a sensitive and responsive manner, or when parenting

behaviors are consistently directive and intrusive, parent-child interactions become associated with negative mood and behavior for the children (Kemppinen et al., 2006; Kivijärvi et al., 2001) and are linked to greater externalizing behaviors over time (Sulik et al., 2015).

Parental sensitivity/responsivity depends on dyadic exchanges between the parent and child wherein the child's behavior provides the parent first with a message and then with feedback and an opportunity for the parent to alter the exchange to make it meet the child's needs more effectively (Shin et al., 2008). In this way, a child's affective states, eye contact, social overtures and responses, and play behavior are significantly related to parental sensitivity, and they appear to develop in parallel (Kivijärvi et al., 2001). This feedback loop may be interrupted for dyads with a child on the autism spectrum[1] for whom emotional expressions might be more difficult for the parent to interpret due to features of the condition (van IJzendoorn et al., 2007). This difficulty interpreting and subsequently responding to child cues can lead to negative child (and parent) emotions and the emergence of disruptive behaviors, interrupting the parent-child interaction (Shin et al., 2008).

Autism is a heterogeneous neurodivergence characterized by differences in social-interaction and communication, and a propensity to engage in repetitive or stereotyped behaviors (American Psychiatric Association, 2013). Early social attention behaviors (e.g., social orienting, joint attention, social referencing) are of lower frequency and often slower to develop in children on the autism spectrum, which may disrupt the infant's access to social information from interactions with the parent, which in turn may alter cognitive and social development (Chevallier et al., 2012; Dawson et al., 2004; Mundy, 1995). Parents are generally more

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[1] This paper uses "on the autism spectrum" instead of identity-first language due to the preferences of many parents of very young children. Along those lines, the paper uses the term "autism" in lieu of "autism spectrum disorder" in order to avoid the ableist term "disorder" (Bottema-Beutel et al., 2020).

responsive to children who display greater social communication skills such as eye contact, communicative gestures, and vocalization (Kinard et al., 2017), behaviors that are frequently delayed or different in autism. Van IJzendoorn et al. (2007) found that parent sensitivity did not differ across parents of children on the autism spectrum or with intellectual disability (ID) or neurotypical development, but the rate of child involvement in free play sessions did significantly differ. Children on the autism spectrum (and those with ID) were less involved with their parents during the observation. Additionally, for children not on the autism spectrum, parent sensitivity was significantly associated with attachment security scores, but this was not the case for children on the autism spectrum. More recently, a meta-analysis found that maternal sensitivity may operate differently in autism such that maternal sensitivity may have a larger role in the development of attachment security for children on the autism spectrum (Cossette-Côté et al., 2021). These findings indicate that typical interpretations of parent behavior may not properly account for the manner in which the social-communication differences prevalent in autism can alter the parent-child dynamic.

Typical successful parent approach and response behaviors might not be effective for engaging children on the autism spectrum. For instance, Kasari and colleagues (1988) found that parents of children on the autism spectrum tended to work harder to keep children on task, but that parents modulated their behavior based on child characteristics and that overall, parents of children on the autism spectrum do not differ from parents of neurotypical children in most interactional behaviors with their children. These findings illustrate parent sensitivity to their child's play and joint attention levels, with parents adjusting their instructions and support accordingly. Another study found that children on the autism spectrum were less responsive (e.g., more likely to ignore or turn away) to maternal overtures than neurotypical children,

suggesting that mothers needed additional strategies to engage their children on the autism spectrum, needing to adapt their behavior more than mothers of neurotypical children (Doussard-Roosevelt et al., 2003). Indeed, mothers of children on the autism spectrum in this study elicited child responses more effectively when utilizing higher intensity overtures (e.g., more physical manipulation). This is in contrast to studies with neurotypical children that find that greater parental intrusiveness relates to problem behaviors in children (Kemppinen et al., 2006). These findings highlight the importance of teaching parents specific strategies that aim to increase their sensitive responding in a way that matches the specific needs of their children on the autism spectrum—specifically, strategies to support improvements in child attention and regulation to promote learning through these dyadic interactions. Research examining intervention efforts to improve child learning finds that increasing strategies that support sensitive and responsive parent behaviors—including intervention components that require sensitive responding on the parent's part such as mirrored pacing and following a child's lead—accompanied by strategies that teach new skills (e.g., reinforcement) can ameliorate learning deficits, citing improvements in child language outcomes and joint engagement for children on the autism spectrum (Gulsrud et al., 2016; Mirenda et al., 2022; Siller et al., 2013; Whitehouse et al., 2021).

Parents of children on the autism spectrum may need additional support to establish the kind of affectively rich, engaging interactions observed in neurotypical parent-child dyads. Because child cues are often difficult to interpret and patterns of behavior can be challenging to manage or interrupt, parents of children on the autism spectrum may require a set of autism-specific engagement strategies to help them build sensitive and responsive dyadic interactions that work for their own children. Numerous agencies recommend the inclusion of family members, particularly parents, in early intervention programs (Copple, Bredekamp, & National

Association for the Education of Young Children., 2009; Division for Early Childhood of the Council for Exceptional Children, Sandall et al., 2006; National Research Council, 2001). Along these lines, interventions for young children on the autism spectrum are increasingly integrating parent-mediated treatment as an intervention delivery mechanism (e.g., Green et al., 2010; Kasari et al., 2010; Mirenda et al., 2022; Rogers et al., 2019; Rogers et al., 2012; Shire et al., 2021; Stadnick et al., 2015; Wetherby et al., 2014).

Parent training and coaching confers benefits on both parents and children. For the child, parent-mediated intervention increases the intervention dosage and allows for greater generalization of skills across situations, contexts, and domains; for parents, coaching in these strategies can lead to greater confidence and reduced stress (McConachie & Diggle, 2007). The feasibility of parent-mediated interventions is well established in the intervention literature, with parents demonstrating skill gains and reporting satisfaction with training (Beaudoin et al., 2014; Rojas-Torres et al., 2020). Publications reporting outcomes of parent-mediated intervention have increased steadily over the last fifteen years, with results indicating changes in children's specific autistic characteristics and small improvements in social communication, language, and cognitive functioning (Nevill et al., 2018). However, these improvements are smaller than those found in studies examining outcomes of therapist-implemented intervention, indicating a need to improve parent training practices (Nahmias & Mandell, 2014).

It is critical to consider the need for individualization of parent-mediated interventions to fit within different family contexts and parenting approaches (Ingersoll, 2010; Oono et al., 2013). While early intervention approaches for children on the autism spectrum aim to improve social, communication, cognitive, and behavioral skills to enable children to develop meaningful relationships and to learn from their environment and interactions (Lovaas & Smith, 2003;

Ozonoff & Rogers, 2003), there are differences in the underlying philosophies informing the various approaches. This influences the strategies these interventions employ, and whether or not they explicitly incorporate strategies that may improve parent delivery of sensitive responses in a manner that matches the child's individual preferences. Examining differences in parents' implementation of different treatment approaches is an essential next step in our understanding the role of sensitivity/responsivity in parent-mediated intervention for children on the autism spectrum.

The earliest behavioral treatments for children on the autism spectrum relied upon highly structured strategies, typically administered by trained research staff in highly controlled environments. Early behavioral interventions were usually adult-directed and focused on teaching specific skills by manipulating antecedent (i.e., cues) and consequence strategies (i.e., reinforcement and punishment paradigms; Ingersoll, 2010). In 1987, Ivar Lovaas published his results examining the effects of a behavior modification treatment, now known as Discrete Trial Training (DTT). DTT systematically breaks skills into discrete tasks which are taught using the learning principles of Applied Behavioral Analysis (ABA). Each skill is targeted individually in mass trials, and successful attempts are rewarded with tangible reinforcers. Although DTT uses social rewards paired with tangible reinforcement, limited attention is paid to sensitivity/responsivity during adult-child interaction in the intervention, focusing instead on the teaching strategies employed. Over time, the scope of the skills taught using DTT has expanded to include a more comprehensive curriculum (Leaf & McEachin, 1999; Lovaas & Smith, 2003).

In contrast, early developmentally-based interventions focused on training parents to promote affectively rich, sensitive and responsive caregiver interactions to target social-communication skills (Ingersoll, 2010). Developmental interventions are informed by numerous

developmental theories, such as the constructivist approach to learning. Constructivism emphasizes learning through experiences and the active role of the learner to construct their own knowledge (Narayan et al., 2013). In line with this, developmental interventions typically prioritize child-directed activities and often encourage parents to refrain from didactic instruction to allow the child to learn from the interaction, with the parent modeling skills that are developmentally appropriate for the child (e.g., Mahoney & Powell, 1988). Traditional developmental models focus on the relationship and facilitative strategies that increase parents' sensitive responding to their children and tend to limit the focus on explicitly teaching specific skills through direct prompting (Ingersoll, 2010). So, while child learning is an important goal of developmental interventions, specific teaching strategies are not the emphasis of parent coaching.

Over time, intervention developers have combined strategies based on the principles of ABA with developmental science to provide child-directed and naturalistic learning opportunities in the context of an affectively rich interaction. These interventions are called naturalistic developmental behavioral interventions (NDBIs; Schreibman et al., 2015). The Early Start Denver Model (ESDM) is one such NDBI that prioritizes creating momentum for child learning by optimizing child motivation in child-directed joint engagement activities with an adult (Rogers & Dawson, 2010).

Both traditional behavioral and NDBI approaches integrate parents into the child's therapy but differ in their conceptual frameworks and execution. Highly structured behavioral interventions typically focus on parents' ability to increase generalization of skills across contexts through training in positive behavioral support strategies to address behavioral concerns such as eloping, tantrums, and self-injurious behavior (Ingersoll, 2010). Parents do not often

learn standard discrete trial intervention strategies, but rather strategies to address these

behavioral concerns, which may include alternative forms of communication and increasing

opportunities for the child to respond to parent instructions throughout the day. NDBIs utilize

developmental knowledge (e.g., developmental trajectories and zones of proximal development)

and strategies (e.g., constructivist learning and sensitive responding) to provide a context aimed

to enhance the use of ABA teaching strategies by increasing child attention to and motivation in

the activity, thereby increasing child learning (e.g., Green et al., 2010; Ingersoll & Dvortcsak,

2010; Kasari et al., 2015; Rogers & Dawson, 2010). In NDBI models, parents generally learn a

parent-friendly version of the strategies utilized by the therapists which includes specific

strategies focused on increasing child motivation. Motivational strategies may include

identifying preferred objects and activities and setting activities up in a way that increases dyadic

engagement between the parent and the child. To our knowledge, no studies have compared

parent implementation of traditional behavioral and NDBI interventions, as studies examining

different interventions have typically compared a specific intervention to treatment as usual or

general parent education (Nevill et al., 2018; Rojas-Torres et al., 2020).

Issues with measurement and methodology have impeded greater interpretations of parent

training outcomes (Nevill et al., 2018). Parent training studies have primarily focused on

reporting *trainer* fidelity to the intervention, failing to report on *parent* fidelity to the

intervention (Oono et al., 2013). For studies that do examine parent fidelity, results are most

often reported as percentage of correct implementation or a mastery criteria, but lack an

examination of parents' usage of specific intervention components such as following the child's

lead, affective matching, and scaffolding (which may be linked to parental

sensitivity/responsivity) or the specific number of learning opportunities provided (e.g., Kasari et

al., 2010, 2015; Rogers et al., 2019, Rogers et al., 2014; Rogers et al., 2012; Vismara et al., 2009). Furthermore, the majority of parent-mediated intervention studies do not report on proximal outcomes related to parent-child interaction, making it difficult to identify the proposed mechanism of change (Beaudoin et al., 2014). More typically, studies will link change in sensitive/responsive parenting behaviors to distal child communication and autism outcomes on standardized measures (Weitlauf et al., 2014). Those that do examine different facets of fidelity report mixed results (Beaudoin et al., 2014). For example, a study examining parent implementation of the Joint Attention, Symbolic Play, Engagement, and Regulation (JASPER) intervention model found that "environmental arrangement" and "mirrored pacing" were related to joint engagement in the parent-child interaction (Gulsrud et al., 2016). Another study found that parents' fidelity to the "makes play interactive" and "helps increase complexity of initiations" components of Project ImPACT (Improving Parents As Communication Teachers) predicted children's spontaneous language in the same parent-child interactions (Ingersoll & Wainer, 2013). These studies examined different proximal child outcomes and different intervention components, making it difficult to compare findings across interventions. A recent review of the effectiveness of intervention programs for children on the autism spectrum based on parent participation examined fifteen different programs and found a lack of common methodology to evaluate results (Rojas-Torres et al., 2020).

Measuring active ingredients across models rather than fidelity of a particular intervention may lead to a greater understanding of how best to support parents and how best to maximize child learning from parent-child interactions. The lack of consistency in measures of in-session child outcomes stymies efforts to understand the effects of changes in parent behavior on child behavior. Greater understanding of the effects of intervention training on the parent-

child interaction—in terms of the combined effects of change in parent behaviors (i.e., sensitivity/responsivity and the number of learning opportunities presented) and child behaviors (i.e., engagement with the parent; use of new skills during the interaction)—is essential to elucidate potential mechanisms of change for downstream child outcomes.

Interpretations of parent adherence are confounded by the fact that parent-mediated interventions are designed to be used throughout typical daily parent-child interactions, making them easier for parents to implement but more difficult to measure the actual dosage (Oono et al., 2013). Learning opportunities—opportunities for children to demonstrate a skill, new or practiced—have been proposed as a meaningful measure of treatment intensity for autism interventions (Warren et al., 2007). Learning opportunities are often the focus of structured behavioral interventions, which typically incorporate an emphasis on quality of antecedent and consequence delivery and frequent opportunities to respond directly in the intervention models. NDBIs also highlight the delivery of learning opportunities using ABA strategies but focus more on their delivery within the context of affectively rich dyadic interactions. Learning opportunities have rarely been examined in intervention studies, and only once in a parent-mediated intervention (Davlantis et al., 2019). Measurement of the learning opportunities provided in observations of parent-child interactions could shed light on the intervention dosage children are receiving as a result of parent training in various intervention strategies.

Developmental science has had a large contribution to the development of NDBIs, informing learning targets and contexts as well as relational strategies employed. Embedding ABA teaching strategies in the context of developmentally appropriate, affectively rich interactions with strategies that increase parental sensitivity/responsivity may support children's learning from their environment beyond the intervention session. In fact, in a recent study

examining the feasibility of implementing a modified parent coaching model of ESDM in the community, Mirenda and colleagues found that change in parent scaffolding and following behaviors (facilitative behaviors that indicate sensitive responding) predicted change on child measures of joint engagement (2022). Interventions such as ESDM that specifically include developmental strategies maybe more likely to increase sensitivity/responsivity in parents than traditional behavioral interventions that focus on the teaching strategies rooted in ABA alone such as DTT.

Both sensitivity/responsivity and learning opportunities can be compared across interventions to understand commonalities and differences amongst approaches, providing another measure of fit for parents and potential mechanisms of action. Specific approaches to parent training content may differentially lead to changes in sensitivity/responsivity and/or learning opportunities. One way to understand the key mechanisms of change in parents—and the relationship to change in child behavior—is to carefully examine specific outcomes of parents receiving different content in parent training, such as the content of traditional behavioral interventions compared to the content emphasized by NDBIs.

Specific Aims and Hypotheses

Study 1: Examining Parental Sensitivity/Responsivity

Aim 1: Examine the role of parent coaching style in facilitating change in sensitive/responsive interactions.

Hypothesis: Parents who receive ESDM training will demonstrate more change in sensitive and responsive parenting behaviors over time.

Study 2: Examining Parental Delivery of Learning Opportunities

Aim 1: Determine if there are differences in the *frequency*, *variety*, and *quality* of learning opportunities and increased successful use of *motivational strategies* in the provision of learning opportunities based on parent training method.

Hypotheses: Parents in the ESDM condition will show greater variety and frequency of learning opportunities over the course of coaching. Parents in the DTT condition will provide higher quality learning opportunities over time. Motivational strategies will improve more in the ESDM condition.

Study 3: Examining the Association Between Parental Behaviors and Child Engagement

Aim 1: Explore the relationship between parent sensitivity/responsivity and child dyadic engagement.

Hypothesis: Greater change in parent sensitivity/responsivity over time will be related to greater child engagement during play interactions.

Aim 2: Examine the relationship between learning opportunities and child dyadic engagement.

Hypothesis: Variety, quality, and frequency of learning opportunities provided, and increased use of motivational strategies will each be independently related to child engagement.

Aim 3: Explore the interaction between sensitive/responsive parenting, learning opportunities, and child dyadic engagement.

Hypothesis: Parent sensitivity/responsivity will moderate the relationship between learning opportunities and child engagement.

General Methods

The following three studies utilize data from a large, multisite, randomized control trial comparing the efficacy of two interventions for children on the autism spectrum—ESDM and DTT (Rogers et al., 2021). Participants in the larger study included children between the ages of

12 and 30 months at study entry with a clinical diagnosis of autism spectrum disorder and their primary caregivers. Children were randomly assigned to receive either ESDM or DTT delivered in-home by trained research staff for twelve months. Their parents received the corresponding parent coaching.

Participating parents received roughly three hours monthly of parent coaching delivered by a master's level clinician for the duration of the study (12 months). Parents in the ESDM condition received training and coaching in a manualized parent ESDM intervention (P-ESDM; Rogers et al., 2012), while parents in the DTT condition received coaching focused on addressing parent concerns regarding child development and behavior management strategies. In both groups, parents received reading material, discussed their child's treatment goals, had access to data collection strategies, and received coaching in use of intervention strategies. Parents in the DTT condition typically spent time addressing behavioral concerns which may have included practice with coaching, but often included discussion of strategies and data review.

Sample Characteristics

A skilled clinician conducted child assessments, which included demographics, standardized assessments, and parent report measures, prior to randomization. A total of 80 caregiver-child dyads were included in the analysis of this study. Forty-one children participated in the DTT group and 39 in the ESDM group. Children were, on average, white (55%), males (75%), and the average age at study entry was 23.28 months. Child age ($p = 0.18$) and race ($p = 0.85$) and ethnicity ($p = 0.39$) did not differ significantly across the groups. The majority of participating caregivers were mothers who had completed some college or college education

(57.50%) and maternal education level did not differ across groups (p = 0.53). See Table 1for

additional sample demographic information.

Table 1

Sample Demographic Information

	N	%
Child Race		
White	44	55.00%
Black/AFAM	4	5.00%
Asian	8	10.00%
Native Hawaiian or Other Pacific Islander	1	1.25%
American Indian/Alaskan Native	1	1.25%
Unknown	2	2.50%
More Than 1 Race	20	25.00%
Child Ethnicity		
Hispanic/Latino	17	21.25%
Non-Hispanic/Latino	59	73.75%
Unknown	4	5.00%
Child Gender		
Male	60	75.00%
Female	20	25.00%
Maternal Education		
Some high school/below	1	1.25%
High school diploma/GED	5	6.25%
Some college	23	28.75%
College degree (A.A., B.A., B.S.)	23	28.75%
Some graduate school	6	7.50%
Graduate school degree (Master's or above)	20	25.00%
Unknown	2	1.25%

Characterization Measures

See Table 2 for comparison of sample characterization measures across coaching

conditions.

Cognitive Functioning. Children were assessed at study entry using the *Mullen Scales of*

Early Learning: AGS Edition (MSEL; Mullen, 1995). The MSEL is designed for children from

birth to 68 months of age. T-scores, percentile ranks, and age equivalents can be computed for five scales separately (Gross Motor, Visual Reception, Fine Motor, Expressive Language, and Receptive Language). The Early Learning Composite (ELC; M=100, SD=15) can be used as an indicator of cognitive functioning. For this sample, the mean group composite score was 65.09 (SD = 18.41) at intake. Construct, concurrent, and criterion validity are all verified by independent studies and the technical manual for the MSEL (Mullen, 1995). ELC scores did not differ significantly at baseline across groups (p = 0.9).

Table 2

Sample Descriptive Statistics

Measure	Overall	DTT (N = 41)	ESDM (N = 39)	F	p-value
	M(SD)	*M(SD)*	*M(SD)*		
ADOS-2 Score	8.13 (1.76)	8.32 (1.57)	7.92 (1.94)	5.16	0.64
Mullen Composite IQ	65.09 (18.41)	65.34 (17.62)	64.82 (21.42)	0.02	0.9
Mullen Non-Verbal IQ	79.46 (16.06)	80.02 (16.18)	78.87(16.12)	0.10	0.751
Mullen Verbal IQ	50.79 (23.97)	50.78 (22.83)	50.79 (25.42)	0	0.998

Note. ADOS-2 severity score is a chi-square not F statistic as it is a categorical variable.

Autistic Features. Child autism symptoms were evaluated at study entry with the *Autism Diagnostic Observation Schedule-Second Edition* (ADOS-2; Lord et al., 2012)*,* a standardized protocol for observation of the core symptoms associated with autism. The ADOS-2 has high reliability and discriminant validity (Lord et al., 2012). The ADOS-2 largely operationalizes the process of informing the diagnosis of autism. Analyses include the autism severity score (range 1-10, where 10 is most severe). For this sample, the average intake score was an 8 (SD = 1.76). These scores can be used for comparison across age ranges (i.e., modules), in addition to

indicating autism severity (Gotham et al., 2009; Lord et al., 2012). The autism severity score did not differ significantly across groups (p = 0.64).

Observational Data

As part of the study, parents used wearable video cameras (Looxcie glasses) once per month to film themselves at home, completing three activities (toy play, social routine without objects, and a daily living routine) with their children. Each activity was to last for at least five minutes, and the data collection for each month was to total at least 45 minutes. On average, each activity lasted for 6:27 minutes. If parents failed to record using the Looxcie glasses during a given month, a research staff member would record the parent-child dyad's activities for the month. Toy play activities were selected for coding for the current project in order to provide the most comparable observations across dyads. In order to ensure adequate parent child interaction to code all behaviors of interest, and to meet the requirements of chosen coding schemes (see below), videos lasting at least five minutes from months 1, 4, 8, and 12 (or as close to as data permitted) were selected to understand the trajectory of change in parent-child interactions over the course of the intervention. For videos longer than five minutes, the first five minutes of each video were coded. A total of 287 videos from 80 different parent-child dyads were selected for inclusion in this study; 75% (N = 60) of the sample had all four observations. For the remaining parent child-dyads, 12.5% (N = 10) had three observations, 8.75% (N = 7) had two observations, and 3.75% (N = 3) had just one observation. Seven children from the parent study were excluded from these analyses because they did not have any toy play activities that lasted at least 5 minutes.

Each of the 287 videos were behaviorally coded using three different coding schemes to assess parent sensitivity/responsivity, provision of learning opportunities, and child joint engagement.

Approach to Data Analysis

All analyses were conducted in R under the guidance of a statistician funded by the MIND Institute Intellectual and Developmental Disabilities Research Center (P50HD103526). Data sets were first tested for assumptions of normality. Child baseline MSEL and ADOS scores as well as maternal education level were included in all initial models to ensure that there were no significant covariates, and none were significant, so they were not included in final models. Site was included as a main effect in the final models reported to account for differences found in the original study (Rogers et al., 2021). Time was measured as a continuous variable from treatment start date to account for any differences in video collection timing.

<center>**Study 1: Examining Parental Sensitivity/Responsivity**</center>

Aim 1: Examine the role of parent coaching style in facilitating change in sensitive/responsive interactions.

Given the influence of developmental models' attention to parent sensitivity/responsivity in NDBI models, we hypothesized that parents in the ESDM (an NDBI) condition would exhibit greater change in sensitivity and responsivity during interactions with their children than parents in the DTT (a structured behavioral intervention) condition.

The Parenting Interactions with Children: Checklist of Observations Linked to Outcomes (PICCOLO; Roggman et al., 2009) was used to measure parent sensitivity/responsivity in the 287 parent-child interactions. The PICCOLO is a checklist of 29 observable developmentally supportive parenting behaviors with children ages 10–47 months in

four domains: *Affection* (items related to the parents warmth and physical interaction with the child); *Responsiveness* (items such as parent attention to child, whether the parent follows the child's interest, and how they respond to the child); *Encouragement* (whether the parent uses pauses to give the child time to process and respond and how they verbally respond to child attempts); *Teaching* (parent labeling, questions, and how they respond to child questions). The four domains combine to provide one overall PICCOLO score. The 29 items are scored on a 0-2 Likert scale with 0 indicating that a behavior is absent and 2 indicating a behavior is clearly present in the observation. One score per item is assigned to the entire five-minute observation. See *Appendix A* for complete PICCOLO scoring criteria. The PICCOLO has good internal consistency for all domains (alpha coefficients range .75 to .80), as well as good construct validity (Roggman et al., 2013). A total PICCOLO scores summed across the four domains range from 0-58 and is the main unit of analysis for this measure. Given the nature of the recordings, with parents most frequently wearing the Looxcie video glasses on their face, one item (A2: Smiles at child) was dropped from the analysis, resulting in an adapted range of 0-56 for this study.

PICCOLO Coding

Seven undergraduate student research assistants, naive to condition and time variables, and the lead author coded the 287 video observations. Coders were trained using the PICCOLO manual training videos. During training, coders met weekly with the lead author to review video keys. Coders were considered reliable and ready for independent coding when they achieved 80% agreement with the key on two videos in a row *and* averaged 80% agreement on all coded videos across the four sub-scales. Thirty percent of each coder's videos (N = 109) were double coded to ensure that coders did not drift over time. The average inter-rater agreement was

86.68%. Seventeen videos fell below 80%. These videos were triple coded, and assessments of the disagreement were made to ensure that drift was not an issue. Coders demonstrated a high degree of reliability. The intraclass correlation (ICC) between coders was 0.878 with a 95% confidence interval from 0.824 to 0.916 ($F(101,102) = 15.3$, $p<0.0001$).

Analyses

The primary outcome for this study was the overall PICCOLO score, a measure of parent sensitivity/responsivity, for each parent at each of the four time points. The main independent variable of interest was condition (ESDM or DTT). Due to the use of repeated assessments over time within an individual, repeated measures, random effects models were used to model change over time in parent sensitivity/responsivity. These models allow for assessment of differences in the level (at the first assessment) as well as differences in the rate of change between conditions. These models can handle a different number of observations per person (in the case of drop-out or missed visits) and differences in timing between assessments. They can further include random intercepts and slopes to account for between-person variability in overall level or change over time not explained by other factors, such as condition. Initial models included condition, time since the first assessment, and the interaction between the two; if interactions were not significant, we focused on the main effects model.

Due to the quality of recording on 13 (4.53%) video observations, coders were unable to assign a score for one item on the PICCOLO (R6: Looks at child when child talks or makes sound). In order to keep as much data as possible, overall PICCOLO and *Responsiveness* scores were calculated using multiple imputation (using the Multivariate Imputation by Chained Equations package in R) for those missing observations. For the imputed dataset, we conducted a

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sensitivity analysis, running the models without imputation and results were comparable with the non-imputed dataset.

Results

Our hypothesis that caregivers in the ESDM condition would demonstrate greater sensitive and responsive parenting behaviors after coaching was not supported. As shown in Figure 1, there was no significant change in overall PICCOLO score over time ($\beta = 1.22$, SE = 0.89, p=0.17). Overall, parents were scoring relatively high on the PICCOLO (range 6-56) at baseline (M = 42.41, SD = 7.55) and the average overall PICCOLO score across all time points was 43.66 (SD = 6.34). For children between the ages of 14-49 months, a score of 47 is considered "above average." See Table 3 for average PICCOLO scores across domains and timepoints for the sample.

Figure 1

PICCOLO Change Over Time
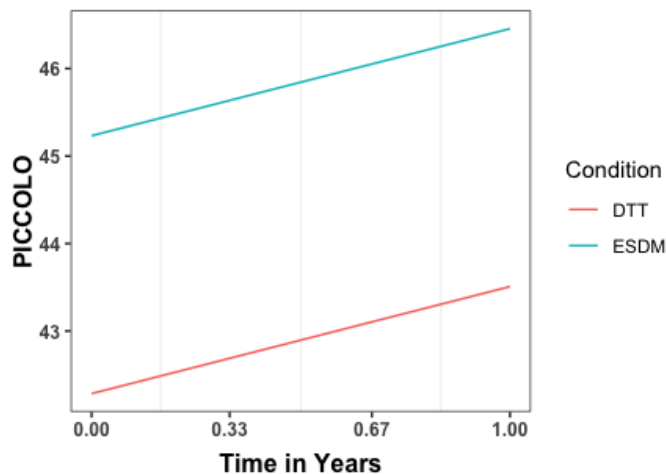
Note. Average change in overall *Note.* Average change in overall PICCOLO score over one

There were significant differences at baseline by condition, with the ESDM group

averaging about 3 points higher at baseline than the DTT group (ß = 2.95, SE = 1.00, p=0.004);

however, this did not result in a different rate of change over time between groups. Additionally,

Table 3

Average PICCOLO Scores Across Timepoints

| PICCOLO Overall				
	T1	T2	T3	T4
DTT	40.46 (1.80)	42.41 (1.75)	43.35 (1.91)	43.24 (1.97)
ESDM	44.03 (1.79)	45.74 (1.57)	45.46 (1.77)	46.03 (1.96)
Affection				
	T1	T2	T3	T4
DTT	9.28 (2.32)	10.20 (1.59)	10.09 (1.48)	9.76 (1.46)
ESDM	9.89 (1.20)	10.25 (1.27)	10.23 (1.00)	9.97 (1.09)
Responsiveness				
	T1	T2	T3	T4
DTT	12.23 (2.44)	12.76 (1.94)	12.74 (1.78)	12.66 (2.02)
ESDM	13.24 (1.21)	13.34 (1.19)	13.34 (1.06)	13.45 (0.99)
Encouragement				
	T1	T2	T3	T4
DTT	11.72 (2.78)	12.08 (2.52)	12.51 (1.93)	12.12 (1.98)
ESDM	12.49 (1.56)	12.78 (1.31)	12.71 (1.41)	12.56 (1.44)
Teaching				
	T1	T2	T3	T4
DTT	7.03 (2.84)	7.80 (3.14)	8.09 (2.44)	8.00 (2.63)
ESDM	8.41 (2.69)	9.14 (2.47)	9.17 (2.24)	9.97 (2.16)

one site started with significantly lower scores (ß = -2.71, SE = 1.25, p=0.03). This study was not

powered to examine site differences, so site was controlled for in all subsequent models, but was

not examined further. See Table B1 for full model estimates.

We conducted a follow-up exploratory analysis on the different PICCOLO domains to

see if there was any change on the *Affection*, *Responsiveness*, *Encouragement*, or *Teaching*

scales and found a significant main effect for time on *Teaching* (ß = 1.42, SE = 0.40, p = 0.01),

indicating that caregivers improved their delivery of sensitive and responsive teaching strategies

over the course of parent coaching, as shown in see Figure 2 (see Table B2 for complete model estimates). No other domains demonstrated significant change over time. The range for *Affection* is 0-12, *Responsiveness 0-14*, *Encouragement 0-14*, and *Teaching* 0-16. As shown in Table 3,

Figure 2

Teaching Change Over Time
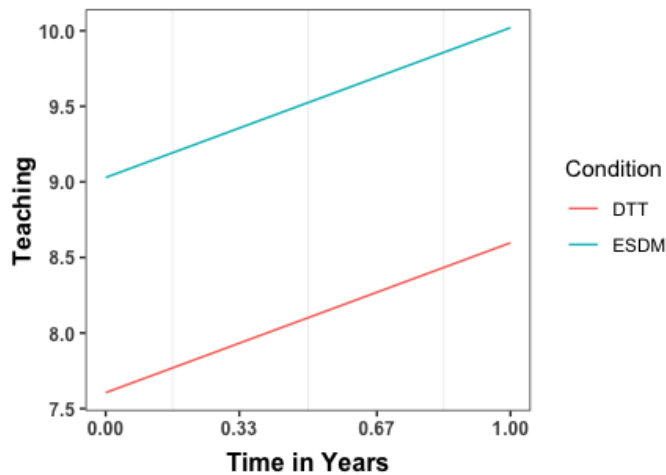
Note. Average change in Teaching domain over one year of parent coaching by condition. average baseline *Teaching* scores were the lowest across all four domains and parents on the other domains fell within 2 or 3 points of the ceiling, indicating areas of parenting strength prior to coaching.

Study 2: Examining Parental Delivery of Learning Opportunities

Aim 1: Determine if there are differences in the *frequency*, *variety*, and *quality* of learning opportunities and whether *motivational strategies* are utilized in the provision of learning opportunities based on parent coaching condition.

Due to the emphasis in ESDM on delivering learning opportunities within affectively rich parenting interactions, we reasoned that parents in the ESDM condition would offer a wider *variety* of opportunities to respond to their children. ESDM also recommends providing an

opportunity for the child to respond every 30 seconds, which we hypothesized would result in a higher *frequency* of learning opportunities. Without the emphasis on the relational strategies, we suspected that parents in the DTT condition will have received greater training on antecedent and consequence strategies than parents in the ESDM condition, resulting in overall higher *quality* of learning opportunities provided. Since ESDM focuses on increasing child motivation to interact with parents, we hypothesized a greater change in *motivational strategy* usage in the ESDM condition due to

A novel coding scheme adapted from Davlantis et al. (2019) was used to code parent provision of learning opportunities. The 287 videos were coded for the *frequency* (i.e., the number of opportunities provided), *variety* (i.e., the type of behavior targeted), and *quality* of the learning opportunities provided. A high-quality learning opportunity is one in which the parent provides clear antecedents, the consequences are related to the child's behavior, and there is a good balance of praise to correction. The use of *motivational strategies* (i.e., environmental arrangement and incorporation of motivating materials) was also coded. All codes were rated on a 1-5 Likert scale with higher scores indicating better implementation of the strategy. See *Appendix C* for complete scoring criteria. Ratings on each code were used in the analyses.

Learning Opportunities Coding

Seven undergraduate student research assistants, naive to condition and time variables, and the lead author coded the 287 video observations. Coders were trained in the principles of ABA and learned about autism and parent implemented intervention before coding training began. During training, coders met weekly with the lead author to review video keys. Coders were considered reliable on a video if their score was within one point on each of the four items (considered 100% agreement). To be considered reliable and ready for independent coding,

coders had to be reliable on four out of five videos in a row *and* average 80% agreement on all coded videos. Thirty percent of each coder's videos (N = 84) were double coded to ensure that coders did not drift over time. The average inter-rater agreement was 93%. Five videos fell below 80%. These videos were triple coded, and assessments of the disagreement were made to ensure that drift was not an issue. Coders demonstrated a good degree of reliability on all four learning opportunities measures. The ICC between coders for *frequency* was 0.795 with a 95% confidence interval from 0.702 to 0.862 ($F(83,84) = 8.78$, $p < 0.0001$) and for *quality* was 0.824 with a 95% confidence interval from 0.741 to 0.882 ($F(83,84) = 10.4$, $p < 0.0001$), and for *motivational strategies* was 0.688 with a 95% confidence interval from 0.557 to 0.786 ($F(83,84) = 5.42$, $p < 0.0001$).

Analyses

Primary outcomes include the *frequency*, *variety*, and *quality* of learning opportunities as well as the use of *motivational strategies* during learning opportunity delivery for each of the four time points. The primary independent variable of interest is condition. Analyses were similar to those described above for the Study 1, with primary interest in assessing differences in level and change in the outcomes between the two conditions on each of the learning opportunities ratings.

Results

Parents' delivery of learning opportunities improved on all indicators regardless of coaching condition. Table 4 displays the average learning opportunity scores across factors and timepoints for the sample. There was a significant main effect of time for *frequency* ($ß = 0.47$, $SE = 0.18$, $p = 0.007$), *variety* ($ß = 0.35$, $SE = 0.18$, $p < 0.05$), *quality* ($ß = 0.46$, $SE = 0.18$, $p = 0.01$), and *motivational strategies* ($ß = 0.71$, $SE = 0.17$, $p = 0.0001$). These findings, illustrated in

Figures 3-6, indicate that over the course of parent coaching, independent of coaching condition, parents improved on all indicators of learning opportunities. There were significant differences at baseline by condition for *variety*, with the ESDM group averaging less than half a point higher at baseline than the DTT group ($\beta = 0.37$, SE = 0.16, p=0.02); however, this did not result in a different rate of change over time between groups. See Tables B3-B6 for full model estimates.

Table 4

Average Learning Opportunities Scores Across Timepoints

Frequency			
	T1	T2	T3	T4
DTT	3.10 (1.19)	3.38 (1.15)	3.69 (1.13)	3.76 (1.17)
ESDM	3.43 (1.07)	3.53 (0.81)	3.74 (0.95)	3.75 (0.98)
Variety				
	T1	T2	T3	T4
DTT	2.97 (1.11)	3.08 (1.05)	3.46 (1.20)	3.48 (1.18)
ESDM	3.41 (1.21)	3.53 (0.94)	3.83 (1.04)	3.72 (1.05)
Quality				
	T1	T2	T3	T4
DTT	2.79 (1.13)	3.28 (1.04)	3.43 (1.12)	3.55 (1.12)
ESDM	3.14 (1.08)	3.31 (0.75)	3.37 (1.09)	3.56 (0.95)
Motivational Strategies				
	T1	T2	T3	T4
DTT	3.05 (0.94)	3.45 (1.15)	3.57 (1.12)	3.85 (1.18)
ESDM	3.05 (1.18)	3.5 (1.00)	3.66 (0.97)	3.72 (0.99)

This is one of few studies to examine delivery of learning opportunities in intervention for children on the autism spectrum and one of the first studies to examine the strategies used in parent delivery of learning opportunities. We focused not only on frequency (see Davlantis et al., 2019) but also on the variety and quality of learning opportunities, in addition to parents' use of motivational strategies, allowing us to compare use of these specific strategies across intervention type. While parents showed significant improvement in the strategies we measured
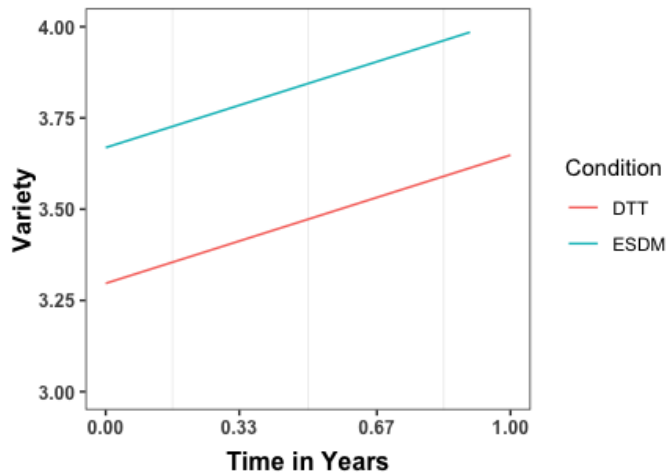
Figure 3

Frequency Change Over Time
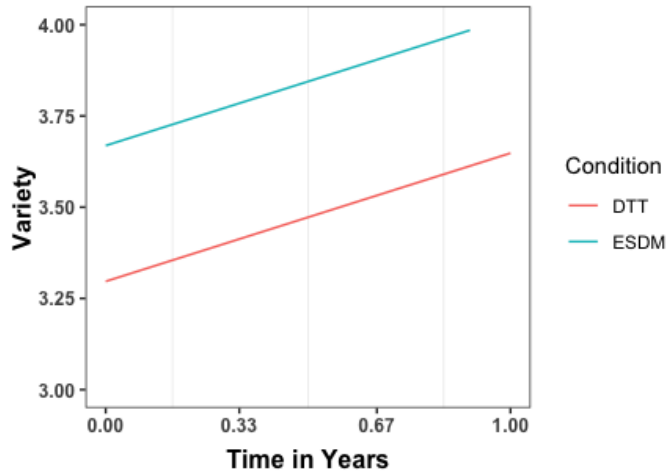
Note. Average change in frequency score over one year of parent coaching by condition.

Figure 4

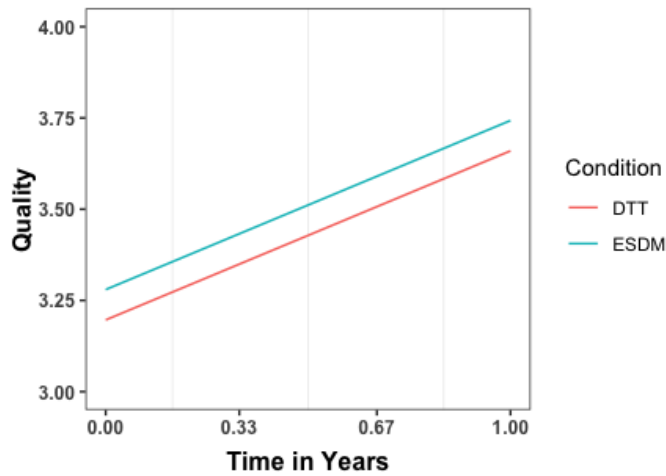*Variety Change Over Time*

Note. Average change in variety score over one year of parent coaching by condition.

over time, our hypothesis that parent coaching method (the NDBI ESDM vs. the structured

behavioral intervention DTT) would result in differences in parent implementation of learning

opportunities did not bear out. We did not detect a significant interaction between condition and

Figure 5

Quality Change Over Time

Note. Average change in quality score over one year of parent coaching by condition.

Figure 6

Motivational Strategies Change Over Time
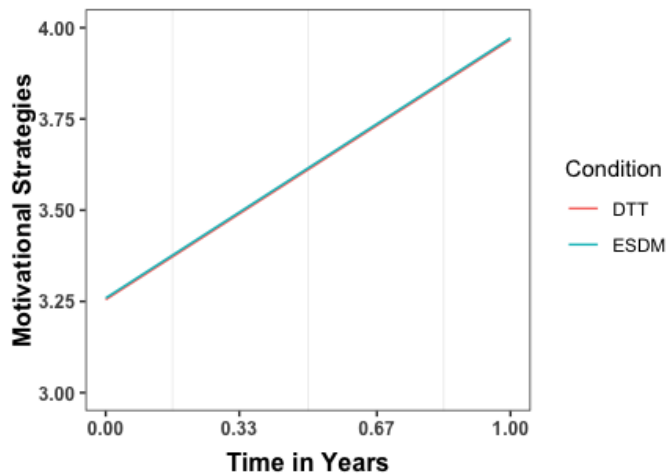
Note. Average change in motivational strategies score over one year of parent coaching by condition.

time for any of the learning opportunity variables indicating no differences between the ESDM and DTT condition.

Study 3: Examining the Association Between Parental Behaviors and Child Engagement

Aim 1: Explore the relationship between parent sensitivity/responsivity and child dyadic engagement.

Aim 2: Examine the relationship between learning opportunities and child dyadic engagement.

Aim 3: Explore the interaction among sensitive/responsive parenting, learning opportunities, and child dyadic engagement.

Recent reviews indicate that the field's understanding of parent-mediated intervention is stymied by a lack of common methodology to evaluate effectiveness (Nevill et al., 2018; Rojas-Torres et al., 2020). Studies to date have primarily focused on associations between change in parenting behaviors and distal child outcomes on standardized measures (Weitlauf et al., 2014). This study aims to measure the association between active intervention ingredients (i.e., parent sensitivity/responsivity and delivery of learning opportunities) and proximal child outcomes (child engagement) across models (i.e., ESDM and DTT). We hypothesize that: 1) Greater parent sensitivity/responsivity will be related to greater child engagement during play interactions. 2)*Variety*, *quality*, and *frequency* of learning opportunities provided, and use of *motivational strategies* will each be independently related to child engagement. 3) Parent sensitivity/responsivity will moderate the relationship between learning opportunities and child engagement.

The Joint Engagement Rating Inventory (JERI; (Adamson et al., 2016) was used to measure child engagement in the session. This coding system was selected because it has been used regularly in other parent-mediated intervention studies (e.g. Gulsrud et al., 2016; Mirenda et al., 2022). The JERI is a flexible system that allows users to select items from 18 different items that assess the quality of the dyadic interaction between caregiver and child. This study uses two items from the JERI: 1) *Child Total Joint Engagement* examines the overall quality of the joint

engagement in the interaction. *2) Child's Initiation of Communication* considers how often the child takes the lead in their interaction with the caregiver and makes overtures (verbal or nonverbal) to the caregiver. These items pull from two different constructs within the JERI— engagement states and child behavior. Together they allow us to measure how engaged the child is with the parent in the session (*Child Total Joint Engagement*) and how often the child takes the lead in the interaction (*Child Initiation of Communication*). Both items are scored on a 1-7 Likert scale with higher scores indicating higher engagement and more frequent communication initiations. See *Appendix D* for complete scoring criteria. One score per code was assigned to the entire five-minute observation and used in the analyses.

JERI Coding

Twelve undergraduate student research assistants, naive to condition and time variables, and the lead author coded the 287 video observations. Coders learned about autism, communication and play development, and parent implemented intervention before coding training began. During training, coders met weekly with the lead author to review video keys. Coders were considered reliable on a video if their score was within one point on both items (considered 100% agreement). To be considered ready for independent coding, coders had to be reliable on two videos in a row, twice *and* average 80% agreement on all coded videos. Thirty percent of each coder's videos (N = 87) were double coded to ensure that coders did not drift over time. The average inter-rater agreement was 92%. Fourteen videos fell below 100%. These observations were checked by the lead author and coder meetings were held to address any discrepancies. Coders demonstrated a high degree of reliability on both JERI measures. The ICC between coders for *Child Total Joint Engagement* was 0.877 with a 95% confidence interval

from 0.817 to 0.918 (F(85,86) = 15.2, p < 0.0001) and for *Child Initiation of Communication*

was 0.797 with a 95% confidence interval from 0.704 to 0.862 (F(85,86) = 8.83, p < 0.0001).

Approach to Data Analysis

We first assessed change in *Child Joint Engagement* and *Child Initiation of*

Communication using repeated measures, random effects models to assess the association

between condition, time since the first assessment, and the interaction between the two. The

interactions were not significant for either model indicating no differences in change over time

across conditions, so we focused on the main effects model. Table 5 displays the average JERI

scores across factors and timepoints for the sample.

Table 5

Average JERI Scores Across Timepoints

Child Total Joint Engagement			
T1	T2	T3	T4
DTT 4.62 (1.81)	4.93 (1.61)	5.40 (1.63)	5.33 (1.61)
ESDM 4.43 (1.91)	4.89 (1.72)	4.97 (1.72)	5.63 (1.21)
Child Initiation of Communication			
T1	T2	T3	T4
DTT 3.59 (1.80)	3.98 (1.75)	4.43 (1.91)	4.42 (1.97)
ESDM 3.57 (1.79)	3.94 (1.57)	4.40 (1.77)	4.88 (1.96)

Represented in Figures 7 and 8, we observed a significant main effect of time for *Child*

Total Joint Engagement (ß = 1.00, SE = 0.24, p = 0.0001) and *Child's Initiation of*

Communication (ß = 1.22, SE = 0.27, p < 0.0001), indicating that overall, child joint engagement

and communication initiations increased over the course of intervention. See Tables B7 and B8

for complete model estimates.

Figure 7

Child Total Joint Engagement Change Over Time
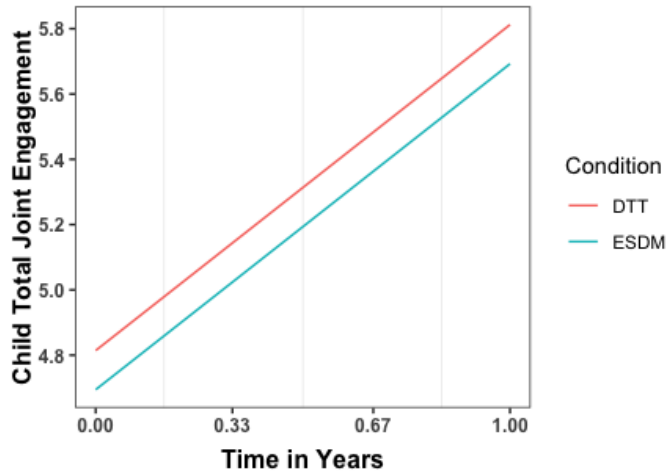
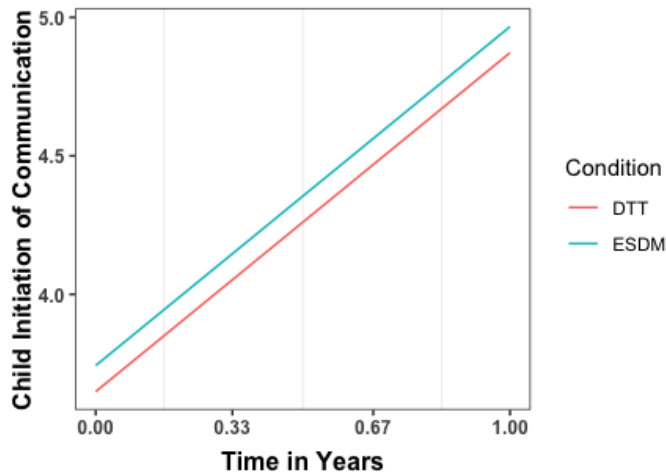*Note.* Average change in joint engagement score over one year of parent coaching by

condition.

Figure 8

Child Initiation of Communication Change Over Time

Note. Average change in communication initiation score over one year of parent coaching by

condition.

Part A: Parent Sensitivity/Responsivity and Child Dyadic Engagement

Aim 1: Explore the relationship between parent sensitivity/responsivity and child dyadic engagement.

Analyses

Repeated measures, random effects models were used to assess the association between parent sensitivity/responsivity and child engagement during the interaction. We were primarily interested in the association between change in parent sensitivity/responsivity (PICCOLO) and JERI scores (*Child Total Joint Engagement*, *Child Initiation of Communication*). Models therefore included the PICCOLO change score, accounting for PICCOLO baseline score and time since the first assessment. If the change models were not significant, we examined the association between parent sensitivity/responsivity (PICCOLO) and child engagement (JERI) within the same interaction (same time point). Models therefore include the PICCOLO score at each visit and time since the first assessment, with specific interest in the value for the PICCOLO score.

Secondary analyses to assess the four PICCOLO domain scores (*Affection*, *Responsiveness*, *Encouragement*, and *Teaching*) were conducted if the overall PICCOLO score was significant, to probe specific areas that might explain the overall difference.

Results

Consistent with our hypotheses, findings indicate that improvement in sensitive and responsive parenting behaviors resulted in greater levels of child dyadic engagement. We found an association between PICCOLO change and *Child Total Joint Engagement* score with an increase in the PICCOLO change associated with a higher joint engagement score ($\beta = 0.07$, SE $= 0.02$, $p < 0.0001$). See Table B9 for full model estimates.

Secondary analyses assessed the sub-domains of the PICCOLO and found significant associations with change in *Affection* (ß = 0.17, SE = 0.06, p = 0.008), *Responsiveness* (ß = 0.24, SE = 0.06, p < 0.0001), *Encouragement* (ß = 0.20, SE = 0.05, p = 0.0001), and *Teaching* (ß = 0.08, SE = 0.04, p = 0.03), suggesting that the association is not driven by any one sub-domain. See Tables B10- B13 for complete model estimates.

There was a significant association between PICCOLO overall score and *Child Initiation of Communication* (ß = 0.04, SE = 0.02, p = 0.01) such that a higher PICCOLO score in a given interaction was associated with a higher score of *Child Initiation of Communication* in that same interaction. Table B14 contains full model estimates.

Part B: Learning Opportunities and Child Dyadic Engagement

Aim 2: Examine the relationship between learning opportunities and child dyadic engagement.

Analyses

The primary independent variables of interest for this aim include the *frequency*, *variety*, *quality*, and *motivational strategies* of the learning opportunities provided at each of the four time points. Models for this aim are similar to those described in Part A. Model building began by considering each of the learning opportunity ratings separately as a predictor of child engagement. The correlation between the learning opportunity ratings were assessed (see Table 6). Models comparing items that fell in the range of 0.6-0.8 were assessed and did not differ significantly, so a final model that includes each of the four learning opportunity items found to be associated with child engagement is reported.

Table 6

Pearson Correlation Among Learning Opportunities Variables

		1	2	3	4
1	Frequency	1	.52	.76	.65
2	Variety		1	.52	.54
3	Quality			1	.68
4	Motivation				1

Results

As predicted, we found that improvement in the delivery of learning opportunities independently predicted greater levels of child dyadic engagement. There was a significant association between *frequency* change and *Child Total Joint Engagement* such that each point of improvement on *frequency* was associated with almost a half point higher *Child Total Joint Engagement* score (ß = 0.46, SE = 0.09, p < 0.0001). This significant association was true for *variety* change (ß = 0.27, SE = 0.09, p = 0.002), *quality* change (ß = 0.46, SE = 0.08, p < 0.0001), and *motivational strategies* change (ß = 0.63, SE = 0.08, p < 0.0001). See Tables B15-B18 for complete model estimates. In a joint model examining all four items, only *motivational strategies* change remained significantly associated with change in *Child Total Joint Engagement* (ß = 0.41, SE = 0.10, p = 0.0001) suggesting it is driving the association of between joint engagement and the learning opportunities. Table B19 contains full model estimates.

There was also a significant association between *motivational strategies* change and *Child Initiation of Communication* such that each point of improvement on *motivational strategies* was associated with a quarter point higher *Child Initiation of Communication* score (ß = 0.25, SE = 0.10, p = 0.01), see Table B20 for complete model estimates. There was no significant association between overall *frequency*, *variety*, or *quality* scores and *Child Initiation of Communication.*

Part C: Parent Sensitivity/Responsivity, Learning Opportunities, and Child Dyadic Engagement

Aim 3: Explore the interaction among sensitive/responsive parenting, learning opportunities, and child dyadic engagement.

To identify potential mechanisms of change for child outcomes in parent-mediated intervention, we must first understand how parent coaching impacts parent-child interaction. This study examines the combined effects of change in parent behaviors (i.e., sensitivity/responsivity and learning opportunities presented) and child behaviors (i.e., engagement with the parent) in order to address previously identified limitations in our ability to compare active ingredients of parent-mediated intervention and child proximal outcomes (Nevill et al., 2018; Oono et al., 2013; Rojas-Torres et al., 2020).

Analyses

The main independent variables of interest for this aim include parent sensitivity/responsivity and the *frequency*, *variety*, *quality*, and *motivational strategies* of the learning opportunities at those same time points. The analyses for this aim builds on the model used above by adding the overall PICCOLO score and its interaction with the learning opportunity ratings to the model. Although we found that *Teaching* was changing over time in Study 1, when we looked at associations between change on the PICCOLO overall and domain scores in Study 3 Part A, they were all significantly associated with *Child Total Joint Engagement* and no PICCOLO change was associated with *Child Initiation of Communication*. For that reason, these models utilized the overall PICCOLO score instead of any domain scores since the domain scores factor onto the overall score.

Results

Our hypothesis that parent sensitivity/responsivity would moderate the relationship between learning opportunities and child engagement was not supported. Rather, we found that one variable from Learning Opportunities coding, parent improvement in their use of *motivational strategies*, was the most significant predictor of child dyadic engagement. Because *motivational strategies* change appeared to drive the learning opportunity findings related to child engagement, we examined a joint model with PICCOLO change, *motivational strategies* change, and *Child Total Joint Engagement*. Once again, only *motivational strategies* change was associated with change in *Child Total Joint Engagement* ($\beta = 0.41$, SE $= 0.08$, p < 0.0001). Table B21 contains complete model estimates. Similarly, in a model examining the relation between *Child Initiation of Communication* and overall PICCOLO and *motivational strategies* scores, *motivational strategies* score alone was associated with higher *Child Initiation of Communication* scores ($\beta = 0.27$, SE $= 0.10$, p $= 0.01$). See Table B22 for complete model estimates. Thus, parental use of motivational strategies appears to be a significant factor in predicting child dyadic engagement.

General Discussion

Parents are increasingly being asked to become interventionists for their young children on the autism spectrum. Various interventions for young children on the autism spectrum integrate parent-mediated treatment (e.g., Green et al., 2010; Kasari et al., 2010; Mirenda et al., 2022; Rogers et al., 2019; Rogers et al., 2012; Shire et al., 2021; Stadnick et al., 2015; Wetherby et al., 2014). While it seems that parent-mediated interventions do not have as large of an effect on child outcomes as do high-quality therapist-mediated interventions examined in research studies, (Nahmias & Mandell, 2014), we do not currently have enough methodological consistency across studies to understand the mechanisms of change in parenting behavior and

how those changes affect child outcomes (Nevill et al., 2018; Rojas-Torres et al., 2020). This study aimed to address these limitations by measuring active ingredients across intervention models rather than specific intervention fidelity variables and by examining proximal rather than distal child outcomes. Due to the different conceptual frameworks informing the two interventions included in this study, we expected to see between-group variability in parents' adoption of sensitive and responsive parenting behaviors and in their delivery of learning opportunities. We also expected to see differences in child engagement as a result of this variability.

Developmentally informed interventions, such as ESDM, include specific strategies that may result in higher parent sensitivity/responsivity in parent-child interactions while that is not an emphasis in structured behavioral interventions. Despite these differences in coaching strategies, we did not find differences in parent sensitivity/responsivity between the ESDM or DTT parent coaching condition. These findings are consistent with a recent Canadian study examining a community implementation of an adapted version of ESDM that found no group differences between the effects of their parent coaching intervention and that of the enhanced community treatment group on parenting scaffolding behavior and parent following in (Mirenda et al., 2022).

Overall, caregivers in both the ESDM and DTT condition started with fairly high scores on the PICCOLO, which means it is possible that there was a ceiling effect given that parents in this study were already demonstrating sensitive and responsive parenting behaviors. Other studies have found that parents of children on the autism spectrum do not differ in sensitive and responsive parenting behaviors compared to parents of neurotypical children but that child responses to parenting behaviors differed for children on the autism spectrum (Kasari et al.,

1988; van IJzendoorn et al., 2007; Wan et al., 2019). This may suggest that if parents have an average or greater baseline measure on parent sensitivity/responsivity then it is not an important variable to focus on either as a coaching or an outcome variable.

However, we did find that parents improved over time on the teaching domain of the PICCOLO, which includes items that measure parent labeling, questions, and contributions to activities and pretend play. This suggests that teaching behavior was improved as a function of coaching in both groups.

Studies have found intervention effects on specific sensitive and responsive parent behaviors (Siller et al., 2013; Whitehouse et al., 2021) and others report on parenting behaviors that may be associated with higher levels of sensitive parental responses like mirrored pacing (Gulsrud et al., 2016), scaffolding and following (Mirenda et al., 2022), or parent interactional skill as measured by improvement on a specific intervention fidelity tool (Rogers et al., 2014, 2019). However, it is difficult to parse these results because they often examine distal child outcomes with mixed results and changes in parenting behavior are often reported as components of the specific intervention's fidelity. Studies have long indicated that parents of children on the autism spectrum do not differ from parents of neurotypical children in most interactional behaviors with their children, but the responses of children on the autism spectrum differ (Kasari et al., 1988; van IJzendoorn et al., 2007; Wan et al., 2019). For that reason, we examined the association between parent sensitivity/responsivity and the proximal outcome, child dyadic engagement. We found that parent improvement on the PICCOLO was associated with higher joint engagement scores and that when parents demonstrated greater parent sensitivity/responsivity, children had a higher rate of initiating communication. Taken together, these findings suggest that parent sensitivity/responsivity is an important component of child

dyadic engagement to consider and to examine in initial assessments. It is also important for future studies to examine which strategies actually do increase parent sensitivity/responsivity to better understand how to target parent coaching to best support parents who may start with lower levels of sensitive responding.

Both NDBI and structured behavioral interventions are informed by ABA, emphasizing specific teaching strategies to maximize learning opportunities for children on the autism spectrum. While the examination of learning opportunities has been proposed as an important tool for measuring intervention intensity (Warren et al., 2007) it may also allow us to compare active ingredients across interventions that typically report strategies on a fidelity tool specifically designed for each intervention package. We found that parents improved on all four indicators of learning opportunities—frequency, variety, quality, and motivational strategies—over the course of parent coaching with no differences between coaching conditions.

Improvement on each indicator of learning opportunities was independently related to joint engagement, but motivational strategies appeared to be the most significant driver of child dyadic engagement—it alone remained significant in a joint model examining the association between all four learning opportunity indicators and child joint engagement. Similarly, change in motivational strategies was the only significant association for child initiation of communication. In fact, motivational strategies alone remained significant when included in models examining the association among parent sensitivity/responsivity, learning opportunities, and child dyadic engagement.

This is only the second study examining the role of learning opportunities in parent-mediated intervention (Davlantis et al., 2019) and the first to look at proximal measure of child outcomes and to compare parents across interventions. Future examination of learning

opportunities as a specific intervention component may open the door for other studies to compare parenting behaviors across interventions. For instance, it is possible that the results regarding the use of motivational strategies and learning opportunities align with findings from studies examining specific intervention fidelity components. Our measure of motivational strategies included the parent maintaining instructional control over the materials (see *Appendix C*) which might align with the recent JASPER findings that "environmental arrangement" was related to joint engagement in the parent-child interaction (Gulsrud et al., 2016) and the Project ImPACT finding that "makes play interactive" predicted children's spontaneous language in the same parent-child interactions (Ingersoll & Wainer, 2013). It is possible that this measure of learning opportunities may be able to cross specific intervention fidelity tools, allowing for additional comparison of active ingredients of parent-mediated intervention across intervention models.

We found that parent increased use of motivational strategies improved child dyadic engagement in parent-child interactions when accounting for parent sensitivity/responsivity, and that parents were able to improve their use of motivational strategies over the course of parent coaching, regardless of condition. These data also suggest that focusing solely on parent sensitivity/responsivity as a primary mechanism for child engagement may not be sufficient and that focusing on parent teaching strategies inside learning opportunities, especially child motivation, has positive impact on increasing child dyadic engagement. As researchers and community practitioners endeavor to support parents of children on the autism spectrum, these findings may help inform coaching programs.

Autism is heterogenous and there is evidence of different patterns of social motivation across development (Burnette et al., 2011). The social motivation hypothesis of autism—not to

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be confused with the antiquated and ableist view that individuals on the autism spectrum are unmotivated by social stimuli—recognizes individual differences in the socio-emotional development of individuals on the autism spectrum and the varied role social motivation has on individual development (Mundy, 2019; Mundy & Sigman, 2015). These results highlight the importance of empowering parents to identify what is motivating for their individual children and to incorporate that into meaningful interactions to facilitate child learning.

That coaching condition was not significantly associated with change in parenting behavior echoes the results of the larger study, which found that outcomes on language and cognition did not differ according to intervention style. (Rogers et al., 2021). We do not have parent coaching fidelity data, so it is possible that the highly trained clinicians delivering parent coaching in both conditions were providing tips and strategies that crossed both groups and limited differences. It is also important to note that these findings come from a large research study conducted with families living in urban areas near a university with relatively high education levels. The present study is the first study to compare parents being coached in two separate coaching interventions, so results need be replicated before recommendations should be made. Future studies should seek to replicate these findings with community samples.

It is important to note there are several limitations to this study. First and foremost, the children in this study were receiving high quality, intensive in-home treatment with a skilled team as part of the larger study. While we did our best to control for this by examining proximal outcomes related specifically to the parent-child interaction, child behavior during sessions was very likely to be influenced by the therapist-directed treatment. Given the bi-directional nature of parent-child interactions, it is possible that change in child behavior effected change in parent behavior. Additionally, parents were in the home when their children were receiving high-quality

intervention services and it is possible that parent behavior was influenced by observing the skilled staff members interacting with their child in a way that interfered with coaching method effects. Second, there were site differences at baseline in parent sensitivity/responsivity that we could not explore due to the power of the study. However, understanding how parents in different regions interact with their children may help to inform future coaching efforts. Third, the data for this study come from a large efficacy study with strict inclusion criteria (see Rogers et al., 2021 for more information). Parents were fairly well-educated and families were able to accommodate 15-25 hours per week of in-home intervention services which may indicate that parents in this sample were highly motivated and had the resources and support to participate in parent-coaching. Additional studies should endeavor to replicate these findings in community-based coaching programs.

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Appendix A

PICCOLO Scoring Criteria

PICCOLO Observation Notes

Item	Guideline	Additional Observation Notes
Affection		
1. Speaks in a warm tone of voice	Parent's voice is positive in tone and may show enthusiasm or tenderness. A parent who speaks very little but very warmly should be coded highly.	Flat and toneless or sarcastic and demanding voices are not warm. Score as 0 unless there were some moments of warmth. Warmth may sound like *motherese* (e.g., exaggerated intonation, high pitch), though not always. Enjoyment and interest may also sound warm. Enjoyment and interest may also sound warm. The parents voice cannot be harsh and warm at the same time. Sometimes a parent is warm at the beginning but the warmth fades, so the last part of the observation is important to consider. For a score of 2, the parent's voice should be mostly warm throughout.
2. Smiles at child	Parent directs smiles toward child, but parent and child do not need to be looking at each other when smile occurs. Includes small smiles.	For a score of 2, the parent should smile about once per minute and needs to be looking at or clearly facing the child. Smiling should be about the child. Ignore smiles to the camera or to another child or adult or smiling about something funny in a book or toy. Also ignore smiles that seem to be from nervous laughter or self-consciousness. The child does NOT have to be looking at the parent.
3. Praises child	Parent says something positive about child characteristics or about what child is doing. A "thank you" can be coded as praise.	Praise is always in a positive tone, in response to child behavior, and *after* rather than *during* the child's behavior. Praise is typically in response to the child's accomplishment or compliance. It includes "yeah" and "all right" if the words are a clear, positive response to something the child has done. Consider cultural context and slang (e.g., "sweet," "cool"). Sometimes praise can also be coded as "positive expressions" or "shows emotional support" but not always, so consider guidelines carefully. Consider missed opportunities: The parent frequently asks the child to do

		something but never or rarely praises the child when he or she complies.
4. Is physically close to child	Parent is within easy arm's reach of child, comfortably able to soothe or help. Consider context: Expect more closeness for book reading than for playing house.	The parent should be close enough to the child to easily soothe, show affection, or give or get help or reassurance. The parent should be no more than an arm's length away. The parent should not be avoiding physical proximity or contact. Look at the parent's body posture: leaning toward the child, showing physical affection, or repositioning to remain close.
5. Uses positive expressions with child	Parent says positive things or uses words like "honey," "kiddo," or an affectionate nickname. (*Note*: Emphasis on verbal expressions.)	Consider other terms such as "son," "buddy," or "mijo." Consider the cultural and language context (e.g., diminutives in Spanish). Other positive expressions include "I love you," "You are so silly," "you are my baboo," and "Are you my little girl?" Compliments that are not praise for specific behaviors (e.g., "You are pretty like your mommy") can also be considered positive expressions. A shortened form of a name (e.g., "Ty" for Tyler) may be used as a positive expression but is weaker than a more affectionate nickname. Terms that are more strongly positive or affectionate carry more weight for scoring this item.
6. Is engaged in interacting with child	Parent is actively involved together *with* child, not just with activities or with another adult.	This item is not scoring *parallel play*, when parent and child are each playing but doing their own thing next to each other. The parent and child need to be playing together and focused on the same activity with the parent being neither directive nor passive. For younger children, the parent is typically engaging with the same toy as the child, but with more verbal children, the parent may just be talking about the toy or the child's behavior. For a score of 2, the parent is involved most of the time.
7. Shows emotional warmth	Parent shows enjoyment, fondness, or other positive emotion about child or directed to child. (*Note:* Includes verbal but emphasis on nonverbal.)	Consider the overall feeling—the parent is having a good time with the child, is positive and interested throughout, and is not bored or wondering how much longer he or she has to play with the child. Physical affection shows warmth. Consider the parent's interest along with warmth, but if the parent is showing some interest but his or her overall

		emotion is flat, score as 0 unless positive interest is truly directed toward the child and the child is clearly aware of the interest.
Responsiveness		
1. Pays attention to what child is doing	Parent looks at and reacts to what child is doing by making comments, showing interest, helping, *or* otherwise attending to child's actions.	The parent is paying enough attention that the parent could (if asked) describe what the child is doing during most of the observation. Consider missed opportunities: The child tries to show the parent something or calls to the parent and the parent does not look, make comments, or show much interest. Parent engagement in the activity is not required for this item if the parent watches and reacts.
2. Changes pace or activity to meet child's interests or needs	Parent tries a new activity or speeds up or slows down an activity in response to where child looks, what child reaches for, what child says, or emotions child shows.	The parent initiates the change to keep the child engaged in response to the child's getting bored or frustrated. For example, the child is bored with hearing the story, so the parent starts asking questions or the child is trying to do something difficult, so the parent slows down and gives hints. If the parent never loses interest or never tries something difficult, or if the parent does not change the pace, score as 0. If the parent never adapts to the child's pace—moves too quickly to a new activity or sticks with an activity too long—score as 0. If the child loses interest right away after the parent has changed the pace or activity, score as 1. The parent can also be scored for changing pace if he or she suggests a new activity, but the child does not want to do it and the parent sticks with what the child is already doing.
3. Is flexible about child's change of activities or interests	Parent accepts a child's choice of a new activity or toy *or* shows agreeableness about the change or about child playing in unusual ways with or without toys.	The parent supports the child's initiation. For example, the parent lets the child choose how or when to turn the pages in a book, lets the child explore toys, and is neither directive nor passive. If the child does not initiate anything, score as 0. If the parent is passive or uninvolved, score as 0 because he or she is not being flexible—the parent has to change something he or she is doing, not just go from nothing to nothing.
4. Follows what child is trying to do	Parent both responds to *and* gets involved with child's activities	This item involves yielding to the child's interests and motivation and doing what the child seems to want or attending to what the

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		child seems interested in. it includes behaviors like repeating what the child says and imitating what the child does, engaging as a play partner in play the child initiates, and helping the child do something if the child is struggling. It involves more than just talking about the toys. If the child does nothing, the parent cannot follow, so score this item as 0. If the child makes only a few initiations but the parent follows each one and gets involved, score as 2.
5. Responds to child's emotions	Parent reacts to child's positive or negative feelings by showing understanding or acceptance, suggesting a solution, reengaging the child, labeling or describing the feeling, showing a similar feeling, or providing sympathy for negative feelings	For a score of 2, the parent frequently matches the child's expression and intensity of feeling and is neither flat nor harsh. This might be subtle, but a child is always displaying an emotion, even if it is not strong or animated. If a child is disengaged, that is an emotion, and the parent's appropriate response would be to reengage the child in some way or to provide an opportunity for quieter play or rest. The parent may describe emotions by saying what the child likes: "You really like playing with cars, doing you?" "You don't like the sound that makes, do you?" or "It feels good, huh?" Consider missed opportunities; for example, if the child is excited about a toy but the parent's emotional expression remains flat.
6. Looks at child when child talks or makes sounds	When child makes sounds, parent clearly looks at child's face or (if eyes or child's face are not visible) parent's position and head movement face toward child.	Other than reading in the lap, the parent generally looks at the child when the child talks. The parent may turn toward the child or simply flash eyes toward the child most of the time when the child vocalizes or speaks. If the parent is already looking in the direction of the child when the child begins to vocalize, then the parent is looking at the child when the child talks or makes sounds. If parent and child are both looking at the same object and talking about it or the parent orients toward the object the child is talking about, that is joint attention and a good parenting behavior, but it does not fit this item. Consider missed opportunities: The child calls to the parent or makes sounds, and the parent does not look toward the child.

7. Replies to child's words or sounds	Parent repeats what the child says or sounds child makes, talks about what child says or could be saying, *or* answers child's questions.	For a score of 2, the parent responds to most of the child's vocal sounds. If the child makes no sounds, scores as 0. I the child makes only one or two sounds, but the parent is consistently responsive, score as 2. Some replies, such as "uh huh" may seem unresponsive; if so, score lower. Consistency is more important than frequency. Consider missed opportunities: The child is talking or making sounds, and the parent says nothing or says very little.
Encouragement		
1. Waits for child's response after making a suggestion	Parent pauses after saying something the child could do *and* waits for child to answer or do something, whether child actually responds or not.	The parent makes a suggestion for the child to do something specific and then pauses and does not do the activity or action suggested, move the child's hands, or do anything further to interfere with what the child is doing—the opposite of intrusive play. Waiting often looks like the parent is leaning back, has dropped hands, is relaxing, and has an expression of openness and patience. The parent may repeat the suggestion after a few seconds, but the tone does not feel impatient or demanding. Suggestions may be phrased as questions, such as "Do you want to play with the ball?" or "How about we put the blocks in the basket?" The parent may begin the behavior but then pause to wait for the child's response. This item does not include questions that ask for information such as "What's that?"
2. Encourages child to handle toys	Parent offers toys or says positive things when the child shows obvious interest in toys. (Does not include preventing children from mouthing toys.)	This item includes handing toys to the child, showing toys to the child, moving toys closer to the child, demonstrating something with the toy, highlighting toys by moving or using them, making noise with a toy to attract attention, or praising what the child does with the toys. This item could also include imitating what the child does with a toy without interfering or interrupting what the child is doing. The object does not have to be a toy. This item does not include passive watching.
3. Supports child in making choices	Parent allows child to choose activity or toy *and*	The parent can accept the child's choices and get involved or can offer choices and get involved. The parent can offer genuine

	gets involved with activity or toy child chooses.	choices verbally such as by asking, "Which one do you want?" or by describing choices or offering alternative suggestions that are true options. Rhetorical questions such as "Do you want me to read the book?" while opening the book and starting do read do not offer a choice. The parent can offer choices nonverbally by putting more than one toy in reach.
4. Supports the child in doing things on his or her own	Parent shows enthusiasm for things child tries to do without help, lets child choose how things are done, *and* lets child try to do things before offering help or suggestions. Parent can be engaged in activities child does "on his or her own."	To get a score of 2, the child must try to do something on his or her own *and* the parent should clearly do at least two of the following three things: 1) show enthusiasm, 2) let the child choose, and 3) let the child try without help. However, even if the parent does not offer help or does not make a suggestion, the parent should still be watching, waiting, and showing interest and positive response to what the child does on his or her own, without interfering, in order to get a score of 2. If the parent does any one of these things—shows enthusiasm or lets the child choose or lets the child try without help score as 1. If the parent also interferes with the child doing things on his or her own by criticizing or not letting the child have choices, or not letting the child try to do things before offering help or suggestions, do not score as more than a 1. If the child does not try to do anything on his or her own, score as 0.
5. Verbally encourages child's efforts	Parent shows verbal enthusiasm, offers positive comments, *or* makes suggestions about child's activity.	This item also includes the parent cheering the child on as the child tries to do something. Examples include the following: "Go ahead," "You can do it," "Try again," "You are really working hard," "Go for it," "You can do it," "You're getting it," "Keep trying," and "Try it [slower, faster, softer, harder]." Responses could include describing what the child is doing such as "You are putting all the blocks away in the box" or "You are stacking the blocks carefully." This item also includes praise that is for effort: "There you go" or "You did it." This behavior is most likely when the activity is challenging for the child. Consider missed

		opportunities: The child is trying hard, but the parent does not encourage before, during, or after the event.
6. Offers suggestions to help child	Parent gives hints or makes comments to make things *easier* for child without interfering with child's play.	The suggestions have to be helpful—something that will make it easier for the child to do what the child seems to be trying to do. Examples include "It's upside down," "Push harder," and "Turn it over." This item also includes hints such as after asking the child, "What's that?" the parent may say, "Remember, we saw one at Grandma's house last night?" Or if the child is counting or saying the alphabet and gets stuck, the parent may give a hint by saying the next number or letter. Consider missed opportunities: The child is struggling, but the parent offers no suggestions.
7. Shows enthusiasm about what child is doing	Parent makes positive statements, claps hands, or shows other clear positive response to what the child is *doing,* including quiet enthusiasm such as patting child, nodding, smiling, or asking child questions about activities.	The enthusiasm needs to be about the child's behavior, not for the toys or the parent's own ideas. Notice quiet parents' enthusiasm shown by nods, interest, and questions. Consider missed opportunities: The parent does not seem enthusiastic or interested when the child is excited about the activity.
Teaching		
1. Explains reasons for something to child	Parent says something that could answer a "why" question, whether child asks a question or not.	The parent's reasons generally have a causal structure and explain how things happen or whey they happen, or what happens to something. Some parents use the words "so" or "because" or "if…then." Examples include "Put the lid on so it won't spill," "It can spill if the lid isn't tight because it can come out through the gap between the bottle and the lid," "We have to cook the food so we can eat it," or "If you don't cook the food, then it will make us sick." Explaining how things happen can be a description of a process such as "The snow is on the ground in the winter, but when spring comes it starts to warm up and melt into water for the flowers." This is a less frequent behavior, so one extended or complex explanation can be scored as a 2.

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2. Suggests activities to extend what the child is doing	Parent says something child could do to add to what child is already doing but does not interrupt child's interests, actions, or play.	Suggestions must build on what the child is already doing by stating what the child can do to add to how the child is already playing, expand on the play, or make the play more complex. Suggestions to extend play must both build on what the child is doing and add to it in some way.
3. Repeats or expands child's words or sounds	Parent says the same words or makes the same sounds child makes *or* repeats what child says while adding something that adds to the idea.	The parent repeats the child's exact words or repeats the child's sounds or expands by adding words or sounds to what the child says. If the child says, "Doggie," the parent may say, "That's right; it's a doggie." Or expand with more complexity, such as saying, "Yeah, it's a big brown doggie sitting by his doghouse."
4. Labels objects or actions for child	Parent names what child is doing, playing with, or looking at.	Nouns and verbs are labels for objects and actions: "It's a stove, and you can cook with it." When the parent says things like, "The book as a hole," the parent is labeling both the book and the hole. Labels often occur naturally as part of conversation and can be easy to miss. The parent points to pictures in the book: "See here, she is spinning the web," labeling both action (*spinning*) and object (*web*); "That's a stethoscope," labeling an object (*stethoscope*); "You're giving more medicine to the bear," labeling both action (*giving*) and objects (*medicine, bear*). Consider diversity of materials and actions available to label.
5. Engages in pretend play with child	Parent plays make believe in any way—for example, by "eating" pretend food.	Pretending can occur by taking on a role (fighting in rough and tumble play, being the patient in doctor play), using an object to represent something else (pretending a block is a car by moving it on the floor and making car sounds), pretending something is real (eating the pizza, saying something is hot, making animal sounds for little plastic animals, making car sounds for cars, or making dolls talk), or pretending to be the characters in a book (animating voice and facial expression while reading). The parent actually needs to be pretending, such as by making a statement "as if" the pretending is real, not just narrating the child's pretending. For example, not just saying, "You can

		pretend to make supper," but "Please make me supper." Not just, "Put the groceries in the cart," but "What else do we need to buy?" It is not enough for parent to describe the child's pretending; the parent must be pretending too in some way.
6. Does activities in a sequence of steps	Parent demonstrates or describes the order of steps or does an activity in a way that a definite order of steps is clear even if parent does not say exactly what the steps are. Book reading counts *only* if parent makes the steps explicit by exaggerating or explaining the steps of reading.	Steps need to occur close together with clear linkages and not be broken up with other activities in between. The step-by-step sequence should be something you could describe easily in words: "First, then child gibes the parent the thing to buy. Then, the parent scans it. Then, the child gives her the next thing, and she scans it. They do that for each thing, and she tells him how much he owes." A sequence of steps often gets repeated, described in words, or explicitly demonstrated in steps. If there is no description or repetition, the demonstration should be of something that could not be done in another sequence (e.g., take the lid off the pot, put something in the pot, stir it, and put the lid back on). Game like routines such as Peekaboo typically follow a specific sequence of steps. If a parent says something like "We have to put these toys away first before we can get the other toys out," and then does that, it counts as a sequence of steps. Include counting and the order of book reading *only* when the parent is explicitly teaching how to count or how to look at a book.
7. Talks to child about characteristics of objects	Parent uses words or phrases that describe features such as color, shape, texture, movement, function, or other characteristics.	Characteristics of objects are described primarily by adjectives. Statements about function such as "Books are for reading" or "This is for listening to the heartbeat" are also about the characteristics of objects. When the parent says, "Dogs say 'woof,'" it is a functional characteristic of an object (but not explaining). Both variability and frequency are important. Saying "red" lots of times is not as clear as saying "big," "red," and "round." This item includes referring to the number of objects: "There are two lions." When the parent says the food the parent and child have just pretended to cook is hot, it

		can be both pretending and talking about characteristics of objects. When the parent talks about pictures in a book, the words may both label and talk about characteristics of objects (simply reading the words in a book does not count)> Listen carefully because toys may bring out words about colors and shapes, but words can also be used to describe the objects. For example, if a parent says, "Here's a square. Can you put it in the box?" the parent has labeled the objects, but the words were not used as descriptions. If the parent says, "It's a square block, and it goes in the square hole," then the parent is describing characteristics of the objects. Complexity and variety (color, shape, texture, function) count more.
8. Asks child for information	Parent asks any kind of question or says, "Tell me," "Show me," or other command that may require a yes/no response, sort answer, or longer answer—whether or not child replies. Does not include questions to direct attention ("See?") or suggest activities ("Wanna open the bag?")	Questions must be asked in a way likely to elicit communication from the child, not just imitation. The parent must wait for an answer and appear to clearly expect an answer from the child. Questions that are truly asking for information are often repeated if the child does not reply right away. These questions do not include rhetorical questions, suggestions phrased as questions, or confirmation questions such as "Do you want to stir the pot?" or "It's a big spoon, isn't it?" Count either many simple questions such as "What's that?" or a few open-ended questions such as "tell me about what you are building with these blocks," followed by encouraging prompts, such as "And what else?"

Table from (Roggman et al., 2009).

Appendix B

Full Model Estimates for All Analyses

Table B1

Results of Model of PICCOLO Change Over Time

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	42.28	1.06	40.06	277.96	0
ESDM	2.95	1.00	2.94	277.99	0.004
Time	1.22	0.89	1.37	277.97	0.171
Site B	0.47	1.19	0.39	277.99	0.693
Site C	-2.71	1.25	-2.17	277.99	0.031

Table B2

Results of Model of Teaching Domain Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	7.61	0.43	205	17.89	0
ESDM	1.42	0.40	77	3.57	0.001
Time	0.99	0.40	205	2.49	0.014
Site B	0.11	0.48	205	0.24	0.810
Site C	-1.24	0.50	77	-2.49	0.015

Table B3

Results of Model of Frequency Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	3.36	0.16	205	21.14	0
ESDM	0.13	0.14	77	0.93	0.357
Time	0.47	0.18	205	2.70	0.007
Site B	0.10	0.17	205	0.56	0.579
Site C	-0.37	0.18	77	-2.06	0.043

Table B4

Results of Model of Variety Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	3.30	0.17	205	19.13	0
ESDM	0.37	0.16	77	2.34	0.022
Time	0.35	0.18	205	1.99	0.048
Site B	-0.15	0.19	205	-0.80	0.426
Site C	-0.50	0.20	77	-2.46	0.016

Table B5

Results of Model of Quality Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	3.20	0.15	205	21.18	0
ESDM	0.08	0.13	77	0.62	0.539
Time	0.46	0.18	205	2.59	0.0104
Site B	-0.08	0.16	205	-0.49	0.624
Site C	-0.33	0.17	77	-1.92	0.058

Table B6

Results of Model of Motivational Strategies Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	3.25	0.17	205	19.62	0
ESDM	0.00	0.15	77	0.03	0.978
Time	0.71	0.17	205	4.09	0.0001
Site B	-0.00	0.18	205	-0.03	0.980
Site C	-0.23	0.19	77	-1.19	0.239

Table B7

Results of Model of Total Child Joint Engagement Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	4.81	0.29	205	16.79	0
ESDM	-0.12	0.27	77	-0.44	0.661
Time	0.20	0.24	205	4.09	0.0001
Site B	-0.01	0.32	205	-0.02	0.981
Site C	-0.51	0.34	77	-1.50	0.137

Table B8

Results of Model of Child Initiation of Communication Change Over Time

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	3.65	0.30	205	12.14	0
ESDM	0.09	0.28	77	0.33	0.741
Time	1.22	0.27	205	4.58	<0.0001
Site B	0.23	0.34	205	0.69	0.492
Site C	-0.50	0.35	77	-1.41	0.163

Table B9

Results of Model of PICCOLO Change Associated with Child Total Joint Engagement

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	0.37	0.77	0.47	277.99	0.636
PICCOLO Change	0.07	0.017	4.05	277.99	<0.0001
ESDM	-0.46	0.25	-1.83	277.99	.007
Time	0.91	0.24	3.81	277.99	.0002
PICCOLO Baseline	0.10	0.018	5.67	277.99	<0.0001

Table B10

Results of Model of Affection Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.39	0.83	205	2.86	0.005
Affection Change	0.17	0.06	205	2.67	0.008
ESDM	-0.19	0.27	77	-0.68	0.498
Time	0.99	0.24	205	4.10	0.0001
Affection Baseline	0.23	0.09	77	2.74	0.008

Table B11

Results of Model of Responsiveness Change Associated with Child Total Joint Engagement

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	0.92	0.89	1.03	277.96	0.302
Responsiveness Change	0.24	0.06	3.92	277.57	0.0001
ESDM	-0.36	0.26	-1.37	277.99	0.172
Time	0.97	0.24	4.07	277.99	<0.0001
Responsiveness Baseline	0.30	0.07	4.25	277.98	<0.0001

Table B12

Results of Model of Encouragement Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	1.04	0.78	205	1.34	0.182
Encouragement Change	0.20	0.05	205	3.96	0.0001
ESDM	-0.30	0.25	77	-1.18	0.242
Time	1.00	0.24	205	4.20	<0.0001
Encouragement Baseline	0.30	0.06	77	4.72	<0.0001

Table B13

Results of Model of Teaching Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.65	0.37	205	7.12	0
Teaching Change	0.08	0.04	205	2.17	0.031
ESDM	-0.52	0.23	77	-2.21	0.030
Time	0.89	0.25	205	3.64	0.001
Teaching Baseline	0.28	0.05	77	6.14	<0.0001

Table B14

Results of Model of Overall PICCOLO Score Associated with Child Initiation of Communication

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	1.77	0.75	2.36	278.98	.0108
PICCOLO	0.04	0.02	2.51	278.98	.013
ESDM	-0.02	0.28	-0.07	278.99	.944
Time	1.20	0.27	4.48	278.99	<0.0001

Table B15

Results of Model of Frequency Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.16	0.41	205	5.31	0
Frequency Change	0.46	0.09	205	5.41	<0.0001
ESDM	-0.29	0.23	77	-1.28	0.205
Time	0.79	0.24	205	3.32	0.001
Frequency Baseline	0.78	0.12	77	6.69	<0.0001

Table B16

Results of Model of Variety Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.67	0.39	205	6.78	0
Variety Change	0.27	0.09	205	3.12	0.002
ESDM	-0.41	0.23	77	-1.71	0.092
Time	0.88	0.24	205	3.62	0.001
Variety Baseline	0.66	0.12	77	5.67	<0.0001

Table B17

Results of Model of Quality Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.50	0.40	205	6.19	0
Quality Change	0.46	0.08	205	5.45	<0.0001
ESDM	-0.26	0.24	77	-1.06	0.291
Time	0.80	0.24	205	3.38	0.001
Quality Baseline	0.72	0.12	77	5.84	<0.0001

Table B18

Results of Model of Motivational Strategies Change Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	2.09	0.39	205	5.38	0
Motivation Change	0.63	0.08	205	7.63	<0.0001
ESDM	-0.13	0.22	77	-0.60	0.547
Time	0.58	0.23	205	2.46	0.015
Motivation Baseline	0.81	0.11	77	7.14	<0.0001

Table B19

Results of Model of All Learning Opportunities Associated with Child Total Joint Engagement

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	4.56	0.22	202	21.13	0
Frequency Change	0.07	0.12	202	0.54	0.592
Variety Change	-0.16	0.09	202	-1.69	0.093
Quality Change	0.08	0.12	202	0.66	0.513
Motivation Change	0.41	0.10	202	4.06	0.0001
ESDM	-0.04	0.29	78	-0.13	0.894
Time	0.69	0.23	202	2.93	0.004

Table B20

Results of Model of Motivational Strategies Change Associated with Child Initiation of Communication

Term	Value	Standard Error	DF	t-value	p-value
(Intercept)	1.85	0.47	205	3.95	0.0001
Motivation Change	0.25	0.10	205	2.59	0.010
ESDM	0.07	0.27	77	0.25	0.801
Time	1.09	0.27	205	3.97	0.0001
Motivation Baseline	0.55	0.14	77	4.03	0.0001

Table B21

Results of Model of PICCOLO Change and Motivational Strategies Change Associated with Child Total Joint Engagement

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	4.54	0.22	20.76	277.99	0
PICCOLO Change	0.01	0.02	0.87	277.99	0.386
Motivation Change	0.41	0.08	4.83	277.99	<0.0001
ESDM	-0.01	0.29	-0.05	277.99	0.964
Time	0.71	0.23	3.04	277.99	0.003

Table B22

Results of Model of Overall PICCOLO Score and Motivational Strategies Score Associated with Child Initiation of Communication

Term	Estimate	Standard Error	Statistic	DF	p-value
(Intercept)	1.59	0.74	2.15	277.97	0.032
PICCOLO	0.03	0.02	1.47	277.96	0.142
Motivation	0.27	0.10	2.71	277.99	0.007
ESDM	0.03	0.27	0.09	277.99	0.926
Time	1.04	0.27	3.79	277.99	0.001

Learning Opportunities Scoring Instructions

Adapted from (Davlantis et al., 2019)

Learning Opportunities Coding Manual

Background

When a parent-child dyad interacts, numerous natural learning opportunities might occur. A **learning opportunity** is a situation in which a child is given the opportunity to demonstrate a skill or behavior, new or practiced and receives feedback to help inform future responding.

Parents and children interact across many activities in a typical day. For instance, they may play together, eat together, complete art activities, go out into the community. read books and do chores. In each of these settings, parents typically provide learning opportunities to their children, whether intentional or not. They might provide instructions to their children, such as, "Throw the ball," or ask a question like, "Do you want more soup?" Each of those would constitute a learning opportunity for the child— to practice a new/emerging skill. In addition to more obvious learning opportunities like instructions and demonstrations, parents create many nondirective learning opportunities for their children. For instance, in a play activity, a parent could play with their child by having a Peppa Pig figurine get in a car and drive while the child has access to the toys, hoping their child will join in the play. Or while singing *Row, Row, Row Your Boat*, a parent might create an opportunity for expressive language learning by pausing in the middle of the lyrics to allow the child to fill in a word.

A learning opportunity can be initiated by either the parent or the child. In the examples above, the parent is initiating the learning opportunity by asking questions, giving instructions, modeling skills, offering play, and soliciting communication. A child-initiated learning opportunity typically involves a spontaneous child behavior that is capitalized on by the parent. For instance, in the Peppa Pig example, if the parent is driving the car and the child looks around the room, notices a hula hoop, and says, "Hula hoop!" and the parent responds, "Oh, you want to hula hoop? Let's go get it!" that is a spontaneous child behavior followed by a parent response that provides additional language and direction (i.e., a learning opportunity). Or between activities, a child might notice something in the environment, such as a helicopter toy out of reach, and point to the toy to request it. If the parent names it and fetches it for the child, those consequences create a learning opportunity.

The behaviors displayed by the child during the learning opportunity may be contingent and communicative (i.e., vocalizations, unintelligible utterances, gestures, eye contact, facial expressions), contingent motoric, or non-responsive to the parent initiation. A child's behavior may be cooperative (e.g., following the parent's instruction, asking a related question, an on-topic verbal response or gesture, any attempts) or noncooperative (e.g., throwing, kicking, ignoring the parent, tantrumming, or engaging in an off-task behavior). Both types of responses following a parental initiation constitute a contingent response. What is important

for determining the quality of the learning opportunity is how the parent responds to (consequates) the child's behavior.

A high-quality learning opportunity is one in which the parent provides a timely, clear consequence to the child behavior that supports child learning of developmentally appropriate skills. A low-quality learning opportunity is one in which the parent provides an unclear antecedent and/or a noncontingent, unclear, inappropriate, or nonexistent consequence to a desired behavior. An appropriate consequence provides some type of reward for desired behavior and either no consequence (ignore) or correction for an undesired behavior (including child non-responsiveness).

The ABC Pattern of Behavior

For the purposes of our coding, we will think of learning opportunities within the ABC pattern of behavior:

1) **The antecedent (A).** An antecedent constitutes a stimulus or opportunity for a child's behavior. *What did the parent say or do in an attempt to elicit the desired child behavior? What provoked the child to act or speak? Was there some stimulus in the environment that elicited the child's behavior?*

2) **The child's behavior (B).** The child's action (verbal or nonverbal). A behavior may be in response to an antecedent or it could be spontaneous (e.g., starting to sing a song). Note that a lack of response (ignoral) to an antecedent would also constitute a behavior (e.g., if the parent asks the child, "Do you want juice?" and the child continues to play with his hands, this would be coded as "No Response.") *What did the child do?*

3) **The consequence (C).** A consequence is the parent's response to the child's behavior. This includes verbal and nonverbal responses and environmental consequences that the parent sets in motion. For instance, the parent might verbally praise the child or may grant the child access to a material, the parent might continue to play a game or sing a song after the child's turn, or she/he might pair a verbal and nonverbal response. The parent might give the child a tangible reinforcer like an M&M or may provide a smile with gaze and nod, or tickles/hugs. The consequence might be withholding rewards like social attention or desired objects (e.g., the parent ignores the child behavior) or it might be a parental behavior that is unrelated to the child's behavior (e.g., the child completes a puzzle, and the parent immediately starts singing the theme song to *Vampirina without providing social attention to the child*). To identify the consequence, ask, "What does the parent do as a response to the child's behavior or lack of response?" Note that if a parent and child are playing together, the consequence might be that the parent continues to play with the child in an ongoing game or routine. *What was the parent's response to the child's behavior?*

Definitions

In this project, we will code 4 variables capturing different aspects/characteristics of the parent-child interaction. The first two relate to the use of antecedents by the parent and the last two consider the complete learning opportunity:
      1.   Antecedent Frequency Matches Child Responding

2.   <u>Provides a Variety of Opportunities to Respond</u>
3.   <u>Provides High Quality Learning Opportunities</u>
4.   <u>Activities and Materials Are Used to Build Child Motivation</u>

Each of these variables will be rated on a score of 1-5, with 5 representing highest quality LO's and 1 representing lowest quality LO's. Definitions of each variable and behavior anchors for each of the 1-5 ratings are described below.

1. ***Antecedent Frequency Matches Child Responding***. **Parent provides opportunities to respond frequently throughout the interaction**. The rate of opportunities that is appropriate for the parent to use will depend on the child's age, skill level, and mood. Pay attention to how *often* the parent provides the child with an opportunity to respond. Another way of thinking of this is how often is the parent providing the child with an *antecedent*. This can be asking a question, indicating a choice of toy or activity (verbally or nonverbally), repeating a word to get a response, continuing a play activity or conversation to encourage more responding, giving an instruction to complete an action like put a puzzle in place, etc.

   Generally, a parent will present an opportunity for the child to respond at least, every 30 seconds unless there is something in the interaction that would make this inappropriate (e.g., a child is in the middle of a tantrum). If a parent is providing opportunities too frequently (e.g., asking numerous questions or giving multiple conflicting instructions without allowing the child adequate time to respond or enjoy the reinforcement), this would lower the score. Note: In situations where the antecedent is unclear, look for situational or environmental antecedents like a toy being present in the surrounding area. It is also possible that the child's behavior is spontaneous. These instances would not count towards the parent's delivery of antecedents, but the parent response to the child behavior would be coded under *Quality*.

   5: Learning opportunities are consistently provided to the child throughout the observation (roughly every 10-30 seconds) at a rate that keeps the child engaged and encourages responding. The parent takes advantage of most opportunities to help child learn. The child has adequate time to respond before a new learning opportunity is presented. OR the child gets upset and the parent clearly adapts the frequency of demands to account for child mood. Changes to the materials, level of difficulty, and other aspects of the *content* of the antecedent the parent may make to regulate child mood are captured in the other codes.

   4: Opportunities to respond are provided on average every 30 seconds, but there is some room for improvement in their delivery. For instance, the parent might repeat a command multiple *times before the child has the chance to complete the instruction,* however the parent cues are related enough that the child is not receiving conflicting information. Alternatively, the parent might miss some obvious opportunities to create a learning opportunity (e.g., the parent is taking more of a passive role in the interaction).

3: There are issues with the pacing of opportunities to respond (e.g., may be too frequent—more than every 10 seconds or too infrequent—average less than every 30 seconds), but this does not result in behavioral issues.

2: There are issues with the delivery of opportunities to respond and it is the pacing that contributes to child frustration/boredom in such a way that disrupts the parent-child interaction. For example, the child is upset, and the parent continues to provide a high frequency of opportunities to respond OR the child is unengaged, and the parent provides very infrequent opportunities to respond OR the parent ignores child initiations and focuses on providing his/her own cues instead, controlling the activity.

1: There are minimal learning opportunities provided. The parent is primarily observing the child and not interacting. NOTE: This includes instances of parent narration (e.g., the parent is narrating what the child is doing with no expectation of child response and does not provide any other learning opportunities).

2. *Provides a Variety of Opportunities to Respond*. **Parent provides a variety of opportunities to respond, allowing for a range of child responses to different forms and materials.** The parent should vary both the *content* of the cues that they present to the child throughout the session (e.g., in a puzzle activity, the parent can provide the cues, "put on," "over here, and "this one" to help the child complete the puzzle and this would be varying their content) as well as the *form* of the cues (e.g., instructions ["put on"], questions ["what piece goes next?"], gestures [points to puzzle piece], taking a turn with a toy, cloze statements ["it's a _____ " while holding up a lady bug piece]).

 In addition to varying the way they present cues; consider the way the parent expects the child to respond and has the child interact with materials in the learning activity. For example, if the 5-minute video only involves the child completing a 6-piece bug puzzle in the same way multiple times, this would score lower than a video in which the parent takes a turn with the puzzle, naming the bugs, pretending to catch the bugs, or asks the child to pretend to feed the bugs, name the bugs etc.

 Similarly, if the parent is varying form and content but the expectation of the child's response is not varied, this would score lower (e.g., "Where does this go?" and, "Put it over here," in a puzzle activity require the same child response). A good rule of thumb for this item is to ask yourself, "What is the child being asked to do in this video?" and counting the different types of behaviors expected (e.g., completing the puzzle, verbally identifying the bugs, choosing which piece to go next, cleaning up).

 Make sure to include instances of prompting towards this item. For instance, if a child is struggling to complete an action but the parent continues to repeat the same cue over and over, this would count towards a lack of variety in their form and content. If the parent prompts new behaviors that would increase variety.

  (**Note**: See *Supplemental Materials > Hierarchy of Opportunities to Respond* for help defining different antecedent forms.)

5: The form and content are both varied across the observation and the parent and child use the materials in different ways OR use a variety of materials. The child has opportunities to respond in different ways throughout the observation.

4: The form and content are fairly well varied OR there are a lot of different materials, but the activity is a bit repetitive at times. The child has the opportunity to respond using different modalities.

3: The parent manages to vary the form OR the content of their cues, but not both, OR the expectation for form of child responses lacks variety (e.g., always a motor action or verbal response).

2: The activity is largely repetitive, the child is asked to do the same thing over and over without much variability in the instructions provided by the parent (e.g., "put in" during puzzle activity) and there is little variety in expectation of child response (e.g., only putting the puzzle piece in the puzzle).

1: There are minimal opportunities for the child to respond OR only one type of opportunity to respond is provided in the observation and materials are not varied.

3. ***Provides High Quality Learning Opportunities*. Parent utilizes high-quality antecedent and consequence strategies.** Consider the ABC pattern of behavior when coding this item:
   - **Antecedent (A).** To identify, ask: What did the parent say or do in an attempt to elicit the desired child behavior? What provoked the child to act or speak? High quality antecedents are those in which it is clear how the child is supposed to respond. Did the parent gesture to toy choices? Did they set out materials and allow the child to explore them? Did the parent say something? If the antecedent is verbal, consider the language the parent is using and the child's verbal level. The antecedents provided should be close to the child's language level and understandable by the child (e.g., not giving multiple sentence cues to a child who is barely verbal). A high-quality learning opportunity may occur without a clear antecedent presented the parent if the parent responds (see C) to spontaneous child behavior.
   - **Child Behavior (B).** What did the child do? (Note: If the child does not respond to (ignores) a clear instruction or question, that would be considered a behavior.)
   - **Consequence (C).** What was the parent's response to the child's behavior? A high-quality response to the child's behavior should match the child's behavior (ignore or correct inappropriate behavior or no response and reward/praise appropriate behavior). For example, if the child puts the piece in the puzzle, an appropriate consequence would be to respond to the child (e.g., "Yay!" "Good job!" "It goes there!" "You put it in!" "Yes, the hat goes on the head!"). The praise or verbal responding may be even more powerful if it is paired with tangible reinforcement (e.g., the parent doing something the child likes, granting access to a material, or continuing a play activity). If the child answers a parent question, an appropriate consequence would be acknowledging the child's response. If the parent asks the child, "Which one?" and he or she indicates the desired toy, the appropriate consequence would be to provide the

toy to the child. If the child hands the parent a juice box to open, the parent opens the box and hands it back to the child. Parents may also label the child's actions or toys as a consequence (e.g., "Bird," or "In," in response to the child putting a bird puzzle piece in the puzzle). An inappropriate child response would be ignored or redirected by the parent and a lack of child response would lead to prompting or assistance from the parent.

- o   Note: It does not matter if the child behavior is spontaneous or parent-initiated, all that matters is the parent's response to the child's behavior.
- o   *Prompting*. Sometimes a parent might desire a fuller or more sophisticated response from the child (e.g., the child points to their desired toy but the parents want them to vocalize). Pay attention to how often the parent is prompting for a greater (e.g., more advanced or complex) response from the child. If this occurs too often, this will count against the parent, especially if the child begins to lose interest or get frustrated as a result of the delay in consequence. If prompts are supportive of a correct answer, this would count towards the quality of the ABC. If a child fails to respond to the antecedent, the consequence should be a prompt to help the child complete the behavior.
- o   *Narration.* A parent narrating the child's behavior is considered an engagement strategy, not an opportunity to respond because the parent is not expecting or prompting for a *behavior* from the child. For example, if a child is playing with a train set and the parent sits nearby stating what the child is doing (e.g., "Driving train) this is different than the parent providing a reframe or an expansion (e.g., Parent hands the child the train to put on the track and labels, "Train" when the child starts pushing). The difference is in the parent's active role in the interaction with the child and the parent's role in eliciting *behavior.* Ask yourself: Does the parent's contribution to the interaction change the child's behavior in any way or are they simply narrating what the child is doing?

5: Learning opportunities are provided at the highest quality. Antecedents are clear and appropriately suited to the child's level and the consequences are delivered promptly in response to the child positive behavior and encourages the likelihood that the child will repeat the behavior in the future. Inappropriate behaviors are ignored or corrected. Prompting supports child responding to maximize both success and independence.

4: Most learning opportunities are high in quality, but there are occasional instances where an antecedent is left hanging or a child behavior is not consequated. Prompts are appropriate and well-suited to the child's level.

3: There is room for improvement in the delivery of the ABCs. Either antecedents or consequences are delivered poorly up to 50% of opportunities (e.g., child told to do multiple things in quick succession, consequences are perfunctory acknowledgments, antecedents provided are at times too complex or consistently too simple) OR prompting is somehow insufficient (e.g., not enough, only utilizes one form, not well-executed). OR an inappropriate behavior is rewarded.

2: Antecedents are mostly unclear or developmentally inappropriate as evidenced by the child's confusion or the parent's continuous prompting of a different response and consequences are often inconsistent or inappropriate (e.g., the parent reinforces negative behaviors). More than 50% of antecedents and /or consequences are delivered poorly.

1: There are minimal learning opportunities provided. It is hard to tell if the parent is employing any kind of antecedent or consequence strategies.

4. **Activities and Materials Used to Build Child Motivation. The parent uses materials and self and arranges activities in a way that enhances the child's interest in performing the skills to be taught.** Think about the set-up of the activity. Is the child interested in the materials? Is it set up in a way that allows for the parent to maintain some control of the activity? Are there too many or too few materials present to keep the child engaged for 5 minutes? Pay attention to how the parent reacts to child indications of interest or attention. Note that compliance does not always indicate child motivation.

> **5**: The activity is set up in such a way that the child is highly motivated to interact with the materials, the activity, or the parent. The parent keeps instructional control of the materials. Parent is proactive and alters the activity or interaction in order to match the child's level of interest and keep engagement as the child's interest changes. Note that it is acceptable for a parent to have a child close out an activity before moving on to something new if the child's interest changes (e.g., "Two more pieces and then we can choose a new toy"). The expectation is not that the parent immediately moves on to something new, but that they are clearly responding to the child's interests.

> **4**: There are ways in which the activity could have been better set up to allow for more engagement in the activity (e.g., the parent and child could share the materials, so the child is not playing by themselves while parent is modeling an appropriate turn) OR the child clearly wants to end an activity and the parent takes longer than optimal to respond but does respond before the child engagement is entirely lost.

> **3:** There are obvious ways in which the activity might have been better constructed to allow for more child motivation in activity. OR the child is interested in the materials, but the parent is unsuccessful in their attempts to engage the child in learning opportunities. OR the child never gets engaged with the parent's attempts despite continuous efforts to find something that interests the child.

> **2:** The parent briefly motivates the child to interact with materials but fails to add much to the overall activity (e.g., only narrating what the child is already doing or the set up does not give the parent any control of materials). OR the child is clearly bored and/or disinterested in the activity and the parent does not attempt to engage the child with new materials or activities in a timely manner and it results in

behavioral issues. OR the parent use of antecedents or consequences decreases child motivation in the activity.

1: The child is not motivated. The parent does not address the child's motivation at all.

Supplemental Materials

	Hierarchy of Opportunities to Respond		
	Type of Opportunity	**Definition**	**Example**
Decreasing levels of support	Physical Prompt	Parent physically helps child complete the action.	Parent places hand over child's hand to help place a coin in the piggy bank.
	Gesture/Play Model	Parent models the action expected from the child.	Holds up a toy and models a point. Feeds a doll with a spoon.
	Verbal Model (exact or open-ended)	Parent models a sound or word for the child to imitate or provides the first part of a familiar phrase for the child to complete. Parents singing a song or reading a book without pausing for child participation is coded here.	Says, "spoon" when the child is reaching for the spoon.
	Instruction	Parent gives a direct instruction telling the child exactly what to do.	Says, "Feed the boy."
	Question	Parent asks a direct question for child to answer. The level of support varies with the type of question (e.g., require a choice among options or open-ended).	Says, "Should the boy eat peas or yogurt?"
	Facial Expression	Parent waits expectantly while attending to the child. Lifts eyebrows and opens eyes wide while controlling access to desired materials or activities.	Holds up the doll and gives child an expectant look.
	Comment	Parent makes a leading comment when child is attending to parent.	Gains the child's attention and says, "The boy is hungry."
	Situational	Parent set-up activities or situations that are incomplete or broken to elicit communication. Or there is	Puts a doll, spoon and bowl on the table near the student. Struggles to

| | | something in the environment that provokes a child behavior. | open a jar of bubbles to allow for child response. There is a desired toy out of reach. |
| | Spontaneous | It is not clear what has precipitated the child's behavior. | The child spontaneously requests a song. |

Joint Engagement Rating Inventory Scoring Instructions

Adapted from (Adamson et al., 2016)

Joint Engagement Rating Inventory Coding Instructions

Introduction
This coding project examines the **child's engagement** within a parent-child dyadic interaction using an adaptation of the Joint Engagement Rating Inventory (JERI; Adamson, Bakeman, & Suma, 2016). The JERI is used in numerous studies of early joint engagement and communication development in typically developing toddlers and young children with autism spectrum disorder and other developmental challenges. In addition, the authors work with colleagues to continue to adapt rating items for use in a range of intervention and developmental studies. The JERI includes items that examine both parent and child behavior, however, for the purposes of this specific project, we have chosen to focus on Child Engagement State Items (i.e., Total Joint Engagement) and Child Behavior Items (i.e., Initiation of Communication).

Instructions
The observer's task is to view video records of a five-minute parent-child toy play activity and to make judgments about the interaction using seven-point items. Two pre-selected items are defined, each with 7 points: 1 indicates a very low rating and 7 a very high rating. Anchors and midpoints are specified for each item. Note that these are descriptions, not value judgments. A rating of 7 is not necessarily better than a lower rating nor is it always optimal. Ratings should be based on what occurred during the entire five-minute observation period, not just the period of time when the caregiver and child were interacting. When selecting a code if you are stuck between two scores and unsure which to choose, go with the lower score.

Note Taking
Raters should take notes as they watch (and re-watch) the video of an interaction. At first, these notes might be quite copious, however, as the coder develops a fuller understanding of what is needed to make rating decisions, these notes likely will become more concise and targeted. In all cases, these are not data, and no reliability assessment will be made of them. However, they will guide decisions, and they will be useful when raters discuss why they selected a specific rating. **At minimum**, the notes will likely include timestamps of state switches. Each coder should focus on how it is easiest and most efficient for them to take notes, what strategies work best for them for grouping items when viewing and rating, and to monitor the time it takes to complete an assignment (we suggest a minimum of 2 viewings of a video). It is

helpful to review the definitions before coding, keep them open while viewing the video, and reference them when making final coding decisions.

One essential element of the notes is general time markers. These are needed to estimate the amount of time spent in various engagement states. *They also can help keep memorable moments from dominating a rater's attention when deciding on a rating*. Similarly, keeping notes of specific events such as the level of parent involvement, the occurrence of a specific activity, and the child's verbal or non-verbal communication, can help keep track of positive and negative instances (e.g. the level of child engagement in the activity, if there is coordinated parent-child attention, or whether the child's communication is directed).Notes also provide a helpful reminder of what happened should the video need to be reviewed for agreement, reliability, or clarification of a question at a later date.

Notes help to keep track of what is actually happening rather than what a rater readily remembers. *Raters are not expected to keep notes as specific as would be needed to do micro-coding (accounting for each second)*, but the notes should be thorough enough to remind the rater what they determined to be relevant when assigning a rating for a particular item.

See JERI Coding Form Notes Template for an example of the level of detail we typically expect from coders.

Definitions

In this project, we will code 2 variables capturing different aspects/characteristics of the child's engagement in the parent-child interaction. The first relates to the child's overall engagement in the activity and the last considers the child's communication:

5. Child's Total Joint Engagement
6. Child's Initiation of Communication

Each of these variables will be rated on a score of 1-7, with 7 representing a high rating and 1 representing the lowest. Definitions of each variable and behavior anchors for each of the 1-7 ratings are described below.

Child's Total Joint Engagement

This coding project utilizes the *Child's Total Joint Engagement* item. In this scheme, the rater is asked to assess the child's joint engagement with objects or events, both real and symbolized (e.g., imaginary), that they **share with the caregiver.**

The term "joint" is key to these items. It refers to a shared topic. Thus, for a child to be considered "in" joint engagement, he or she **must be attending to the same object or event as the caregiver**. It may be helpful to think of this engagement as triadic since it involves the child, a shared object, and (either explicitly or implicitly) a partner. Joint engagement may also occur when the topic is in the here and now (e.g., during a toy car activity, the child is rolling the car to the caregiver. The caregiver acknowledges the car and rolls it back to child, indicating that both parent and child are attending to the same object) or when it is partially or fully present through symbols (e.g., during a block activity, the caregiver lifts a block and

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makes rocket ship sound effects and the child says, "3, 2, 1 blast off!") What is significant to note is that the child and the caregiver are focused on the same object or event within the activity and are not merely playing parallel to each other with the same materials (e.g., during a matching game the child is looking for a match while mom is looking for her own match; materials are shared but there is no attention to each other's efforts).

Because joint engagement involves the flow of the child's attention, we find it helpful to think of it as a "state" because it emphasizes that joint engagement has duration and that it occurs in episodes that begin and end. Thus, we do not credit a fleeting glance to a person or a single quick point to a shared object as joint engagement. To help differentiate joint engagement from other states (including unengaged, onlooking, and object) and decision rules about when a joint engagement state gradually wanes refer to the table on pg. 6.

One of the challenges of rating joint engagement states is to **remain child centered**. The ratings are made of the child's attention while the child is actively engaged with a partner whose participation is needed for a joint engagement state to occur. The partner's participation is usually evidenced by active manipulation of the object although it may also be conveyed by communicative acts that are related to the shared event. **A child cannot be in a state of joint engagement if the partner is not involved.** There may be times when a child is seeking joint engagement, but the caregiver is not engaged with a shared object or vice versa where the caregiver is trying to engage the child, but the child is ignoring the caregiver's bids for attention. **There are also times when a caregiver is merely *narrating* the child's actions and not actively engaged in a shared activity** (e.g., the child is playing with a train set and mom is watching and saying "choo choo" without actively participating by taking turns, making suggestions, asking questions, etc.). In such instances, the child is not in a state of joint engagement.

Another challenge is to determine if the child is indeed actively involved with a shared topic that focuses on objects and events over and above the social interaction.

- Joint engagement is not credited when the caregiver and child engage in dyadic play (e.g., a game of peek-a-boo) that does not include a shared focus other than their mutual activity. When there appears to be a topic beyond the social interaction, be sure that there are clear indications that the child is engaged with the shared topic (e.g., during an animal puzzle activity, the caregiver asks, "Do you remember when we saw a monkey at the zoo?" and the child responds, "Yeah! He was eating bananas!")
- Partners may act in ways that make it appear that the child is sharing an object or an event even when the child's attention is elsewhere. They may also attract attention so that the child watches their display or demonstration without fully engaging with it; in such cases the child is considered to be in a state of "onlooking" rather than in a state of "joint engagement." For example, during a turn-taking activity, the caregiver gives suggestions during the child's turn (e.g., "Faster," "Look out for the tunnel!"), but when the caregiver's turn is happening, the child is looking elsewhere or playing with different materials.
- Be careful not to assume that a child is jointly engaged with the topic of a partner's speech and gestures if the only indication of their involvement is that they seem to be

listening to the partner. It is important that there be clear indications that the child is engaged with the same specific topic on which the partner is focused.

This item focuses solely on the amount of joint engagement. As described above, joint engagement occurs when the child actively engages with the same object or event that the partner is attending to. Joint engagement may be as brief as a 3 second episode or it may be sustained for many minutes. The overall amount of joint engagement is the sum of time spent in all periods of joint engagement. **Child's Total Joint Engagement** describes the overall *quantity* of joint engagement during a scene.

Coding Tip: Because this item focuses on *quantity*, it is helpful to jot down time stamps of joint engagement to allow you to calculate the overall joint engagement for the observation.

The anchors are:

1: No episodes of the joint engagement state. The child might be unengaged for the entire interaction, never getting involved in the activity, or may be totally engaged in the object, oblivious to the caregiver's contributions.

2: Characterizes a child who is jointly engaged for no more than 20% (1 minute) of the observation. This might be one sustained, minute-long joint engagement interaction, or a series of more brief periods of joint engagement.

3: The child is jointly engaged for roughly 30% (1:01-2:29) of the overall observation. This may consist of several brief or a few relatively sustained episodes.

4: Characterizes a child who is in joint engagement for approximately half of the observation (roughly 2:30-2:59). This may consist of several brief or a few relatively sustained episodes.

5: The child is jointly engaged for 60-75% of the observation (approximately 3:00-3:45). This may consist of several shorter or a few relatively sustained episodes of joint engagement

6: Characterizes a child who is in joint engagement for more than 75% but less than 95% of the observation (about 3:46-4:30). This may consist of several shorter, few relatively sustained episodes of joint engagement, or one long episode.

7: The child is almost always (roughly 95% or 4:31 minutes of the 5-minute observation) spent in the joint engagement state.

Child's Initiation of Communication

A communicative initiation occurs when the child attempts to lead the interaction with his or her caregiver in a new direction. Thus, a turn that is an initiation is **more than a direct response to the caregiver's previous turn**.

An initiation often occurs at the beginning of a series of communicative turns. For example, the mother and child are discussing a picture of a giraffe, and the child says, "Baby!" and points to a new photo of a baby to call the caregiver's attention to it. An initiation may also occur within an ongoing sequence when the child introduces a new object or topic in a way that might redirect or substantially expand the interaction. For example, a communication initiation occurs when, after sharing a toy car with the caregiver, a child picks up a second car and says, "Let's race, Mommy!" Another example of an initiation is when the child draws attention to a new feature of an object such as its color without being prompted. However, if the child stayed focused on the original car and said, "Red," after the mother asked, "What color is this?" or after they were naming colors of other objects, this would not be considered an initiation because it does not move the interaction in a new direction but rather follows directly upon the prior turn.

The child's communicative initiations may be *verbal* (spoken, augmented, or manually signed) or *nonverbal* (communicative gestures, an intentional vocalization). Nonverbal initiations are often more difficult to identify than verbal initiations. Examples include showing or offering an object to the caregiver in an attempt to start a shared activity or pointing emphatically to an object that the child wants the caregiver to see. Note that if a child hands a caregiver an object and then walks away or turns his attention to different object, the child is not initiating an interaction with the caregiver. For simplicity we often use the terms verbal and nonverbal to describe communication. Our definition of verbal communication includes speech as well as use of an AAC device to produce a word, and manual sign. Nonverbal communication refers to intentional actions that convey specific messages including communicative gestures (e.g., pointing) and discrete affective expressions (e.g., a smile).

The child may inadvertently influence the course of the interaction without making an initiation. For example, a partner may join in on the child's on-going activity without being invited to do so. Or a child may grab an object from the caregiver without indicating an intention to communicate that he wanted to start a turn taking sequence. Even if the caregiver treats the grab as an invitation to start a game of turn taking, do not consider such inadvertent influence evidence of child's initiation of communication. Also remember that initiations must be directed to the caregiver. For example, a child engaging in solitary pretend play with a school bus in the corner may introduce many new topics and expansions to herself without directing these comments or play to the caregiver.

The item, *Child's Initiation of Communication*, characterizes **the child's active attempts to initiate communication during his or her interactions with the caregiver**. A high rating usually indicates that a child had made many initiations about a variety of different topics throughout the scene. It can also indicate that the child has repeated the same distinctive initiation (e.g., "asking" the caregiver to blow up a balloon over and over again either verbally by saying "more balloon" or nonverbally by emphatically offering the mother the balloon to blow up again). However, do not credit all repetitions as initiations if they are not distinct attempts to start a new round of interaction (e.g., the child who repeatedly whines "I want" when asking for an object.) Give primary consideration to how often and how clear and readily

interpretable the child's initiations are, not to their specific form. A child who is high on this item often gives you the sense that he or she is taking the lead.

    Coding Tip: Write down all examples of child-initiated communication. Make sure to note whether the instances are clearly child-led and the clarity of the child's communication. It is helpful for discussing videos if you include the time stamp for the initiations when possible

The anchors are:

        1: Never makes a communicative initiative. This might be a child who does not acknowledge the parent, or it could be a parent-child interaction where the parent takes the lead, and the child is constantly responding without taking any initiative in the interaction.

        2: Child makes a single initiation in the five-minute observation or multiple instances of child communication that are not clearly directed to parent (e.g., self-directed babbling).

        3: Child makes two clear initiations in the five-minute observation (may include multiple unclear instances of initiation).

        4: Child clearly takes the lead a few times during the interaction with the caregiver. There may be other instances that are ambiguous, but at least 3 instances of clear communication

        5: Child makes multiple (4-5) clear communicative initiations; some communication may be unclear to the parent (note that lack of clarity is different than the parent ignoring the child's initiation).

        6: Child makes several (at least 6) clear communicative initiations, may include some communications that are not clear to the parent.

        7: Continually makes **clear** communicative initiations (more than 6). Child leads the activity numerous times throughout the interaction.

Engagement State Definitions

<table>
<tr><td colspan="3">Note: The distinction between forms is descriptive, not evaluative. For example, coordinated joint engagement is not "better" than supported joint engagement. Rather in episodes of coordinated joint engagement, the child is actively acknowledging the partner and in episodes of supported joint engagement the child is not actively acknowledging the partner's involvement with their shared topic.</td></tr>
<tr><td>Engagement State</td><td>Definition</td><td>Example</td></tr>
<tr><td>Unengaged</td><td>No apparent engagement with a specific person, object, or symbols. The child may be unoccupied, may be scanning the environment as though looking for something with which to be engaged, or may be flitting between foci without committing to any. This also includes when the child is crying or having a tantrum and is not focused on any particular object or person.</td><td>Child is moving around the room looking at various toys available to them but is not actively playing with a specific item.</td></tr>
<tr><td>Onlooking</td><td>The child is watching another person, observing his or her activity. The child may be looking primarily at the other person, or at objects the other person is manipulating, or at both the person and object. The child is not involved with the other's activity but is merely an audience, a listener, and, at the moment, is making no active commitment to being an actor in the "show" being observed. This state requires definite interest in whatever the child is watching, particularly since the state is maintained primarily by the child's interest, not actions. This does not include times when the child is animated as well as interested while involved with an object, person, and/or symbol</td><td>Child is watching parent play with a toy train, focusing on the train moving around on the tracks without attempting to engage with the toy or parent.</td></tr>
<tr><td>Object</td><td>The child is engaged in object play, exploring or playing with object(s) by him or herself. The partner may attempt to engage the child during Object play, but the child ignores her. Do not include times in which the child is merely in contact with an object, as when he or she "absent-mindedly" holds a small toy while scanning the room, that would be considered *Unengaged*.</td><td>Child is playing with train set and is not interacting with the parent or acknowledging parent bids for attention.</td></tr>
<tr><td>Person</td><td>The child is engaged with another person only. The child must be engaged actively with the other person, not merely *Onlooking*. Typically, the other person is also engaged with the child, but this person's level of involvement may be minimal (i.e., only looking at the child) or even nonexistent. If objects are involved, they play only a minor role (e.g., child holds on to a toy but seems to pay no attention to it).</td><td>The parent tickles the child, and the child appears to be reacting to the tickling activity; the child and parent make a game of the child jumping into the parent's arms.</td></tr>
<tr><td>Supported Joint</td><td>The basic definition of JOINT ENGAGEMENT is that the child is actively involved with an object or event with which the other person is also engaged. Thus, a key decision is whether or not the other person is engaged with the same topic as the child. Usually, the partner's engagement is evidenced by active manipulation of the object. However, the partner may be engaged without touching the object when, for example, he or she remains</td><td>Mother and child take turns rolling a ball and the child is focused only on the movement of the ball; Mother demonstrates the ways that a toy works as the child observes and then immediately imitates</td></tr>
</table>

	actively focused on a shared event while the child is playing with the object. If the other person is looking at or touching the object primarily to help the child gain access to an object (e.g., clearing away interfering toys, essentially "housekeeping"), but is not clearly changing the child's experience with the object, this would be *Object* and not *Joint*. Also, if the other person is merely talking about the event, essentially providing a background narrative of the child's activity, this is not considered *Joint*. For a joint state to be coded as *Supported Joint*, the other person's involvement influences the child's activity with the object, but the child does not acknowledge this involvement. To be coded as supported *Joint* rather than *Object*, it must appear that the partner's involvement with the object is in some way influencing the child's experience of the object or event.	her action on the object; Mother is making a toy collide with a toy the child is manipulating, and the child does not acknowledge the mother.
Coordinated Joint	Joint coordination involves elements of *Person* engagement and *Supported Joint* engagement that occur in an alternating and/or integrated fashion. The key here is coordination of attention to objects and people. Typically, the child indicates his or her attention to the other person by glancing toward the other person. Unlike in *Supported Joint*, the child acknowledges the partner's involvement. Thus, while the mother's involvement with the shared object during *Supported Joint* is always evidenced by active manipulation, in coordinated joint her level of activity directly on the object may be quite minimal because the child is taking a more active role in balancing attention between the shared object and the social exchange.	The child pushes the truck the mother is pushing and then looks back and forth between the mother's face and the truck; the child bangs his or her hand onto the same toy that the mother is manipulating and then looks at the mother, bangs the toy, and then looks back at the mother, smiling; the child holds up a toy plane, shows it to the mother, and then moves it through the air while the mother acknowledges their shared focus by laughing and saying "zoom."