

Supporting parents in the use of the early start Denver model as an intervention program for their young children with autism spectrum disorder

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Abstract: Parents are the logical intervention agents for young children with autism spectrum disorder (ASD). The early start Denver model (ESDM) is a promising early intervention approach for children with ASD that can be implemented by parents. This study evaluated the effects of training parents in the use of the ESDM. We used a non-concurrent multiple probe across participants design to evaluate the effects of providing five mothers of young children with ASD with one hour per week of training for 12 weeks. Outcome measures included mothers use of the ESDM techniques and measures of the children's levels of engagement and imitation, and expressive language skills. Maintenance of outcomes after one month was also assessed. Results showed four of the five mothers increased the percentage of ESDM techniques that they were using usually or consistently. Four of the five children showed some improvement on at least one of the child outcome measures. This suggests mixed results for supporting parents in the use of the ESDM. Implications and future research directions are discussed.

Keywords: Autism spectrum disorder, early start Denver model, parent training, preschool children

Autism spectrum disorder (ASD) is a pervasive developmental disorder characterized by difficulties with social communication and the presence of restricted and repetitive behaviors, interests, and activities (American Psychiatric Association 2013). It is suggested that the prevalence of ASD in the United States may be as high as one in 59 individuals (Centers for Disease Control 2018). Further, recent developments in identification techniques mean that many children can be reliably diagnosed with ASD before the age of two years (Barbaro and Dissanayake 2010, Chawarska *et al.* 2007). The ability to identify children with ASD at a young age means that intervention can also begin earlier (Dawson and Bernier 2013). Indeed, research suggests that young children with ASD may respond particularly well to interventions aimed at improving cognitive, social, and communicative functioning (Bibby *et al.* 2002, Granpeesheh *et al.*, 2009, Harris and Handleman 2000).

Several meta-analyses suggest that intensive early intervention, that is intervention programs that are implemented for 20 or more hours per week over an

extended period of time, may lead to better child outcomes compared to treatment-as-usual or eclectic treatments (Reichow, 2012). However, it is likely that many families may not be able to access or afford such intensive levels of intervention (Freitag *et al.*, 2012, Vismara *et al.*, 2009). This may be due to factors such as a lack of government funding or the limited availability of suitably trained professionals. In such cases, it would seem of some value to evaluate the extent to which parents can learn to implement effective early interventions with their children with ASD. Parents may be able to implement intervention techniques throughout the day and across a range of natural environments and activities rather than only during designated therapy sessions, thereby potentially increasing the amount of intervention that the child receives (Dawson and Bernier 2013, Granpeesheh *et al.*, 2009). There is now good data to suggest that parent training can be effective for supporting parents in the use of early intervention techniques for improving the cognitive, social, and communication skills of children with ASD (McConachie and Diggle 2007, Meadan *et al.*, 2009, Patterson *et al.*, 2012).

The early start Denver model (ESDM) is an evidence-based naturalistic developmental behavioral

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intervention approach which can be delivered by parents (Rogers and Dawson 2010, Rogers *et al.*, 2012a). It is developed specifically for children with or at risk for, ASD who are between the ages of 12 and 60 months. Many of the intervention techniques used in the ESDM are based upon those used in two pre-existing models of intervention: the Denver Model and pivotal response treatment (PRT). The Denver model is a developmental- and relationship-focused intervention which incorporates techniques designed to foster positive relationships between parent and child, and to increase the child's motivation to engage in social interactions (Dawson 2008, Rogers *et al.*, 1986). PRT is a set of (naturalistic) behavioral instructional techniques that are also intended to increase children's motivation to participate in learning activities (Koegel *et al.*, 2016, Rogers and Dawson 2010). The techniques that ESDM draws from PRT are: opportunities for child choice, use of natural reinforcers, reinforcement of attempts, interspersal of maintenance and acquisition tasks, turn-taking, and the application of systematic instructional procedures (e.g. response prompting, chaining, shaping, and fading procedures).

To date, there appear to be eight studies (reported in nine publications) which have evaluated the effectiveness of ESDM parent training/coaching (Estes *et al.*, 2014, Rogers *et al.*, 2012b, 2018, Vismara *et al.*, 2009, 2012, 2013, 2016, Vismara and Rogers 2008, Zhou *et al.*, 2018). In each of these studies, parents participated in one to three hours of parent coaching per week for 12 or 26 (Zhou *et al.*, 2018 only) weeks. This training was delivered either in person in a clinical setting or remotely via the internet. The results of five of these studies suggest that the coaching was generally effective in improving parent use of the ESDM techniques and that some child outcomes also improved with parent use of the ESDM techniques (Vismara *et al.*, 2009, 2012, 2013, Vismara and Rogers 2008, Zhou *et al.*, 2018). In contrast, the results of two of the studies suggest that, while use of the ESDM techniques increased significantly more for the parents in the intervention group, outcomes for the children in this group did not improve more than those of children in the control group (Rogers *et al.*, 2018, Vismara *et al.*, 2016). The results of the final study suggest that, although parents in the ESDM parent coaching group improved their use of the techniques, this improvement was not greater than that of the parents in the treatment-as-usual group (Rogers *et al.*, 2012b). In light of these mixed findings, there would seem to be value in additional research aimed at evaluating programs for supporting parents in the use of the ESDM.

In the current study, we evaluated the effects of training five parents to use the ESDM with their young child with ASD. The 12-week parent training program was delivered to the children's mothers in weekly one-

hour home-based sessions over 12 weeks. We measured parent implementation of the ESDM techniques and child engagement, imitation, and expressive language. These measures were chosen to allow comparison with previous ESDM parent training research (Vismara *et al.*, 2009, 2012, Vismara and Rogers 2008). They also represent three key developmental areas targeted by the ESDM (Rogers and Dawson 2010). In addition, we evaluated the maintenance of gains one month after treatment. The study was designed to extend previous research on parent-implemented ESDM interventions in several ways. First, we evaluated the effectiveness of the training in the child's home rather than in a clinic or via distance. Another notable feature of the present study is that it appears to be the first independent evaluation of parent-delivered ESDM intervention. All previous studies have included at least one author who was involved in developing the ESDM. This is important because replication by independent research teams would help to establish and extend the external validity of the findings reported by the original researchers.

Methods

Ethical considerations

The relevant University Ethics Committee approved the study. Parents gave informed consent for their child to participate.

Participants

Five children and their parents were recruited for this study. The parents of two of the children were referred by a local organization that provides home-based autism information sessions. Another two parents were referred by a local area District Health Board. The final parent made direct contact with the first author after finding her details on a website listing certified ESDM therapists. Inclusion criteria for participating in this study were: (a) the child was under the age of 5 years at the start of the study; (b) the child had a clinical diagnosis of ASD or was on the waiting list for diagnosis and was considered "at risk" for an ASD diagnosis on the Social Communication Questionnaire (SCQ; Rutter *et al.*, 2003); (c) the child did not have another serious or specific medical, genetic, neurological or sensory condition, and (d) the child was not receiving 10 or more hours per week of early intervention of any type at any time during the study. Parents also had to provide consent to allow videotaping of their interactions with the child during parent training sessions. All of the participating parents had been involved in no more than one other autism-specific parent training program, but they were not participating in any such programs during the present study. This is because parent training is a very common publicly funded intervention in New Zealand, and it was not possible to recruit families who had not received some type of parent training.

Table 1 Family Demographic Characteristics

	Dean	Rick	Sean	Idris	Alex
Primary participant	Mother	Mother	Mother	Mother	Mother
Marital status	Married	Long-term relationship	Married	Married	Married
Employment	None	Part-time	None	Full-time	None
Education	High School	Bachelor's	High School	Master's	High School
Languages spoken at home	English and Cambodian	English	English	English and Tamil	English

None of the parents had specific training in comprehensive NDBIs prior to the study.

Table 1 provides a summary of each family's demographic characteristics. The parents were all mothers. Dean, Rick, and Sean's mothers had previously participated in an autism parent education program, while Rick's mother had attended a 1-day play workshop. Alex's mother had attended a 12-week group parent training program related to improving communication for children with ASD. Dean and Rick's mothers spoke English as a second language. It was determined that both had sufficient language skills to understand the context of the coaching, although some words were simplified for Dean's mother. Prior to the baseline phase, parents completed the SCQ and the first author administered the Vineland-II via interview. Table 2 provides a summary of each child's age, ethnicity, and diagnostic outcomes based on the SCQ (Rutter *et al.*, 2003) and adaptive behavior based on the second edition of the Vineland Adaptive Behavior Scales (Vineland-II; Sparrow *et al.*, 2005).

Prior to the start of the study, Dean, Rick, and Alex were diagnosed by a multidisciplinary team who used the Autism Diagnostic Observation Schedule- Second Edition (ADOS-2; Lord *et al.*, 2012) as part of the diagnostic process. Idris was diagnosed with ASD by this same team, but not until the 10th week of the parent training phase of this study. Idris' mother was concerned that he may have ASD and he was on the waiting list for diagnostic evaluation at the start of the study. It was determined that he was eligible to participate because he was risk of ASD on the SCQ (Rutter *et al.*, 2003) and, based on the team's knowledge of ASD, it seemed highly likely that he would receive a diagnosis. Sean was diagnosed with ASD by a private pediatrician prior to commencement of the current study.

Dean went to a local kindergarten twice a week and attended a playgroup with his mother three times a week. He also received monthly visits from a speech-language pathologist. Rick went to day care three times a week. For the 1st month of the current study, Rick was participating in a food therapy intervention and visited an occupational therapist once per month. Sean's went to kindergarten three times a week, and was participating in a weekly food therapy intervention. In the 9th week of the current intervention, Idris began to attend kindergarten three times a week. He received no

other intervention for the duration of the study. Alex attended kindergarten three times a week and was visited monthly by a speech language pathologist.

Setting and personnel

All parent training sessions took place in each family's home. The trainer (first author) delivered the training via PowerPoint® presentation in Sean's family's dining room and in the living room for the remaining four families. Play activities took place in various locations around the house including the living room, bedrooms, and outside. Alex's younger brother was consistently present during each session. For the remaining children no-one other than their mother was present for most of the sessions. Idris' family moved house in the 6th week of intervention. The trainer was a PhD student and practicing educational psychologist. She had five years of experience working with children with ASD and was a certified ESDM therapist. Although she also had experience working with parents of children with ASD, she had not participated in any training related specifically to ESDM parent coaching. She prepared for the role by practicing ESDM parent coaching with a family who was not involved in the study. She received feedback from the parent and also reflected on her own fidelity.

Materials

During play activities, the participants had access to any available toys and materials that were already in their home. The trainer occasionally brought additional toys to demonstrate how parents might use these materials for promoting particular skills (e.g. a Swiss ball, a toy monkey with accessories, and shaving foam), but these were not used during the initial 10-min of parent-training sessions. During the curriculum assessment, the trainer brought a large box containing an assortment of developmentally appropriate toys, which are listed in Rogers and Dawson's (2010) ESDM therapist manual.

Dependent variables

Data was recorded by the first author. Data were collected on the parent's correct/accurate use of the ESDM techniques and on four child measures: engagement, imitation, functional utterances, and intentional vocalizations (Idris and Alex only). The extent to which parents correctly/accurately implemented the ESDM procedures is referred to as parent fidelity of

Table 2 Child Demographic Characteristics, Social Communication Questionnaire (SCQ) and Vineland-II Results

	Dean	Rick	Sean	Idris	Alex
Age at start of study	3:0	4:11	4:0	1:11	2:11
Age at diagnosis	2:2	3:5	3:3	2:4	2:1
Ethnicity	Cambodian	NZ European	NZ European	Indian	Māori
SCQ	Risk of ASD	Risk of ASD	Risk of ASD	Risk of ASD	Risk of ASD
Vineland II Domain Standard Scores					
Communication	74	85	52	58	59
Daily Living	73	75	58	100	71
Socialization	65	61	63	73	76
Motor skills	82	84	64	100	74
Maladaptive behaviour index	N/A	Clin. sig.	Elevated	N/A	N/A
Internalising	N/A	Clin. sig.	Clin. sig.	N/A	N/A
Externalising	N/A	Elevated	Elevated	N/A	N/A

Note: NZ = New Zealand; Clin. Sig. = clinically significant

implementation. Parent fidelity of implementation was rated holistically for each 10-min videotape. Specifically, it was rated using an 18-item checklist based on the 13 ESDM fidelity categories (Rogers and Dawson, 2010). An adapted checklist was used to increase the ease of data collection and to increase objectivity. These categories were: (a) management of child attention; (b) quality of behavioral teaching; (c) quality of instructional techniques, (d) ability to modulate child affect and arousal; (e) management of unwanted behaviors; (f) quality of dyadic engagement; (g) child choice and optimization of child motivation; (h) display of positive affect; (i) sensitivity and responsiveness to child communications; (j) use of multiple and varied communicative functions; (k) appropriateness of language; (l) use of flexible joint activity routines with theme and variation in activities; and (m) smooth transitions. Each item was rated on a Likert-type scale from 0, which indicated that the parent never used that specific technique, to 4, which indicated that the parent consistently used that specific technique. Scores of 3 (i.e. the parent usually used the technique) and above for each item were considered to indicate an acceptable level of parent fidelity of implementation. The percentage of the 18 techniques that parents used usually or consistently (scores of 3 or 4) was reported for each session. Specific details of scoring and a copy of the checklist can be obtained from the first author.

To record the child dependent variables, each 10-min of video was divided into 60, 10-s intervals. Whole interval recording was used to measure whether each child showed behaviors indicating engagement for the entire 10-s of each interval (Kennedy, 2005). Partial-interval recording (Kennedy, 2005) was used to record whether or not any instances of imitation, functional utterances, or intentional vocalizations (Idris and Alex only) had occurred during each 10-s interval. Definitions of the child dependent variables are as follows:

Engagement with the mother was defined as any clear indication that the child was attending to the adult's face, voice, and actions, as well as any instances

of the child showing social initiation. This definition was based off the description of child attention from the ESDM therapist manual (Rogers and Dawson, 2010). More specifically, this dependent measure was recorded when the child was observed to be: (a) orientated towards the adult, that is facing the adult; (b) smiling and/or laughing in response to the adult's action; (c) looking in the direction that the adult was pointing/indicating; (d) giving, sharing, or showing objects to the adult; (e) imitating the adult's actions; (f) taking turns with the adult; (g) following directions given by the adult; (h) communicating with the adult through words, vocalizations, and/or gestures; and/or (i) continuing or elaborating on the adult's play actions.

Imitating was defined as performing an action with or without an object, or producing an utterance or vocalization, within 10-s of an adult model and without prompting from an adult, such as the adult saying *Do this* or physically helping the child to perform the action.

A *functional utterance* was defined as any utterance by the child that: (a) occurred without adult prompting or modelling of the utterance within 10-s of its occurrence, (b) was contextually related to the interaction with the adult, for example, not unrelated speech, not repetitions of the child's own speech, and not repetitions of adult's prior speech, and (c) contained a phonetically correct approximation of the correct word or word combination (e.g. not saying horse when labelling a cow). Finally, an *intentional vocalization* was defined in the same way as a *functional utterance*, except that it did not contain a phonetically correct approximation of the word or word combination. This measure was only recorded for Idris and Alex because it was appropriate for their level of language development.

Experimental design

The effects of the intervention were evaluated using a non-concurrent multiple probe across participants design (Kennedy, 2005). In line with the requirements of this design, the baseline phase for each child started when the child was recruited. There was some degree

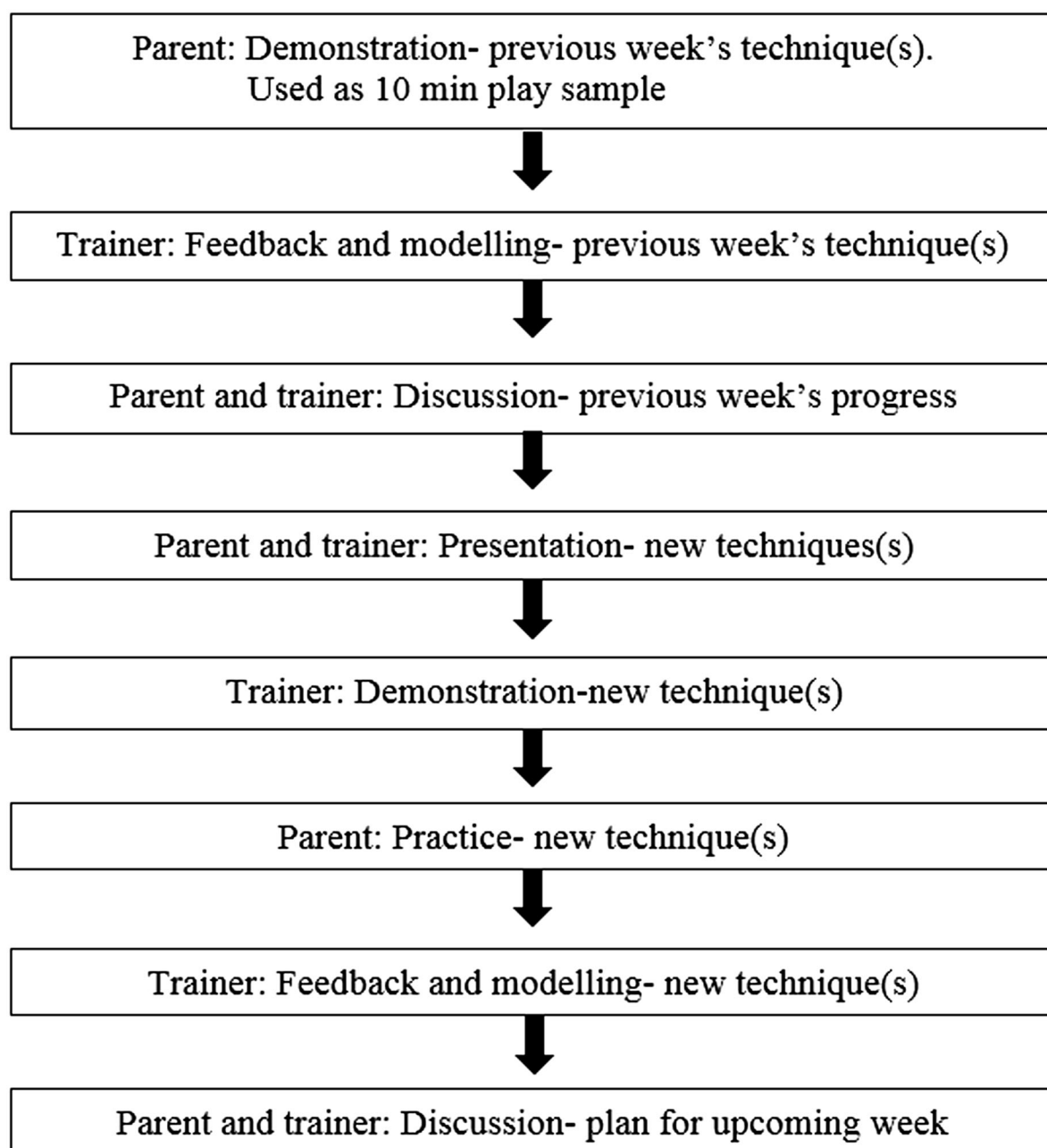


Figure 1 Structure of the 11 parent training sessions.

of overlap for all participants, except for Alex, who began baseline after Rick and Sean had completed the study. Each child/parent dyad participated in the following sequence of phases: baseline, parent training, and follow-up.

Procedures

Baseline

A maximum of one session occurred per week for each child. At the start of each session, the trainer instructed the child's mother to *Play with your child as you normally would*. Once the child was settled into play with his mother, the trainer began filming for 10-min. The trainer did not give any comment or feedback about the play or the parent's interaction with the child during or after the filming.

Parent training

This phase lasted for 12 weeks, with one 1 hour-long parent training session per week. The procedures used in this phase were based on those described by Vismara *et al.* (2009, 2012). During the first parent training session, the trainer played in a naturalistic way with the child for approximately 1 hour. A second research assistant (postgraduate student who was trained but not certified in ESDM) then noted on the ESDM curriculum checklist (Rogers and Dawson, 2010) whether the child displayed a range of developmental skills and instructed the trainer to probe additional skills during the play. The 10-min. play samples were not conducted in this session. Based on this first session and in consultation with the parents, one to three goals were selected for each child for each of the nine

developmental domains (i.e., receptive communication, expressive communication, social skills, imitation, cognition, play, fine motor, gross motor, and behavior). Dean and Rick were the only children who were at a developmental level to have goals in the joint attention domain.

After the 1st week, each subsequent 1-hour session was based upon a chapter from the ESDM parent manual (Rogers *et al.*, 2012a) and 10-min. play samples were collected in each of these sessions. Most ESDM fidelity items were covered during Weeks 2–4, while the remaining weeks focused on how to teach the children specific skills. Specifically, the content covered each week was as follows: Week 2- attention, Week 3- sensory social routines, Week 4- joint activity routines, Week 5- non-verbal communication, Week 6- imitation, Week 7- behavioral learning theory, Week 8- joint attention, Week 9- functional play, Week 10- pretend play, Week 11- speech, and Week 12- recap. Figure 1 illustrates the structure of the remaining 11 parent training sessions, which is an abbreviated version of that outlined by Vismara *et al.* (2009). The 10-min play samples took place during the warm-up activity at the start of the session. Sessions for Rick and his mother were split across 2 days after the 2nd week of parent training because it was determined that his mother was not able to focus on the PowerPoint® presentation and monitor Rick at the same time. In the 1st session of the week Rick and his mother demonstrated the previous week's skills and received feedback from the trainer. Data were collected in this session. In the 2nd session of the week, Rick's mother and the trainer discussed the previous week's progress, went through the PowerPoint® presentation, and discussed the goals for the upcoming week. The 8th parent training session for Idris and his mother was also split over 2 days because on the first day he was sleeping when the trainer arrived.

Follow-up probe

This occurred 4 weeks after the final parent training session and was identical to baseline. Following this probe, the trainer offered to meet with the parent(s) to discuss new developmental goals for the parent to continue teaching their child. Three parents agreed to this. However, Idris and Alex's parents wanted to continue targeting the goals from parent training.

Interobserver agreement

Interobserver agreement (IOA) was assessed by having an independent observer (post-graduate student, trained in ESDM, who had not met the families), who was not blind to treatment phase, record data from the videotapes for parent fidelity of implementation and the four primary child-related dependent variables. These IOA checks were conducted for 30% of the 10-min videos and occurred across all phases of the study for all five parent/child dyads. The independent observer was trained in use

of the data collection sheets and on the operational definition of each dependent variable. The observer also practiced coding a videotape for each child and any issues that arose were discussed with the primary researcher, who directed her to the relevant sections of the operational definitions. These practice videos were not included in the overall calculation of IOA. The overall percentage of agreement for the child-related variables was calculated for each session using the formula: $\text{Agreements} / (\text{Agreements} + \text{Disagreements}) \times 100\%$. Mean IOA for engagement was 86% (68–100%). Mean IOA for imitation was 94% (66–100%). Mean IOA for functional utterances was 93% (55–100%). Mean IOA for intentional vocalizations for Idris and Alex was 94% (87 to 98%).

For IOA checks related to parent fidelity of implementation, an agreement was recorded any time both raters gave a score of usually/consistently, or both did not give a score of usually/consistently. Mean (and range of) IOA for parent fidelity of implementation was 79% (16–100%). IOA was above 55% across all sessions aside from the Alex's second to last parent coaching session, when it was 16%. In this session, on all but two items where disagreements occurred, one rater gave a score of "sometimes" while the other rater gave a score of "usually". This was the most common type of disagreement across all sessions and occurred for all 18 fidelity items. Indeed, when these disagreements were excluded, IOA for parent fidelity of implementation was 96% (72–100%).

Procedural integrity

Data on procedural integrity (PI) was collected during 30% of the 10-min videos and occurred across all phases of the study for all five parent/child dyads. During the baseline and follow-up phases, the same independent observer who conducted the IOA check assessed PI by scoring the videotape using a checklist of the procedural steps. The checklist described each step of the procedures during that phase, for example "the session lasted 10 min", and "Researcher did not provide any feedback to the parent on their play or interaction with the child". The percentage of PI was calculated using the formula: $\text{steps correct} / \text{total steps} \times 100\%$. Mean PI during these phases was 100% for all participants.

During the parent training phase PI was coded in person by several different independent observers (post-graduate students) using a checklist which described each step of the training (see Figure 1). For example, "Parent and trainer discussed progress from previous week" and "trainer provided feedback on previous week's skills". PI during this phase was 100% for Rick, Sean, Idris, and Alex, and 97% for Dean (range = 94 to 100%).

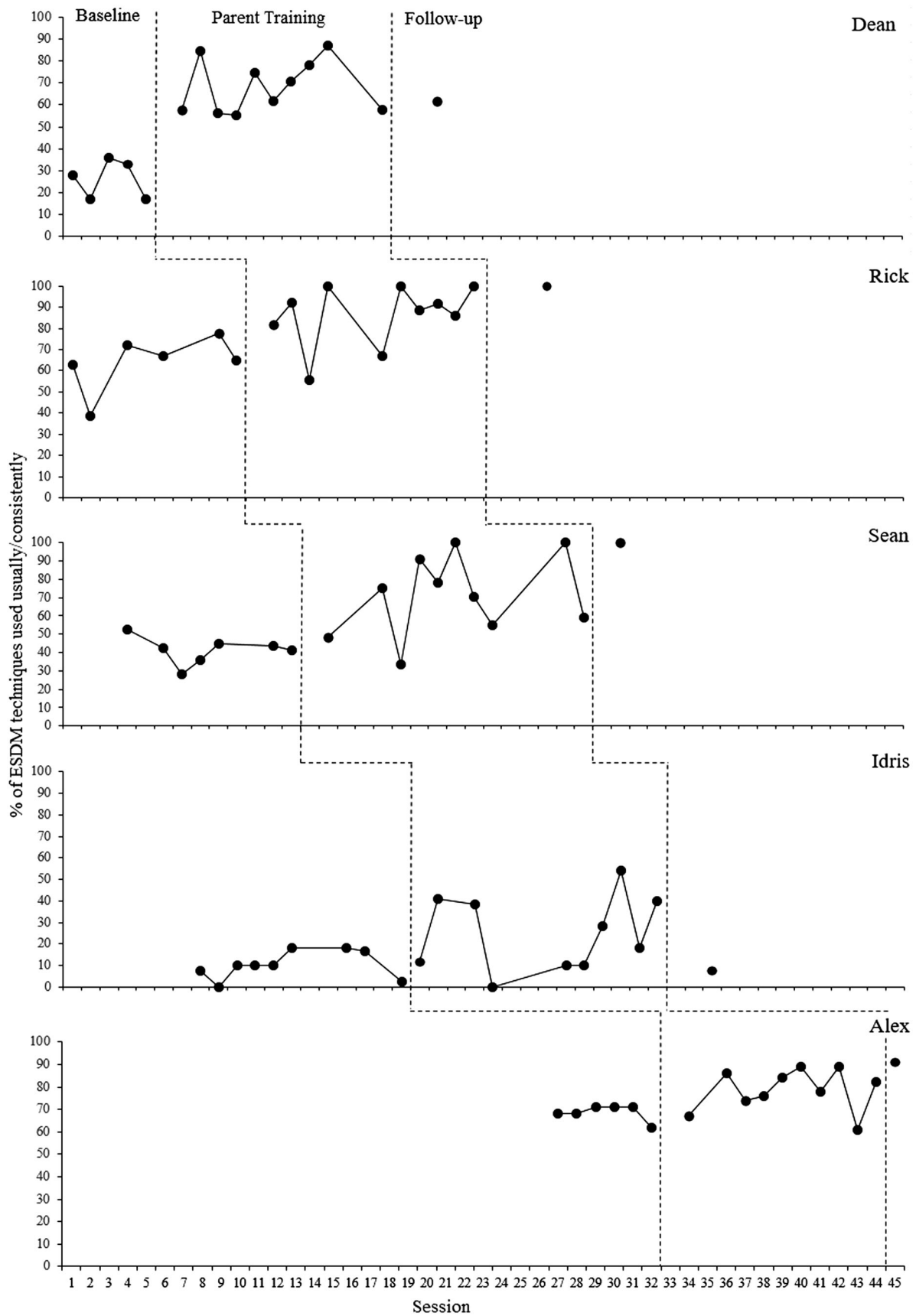


Figure 2 Percentage of ESDM techniques that mothers were using usually/consistently across phases.

Results

The non-overlap of all pairs (NAP) statistic was calculated to determine the effect size of improvements from

baseline to parent training for each of the primary dependent variables (Parker and Vannest, 2009). NAP scores between 0 and 0.65 indicate “weak effects”,

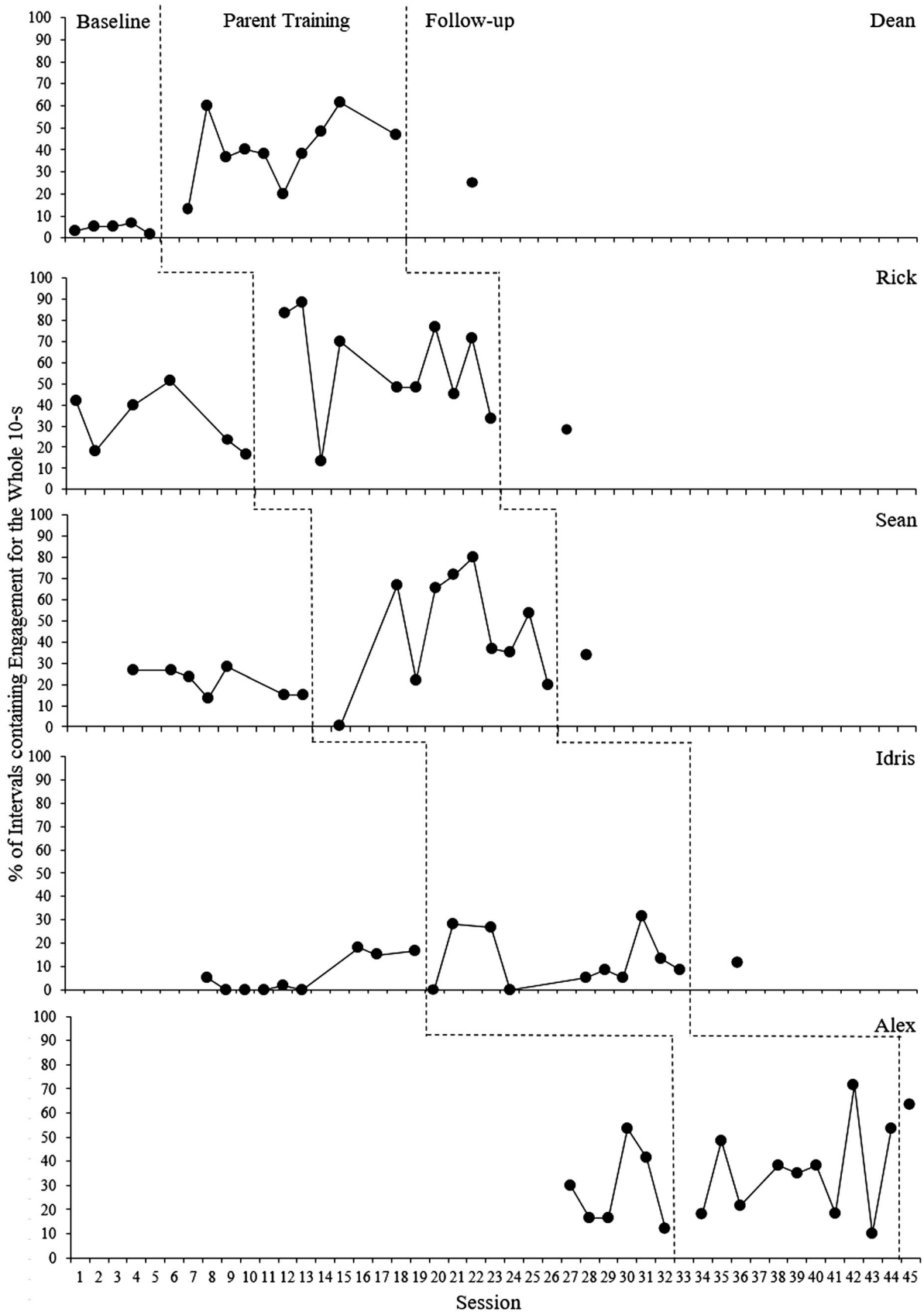


Figure 3 Percentage of 10-s intervals with full engagement per 10-min play sample for each child across phases.

scores between 0.66 and 0.92 indicate “medium effects”, and scores between 0.92 and 1.0 indicate “strong effects”.

Fidelity of implementation

Figure 2 shows the percentage of ESDM techniques that each child’s mother usually or consistently used

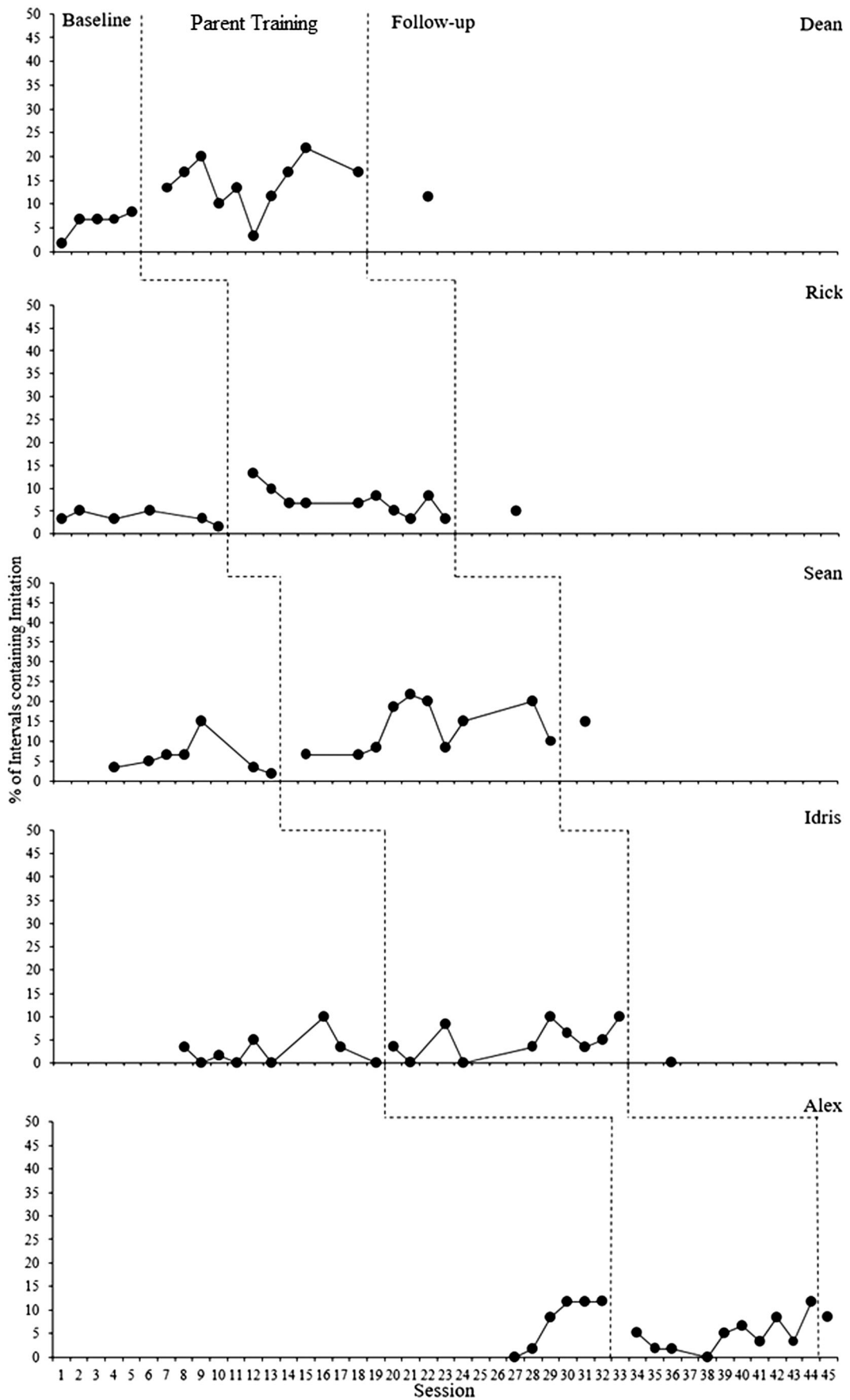


Figure 4 Percentage of 10-s intervals containing at least one independent (unprompted) instance of imitation per 10-min play sample for each child across phases.

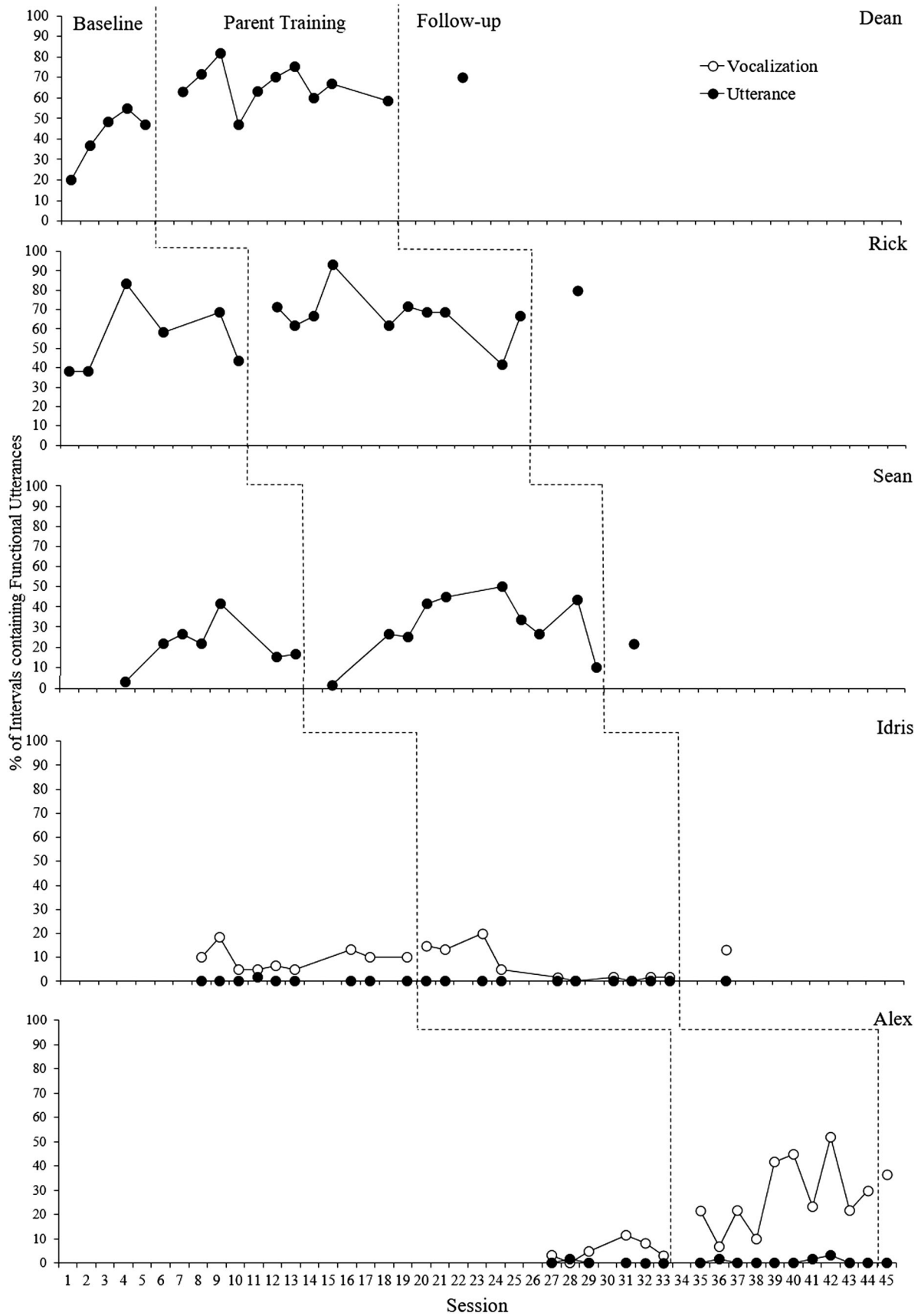


Figure 5 Percentage of 10-s intervals containing functional utterances and intentional vocalizations per 10-min play sample for each child across phases.

(referred to herein as correct implementation) for each baseline, parent training, and follow-up session. Dean’s mother’s mean percentage of correct implementation

increased from 26% in baseline to 68.3% in parent training (NAP=1.0) and 61% at follow-up. The increase in parent training was immediate, relatively

flat in direction, and moderately variable. Rick's mother's mean percentage of correct implementation increased from 64% in baseline to 86% in parent training (NAP=0.88) and 100% at follow-up. The increase in parent training was relatively immediate, with a slight positive trend, and was highly variable for the first 6 sessions before becoming stable. Sean's mother's mean percentage of correct implementation increased from 41% in baseline to 71% in parent training (NAP=0.90) and 100% at follow-up. The increase in parent training was immediate, generally positive in direction, and highly variable. Idris' mother's mean percentage of correct implementation increased from 10.4% in baseline to 25% in parent training (NAP=0.80) and then decreased to 7.7% at follow-up. There was an increase for the first three sessions, a decrease for the following three sessions, and then an increase for the final four sessions. Alex's mother's mean fidelity increased from 56% in baseline to 74.5% in parent training (NAP=0.83) and 100% at follow-up. There was a slight increase from baseline to parent training, with a generally stable trend and less variability than the other mothers.

Engagement

Figure 3 shows the percentage of intervals with engagement for the whole 10-s for each child and session. For Dean, mean engagement increased from 3.6% in baseline to 40.3% in parent training (NAP=1.0) and 25% at follow-up. There was an immediate increase in parent training, with a flat trend, and moderate variability. For Rick, mean engagement increased from 31.9% in baseline to 57.6% in parent training (NAP=0.8) and decreased to 28.3% at follow-up. There was an immediate increase in parent training, with a flat trend, and high variability. For Sean, engagement increased from 21.2% in baseline to 45% in parent training (NAP=0.79) and 33.3% at follow-up. There was a delayed increase in the second parent training session, with a flat trend, and high variability. For Idris, mean engagement increased from 6.3% in baseline to 12.7% in parent training (NAP=0.67) and 11.7% at follow-up. There was minimal improvement in parent training, and the data were moderately variable. For Alex, mean engagement increased slightly from 28.3% in baseline to 35.3% in parent training (NAP=0.63) and 63.3% at follow-up. There was minimal improvement in parent training and a flat trend with high variability.

Imitation

Figure 4 shows the percentage of intervals containing independent (unprompted) instances of imitation for each child during each 10-min play sample. The mean percentage of intervals containing imitation for each child is presented below. For Dean, imitation increased from 6% in baseline to 14.3% in parent training

(NAP=0.92) and 11.7% in follow-up. The increase in parent training was immediate, relatively flat in direction, and highly variable. For Rick, imitation increased from 3.6% in baseline to 7.2% in parent training (NAP=0.86) and 5% in follow-up. There was an immediate increase in parent training, with a decreasing trend, and minimal variability. For Sean, imitation increased from 6% in baseline, to 13.5% in parent training (NAP=0.89) and 15% in follow-up. There was a delayed increasing trend in parent training, with moderate variability. For Idris, mean imitation increased from 2.6% in baseline to 5% in parent training (NAP=0.69). There was no increase in parent training, a flat direction, and moderate variability. There were no instances of imitation for Idris at follow-up. For Alex, imitation decreased from 7.5% in baseline to 4.7% in parent training (NAP=0.34) and then increased to 8.3% in follow-up. There was an immediate decrease in parent training, with an increasing trend, and moderate variability.

Functional utterances and intentional vocalizations

Figure 5 shows the percentage of 10-s intervals containing functional utterances and/or intentional vocalizations for each child and session. The mean percentage of intervals containing functional utterances/intentional vocalizations for each child is presented below. For Dean, functional utterances increased from 41.4% in baseline to 65.7% in parent training (NAP=0.95) and 70% at follow-up. There was an immediate increase in parent training with a relatively flat trend, and moderate variability. For Rick, functional utterances increased from 55% in baseline to 67.1% in parent training (NAP=0.72) and 80% at follow-up. There was no increase in parent training, a flat trend, and moderate variability. For Sean, functional utterances increased from 21% in baseline to 30.3% in parent training (NAP=0.72) and 21.7% at follow-up. There was no increase compared to baseline, the trend in parent training was flat overall, and variable. Idris only had one functional utterance "no" across all sessions and phases. This occurred in the 4th baseline session. For Idris, intentional vocalizations decreased from a mean of 9.3% in baseline to 6% in parent training (NAP=0.29) and increased to 13.3% at follow-up. Vocalizations remained the same as baseline for the first three parent training sessions, before decreasing to near 0 levels for the rest of the phase. For Alex, functional utterances remained relatively stable at 0.3% in baseline, and 0.7% in parent training (NAP=0.57). He did not have any functional utterances at follow-up. His intentional vocalizations increased from 5.3% in baseline, to 27.3% in parent training (NAP=0.95) and 36.6% at follow-up. There was an immediate increase in parent training, with a positive trend, and high variability.

Discussion

The results suggest that a 12-week, home-based parent training based on the ESDM was effective in increasing most parents' use of ESDM techniques with their children. Indeed, all parents, except Idris' mother, used between 80 and 100% of the ESDM techniques during several parent training sessions, and the improvement in the use of the techniques was maintained at the 1-month follow-up. In terms of child outcomes, all children, except Idris, showed some improvement on at least one of the child outcome variables. Specifically, Dean showed improvements in engagement, imitation, and utterances during parent training, while Rick and Sean showed improvements in engagement, and Alex showed a steady improvement in his use of intentional vocalizations. Some child improvements were maintained at follow-up but Rick and Sean's improvements in engagement were not, and nor were Dean's imitation gains.

These results are comparable with previous parent coaching studies which have also found that the majority of parents learned to implement intervention techniques with their young children with ASD (McConachie and Diggle, 2007, Meadan et al., 2009, Oono et al., 2013, Patterson et al., 2012, Vismara et al., 2009, 2012, 2013, 2016, Vismara and Rogers, 2008). Thus, the findings of this study provide further support that many parents can learn to implement interventions with their young children with ASD. In the Rogers et al. (2012b) RCT, parents also received 1-hour per week of training for 12 weeks using the same teaching techniques as were used in this current study. However, in that study, only 45% of parents in the ESDM parent training group reached an acceptable level of fidelity. Although it is not possible to directly compare this single case study with a large RCT, these conflicting results suggest that more research is needed to understand why some parents learn the ESDM techniques within 12 weeks, and some do not.

In the current study, there were differences between each parents' fidelity of implementation during baseline. Indeed, during several baseline sessions, Rick's mother usually/consistently implemented almost 80% of the techniques. Although the majority of parents in previous ESDM parent coaching studies did not have high fidelity of implementation during baseline, Rogers and Vismara (2015) suggested that some parents may develop effective play and interaction skills with their child prior to treatment. It is possible that Rick's mother had high fidelity of implementation because Rick had been diagnosed with ASD for longer than the other children and, thus, she might have had more time to figure out effective play and interactional strategies. She had also previously participated in a 1-day workshop on play-based intervention for young children

with ASD. Further, Rick's mother's fidelity did improve in parent training which may suggest that the training was still beneficial for her.

Idris' mother did not learn to usually/consistently use many of the ESDM techniques. This is consistent with several previous ESDM parent coaching studies, which have found that at least one parent did not reach high levels of fidelity during parent training (Rogers et al., 2012b, Vismara et al., 2009, 2013, 2016). It is possible that the training was less effective for Idris' mother because (a) she had the lowest baseline fidelity and so might have needed more time to practice using the procedures; (b) she was working full-time which may have prevented her from practicing the ESDM techniques; and/or (c) she was less invested using the ESDM techniques with Idris prior to the 10th week of parent training because he did not yet have a formal diagnosis of ASD. Again, more research is needed to determine why parent training/coaching programs are less effective for some parents. Research should also aim to develop more effective procedures to support parents who may not respond as well to existing parent training programs.

Although four of the parents showed some improvement with respect to using the ESDM techniques, the children did not show increases across all outcomes. This is consistent with previous research which suggests that, while most parents can be taught to use intervention techniques, their improved use of these techniques does not always translate to consistent improvements for their children (Oono et al., 2013, Vismara et al., 2016). The lack of a consistently positive child response to parent use of the ESDM could relate to a number of factors, such as the child's (a) severity of symptoms, (b) level of adaptive behavior functioning, (c) age and (d) the actual amount of intervention that parents deliver outside of formal structured therapy sessions. Idris and Alex, for example, had low communication scores on the Vineland-II (Sparrow et al., 2005), which could partially explain why their functional utterances did not improve. Future research could aim to isolate the extent to which these and other factors may be predictive of early intervention outcomes for any given child/parent dyad and what different or additional supports may be indicated in light of these factors. More research is also needed into the relationship between parent ESDM fidelity and child improvements. For example, it is not clear whether very high fidelity (well over 80% of techniques used usually/consistently) leads to greater child improvements than adequate fidelity or whether parent use of some ESDM techniques is particularly effective for improving child outcomes.

The results of this study are also unique in suggesting there may be some benefits to a home-based ESDM parent training program. This is an important finding

given the potential advantages of teaching skills in a child's natural environment (Rogers *et al.*, 2012b, Oosterling *et al.*, 2010). Of course, professionals should consult with parents to identify the most acceptable setting(s) for providing support and training to the parent and child.

This appears to be the first ESDM parent training study which has been conducted independently of the developer of the model. In addition, the trainer had been a practicing ESDM therapist for less than a year and had not received formal training in ESDM parent coaching. Thus, as the majority of parents were able to learn the to implement the ESDM procedures, this suggests that the ESDM may be effective in real-world contexts, not just when implemented in clinic settings by highly-trained professionals (Smith *et al.*, 2007). However, it is also possible that the training would have been even more effective if the trainer were more highly trained and experienced.

While the teaching procedures used in this study were very similar to those used in the initial ESDM parent training/coaching studies (i.e. Rogers *et al.*, 2012b, Vismara *et al.*, 2009, 2012, 2013), they are quite different from those used in the most recent studies (Vismara *et al.*, 2016, 2018, Rogers *et al.*, 2018). These had a much greater emphasis on explicit coaching strategies, such as parent reflection, collaborative discussion, and joint planning (Rogers and Vismara, 2015, Hanft *et al.*, 2004). This could be seen as using a collaborative approach to working with parents, while the training techniques used in the current study appear to align more with an "expert model" of teaching (Brookman-Frazee, 2004). Research suggests that a collaborative approach to working with parents might lead to better parent and child outcomes for some families (Brookman-Frazee, 2004). Therefore, although this study had some positive results, it is possible that collaborative parent coaching strategies may have resulted in better outcomes. In future, researchers should compare the effectiveness of these two approaches.

There are several limitations to this study. First, there was only one post-parent training data point. It is possible that these data points were not representative of typical parent-child interactions and, therefore, only limited conclusions can be drawn about the maintenance of both parent and child outcomes over time. Second, partial interval recording of functional utterances may not have been the most developmentally appropriate or sensitive measure for Dean or Rick. This is because they both produced many functional utterances. Third, it is not possible to directly compare fidelity in the current study to fidelity reported in previous ESDM research because an adapted, simplified version of the ESDM fidelity rating scale was used in the current study (Rogers and Dawson, 2010). Fourth, the primary rater was the trainer/first author, and was therefore not

blind to treatment phase. Fifth, Idris was the only child who was not diagnosed at the start of parent training. Therefore, his results are not directly comparable with the remaining four children and it is not clear how his lack of diagnosis effected his response to treatment. Further, although Dean's mother spoke conversational English, some of the language in the PowerPoint® presentations needed to be simplified to increase her understanding of the concepts. It is possible that the intervention was less effective because of this potential language barrier. Finally, the findings of this study are limited to only five parent/child dyads and thus should be replicated with a larger and more diverse sample of parents and children.

The results of this study suggest that home-based parent training based on the ESDM may be effective in teaching some parents to implement ESDM strategies with their young children with ASD. Further, parent use of these strategies may improve some outcomes for their children with ASD. However, it is possible that some parents need more support to learn the ESDM techniques, and more research is needed in this area.

Conflicts of interest

The authors declare no conflicts of interest.

Compliance with ethical standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained for all individual participants included in the study.

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