Effects of a low-intensity Early Start Denver Model-based intervention delivered in an inclusive preschool setting

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The Early Start Denver Model (ESDM) is a promising early intervention for promoting improved social, cognitive, and communication outcomes for young children with autism spectrum disorder (ASD). However, most studies evaluating group-based delivery of this program have used 15–25 h per week of intervention in specialized ESDM preschools with low child–teacher ratios. Thus, the positive results from such studies might not be obtained when this intervention model is evaluated in more typical inclusive preschool settings. In this study, a low-intensity version of the ESDM was delivered to three young children with ASD in their regular inclusive preschool by a certified therapist who did not typically work at any of the preschools. The intervention procedures were implemented for 3 h per week over an 8- to 10-week period. Data were gathered on children's levels of participation, imitation, and communication from weekly 10-min video recordings. The effects of the intervention were evaluated using a multiple probe across participants design with 3 weekly follow-up probes, 3 weeks after the intervention ended. All participants showed improvement in active participation, imitation and either intentional vocalizations or spontaneous functional utterances. These results were generally maintained at follow-up. This low-intensity version of the ESDM would seem effective for use in real-world preschool environments.

Keywords: autism spectrum disorder, early intervention, preschools, Early Start Denver Model

The distinguishing features of autism spectrum disorder (ASD) are difficulties in social-communication and the presence of restrictive or repetitive behaviors or interests (American Psychiatric Association [APA] 2013). Many individuals with a diagnosis of ASD will require life-long support (Lord *et al.* 2018). Early intervention (EI) can lead to improved outcomes for young children with ASD (Debodinance *et al.* 2017). Currently, EIs that incorporate both behavioral and developmental aspects (naturalistic developmental behavioral interventions; NDBIs) appear to be the most widely used and are supported by a growing evidence base (Ospina *et al.* 2008, Tiede and Walton 2019). NDBIs focus on incorporating teaching and learning into a child's everyday routines and thus are likely to be well suited to implementation in children's natural environments (Tiede and Walton 2019), such as at home or in an inclusive preschool setting.

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Delivery of EI in an inclusive preschool setting might have several educational benefits. Specifically, inclusive environments may provide young children with ASD with opportunities to observe appropriate communicative and social behaviors and to practice these behaviors with their typically developing peers (Koegel *et al.* 2001, Vivanti *et al.* 2017). This would seem to be especially important given that a core feature of ASD is difficulty in social communication. Group-based delivery of EI may also be more efficient than individual intervention as it allows for delivery to more than one child at a time (Leaf *et al.* 2018). Inclusive preschool environments may also more closely represent the group-based teaching formats that children with ASD are likely to encounter when they reach school-age.

Further, there is increasing international commentary on the inclusion of children with disabilities, including ASD, in mainstream educational settings (Barton and Smith 2015, Pellicano, Bolte, *et al.* 2018). Within the field of early childhood special education, for example,

DOI 10.1080/20473869.2019.1707434

it is generally accepted that when possible, children with ASD should be taught alongside typically developing peers in natural environments (Ledford and Wolery 2011). The Division for Early Childhood (DEC) also recommends that EIs be embedded in children's typical routines and contexts (DEC 2014). There are also legal imperatives for the provision of intervention in an environment with the least amount of restriction required to meet a child's needs and with ongoing opportunities for interaction with typically developing peers (Broderick 2017, United Nations 2006). Inclusive preschool environments would appear to satisfy these recommendations as they offer a natural environment with access to typically developing peers.

The intervention used in the present study is the Early Start Denver Model (ESDM), a comprehensive NDBI designed for use with children aged between 12 and 60 months (Rogers and Dawson 2010). The model draws on earlier work from the Denver model (Rogers et al. 1986, Rogers and DiLalla 1991) and makes use of a range of behavioral tactics, such as Pivotal Response Training (PRT; Koegel *et al.* 1999) within a relationship-focused developmental framework. The ESDM is a comprehensive intervention that can be delivered to children individually in many different contexts, and a group-based version of the ESDM (G-ESDM; Vivanti *et al.* 2017) allows for delivery to more than one child at a time.

The ESDM can be classed as a 'promising' EI (Baril and Humphreys 2017, Waddington *et al.* 2016) meaning that a number of studies have documented improved outcomes for children receiving ESDM therapy but there is not yet enough evidence for ESDM to be considered 'evidence-based'. G-ESDM has been evaluated across five studies to date (Eapen *et al.* 2013, Fulton *et al.* 2014, Vivanti *et al.* 2013, 2014, 2019). Participants across the five studies received 15–25 h per week of group-based ESDM intervention at specialized ESDM preschools with teacher/therapist–child ratios of 1:3 (Vivanti *et al.* 2013, 2014) or 1:4 (Eapen *et al.* 2013, Fulton *et al.* 2014, Vivanti et al. 2019). In two studies (Eapen *et al.* 2013, Fulton *et al.* 2014) participants received an additional 1 h per week of one-on-one ESDM therapy.

For four of the G-ESDM studies, the intervention was delivered in autism-specific ESDM preschools (Eapen *et al.* 2013, Fulton *et al.* 2014, Vivanti *et al.* 2013, 2014). Collectively, results from these studies suggest that the ESDM was associated with improvements in child cognitive skills (Eapen *et al.* 2013, Fulton *et al.* 2014, Vivanti *et al.* 2013, 2014), various language/communication outcomes (Eapen *et al.* 2013, Vivanti *et al.* 2014), gross motor skills (Eapen *et al.* 2013), and reduced levels of challenging behavior (Fulton *et al.* 2014). Eapen *et al.* (2013) also reported a significant decrease in participants' autism symptoms, however, the remaining three studies reported no significant change in autism severity/symptoms.

The remaining G-ESDM study (Vivanti et al. 2019) compared outcomes of children with ASD who received ESDM in an inclusive preschool with those who received ESDM in a specialist ASD preschool. Participants from both groups demonstrated improvements across a range of outcomes including language/communication, social interaction, imitation, adaptive behavior, and ASD symptoms. There did not appear to be any significant difference between inclusive versus specialized delivery in terms of child improvements. The authors concluded that inclusive preschool-based delivery of ESDM is a feasible and potentially effective approach to EI for young children with ASD.

While results from the study by Vivanti et al. (2019) suggest that the inclusive preschool-based delivery of ESDM can improve outcomes for children with ASD, the study's setting may not be representative of typical preschools in many communities. Specifically, the child–teacher ratio at the preschools in Vivanti *et al.*'s study was 1:4 whereas in some communities ratios may be much higher. For example, in New Zealand preschools, child–teacher ratios may legally be as high as 1:15 (Education (Early Childhood Services) Regulations, 2008). A higher ratio is likely to mean that teachers have less time to dedicate to one-on-one and small group teaching and it is not known whether ESDM can be effectively implemented in settings with higher child–teacher ratios. Additionally, in the Vivanti *et al.* study, intervention was delivered in designated ESDM preschools where one staff member at each center was a certified ESDM therapist and all teaching staff received ESDM training and in vivo coaching throughout the study. Communities may not have access to this level of specialized staff or ongoing training, particularly in underserved areas such as rural and low socioeconomic communities (Singh and Garrett 2019). Research focused on ASD services that support underserved populations is a current priority in international autism research (Pellicano, *et al.* 2018). Consequently, it may be valuable to evaluate the delivery of ESDM in settings that more closely reflect the conditions in these types of communities. Indeed, the need for research that addresses the community viability of the G-ESDM has been recently acknowledged (Capes *et al.* 2019).

The current study took place in New Zealand, where there is no national disability insurance scheme and many families rely primarily on government-funded EI services. For many young children with ASD, these services are provided through the Ministry of Education and the child's local preschool. There is also a strong legal and social emphasis in New Zealand on providing services to children with disabilities in inclusive settings (Ministry of Education 1996). Thus, inclusive preschool-based intervention would seem to make logical

sense in a New Zealand context. The ESDM seems particularly well suited to implementation in New Zealand preschools because its emphasis on positive relationships, whole-child development, and child-centered learning mirrors three of the four principles that underpin Te Whaariki, the New Zealand preschool curriculum (Ministry of Education 1996).

The main purpose of the present study was to evaluate whether it was feasible for a certified therapist to deliver ESDM intervention with a high degree of fidelity in a typical New Zealand preschool environment without the need for major changes to the environment or typical preschool routine. A second purpose was to evaluate the intervention's impact on the participation, communication, and imitation of the young children with ASD who participated in the present study. Finally, it is hoped that the findings from this study will help to inform future research focused on training regular teachers in similar inclusive preschool settings in the effective provision of EI to children with ASD.

Method

Ethical clearance and informed consent

This study received ethical clearance from the New Zealand National Health and Disability Ethics Committee (reference number 18/CEN/29/AM01) and was registered with the Australian New Zealand Clinical Trials Registry (ANZCTR; registration number 12618000324213). Parents provided written consent for their child's participation in the study. Child assent was inferred by the children's willingness to take part in the play activities.

Participants

Three children who met the following inclusion criteria were recruited from local preschools: (a) chronological age of 60 months or less at the start of the study, and (b) a clinical diagnosis of ASD. Children with other medical, genetic, neurological, or sensory conditions (e.g. Down syndrome or fragile X syndrome) were excluded, as were children who were receiving more than 10 h per week of EI at the start of the study. The characteristics of the three participating children are summarized in Table 1. Demographic information was collected from the parents and adaptive behavior was assessed by interviewing teachers using the third edition of the Vineland Adaptive Behavior Scales (Vineland-3; Sparrow *et al.* 2016).

Luke

Luke (pseudonym) was a Pākehā (New Zealand European) boy. He was 4:8 (years:months) old at the beginning of the study. He received a diagnosis of ASD at 18 months by a clinical team who use the Autism Diagnostic Observation Schedule-2 (ADOS-; Lord *et al.* 2012) as part of the assessment process. Luke's Vineland-3 scores are displayed in Table 1. Luke was reported by his mother and teachers to occasionally use functional sounds and words. Prior to the start of the study, Luke had been provided with a simple core-vocabulary communication board, but his teachers reported limited success with this. Luke's teachers described him as a happy, affectionate boy who showed an interest in simple puzzles and shape sorters and loved to play on the swings and walk over the bridge in the playground. Luke was reported by his mother and teachers to engage in self-biting and biting others when frustrated. Luke was not toilet trained and appeared to

Table 1 Participant demographic characteristics and Vineland-3 results

	Luke	Ian	Jordan
Age (years:months)	4:8	4:9	4:5
Gender	Male	Male	Male
Ethnicity	Pākehā	Filipino–Pākehā	Māori–Pākehā
Vineland-3	41	70	58
Adaptive Behavior Composite			
Communication (sum of v-scale scores)	6	39	19
Percentile rank	<1	19	<1
Receptive	0:1	2:1	1:4
Expressive	0:5	2:5	0:11
Written	<3:0	6:4	3:6
Daily living skills (sum of v-scale scores)	11	22	20
Percentile rank	<1	<1	<1
Personal	1:7	2:6	1:11
Domestic	<3:0	<3:0	<3.0
Community	<3:0	<3:0	<3.0
Socialization (sum of v-scale scores)	15	23	20
Percentile rank	<1	<1	<1
Interpersonal relationships	0:4	1:3	0:11
Play and leisure	0:11	1:11	0:11
Coping skills	<2:0	<2:0	<2:0
Motor skills (sum of v-scale scores)	12	15	20
Percentile rank	<1	1	4
Gross motor	1:7	1:5	2:8
Fine motor	1:5	3:0	2:9

have an aversion to wearing diapers. In addition to his time spent at the inclusive preschool, Luke spent 2.5 h per week at a center-based preschool program for families with young children with developmental delays. Each 2.5-h session included a group music session as well as a 20-min session for each of four specialist therapies: music therapy, physiotherapy, speech-language therapy, and EI teaching.

Ian

Ian was a 4:9 boy of Filipino and Pākehā descent who had received a clinical diagnosis of ASD when he was 2.5 years old, from the same clinical team that diagnosed Luke. Ian's Vineland-3 scores are displayed in Table 1. According to Ian's parents and teachers, Ian spoke fluently, but his conversations were mainly limited to topics that he was interested in or replies to questions. Ian's teachers also indicated that Ian showed an interest in his peers but was often inappropriate in his social interactions (e.g. positioning his face and torso very close to his peers or interrupting activities by taking/pushing materials or making loud noises). According to Ian's parents and teachers, Ian showed a strong interest in reading and writing and could read and write a wide range of simple words independently. Ian was not receiving any EI outside of kindergarten, however, the EI team from the Ministry of Education provided support and advice to Ian's teachers.

Jordan

Jordan was of Pākehā and Māori descent and was aged 4:5 at the beginning of the study. He was diagnosed with ASD at the age of 3 years by a clinical team from the same service that diagnosed Luke and Ian. Jordan's Vineland-3 scores are displayed in Table 1. Jordan's mother and teachers reported that he had a limited repertoire of functional words which he used irregularly (e.g. 'ready, steady, go'). According to his preschool teachers, Jordan had recently begun to spontaneously sit in on group activities. He also reportedly enjoyed music and would often sing. Jordan received 2.5 h per week of intervention at the same center-based preschool program as Luke.

Setting

Each child attended a different preschool. Each preschool consisted of a large open-plan indoor space with a carpeted 'mat area' and several smaller activity centers spread around the room. Materials at each activity center varied across sessions and preschools, but typically included playdough, art and craft, puzzles and a family corner with dress-up costumes, dolls, play furniture and play food. Children at each preschool also had free access to books, blocks, small, hand-held musical instruments, toy cars, and trains. Each preschool had a kitchen, bathroom/toileting area, and outdoor spaces with sandpits, swings, monkey bars, trees, and a slide. Play materials included balls, sandpit toys (e.g. buckets and spades), ride-on toys (e.g. bikes and scooters) and water for play. Luke and Ian's preschools both also included a small 'forest' area, complete with a playhouse and bridge at Luke's preschool, and free-ranging chickens at Ian's preschool.

The preschool that Luke attended offered five, 6-h sessions per week and Luke attended for three 4-h sessions per week. The preschool was licensed for 40 children per session and was staffed by three qualified early childhood education (ECE) teachers, a part-time teaching assistant, and an administrator. The activities that were frequently included in Luke's intervention sessions were puzzles, playdough and outside play on the swings and playground.

Ian attended preschool along with his younger sister. The preschool offered five, 6-h sessions per week, Ian attended all five sessions. The preschool was staffed by four qualified ECE teachers and a part-time administrator and was licensed for 43 children per session. Ian's intervention sessions often included drawing, eating morning tea, dancing to music, and playing outside.

Jordan attended preschool for 6 h, 2 days per week and for 4 h a further 2 days per week. Days at Jordan's preschool were divided into morning and afternoon sessions and all intervention sessions were conducted in the afternoon. Afternoon sessions included up to 30 children and were staffed by three qualified ECE teachers and a teaching assistant. The activities that were frequently included in Jordan's intervention sessions were puzzles, blocks and outside play on the swings and playground.

Materials

An Apple iPhone, on a tripod, was used to videotape sessions. The ESDM manual (Rogers and Dawson 2010), the group ESDM manual (Vivanti *et al.* 2017), and existing toys and play materials from the preschools were used in the delivery of the intervention. Interventionist fidelity was measured using a modified version of the ESDM teacher fidelity rating scale (Rogers and Dawson 2010).

Dependent variables

To select dependent variables (DVs), the first author met with each child's teacher(s) and parent(s) to gain feedback on possible target behaviors based on their knowledge of their child. The first author also spent 2 h observing each child playing at their preschool and then selected target behaviors based on these observations together with teacher and parent suggestions. Due to the overlap in priorities across the different children, a set of common DVs was selected for all participants and then individually adjusted as necessary, according to the developmental needs of each child. For example,

all parents and teachers indicated that improving the child's expressive language was a priority and consequently all children had a DV related to improving expressive language. However, the specific expressive language target for each child was individualized. Luke's goal, for example, was to increase intentional vocalizations (IV) because it was not considered by the teachers and parents to be developmentally appropriate to target spontaneous functional utterances (SFU). In contrast, Ian's goal related to increasing SFU and to be recorded, functional utterances had to be accompanied by eye contact. For Luke and Jordan's teachers and parents, a priority goal was for their child to correctly follow instructions. However, it was decided that this

Table 2 Operational definitions and measurement of each child's dependent variables (target behaviors)

Target behaviors	Participant(s)	Definition	Measurement
Spontaneous functional utterances	Ian, Jordan	Any utterance by the child that: (a) occurred without adult prompting or modeling of the utterance within 10-s of its occurrence, (b) was clearly used to communicate to an adult or peer, (c) served a purpose that was contextually related and meaningful to the interaction and (d) contained a phonetically correct approximation of the correct word or word combination. In Ian's case, he also needed to be facially oriented towards the adult or peer to whom he was directing the utterance either immediately before, during or immediately after the utterance.	Partial interval recording (10-s intervals)
Intentional vocalization	Luke	Any vocalization by the child that: (a) occurred without adult prompting or modeling of the vocalization within 10-s of its occurrence, (b) was related to the interaction and (c) did not contain a phonetically correct approximation of the word or word combination. Also, the vocalization needed to be communicative, so the child needed to be at least partially oriented toward the adult and the vocalization needed to occur within 10-s of an adult action or utterance or the child needed to appear to be making a request, rejection or comment (as evidenced by accompanying behavioral indicators such as reaching, pushing away, showing or pointing). Finally, whining, screaming, crying, laughing, unrelated speech, stereotypy and echolalia were not counted.	Partial interval recording (10-s intervals)
Imitation	Luke, Ian, Jordan	Performing an action with or without an object or performing a facial expression, within 10-s of an adult or peer model and without prompting from an adult.	Partial interval recording (10-s intervals)
Active participation	Luke, Ian, Jordan	A child was considered to be 'actively participating' when they spent the whole interval: (a) facially oriented towards an adult or peer; (b) directing affect (smiling and/or laughing) toward an adult or peer; (c) looking in the direction that the adult or peer was pointing; (d) giving, sharing, or showing objects to an adult or peer; (e) imitating an adult or peer; (f) taking turns with an adult or peer; (g) following directions given by an adult or peer; (h) communicating with an adult or peer with words, vocalizations, and/or gestures; and/or (i) continuing or elaborating on an adult's or peer's play actions. Instances where the child was singing to him/herself or engaged in an isolated activity were not included.	Whole interval recording (10-s intervals)

was too difficult to objectively measure as a DV and so it was instead included in each child's teaching goals. The operational definitions of each of the child DVs are presented in Table 2.

Data collection

Data on each child's target behavior(s) were collected via 10-min video recordings of the target child in the preschool setting. This approach to data collection was consistent with existing ESDM research (e.g. Vismara and Rogers 2008, Vismara *et al.* 2009, 2012, Waddington et al. 2019) and was considered to be the most pragmatic approach to data collection given the nature of the research questions and the setting in which data were to be collected. Where practicable, videos for the intervention phase were taken at the same time and day each week, the video was always the first 10 min of the intervention session. Baseline and follow-up videos were taken at the same time and day as intervention videos for each child.

Research design

The study was intended to follow a non-concurrent multiple-baseline across participants design (Harvey *et al.* 2004, Watson and Workman 1981). This design was selected because it allowed the flexibility necessary to work around the logistical constraints often associated with applied educational research, without compromising experimental control. However, continuous data collection during baseline was not possible due to participant absences and changes in the preschool schedule. Consequently, the study design is perhaps best considered a multiple probe across participants (Kennedy 2005). The study included the following sequential phases: (a) pre-baseline, (b) baseline, (c) intervention, and (d) follow-up.

The length of baseline phase for each participant was randomly selected before baseline data collection began, in line with the requirements of the nonconcurrent multiple-baseline design. To randomly select the length of baseline for each participant, the first and last authors pre-determined three different lengths of baseline: (a) 3 sessions, (b) 4 sessions and (c) 5 sessions. These authors then used a random number generator to select a number between 3 and 5 for each participant. The number selected for each participant represented the number of sessions in that participant's baseline phase.

Procedures

Pre-baseline

After administering the Vineland-3 (Sparrow *et al.* 2016), the first author informally observed target children during regular preschool routines and spoke with teachers and parents to determine a set of individualized ESDM teaching goals for each target child, to be used during the intervention phase. The specific ESDM teaching goals for each child are presented in Table 3. These observations and discussions were also used to help inform the selection of child DVs. As a rule, DVs included broad behaviors that could be objectively measured whereas teaching goals were more specific and/or difficult to objectively measure as a DV. For example, individual teaching goals related to imitation focused on a specific type of imitation (e.g. imitating an action on playdough) whereas the DV for imitation was broad and encompassed multiple types of imitation.

Baseline

As much as practicable, baseline sessions were conducted at the child's preschool at the same time and day of the week that intervention data would be collected.

Each baseline involved a 10-min video-recorded session at the child's preschool. During each session, the first author waited until the child was involved in a play activity, then approached, greeted the child and positioned herself nearby, in the child's line of sight. During the 10-min session, the first author delivered an imitation or verbalization/vocalization probe approximately every 30 s. The purpose of these probes was to provide participants with equal opportunities to imitate and verbalize/vocalize across baseline and intervention sessions. An example of an imitation probe was stacking one block on top of another to make a tower and an example of verbalization/vocalization probe was greeting the child and pausing for a response. The first author did not provide any additional prompts or reinforcement and responded appropriately to any child approaches or initiations (e.g. if a child used a gesture or vocalization to ask for a push on the swing, the first author would give the child a push).

Intervention

Intervention for each child began after the pre-determined number of baseline sessions, provided that the baseline appeared to be adequately stable. Stability was defined as a clear and predictable pattern of response across at least three consecutive data points, with little or no trend and consistent level and variability (Kratochwill *et al.* 2010). For all participants, baselines were adequately stable after the pre-determined number of baseline sessions, so no additional baseline sessions were deemed necessary. It was originally intended that each participant would receive 30 h of intervention delivered over 10 weeks. However, the total number of hours of intervention varied across participants because of child absence due to illness and transition from preschool to primary school for Luke and Jordan. Luke received 23 h of intervention across 8 weeks, Jordan received 24 h of intervention across 9 weeks, and Ian received 27 h of intervention across 10 weeks.

Table 3. Individualized ESDM goals for each child.

Domain	Luke	Ian	Jordan
Receptive communication	Respond to a proximal point by looking and placing object in indicated location Look towards object when shown an object and told 'Luke, look'. Respond to instructions to 'stop' or 'wait' without prompt or gesture.	Follow 2 or more unrelated instructions in a novel context. Retrieve items using 2–3 multiple cues (e.g. size, quantity, color).	Perform a 1-step routine instruction involving body actions (e.g. 'sit down' or 'come here') Respond to instructions to 'stop' or 'wait' without prompt or gesture.
Expressive communication	Vocalize with eye contact and/or gesture to request desired objects. 'Ask' for help by handing object to an adult or verbalizing or looking towards an adult.	Correctly respond to complex 'wh' questions (e.g. 'what', 'where', 'who'). Correctly use 2 or more reflexive pronouns (e.g. 'myself', 'himself', 'themselves').	Produce 6–10 single words or approximations within familiar routines or activities. Produce at least 3 verbs involving actions on self or objects associated with a play routine (e.g. 'roll', 'stop' or 'push').
Social skills/Joint attention	Use a motor prompt to initiate or continue a sensory social routine. Use eye contact while giving/taking objects from others.	Imitate novel songs/finger plays in group situations. Respond appropriately to simple requests/instructions from peers.	Respond to greeting by waving or saying 'hi'/'bye' with 2–3 s of eye contact. Use eye contact while giving/taking objects from others.
Imitation	Imitate 8–10 one-step actions on objects. Imitate 10 visible motor actions inside song/game routines.	Imitate 8–10 one-step actions on objects. Imitate 10 visible motor actions inside song/game routines.	Imitate 8–10 one-step actions on objects. Imitate 10 visible motor actions inside song/game routines.
Cognition	Match/sort identical objects. Match/sort identical pictures.	Count objects with one-to-one correspondence to 10. Give 'one', 'some', 'a lot', 'a little', 'all', 'more' or 'most' when requested by an adult.	Match/sort objects by size. Sort similar objects into like groups/categories (e.g. cars, horses or balls).
Play	Play independently and appropriately with 10 one-step toys. Demonstrate conventional actions on self with a range of objects (e.g. place phone to ear or comb hair).	Spontaneously link 3 or more related behaviors in a play theme. Direct partner (adult or peer) in play, using at least 3 relevant instructions.	Demonstrate conventional actions on self with a range of objects (e.g. place phone to ear or comb hair). Complete play activities and show some attempt to pack away/clean up.
Fine motor	Imitate at least 5 simple actions with playdough (e.g. poke, roll or squeeze). Imitate drawing strokes, scribbles and dots with a crayon/marker.	Use scissors with appropriate grasp and use opposite hand to stabilize and turn paper. Use a tripod grasp with drawing tools.	Imitate drawing strokes, scribbles and dots with a crayon/marker. Snip paper with scissors (at least 3 snips).
Gross motor	Roll a ball back and forth with another person. Imitate gross motor actions in a variety of positions (e.g. sitting, standing or moving).	Imitate gross motor actions in a variety of positions (e.g. sitting, standing or moving). Jump off a step and over objects on the ground.	Imitate gross motor actions in a variety of positions (e.g. sitting, standing or moving). Imitate gross motor actions with movement to songs/music.

Each intervention session typically lasted for 1 h, however, for Luke, the last nine sessions were longer (range: 1.5–2 h) due to him having missed sessions due to illness and transitioning to primary school.

It was intended that the intervention procedures would be embedded into typical preschool activities and thus the usual preschool environment, session structure, and materials were not altered from the usual arrangement of the setting. From the beginning of each session, the therapist (first author) followed the child's lead, that is, the child indicated the activity that they wanted to participate in (either verbally or physically) and the therapist joined them in that activity. Children's goals (see Table 3) were embedded into play activities and behavioral teaching techniques (e.g. the use of clear cues, contingent reinforcement, and least-to-most response prompting) were used to teach target skills/behaviors. In addition, the therapist modeled language by narrating the child's actions and verbally acknowledged all of the child's communicative attempts.

Peers were present during all intervention sessions and were frequently involved in the intervention. However, interactions with peers were not orchestrated by the interventionist and peers were not trained to participate in or mediate the intervention in any way. Instead, the interventionist aimed to encourage and facilitate naturally occurring interactions with peers. For example, when peers did something interesting (e.g. poured water into a hole in the sandpit), the interventionist encouraged the participating child to pay attention to and imitate and/or expand on the play action. Likewise, when a participating child did something

interesting (e.g. a big jump onto a crash pad), the interventionist encouraged peers to pay attention to and imitate and/or expand on the play action. Where reinforcement was not provided by peers or the play action itself, the interventionist provided reinforcement through use of praise and positive affect. When a participating child was interacting with a peer, the therapist attempted to act as 'an invisible support' by standing behind the participating child and scaffolding the interaction using least-to-most response prompting, as recommended in the G-ESDM manual (Vivanti *et al.* 2017). For example, if one of Ian's peers asked him to pass an item at the craft table, the interventionist (positioned behind Ian), would use least-to most prompting to support Ian to follow the peer's request.

When a child's engagement with an activity became overly repetitive, the therapist felt that the learning opportunities had been exhausted or the child appeared to have lost interest, the therapist indicated that the activity was over, asked the child to pack away materials (where appropriate) and followed the child's lead into a new activity. Where the child did not indicate a choice of activity (i.e. was unoccupied for more than a minute), the therapist would present the child with a choice of two activities and wait for the child to choose between the two, prompting a response when necessary.

Follow-up

Three weeks after the end of the intervention phase, follow-up data were collected for Ian and Jordan once per week for 3 weeks. It was not possible to collect follow-up data for Luke because he transitioned to primary school immediately after his intervention phase ended. Follow-up data were collected under intervention conditions. That is, one 10-min video was recorded per week in which the therapist interacted with the target child using ESDM techniques, in the same manner as the intervention sessions. After the second follow-up session, an additional 10-min video recording was collected under baseline conditions. That is, the therapist (first author) interacted with the child in the same manner as during the baseline phase.

Inter-observer agreement

Inter-observer agreement (IOA) was assessed for each participant and each of the DVs. Two independent observers coded the collected data for an average of 29% of the 10-min videos across each phase and for each participant. Both observers had completed the introductory and advanced ESDM training programs. The first observer had an undergraduate degree in psychology and was responsible for coding data for IOA on imitation and active participation (AP). This observer was blind to the purpose and phase of the research. The second observer, a Master of Educational Psychology Student, was responsible for coding data on IV and SFU. This observer physically attended each session that she coded and observed it live, before later coding it from the video. This was because an awareness of the live context was found to be important when coding verbal/vocal DVs, due to the level of background noise present in the video recordings. For the first IOA session, the observer used the application, Behavior Observation Made Easy (Shekhtmeyster 2017), a data recording mobile software application, to live-code the occurrence of vocal/verbal DVs. The percentage agreement for this session was 100%, however, it was decided that the use of the app was unnecessary and future IOA coding for these DVs was conducted using the video recordings and data collection sheets.

Prior to collecting any data, the first author individually taught each observer to use the data collection sheets and explained the definition for each DV. Once the observers indicated that they understood the definitions, they practiced coding three different videos of the first author working with a young child with ASD, who was not a study participant, and discussed any issues they had with the first author.

Interval agreement (Kennedy 2005) was used to calculate IOA percentages. That is, any interval where the first author and the observer both recorded the presence of a target behavior, or both recorded the absence of a target behavior, was counted as an agreement. Conversely, any interval where the primary observer recorded the presence or absence of a behavior and the other (reliability observer) did not, was counted as a disagreement. The following formula was used to calculate the overall percentage of agreements for each session: Agreements/(Agreements + Disagreements) × 100%. Table 4 shows that the mean IOA for all participants and outcomes was between 84% and 98%.

Procedural integrity

A checklist of procedural steps was used to monitor procedural integrity. The first independent observer from the IOA checks, who was blind to the purpose and phase of the study, assessed procedural integrity (PI) by coding the videotapes for 26% of all baseline

Table 4. Mean IOA (and range) for dependent variables across participants.

	Luke	Ian	Jordan
Active participation (whole interval)	84% (68–98%)	83% (72–93%)	84% (80–93%)
Intentional vocalizations	90% (83–100%)	n/a	n/a
Spontaneous functional utterances	n/a	84% (78–95%)	93% (90–98%)
Imitation	97% (95–98%)	92% (88–98%)	98% (90–100%)

sessions and 33% of all follow-up sessions (range = 20–33%). PI was assessed using a checklist based upon the integrity checklist developed by Waddington (2018). The checklist described each step of the baseline/follow-up procedures and the percentage of PI was calculated using the following formula: Number of correct steps/Total number of steps × 100%. Mean PI for each phase and participant was 100%.

Implementation fidelity

The intervention was implemented by the first author, who was a certified ESDM therapist at the time of the study. In order to become a certified therapist, she had successfully completed the ESDM introductory and advanced training workshops and had provided two videotaped submissions of herself delivering ESDM therapy that were assessed as being above the minimum fidelity threshold of 80% by a certified ESDM trainer. To assess the extent to which the therapist (first author) correctly used the intervention procedures, the same independent observer who conducted PI checks measured ongoing implementation fidelity using the modified ESDM fidelity checklist. The checklist included the same 13 categories of adult behavior as the traditional ESDM fidelity scale. For the traditional scale, each category is accompanied by a detailed description of optimal performance of the behavior for that category. However, many of these descriptions included more than one element of performance and/or were subjective. In order to make each description operational for research, and to allow for objective, consistent measurement across coders, the detailed descriptions from the ESDM manual were summarized into objective bullet points for each category. For example, the item 'motivation' was summarized into the following three bullet points: (a) the adult gave the child opportunities to choose, (b) the child showed interest in the activity for the duration of the activity, and (c) there were a mix of maintenance and acquisition tasks.

Implementation fidelity was assessed for 20–25% of intervention sessions for each participant. Mean fidelity was: 85% (range = 83–86%) for Luke, 93% (range = 87–98%) for Ian and 89% (range = 87%–91%) for Jordan.

Data analysis

Data from the video observations were analyzed for child DVs using interval recording. Specifically, each 10-min video was divided into 60, 10-s intervals and each interval was scored for the presence or absence of each target behavior. For each target behavior, an overall percentage of intervals with the behavior present was calculated using the formula: number of intervals with target behavior present/total number of intervals × 100%. These data were then graphed for each child across all phases of the study. These graphs were visually analyzed for observable changes in the trend, level and/or variability in child behavior due to intervention. Visual analysis is commonly used to infer a functional relation between independent and DVs in single-case research (Horner *et al.* 2012, Kratochwill *et al.* 2010, Ximenes *et al.* 2009). Descriptive statistics were also calculated to strengthen and support the results of the visual analysis.

Finally, an effect size was calculated using the Tau-U method (Parker *et al.* 2011), via an online calculator (http://www.singlecaseresearch.org/). The Tau-U method is considered to be superior to both regression and simple nonoverlap approaches to data analysis in single-case research (Parker *et al.* 2011) because it provides a complete measure that includes both trend and level with only minimum assumptions regarding data and the ability to control positive trends in baseline data. The Tau-U value represents the ratio of nonoverlapping pairs across phases and thus provides an indication of the likelihood that change occurred between the given phases as well as the trend of change (i.e. negative or positive). Vannest and Ninci's (2015) guidelines were used to interpret Tau-u values as small ($\leq$0.20), moderate (0.21–0.60), large (0.61–0.80), or very large ($\geq$0.81).

Results

Active participation

Figure 1 shows the percentage of whole intervals containing AP for Luke, Ian, and Jordan across baseline, intervention, and follow-up phases. There were no whole intervals of AP during Luke's baseline phase and the mean percentage of whole intervals containing AP during intervention was 32% (Tau-U baseline-intervention = 1). Visual analysis of Luke's graph shows an immediate increase in AP upon introduction of the intervention and a strong positive trend throughout the intervention phase. For Ian, the mean number of whole intervals containing AP during baseline was 18.5%. During intervention this mean increased to 69% (Tau-U baseline-intervention = 1) and further increased to 74% during follow-up (Tau-U baseline-follow-up = 1). For the follow-up probe conducted under baseline conditions, 73% of whole intervals contained AP. Visual analysis indicated that Ian's levels of AP immediately increased upon introduction of the intervention and remained fairly stable across the entire intervention phase. During Jordan's baseline phase the mean percentage of whole intervals containing AP was 9%. During intervention this increased to a mean of 47% of intervals (Tau-U baseline-intervention = 1). During follow-up, an average of 37% of whole intervals contained AP (Tau-U baseline-follow-up = 0.87). For the follow-up probe conducted under baseline conditions, 7% of whole intervals contained AP. Visual analysis of Jordan's graph shows moderately variable data with a

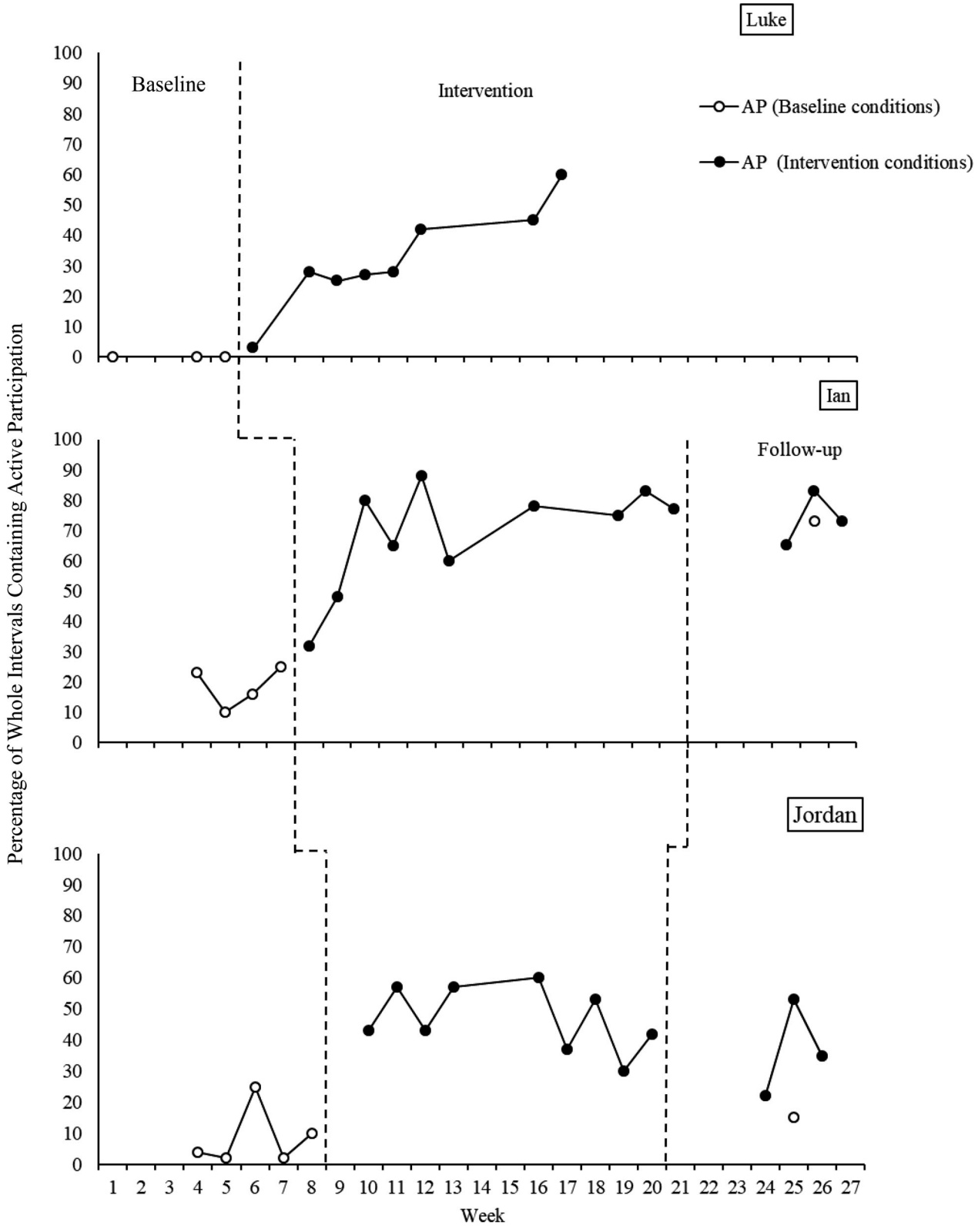

Figure 1 Percentage of 10-s intervals containing active participation for the whole interval.

slight positive trend during baseline, an immediate increase upon introduction of the intervention and more variable data with a fairly stable trend during intervention, and a slight positive trend during follow-up. The Tau weighted average for baseline-intervention AP for all participants was 1 ($p = 0$).

Intentional vocalizations and spontaneous functional utterances

Figure 2 shows the percentage of partial intervals containing IV for Luke, and SFU for Ian and Jordan across baseline, intervention and follow-up phases. The mean percentage of intervals containing IV for Luke

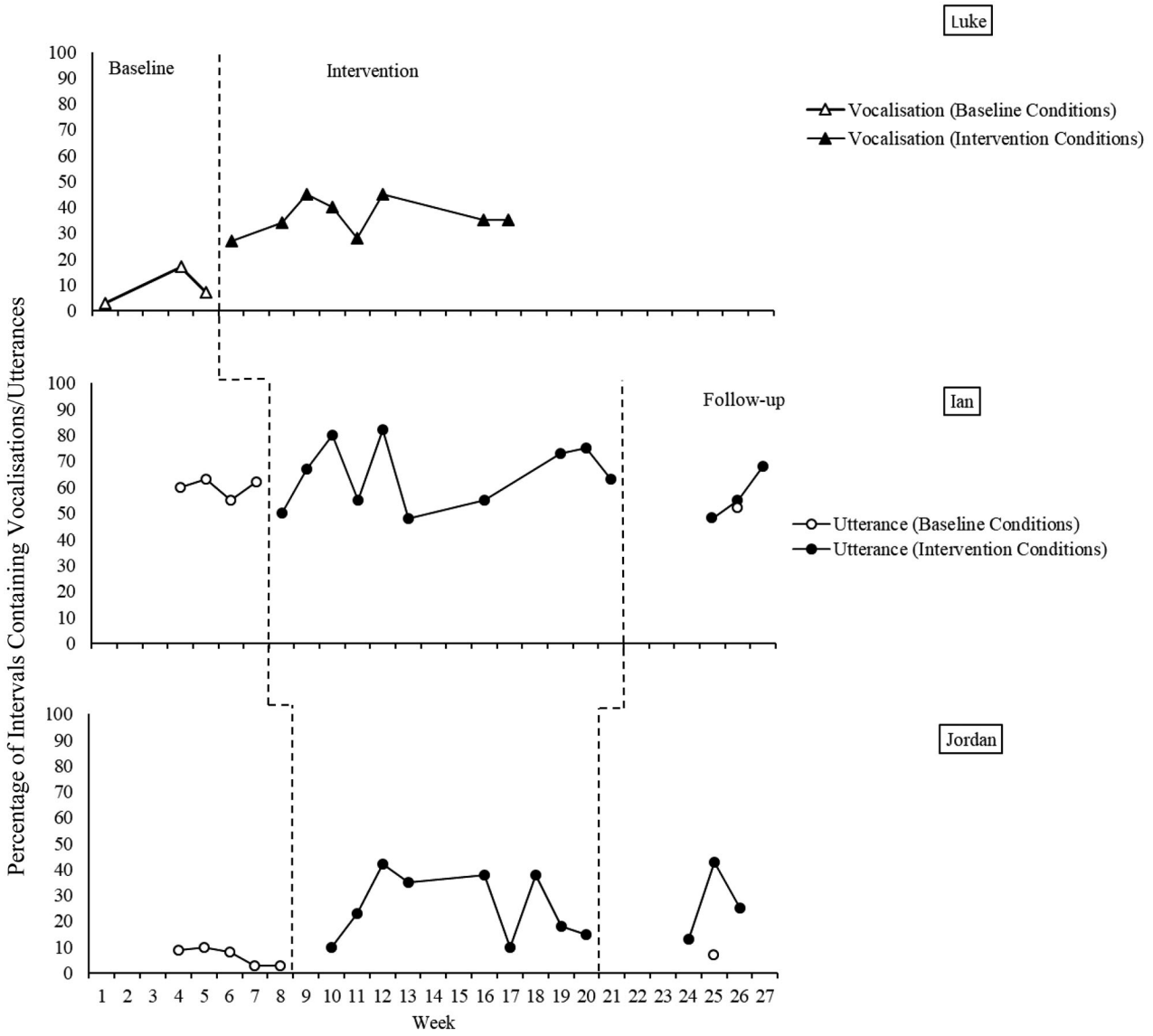

Figure 2 Percentage of 10-s intervals containing intentional vocalizations (Luke) or spontaneous functional utterances (Ian and Jordan).

increased from 9% in baseline to 36% in intervention (Tau-U baseline-intervention = 1). Visual analysis indicates that the increase occurred immediately upon introduction of the intervention, data were moderately variable with a fairly stable trend during baseline and intervention. During Ian's baseline phase a mean of 60% of intervals contained SFU and this increased slightly to a mean of 65% during intervention (Tau-U baseline-intervention = 0.23). During Ian's follow-up phase, the mean percentage of intervals containing SFU decreased to 57% (Tau-U baseline-follow-up = −0.25). During the follow-up probe conducted under baseline conditions, 52% of intervals contained SFUs. Visual analysis of Ian's graph indicates minimal variability during baseline with more variable data during intervention and a positive trend during follow-up. During Jordan's baseline phase there was a mean of 7% of intervals containing SFU which increased to a mean of 25% during the intervention phase (Tau-U baseline-intervention = 0.96) and further increased to 27% during follow-up (Tau-U baseline-follow-up = 1). During the follow-up probe conducted under baseline conditions, 7% of intervals contained SFUs. Visual analysis of Jordan's graph indicates high levels of variability during both intervention and follow-up phases. The Tau weighted average for baseline-intervention SFU for Ian and Jordan was 0.6 ($p = 0.01$).

Imitation

Figure 3 shows the percentage of partial intervals containing imitation for Luke, Ian, and Jordan across baseline, intervention and follow-up phases. The mean percentage of intervals containing imitation during Luke's baseline phase was 2%. There was a minimal increase to a mean of 6% during the intervention phase (Tau-U baseline-intervention = 0.92). Visual analysis of Figure 3 indicates that there was minimal variability in baseline and intervention and a slight positive trend

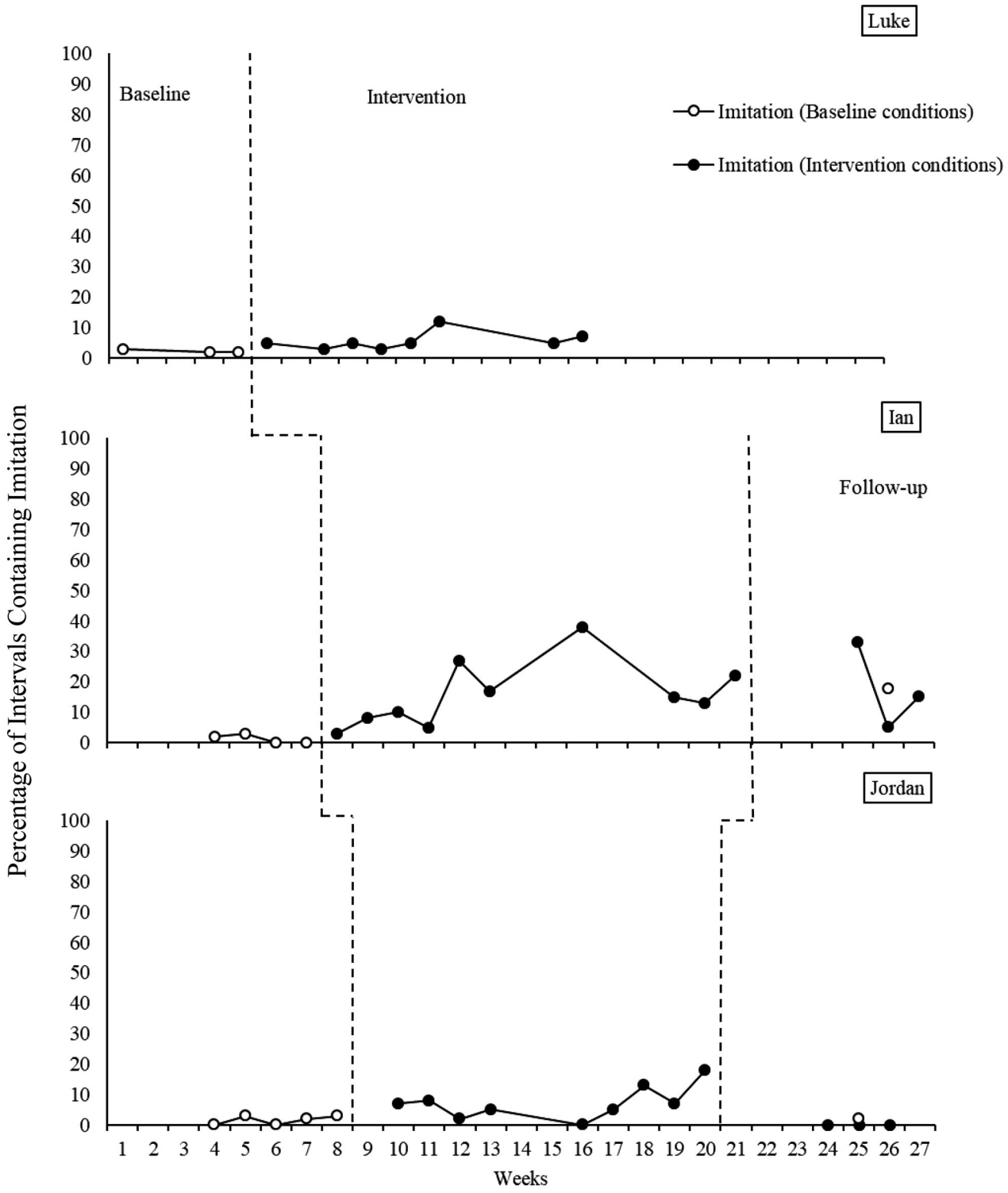

Figure 3 Percentage of 10-s intervals containing imitation.

during intervention. During Ian's baseline phase a mean of 1% of intervals contained imitation. This increased to a mean of 16% during intervention (Tau-U baseline-intervention = 0.98) and further increased to a mean of 18% during follow-up (Tau-U baseline-follow-up = 1). During the follow-up probe conducted under baseline conditions, 18% of intervals contained imitation. Visual analysis of Ian's graph indicates a positive trend during intervention and a negative trend during follow-up. Data were stable with minimal variability during baseline but was moderately variable during intervention and follow-up. During Jordan's baseline phase a mean of 2% of intervals contained imitation. This increased to 7% during intervention (Tau-U baseline-intervention = 0.71). There were no intervals containing imitation during Jordan's follow-up phase (Tau-U baseline-follow-up = −0.6). During the follow-up probe conducted under baseline conditions, 2% of intervals contained

imitation. Visual analysis of Jordan's graph indicates stable data during baseline and follow-up and a slight positive trend during intervention. The weighted Tau value for baseline-intervention imitation for all three participants was 0.86 ($p = 0$)

Discussion

This study aimed to evaluate the effectiveness of inclusive preschool-based delivery of a low-intensity version of the ESDM. Three preschool-aged boys with ASD received 3 h per week of intervention for 8–10 weeks. Intervention was delivered by the first author, a certified ESDM therapist, in the children's usual preschool settings. The author did not usually work at any of the preschools where the research was conducted. The results were generally positive for all three children. Specifically, the delivery of the intervention was associated with improvements in AP, IV, functional utterances, and/or imitation for participating children. All children appeared to improve across two outcomes, however, the specific improvements varied across children. For Luke, there were apparent improvements in AP and IV with only a minimal improvement in imitation. Ian's AP and imitation appeared to improve, and these improvements were maintained during follow-up. However, Ian appeared to make only minimal improvements in his use of functional utterances. For Jordan, AP and functional utterances appeared to improve with improvements maintained during follow-up. However, Jordan's improvements in imitation appeared to be only minimal and were not maintained during follow-up.

Overall, the results point to the feasibility and effectiveness of an external certified therapist implementing ESDM therapy in a typical New Zealand inclusive preschool setting. These findings are consistent with previous evaluations of the preschool-based delivery of the ESDM and with a number of studies into the use of other EIs for children with ASD in preschool settings (Eapen *et al.* 2013, Fulton *et al.* 2014, Tupou et al. 2019, Vivanti *et al.* 2013, 2014, 2019). The variation in outcomes observed across participants is also in line with previous studies as differences in treatment outcomes for children with ASD are well documented (Zachor and Ben-Itzchak 2017). However, direct comparisons across studies are problematic because of differences in child outcomes and the methods used to measure them.

Other studies of low-intensity ESDM delivered by certified therapists in a one-to-one format have reported similarly positive results on child outcomes (Colombi et al. 2018, Devescovi *et al.* 2016, Waddington et al. 2019). The study by Waddington *et al.* used a similar design and child DVs to evaluate outcomes for four children who received 3 h per week of one-on-one ESDM therapy in their homes. Participants from the Waddington *et al.*'s study showed greater improvements than those seen in the present study. This may indicate that, for the outcomes measured, ESDM is more effective when delivered in a one-on-one format in the home rather than a preschool environment that included relatively large numbers of children.

Although the child improvements in imitation were relatively minimal, it was interesting to note a positive trend during intervention for all participants. This positive trend may indicate that participants were indeed improving in their use of imitation, but that improvement was gradual rather than immediate. A longer intervention phase may have revealed an eventual significant improvement in imitation. Indeed, Ian's use of imitation further increased during follow-up, suggesting a continuing positive trend beyond his 10-week intervention phase. However, for Jordan, the minimal gains in imitation made during intervention appeared to be lost during the follow-up phase. Further, the study by Waddington et al. (2019), used low-intensity ESDM delivered over a similar intervention period and reported greater improvements in child imitation than those found in the present study. It is possible that imitation is more difficult to teach in a group setting where control of materials is more challenging. However, it would be useful for future studies to include a longer intervention phase to examine whether greater gains in imitation might be made over a longer period of time.

A logical corollary to the generally positive results observed in the present study would seem to be training regular preschool teachers to use the intervention themselves. Indeed, there is currently a strong focus on implementing and studying evidence-based practices under 'genuine circumstances' (Nahmias *et al.* 2019). Further, training teachers to implement interventions may broaden the reach of said interventions and allow more children with ASD or ASD-like symptoms to benefit from EI (Brian *et al.* 2017). However, there are likely to be additional challenges associated with teacher implementation of the intervention that may impact upon its feasibility for classroom implementation. Specifically, it may be difficult for teaching staff to deliver individualized instruction to children with ASD while they are also responsible for managing other children in the classroom. In classrooms with numerous children, teachers might not be able to deliver as much individualized instruction as a designated therapist. It is therefore possible that low-intensity intervention delivered by an outside provider, as was used in the present study could be a practical delivery option. Nonetheless, future research should aim to evaluate the feasibility of teachers delivering the intervention themselves.

The present study has several limitations that merit discussion. First, data related to social validity were not collected because the intervention was implemented by a trained ESDM therapist and thus it was not clear that the preschool teachers would have had enough direct

experience with the therapy to have provided useful social validation data. However, a consideration of social validity may be important for informing future efforts to train preschool teachers to use the present intervention themselves.

Likewise, the study is limited because we did not assess generalization across people or settings. Unfortunately, it was not possible to assess generalization due to logistical constraints, but clearly evidence of generalization would strengthen the claim of effectiveness for the present intervention. Future research could include a measure of generalization to regular teaching staff and peers and from the preschool to future primary school settings that the children enter at age 5 years (in New Zealand).

Also, we did not measure the impact of the intervention on participating children's interactions with peers. Such a measure is likely to be important because part of the rationale provided for delivery in an inclusive setting is the presence of typically developing peers and the opportunities for interaction and communication that these peers may provide. Likewise, the scale used to measure interventionist fidelity did not specifically measure fidelity during peer interactions. It would seem important for future studies to include a measure of participating children's interaction with peers and for the fidelity scale to include a measure specific to interventionist fidelity during peer interactions. The fidelity scales in the G-ESDM manual (Vivanti *et al.* 2017) include items related to the facilitation of peer interaction and it may be useful for these items to be included in future studies. It may also be valuable for future research to provide a more detailed report on the involvement of peers during intervention sessions. This could include detail of the number of minutes per session that involved peers.

Finally, the results from this study cannot be generalized to all young children with ASD. This study had a small, limited sample size, and participants were all males aged between 4 and 5 years old. Outcomes may vary for other subsets of individuals with ASD such as females or younger children. However, there may be some generality to this intervention given that the three participants in the present study did had differing levels of adaptive behavior (as evidenced by their Vineland scores) at the onset of the study. This would seem to suggest that the present intervention may be of value to a range of children with different levels of developmental functioning.

In conclusion, the results of this study suggest that a therapist-delivered program of ESDM intervention led to improved outcomes for three preschool children with ASD. The strength of the study lies in demonstrating positive outcomes from a relatively low-intensity version of ESDM when delivered in inclusive preschool settings. However, the study is limited due to the absence of social validation, generalization, peer interaction and long-term follow-up data. On the positive side, the present findings point to the feasibility of delivering effective EI to children with ASD in inclusive preschool settings, without having to make major adjustments to the preschool environment or classroom routines. A logical next step would seem to be training typical teaching staff to implement the intervention themselves, thus minimizing the need for outside experts.

Disclosure statement

The authors report no conflicts of interests and are solely responsible for the content and writing of this paper.

Funding

Preparation of this manuscript was supported in part by a PhD scholarship awarded to Jessica Tupou from Victoria University of Wellington.

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