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Parent-Implemented Oral Vocabulary Intervention for Children With Down Syndrome

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Abstract

Young children with Down syndrome (DS) often demonstrate impaired oral vocabulary development; however, few intervention studies have focused on this population. One promising method to improve the oral vocabulary of young children with DS may be to train their parents to intervene at home. In this study, we used tele-education methods (e.g., videoconferences, email) to coach parents to implement an adapted version of Down Syndrome LanguagePlus (DSL+). Four children with DS (ages 5–6 years) participated in the multiple probe across behaviors (i.e., stories) single-case research design study. Increasing trends during baseline and data variability precluded confirmation of a functional relationship; however, results indicated that all participants increased their scores on mastery measures of targeted vocabulary. Three of the four parents implemented DSL+ with high fidelity and responded favorably to social validity interviews.

Keywords

Down syndrome, language, vocabulary, early intervention, parent training

Down syndrome (DS) is a chromosomal condition that occurs in about 1 in every 830 live births per year in the United States (Parker et al., 2010) and is the most common genetic cause of intellectual disability (Fidler & Nadel, 2007). Children with DS often have delays or differences in oral vocabulary development, defined as the ability to use words in speech and recognize words while listening, which may be more pronounced for expressive than receptive vocabulary skills (Martin et al., 2010; O'Toole et al., 2018). DS characteristics, such as impaired hearing (Nightengale et al., 2017), difficulties with verbal working memory (Jarrold & Baddeley, 2001), and differences in mouth structure and muscle tone (Abbeduto et al., 2007), may contribute to this language profile. Environmental factors may also contribute, for example, poor speech production may result in adults' misunderstanding speech and failing to reinforce new words or ask complex questions (Abbeduto et al., 2007; Jordan et al., 2011). Nonetheless, individuals with DS can learn new words through multiple exposures and opportunities to use targeted words in context (Chapman et al., 2006). Parents should be included in vocabulary intervention, given the strong link between children's language interactions with their parents and later vocabulary and literacy skills (O'Toole et al., 2018). However, there is currently limited research on vocabulary interventions to meet the needs of children with DS and their families (Jordan et al., 2011).

Oral Vocabulary Intervention for Children With DS

A robust body of research indicates that early intervention can increase oral vocabulary skills of children without disabilities (Flack et al., 2018; Marulis & Neuman, 2010) and studies have included children with, or at risk for, disabilities (Heidlage et al., 2019; Roberts & Kaiser, 2011; Swanson et al., 2011). Effective interventions include explicitly teaching word meanings (i.e., direct instruction), implicitly teaching words within the context of activities (e.g., incidental teaching), shared book reading, dialogic reading techniques (e.g., describing pictures, asking questions), story repetitions, and the use of words in multiple contexts. In addition, emerging research indicates that technology (e.g., iPads) can support delivery of vocabulary interventions for students with intellectual and developmental disabilities (e.g., Rivera et al., 2013, 2017). However, there is

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limited evidence to support the effectiveness of these instructional strategies, or delivering oral vocabulary intervention using technology, for children with DS.

Two research groups (O'Toole et al., 2018; Smith et al., 2020) have conducted systematic reviews broadly focused on language intervention for young children with DS. O'Toole et al. (2018) identified three studies that involved training parents to implement interventions (two randomized control trials [RCTs] and one quasi-RCT) and included 45 total participants (ages 29 months–6 years). All interventions were multicomponent packages (e.g., enhanced milieu teaching) that each included research-supported components (e.g., incidental teaching, direct instruction). Researchers in only one study reported significant effects on general measures of children's language ability; however, two studies found that children in the intervention group used significantly more of the targeted words at post-intervention. O'Toole et al. (2018) rated the overall quality of the evidence as very low due to the small sample sizes and high risk of bias.

Smith et al. (2020) identified eight language intervention studies with control group designs that included 108 children in the intervention groups and 103 children in the control groups (ages 5–10 years). There was large variability in intervention characteristics (e.g., language components targeted, dosage of intervention), and researchers in only three of the eight studies focused on vocabulary skills. There was a large mean effect (g = 1.01; confidence interval [CI] = [–0.54, 2.57]); however, the results of one study positively skewed the mean (Baxter et al., 2018). Thus, there is a need for more high-quality studies to inform effective vocabulary intervention for young children with DS.

Training Parents to Implement Oral Vocabulary Intervention

The negative impact of early vocabulary deficits on children's future literacy skills (e.g., decoding and comprehension) points to the necessity of early intervention (Skibbe et al., 2008). Such intervention should occur in homes, considering that parents or other primary caregivers are typically a child's first communication partners, and the link between parent interactions and child language development is well-established (Heidlage et al., 2019; O'Toole et al., 2018). Furthermore, parents may not engage in high-quality interactions with their children who have impaired vocabulary development such as commonly demonstrated in children with DS. Training and support might be beneficial (Roberts & Kaiser, 2011).

Parent-implemented language and vocabulary interventions have shown promise for children at risk for disabilities (Heidlage et al., 2019; Roberts & Kaiser, 2011) and children with DS (O'Toole et al., 2018). However, parent training methods are unclear. Roberts and Kaiser (2011) identified 18 studies of parent-implemented language interventions, yet 13 omitted parent fidelity data and nine lacked descriptions of training procedures. Heidlage et al. (2019) identified a similar lack of training descriptions, and O'Toole et al. (2018) did not report specific training information. Thus, there is a need to identify methods for parent training and to identify relations between training methods, training dosage, and levels of intervention fidelity.

Behavioral skills training (BST; Parsons et al., 2012) is a coaching method based on principles of applied behavior analysis with a strong body of research supporting its effectiveness in training adult learners (e.g., teachers, human service staff, and parents; Kirkpatrick et al., 2019). BST includes four primary components: (a) instruction, (b) modeling, (c) rehearsal, and (d) feedback. Although BST can be effectively conducted in applied contexts (e.g., classrooms; Kirkpatrick et al., 2019), researchers also continue to use contrived contexts (e.g., simulated training settings; Conklin & Wallace, 2019). BST procedures can be adapted to meet trainee needs; for example, trainers may use video models if in vivo training time is limited (Kirkpatrick et al., 2019). The use of technology may be advantageous for families who implement intervention when a trainer is unlikely to attend in person (e.g., evenings, weekends). Research indicates that BST can be effectively delivered in tele-education formats with teachers (e.g., Higbee et al., 2016) and with parents (e.g., Lindgren et al., 2016; McDuffie et al., 2013). However, to our knowledge, the present study is the first to investigate the use of BST delivered through tele-education to support parents of children with DS in implementing oral vocabulary intervention.

The Down Syndrome LanguagePlus (DSL+) Intervention

Recently, Næss et al. (2021) responded to the lack of research on oral vocabulary intervention for children with DS by developing a systematic intervention package—The DSL+. Multiple research-supported components (e.g., picture book dialogues, direct instruction, story repetition, and use of words in different contexts) are included in the intervention. DSL+ was designed for children to receive intervention from an educator for 5 days per week for 30 weeks. The developers selected target vocabulary based on (a) age of acquisition (Kuperman et al., 2012), (b) frequency of exposure (Van Heuven et al., 2014), (c) relevance to social relationships, and (d) inclusion in common school curricula. DSL+ includes several visual and auditory representations of the target vocabulary to develop both breadth and depth of word knowledge. Likewise, instruction targets the meaning of multiple words related to a topic (i.e., semantics) and the use and form of words in sentences (i.e., morphology). Instruction follows a reoccurring task structure designed to meet the learning needs

of children with DS and to promote implementation fidelity. Most tasks are delivered using an iPad® application (app), with supplementary materials (e.g., picture cards and toys) for practical activities.

To date, Næss et al. (2021) have completed one RCT to investigate whether DSL+ increased oral vocabulary usage for children with DS. Participants were a national cohort of 103 Norwegian first graders with DS (ages 5–7 years). Analysis of the data is ongoing, but preliminary analysis of qualitative data indicated that educators implemented DSL+ successfully, and a one-way analysis of covariance (ANCOVA) comparing posttest expressive vocabulary scores of a subsample of the identification (ID) numbers scored at that time indicated a significant group effect, $F(1, 42) = 6.57$, $p < .014$, $d = 1.09$ (Næss et al., 2018).

The researchers reported a need for further investigation of participant characteristics related to intervention response and on features of DSL+ design (e.g., dosage needed for mastery, measurement of growth). There is also need to include parents and to investigate training procedures related to high procedural fidelity. In this study, we adapted the intervention for English-speaking children with DS and their parents and used a BST model primarily delivered through tele-education for ongoing coaching. Our primary research question was as follows:

> **Research Question 1 (RQ1):** Does parent-delivered, oral vocabulary intervention increase vocabulary skills of children with DS, as measured by mastery tests of target words?

Our secondary aims were to (a) determine whether our tele-education training model supported adequate procedural fidelity, (b) measure whether the intervention was socially valid for parents, and (c) evaluate differences in responses to receptive versus expressive mastery test administration.

Method

Participant Recruitment and Characteristics

Eligible children were those who (a) were diagnosed with DS, (b) were age 5 to 7 years, (c) communicated by speaking, and (d) correctly responded to 30% or fewer items on a screening assessment. Children also had a parent available to implement five 20-min sessions per week for up to 15 weeks. An institutional review board approved this study, and then we emailed flyers to a regional DS association and parents of children with DS who were nominated by research staff. Seven families responded and met the criteria; six parents consented and participated in screening. We used videoconference screenings to administer a 30-item assessment adapted from our intervention mastery test (six words from each story; see the "Dependent Variable" section). We displayed mastery test picture prompts, read verbal prompts, and provided 5 s for the child to respond (parents clarified as needed). We set a screening criterion of 30% or fewer correct responses to ensure that children had not previously learned most words, and thus, a sufficient number of words could be learned to demonstrate a functional relation (criterion adapted from Lemons et al., 2015). Five of the six children met our screening criterion. One parent declined to participate before intervention started due to time constraints and one participant withdrew before completing the study.

Characteristics of child participants (Polly, Chloe, Trent, and Della) and their parents are reported in Table 1. All children were diagnosed with DS and were between 5 and 6 years in age (three female, all White and non-Hispanic). All the children's standard scores on both KBIT-2 (Kaufman Brief Intelligence Test, Second Edition; Kaufman & Kaufman, 2004; and PPVT-4 (Peabody Picture Vocabulary Test, Fourth Edition; Dunn & Dunn, 2007) were more than 2 *SD*s below the mean of the normative sample (Trent omitted due to early withdrawal). A review of Individualized Education Programs (IEPs) indicated that all children had literacy-related goals (e.g., identify letters); however, only Della's IEP included a specific vocabulary goal. The results from a parent survey about children's early intervention services and home literacy practices (adapted from Al Otaiba et al., 2009) indicated that all children received numerous types of early intervention services, had daily access to literacy activities (e.g., being read to), and interacted with a TV or a computer/tablet on a daily basis.

Mothers were the primary interventionists in all cases; however, they reported that other parents and siblings often assisted or participated in small group activities. All mothers were White and non-Hispanic, their ages ranged from 33 to 48 years, and their highest education levels ranged from some college training to graduate degrees. Two mothers reported that they were stay-at-home mothers and two had full-time occupations outside of their homes.

Settings

Parents conducted all sessions in their homes, which were located in three different cities, approximately 20 to 120 miles outside of a large city in the southern United States. Most sessions occurred at an adult- or child-sized table in a main living area of the homes (e.g., kitchen, den). We did not prescribe a specific time that parents should complete sessions; thus, session times frequently varied (e.g., time of day, day of week).

Materials

We gave parents the following materials: (a) 9.7″ iPads® with preloaded apps, (b) GoPro video recorders, (c) intervention

Table 1. Child and Parent Characteristics.

	Child demographics and assessments						Parent demographics		
Child	Age[a]	Gender	Race/ ethnicity	KBIT-2[b] [90% CI]	PPVT-4[c] [90% CI]	Focus of IEP literacy goals	Age[a]	Occupation	Highest ed. level
Polly	5:10	F	W; N-H	54 [49, 63]	64 [59, 70]	Answer story questions, ID letter names/sounds, ID pictures/objects, read sight words, write letters/name	33	SAHM	College degree
Chloe	5:6	F	W; N-H	56 [51, 65]	34 [30, 42]	Match letters, trace name	35	Non-profit program director	Some college/ vocational training
Trent	6:5	M	W; N-H	—	—	ID letter sounds, read sight words	42	Nurse practitioner	Graduate degree
Della	5:1	F	W; N-H	50 [45, 59]	38 [34, 46]	ID letter names, ID vocabulary, match letters, write letters	48	SAHM	College degree

Note. Demographic data were collected through online surveys. Assessments were researcher-administered at post-intervention. All parents reported the same race and ethnicity as their child. CI = confidence interval; IEP = Individualized Education Program; SAHM = stay-at-home mother; W = White; N-H = not Hispanic; ID = identification.
[a]Child age reported in years and months; parent age reported in years. [b]Kaufman Brief Intelligence Test, Second Edition (Kaufman & Kaufman, 2004). IQ composite reported. [c]Peabody Picture Vocabulary Test, Fourth Edition (Dunn & Dunn, 2007). Age-normed standard score reported.

manuals, (d) story scripts, (e) mastery test cards, and (f) items for application activities (see Table 3). Apps were used for DSL+ activities, uploading session videos (GoPro; Box), video conferencing (Zoom), and email. Intervention manuals included task analyses for using study technology, descriptions of experimental procedures, step-by-step instructions for each activity, full texts for the picture books, and mastery test data forms. Parents used a picture book script on Days 1 through 3 to lead book discussions. We printed mastery test cards on half sheets of cardstock.

Intervention Procedures

Intervention overview. The adapted intervention included five stories with 5 days of activities each. Stories were titled *Hoot Is in a Hurry*, *Lightning the Train*, *Lisa Is Afraid of Monsters*, *The Competition*, and *Tony Wants to Play in a Band*. Sessions were intended to take 20 to 25 min and included two mastery tests (one from the target story and one probe). Parents completed the 5 days of activities and, if their child had not met the mastery test criterion (i.e., 10 of 12 items correct), they repeated the story and corresponding activities up to 2 more times. It was often difficult for parents to complete the group of five sessions on consecutive days; thus, we advised them to continue the sequence as soon as possible if they needed to skip a day.

We made several a priori adaptations to Næss et al.'s (2021) procedures to increase (a) our ability to demonstrate a functional relation within single case research, and (b) feasibility for parent implementers. Næss et al. included 22 stories in their original investigation and we chose five of these stories that the researchers identified as high-interest. We also developed a mastery test that parents could administer each session rather than a pre/posttest. Because sessions occurred in homes, we omitted large-group activities and instead asked parents to include at least one additional conversation partner for group activities.

Parent training. First, parents watched a 13-min video that included (a) an overview of study procedures, (b) directions and video model for administering mastery tests, (c) a video model of the picture book task, (d) video models of the first three tasks in the DSL+ app, and (e) written/verbal directions for completing Days 4 and 5. We created the video to minimize in-person training time; parents could also access it throughout the study. Thereafter, the first author led in-person training (1.5–2 hr) at each participant's home, following a BST format (Parsons et al., 2012). First, she provided verbal descriptions of all intervention materials (e.g., manual, apps). Second, she modeled implementation of the picture book task, practice tasks, and the Story 1 mastery test while the parent played the child's role. Third, the parent rehearsed at least one practice activity and three to five mastery test items while the researcher played the child's role and provided praise and corrective feedback. Fourth, the researcher coached the parent through conducting the first baseline session with their child, including data-sharing procedures.

Subsequently, parents implemented all sessions independently and submitted weekly videos to the research team. We observed the videos and provided ongoing support remotely. The first author held 15 to 30 min videoconferences with each parent once weekly for the first 2 to 3 weeks to answer questions, provide procedural fidelity feedback,

Table 2. DSL+ Activities: Days 1 to 3.

Activity	Goal	Day 1 tasks	Day 2 tasks	Day 3 tasks
Picture book dialogue	Provide context for vocab words	Child views picture book without text; parent uses script to tell story and asks questions	Repeat Day 1	Repeat Day 1
Variations task	Identify multiple examples of main word	Look at images and listen to words	Select yes/no to question, "Is this a picture of . . .?"	Say words from images
Relations task	Identify words associated with main word	Look at images and hear description of word relations	Select (drag) words belonging with main word to box from four options	Say relation word to finish a sentence
Category task	Identify category of main word and other words in category	Look at images and listen to words belonging to category	Select (drag) words that belong in category to box	Say words from images
Role task	Use main word in context	Look video of main word in action	Select answer to relation question after watching video	Say answer to relation question after watching video
Articulation task	Gain awareness of main word articulation	Look at video of mouth and listen to main word	Select picture correctly saying main word	Say main word to teach parrot (record audio)
First sound task	Gain awareness of individual sounds in words	Look and listen to first sound in main word	Select picture correctly saying first sound	Say first sound to teach parrot (record audio)
Singular/plural task	Discriminate singular/plural versions of main word	Look and listen to sentences with singular/plural forms of main word	Select correct picture after watching video of singular/plural pronunciation	Say singular/plural word from images
Present/past task	Discriminate present/past main and related words	Look and listen to sentences of present/past	Make a video acting out present tense of main word	Watch video from previous day (past tense)

Note. All Days 1 to 3 activities were completed within DSL+ app. Parent and child participated in all activities.

and describe experimental decisions (e.g., repeating a story). For the remainder of the study, we emailed parents 1 to 2 times per week. The emails included (a) praise for procedures completed correctly, (b) recognition of child behavior or mastery test scores, (c) corrective feedback as needed, and (d) reminders for study procedures. We asked parents to request when they needed additional support (e.g., phone call, video meeting); however, none requested this beyond the initial 2 to 3 weeks.

Baseline. Baseline sessions included parent administration of the DSL+ mastery test for Story 1 and two additional stories assigned by the research team (see the "Dependent Variable" section for test procedures). We did not introduce any instructional activities during baseline; however, we asked parents to maintain typical home literacy practices (e.g., storybook reading).

Intervention. See Tables 2 and 3 for descriptions of intervention activities. Days 1 to 3 included explicit instruction on target vocabulary words. During picture book dialogues, parents read from the script and the child viewed illustrations in the app. Scripts included short descriptions of pictures and characters, questions, and directions for interactive story effects. For example, *Hoot Is in a Hurry* began with "Look at this! What do you think this book is about?" on the first page, with an illustration of an ambulance. Next, parents described the ambulance (e.g., "He has four wheels. He drives fast like lightning.") while the child activated the effects (e.g., flashing lightning bolt, siren sound). Scripts included directions to provide a hint (and if needed, to model the correct answer) if the child did not respond to questions after 5 to 10 s or responded incorrectly. Questions increased in abstraction across the 3 days (e.g., from "what" to "why"). Book lengths ranged from 9 to 13 pages and dialogues required 5 to 8 min.

Next, participants completed eight tasks in the app focused on the meaning of the "main word" and 10 to 11 related words. For example, *Hoot Is in a Hurry*'s main word was "fast" and related words included "speed," "slow," and "run." During each task, the app played the audio of one instructor voice (a young female) and 20 additional voices throughout, including males, females, adults, and children. For example, during the Day 1 variations tasks, the instructor voice said, "Touch the images and listen to the words," while the child viewed four boxes with question marks. As the child touched each box, the image flipped over and a unique voice stated the word. For *Hoot Is in a Hurry*, this task included four depictions of the word fast (e.g., motorcycle, cheetah) with a different voice for each. The other seven tasks included a variety of instructions (e.g., listening to related words, looking at the main word in action) that increased in complexity each day from looking at images and video, to selecting from options, to saying the correct response. We asked parents to add at least one sentence of their own dialogue to each activity and gave examples in the intervention manual (e.g., "These are all different pictures of the word fast!"). Parents also corrected errors and prompted as needed. These eight tasks typically required fewer than 10 min.

Table 3. DSL+ Activities: Days 4 to 5.

Day & activity	Goal	Tasks	Materials
Day 4			
Picture book review	Abstract thought and reasoning about book content	Child tells story to group members while answering abstract and concrete questions	DSL+ app Day-3 picture book script
Picture book questions	Increased awareness of narrative structure	Child answers summary questions about main character, setting, problem, character feelings, and solution	Day-4 script with questions
Practical activity	Extended understanding of words	Group members play game that applies to main word: - Win: Match photos of win - Friend: Discuss friendship scenarios - Brake: Practice driving and braking - Fast: Sequence pictures from slow to fast - Loud: Play instruments loud and quiet	- Photo cards - Small racetrack and toy cards - Small instruments
Day 5			
Read picture book with full text	Introduce reading comprehension strategies	Group members view picture book; Parent uses full text to tell story and ask concrete/abstract questions	- DSL+ app - Full story text
Group activities	Introduce narrative structure and cognitive strategies	Group members sequence story events with guidance from Day 4 summary questions	- Sequencing photo cards

Note. Activities on Days 4 to 5 included one or two additional conversation partners (e.g., other parent, sibling, or friend).

The purpose of Days 4 and 5 sessions was to support generalization of content from Days 1 to 3. Parents invited one or two additional conversation partners (e.g., siblings, other parents) to join these activities. Day 4 included a picture book review, comprehension questions (e.g., *What was the book about*? *What was the problem*?), and a practical activity. Day 5 included a longer version of the picture book (i.e., the full text), comprehension questions, and a sequencing activity. See Table 3 for more details.

Dependent Variable and Data Collection

The dependent variable was the number of correct items on an oral vocabulary mastery test administered by parents during each session. Mastery test items included words targeted within stories and practice activities (pool of 10 to 11 words per story). Word types were balanced across stories. Target words ranged from one to four syllables in length and included nouns (e.g., ambulance, game), verbs (e.g., run, yell), adjectives (e.g., quiet, slow), and adverbs (e.g., faster, slower). Although the concepts of the words' role in sentences (e.g., The music is loud) and present/past tense (e.g., play/played) were included in DSL+, we omitted these from mastery tests due to the difficulty of picture depictions.

Each item had one expressive and one receptive version. Expressive items included one picture prompt and a verbal statement. For example, for the word *loud*, the parent showed a picture of a child holding his ears while standing by speakers and said, "The boy had to hold his ears at the concert. The music was just too _____." The pictures were included in DSL+ practice tasks but the verbal statements were not. Children were correct if they said the target word within 5 s (articulation errors accepted). During receptive tests, the child viewed four pictures (one correct and three distracters). The parent pointed to each picture, named it, and then read the statement. Children could point to the corresponding picture or say the word without pointing. Each test included 12 items (six receptive and six expressive) pulled from the larger stack of 10 to 11 items. Parents shuffled the two stacks of cards and then administered the first six items from each stack. We instructed parents to refrain from providing feedback during mastery tests.

Parents recorded scores (i.e., 0/1) on paper data forms and then completed a secure web survey hosted at Vanderbilt University (Research Electronic Data Capture [REDCap]; Harris et al., 2009). At study conclusion, the research team reviewed the original data sheets and checked data entry from surveys against the hard copies. Data entry was correct for all sessions. Parents also submitted videos of sessions on Days 1 through 3; Days 4 and 5 were omitted to facilitate inclusion of non-consented conversation partners. Parents recorded videos with GoPro cameras positioned so the child and all materials were visible. GoPros were connected to iPads® using WiFi; parents then uploaded videos to a researcher-owned folder within the Box app.

Interobserver Agreement and Procedural Fidelity

We collected interobserver agreement checks (IOA) on at least 30% of sessions for Polly, Chloe, and Della, selected semi-randomly across phases. Trent's parent had difficulty with video uploads; thus, we observed two of 11 sessions (18.18%). Research assistants (RAs) were trained to a 90% agreement level with the first author prior to collecting data. For IOA, an RA watched the mastery test videos and

independently scored each item. We then added the number of items on which our score agreed with the parent's (total possible = 12), divided agreements by the sum of agreement plus disagreements, and multiplied by 100 (i.e., point-by-point IOA). As seen in Table 4, mean IOA per participant ranged from 94.73% (Della) to 100% (Trent).

We measured parents' procedural fidelity (PF) from video observations in baseline and intervention Days 1 through 3 (generalization activities on Days 4–5 omitted). We tallied each time the parent completed a component correctly (e.g., correct materials present, mastery test items completed, and picture book scripts read). We calculated PF percentages by dividing the number of correct items by the total number of required items and multiplying by 100. As displayed in Table 4, mean PF per participant ranged from 69.71% (Trent) to 89.75% (Chloe). Scores lower than 80% occurred in six of 49 total sessions with PF data. The most common errors were omitting text from picture book scripts or dialogue during app activities (one comment/question required per activity). We also rated overall implementation quality across five indicators: (a) providing 5 to 10 s wait time after questions; (b) providing praise following correct responses; (c) providing error correction for incorrect responses; (d) maintaining a warm, positive tone; and (e) spending the majority of the session in instruction. Results of quality ratings ranged from 3 to 5. The most common error was inadequate wait time.

Experimental Design and Data Analysis

We used a multiple probe across behaviors design (Gast et al., 2018) to analyze the effect of parent-implemented oral vocabulary intervention on children's mastery test scores. Each of the five DSL+ stories was an experimental tier (i.e., behavior) and story order was randomized for each participant (stories did not build on each other). Parents implemented DSL+ for 1 to 3 weeks per story (i.e., 5–15 days). Baseline included at least three sessions; intervention began once baseline data were stable or had a decreasing trend. We limited baseline data collection to prevent parent and child frustration with extended assessment prior to intervention; this procedure meets minimum design standards (What Works Clearinghouse, 2020). During each intervention session, parents collected mastery test data from Story 1 and one additional story (schedule provided by research team). When a participant met Story 1 mastery criterion (10 items correct), they completed three final days of intervention in the sequence during which the parent collected continuous baseline data for the next story. If we observed increasing trends in baseline, parents collected additional baseline data without DSL+ implementation until a stable trend was established. Parents repeated these procedures for Stories 2 through 4 and concluded intervention with Story 5 after 5 days with scores of 10 or higher on the Story 5 mastery test. After a story was completed, mastery tests from that story served as maintenance data.

Item analysis. A secondary aim of this study was to investigate whether participants responded differentially to receptive versus expressive items. Thus, we analyzed mastery test responses within each phase. We collapsed data across the five stories, and then counted the total number of receptive and expressive items answered correctly in each phase, divided by the total number of opportunities, and multiplied by 100 to derive the percentage of items correct by phase. For example, in baseline, Polly correctly answered 97 receptive items out of 222 possible items (six items in each of 37 baseline tests). We divided 97 by 222 and multiplied by 100 to determine Polly correctly responded to 43.69% of baseline receptive items. We displayed results in a bar graph format and compared correct responding across phases and participants.

Social Validity

We measured the social validity of intervention goals, procedures, and results through post-intervention interviews (in person for Polly and Chloe; on telephone for Della). Chloe's mother and father both participated in her interview and agreed on all responses. We asked parents to rate nine statements with a Likert-type scale (1 = *strongly disagree*, 3 = *neutral*, 5 = *strongly agree*). We followed statements with open-ended questions such as "How would you improve the intervention?"

Results

Mastery Test Results

See Figure 1 for graphs of mastery test data. Polly, Chloe, and Della completed between 43 and 57 total sessions. Trent's parent withdrew from the study after 11 sessions due to Trent engaging in challenging behaviors (e.g., shouting, hitting, and elopement) and difficulty with sharing videos due to upload speeds. Across all participants, baseline data demonstrated moderate variability and some increasing trends. Following DSL+ implementation in each tier, there were increases in the level of correct responses for Polly, Chloe, and Della. Changes were immediate in most tiers; for example, Polly's correct responses immediately increased when intervention was implemented in Story 3. In some cases, changes in level occurred after two to three sessions of intervention (see Della's Story 2 data). Data within intervention phases generally demonstrated increasing trends with low to moderate variability. Polly and Chloe met mastery criterion for all stories, Della met mastery criterion for four stories, and Trent and did not reach mastery for any story. These data suggest that three of the four

Table 4. Procedural Fidelity and Interobserver Agreement by Participant and Phase.

Child	Measure	BL[a]	Story 1	Story 2	Story 3	Story 4	Story 5
Polly	PF—I	100%	70.78% (57.63%–83.93%)	86.45% (82.76%–90.16%)	88.36% (85.19%–91.53%)	91.31% (88.89%–93.65%)	86.67%
	PF—Q	—	4.5 (4–5)	5	5	5	5
	IOA	—	94.45% (75%–100%)	96.67% (83.33%–100%)	94.60% (81.82%–100%)	95.37% (83.33%–100%)	97.22% (91.67%–100%)
Chloe	PF—I	100%	88.14% (84.75%–91.22%)	90.36% (89.65%–91.07%)	91.12% (88.52%–95%)	85.29% (84.48%–86.21%)	86.77% (84.48%–89.06%)
	PF—Q	—	4.75 (4–5)	5	4.67 (4–5)	4.67 (4–5)	3.5 (3–4)
	IOA	—	97.92% (91.67%–100%)	96.67% (91.67%–100%)	95.83% (83.33%–100%)	98.61% (91.67%–100%)	95.00% (83.33%–100%)
Trent	PF—I	97.29%	100%	—	—	—	—
	PF—Q	—	4	—	—	—	—
	IOA	—	97.29%	—	—	100%	100%
Della	PF—I	100%	86.00% (83.33%–93.10%)	75.98% (56.62%–87.50%)	79.35% (69.44%–86.36%)	90.40% (84.21%–96.83%)	92.53% (91.38%–93.22%)
	PF—Q	—	4.75 (4–5)	4.75 (4–5)	4.33 (4–5)	4	4.33 (4–5)
	IOA	—	97.22% (83.33%–100%)	95.00% (83.33%–100%)	88.89% (83.33%–100%)	96.43% (83.33%–100%)	92.93% (90.91%–91.67%)

Note. Mean results reported, followed by range. IOA means calculated by story across all phases; PF means calculated within phases. BL = baseline; I = implementation; IOA = interobserver agreement; PF = procedural fidelity; Q = quality.

[a]BL IOA is presented with the corresponding story.

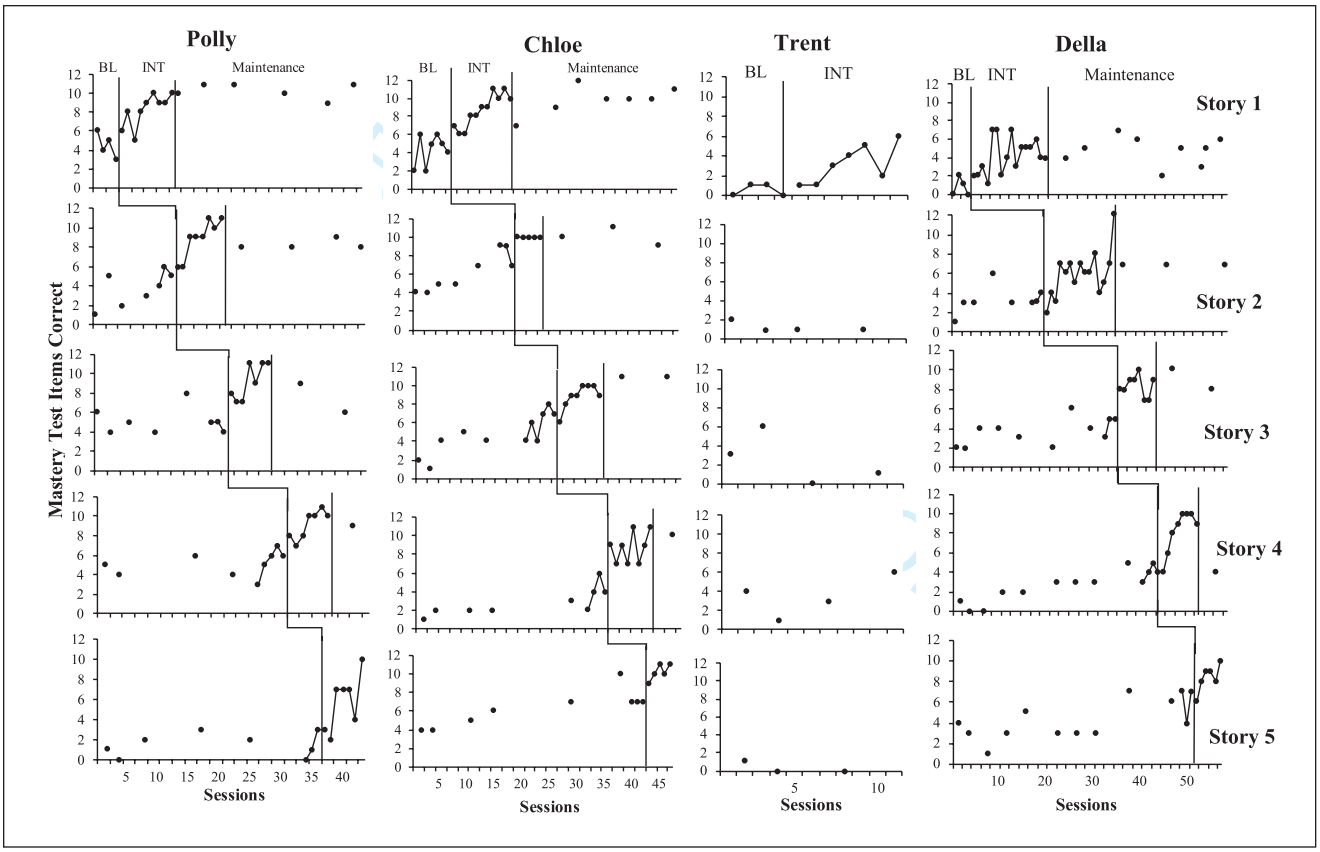

Figure 1. Participants' mastery test performance.
Note. BL = baseline; INT = intervention.

participants learned the correct responses to mastery test prompts; however, the increasing trends in baseline prevent identification of functional relations. Across cases, data in maintenance conditions remained at levels similar to intervention data and displayed low to moderate variability.

Item Analysis

Item analysis results are depicted in Figure 2. Polly responded correctly to more receptive than expressive items across baseline (43.69% receptive, 22.07% expressive), intervention (74.77% receptive, 64.86% expressive), and maintenance (80.77% receptive, 71.79% expressive) phases. Chloe's data displayed the opposite pattern, with data consistently higher for expressive (42.80%, 77.48%, and 87.18% by phase) than for receptive (36.36%, 73.42%, and 80.77% by phase) items. Della's data did not present a consistent pattern. Responses to receptive items were higher in baseline (30.85% receptive, 21.28% expressive) and intervention (53.33% receptive, 36.00% expressive) phases but equivalent in the maintenance phase (46.88% for both). Across participants, correct responses to both receptive and expressive items typically increased across phases. As an exception, Della's percentage of correct responses to receptive items decreased from intervention to maintenance.

Social Validity Results

See Table S1 in the online supplemental materials for social validity results (Trent's parent omitted due to limited experience with DSL+). Parents agreed or strongly agreed (ratings = 4 or 5) with most statements. Parents described their children using target words during and outside of sessions; for example, Polly began asking family members to "whisper," and Chloe began saying "family together" when standing with her mother and father. Ratings on children's engagement during sessions ranged from 3 to 4; follow-up questions indicated more engagement with iPad® activities (Polly), variable engagement (Chloe), and increasing engagement across time (Della). Ratings on whether parents used intervention strategies outside of sessions ranged from 2 to 4; we used these data to hypothesize whether increased scores could be due to treatment diffusion. Two parents explained that they did not purposefully implement strategies, but that they frequently talked about concepts after the children initiated the conversation.

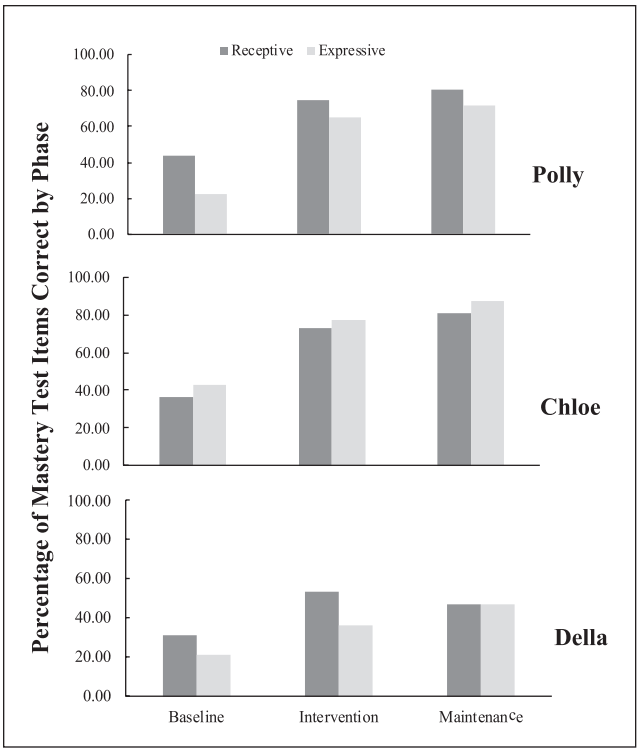

Figure 2. Item analysis of receptive and expressive mastery test administration.
Note. Trent excluded from analysis due to limited data.

Discussion

We conducted this study to investigate whether parent-implemented oral vocabulary intervention for young children with DS would result in increased scores on mastery measures of targeted vocabulary. This study adds to the small number of previous studies that investigated technology-based oral vocabulary intervention (Rivera et al., 2013, 2017) and is one of few studies to focus on oral vocabulary intervention for children with DS (see Næss et al., 2021; O'Toole et al., 2018). We included four children ages 5 to 6 years, three of whom completed the adapted intervention (five stories, 40 to 57 sessions). We trained and supported parents (in all cases, mothers) through a tele-education model.

Three of four children's data demonstrated increases on the parent-administered mastery tests for all five stories, and two children met mastery criteria for all five stories. This suggests that participants learned to respond correctly within the assessment context. Increases in correct responses occurred within a relatively brief duration and with multisyllable words representing complex concepts (e.g., competition, relationships). DSL+ includes multiple instructional components identified as effective for increasing oral vocabulary skills of children identified with, or at risk for, disabilities, including direct instruction of word meanings, picture book dialogues, repetitions of stories, and exposure to target words across many contexts (Flack et al., 2018; Heidlage et al., 2019; Marulis & Neuman, 2010; Swanson et al., 2011). Our results suggest that these strategies may have promise for young children with DS. However, due to increasing trends and variability during baseline phases, we cannot identify a functional relationship between the intervention and mastery test scores. Nonetheless, we believe our findings positively contribute to the literature through the demonstration of a promising and feasible method of tele-education parent training.

Reviews of vocabulary intervention research have found limited information about parent training methods and fidelity outcomes (Heidlage et al., 2019; Roberts & Kaiser, 2011). Although the broader literature on BST indicated that it could be effectively delivered through tele-education (Higbee et al., 2016; Lindgren et al., 2016; McDuffie et al., 2013), to our knowledge, no studies had used tele-education to train parents to implement oral vocabulary intervention. Thus, our findings in these areas are particularly important and encouraging. Initial training was relatively brief, including a video introduction (13 min) and one in-person session (1.5–2 hr). We then used videoconferences or emails (15 min, once per week) for ongoing coaching. Three of four parents maintained acceptable PF, with mean scores ranging from 85.26% to 89.75%. Furthermore, all parents collected mastery test data with a high degree of accuracy (mean IOA ranged from 94.73% to 100%). These results indicate that tele-education models may be an effective way to train and support some parents to implement early intervention; this may be particularly relevant when families live at a distance from trainers.

Trent's parent was the exception to these results. Her fidelity decreased sharply from her first to second observation (97.29%–42.12%) due to Trent's frequent challenging behavior. We gave her multiple strategies to manage challenging behavior during sessions (i.e., differential reinforcement); however, the parent reported an inability to implement the recommendations and the family experienced difficulties with their internet connection. In-person coaching may have been more appropriate for their family to allow the research team to directly model the strategies with Trent. Unfortunately, we were unable to investigate alternative methods within this study.

Three parents' responses during the post-intervention social validity interview indicated that they believed the goals and procedures of the intervention and coaching methods were feasible and acceptable. Furthermore, they described their children using the target words both during and outside of sessions. Despite their positive ratings of the intervention content, parents also gave suggestions for future improvements. These included minimizing time spent on mastery tests, adapting tests to a game-like format, and reducing video requirements (in contrast, one parent

noted that videos provided accountability). These considerations are important for future single-case design research investigations, given that single-case design is characterized by frequent data collection and fidelity checks. Readers should note that we did not ask Trent's mother to complete a social validity survey—she indicated, when she withdrew, that study procedures were not feasible for her.

Our final aim was to compare responses from expressive and receptive mastery test formats. Research indicating that children with DS develop stronger receptive than expressive vocabulary skills (Abbeduto et al., 2007) led us to hypothesize that receptive scores would be consistently higher; however, this was only the case for one participant (Polly). Chloe consistently responded correctly to more expressively administered items and Della's results were somewhat mixed. One explanation for Chloe's results is that, during receptive administration, she sometimes pointed to the most interesting distracter (e.g., animal pictures). Thus, her receptive scores may have been slightly deflated and may have sometimes reflected motivation more than knowledge. Future researchers should continue exploring methods to measure oral vocabulary skill with this population (cf. Martin et al., 2010).

Limitations

We identified two limitations related to our dependent measure. As previously discussed, three participants' mastery test data displayed increasing trends during baseline phases. Although we used a multiple probe design rather than a standard multiple baseline design to reduce the possibility of testing effects, these data indicate that a testing effect likely occurred. Participants may have learned to correctly respond to some mastery test items due to repeated exposure to those items, parents may have incidentally reinforced correct responses, or parents' experience with baseline items may have resulted in them incidentally teaching nontarget words during preceding tiers. Due to these potential confounds, our results for the mastery test outcome should be interpreted with caution. An additional mastery test limitation is that administration included both a picture prompt and a verbal statement. Thus, we do not know which stimulus controlled children's correct responses—the picture, the statement, or a combination of both stimuli.

Two additional limitations relate to participants' characteristics and the use of a tele-education model. All parents reported the same race/ethnicity, similar levels of education, and experience with the required technology (i.e., iPads®). Also, two parents described themselves as stay-at-home mothers. Parents with different technology experiences may require more training and coaching than our participants, and parents who work full-time outside of their homes may have difficulty scheduling intervention sessions. Opinions about the social validity of our research procedures (e.g., filming and submitting videos) could also vary between families. Future research on this topic would benefit from inclusion of a more diverse sample than ours to identify such nuances. Second, we acknowledge that tele-education models may not be appropriate for families with intensive support needs (e.g., for children with challenging behavior). Although technology allowed us to enroll participants who lived up to 120 miles away, this distance prevented us from being able to provide in-person support when needed.

Additional limitations relate to fidelity data collection. We did not collect implementation fidelity during parent trainings; thus, procedures may have differed slightly between participants. We also did not collect fidelity data on parents' implementation of Day 4 and 5 activities. We hypothesized that this would increase the feasibility of the study and families would engage with multiple conversation partners during group activities. However, this precluded our ability to assess implementation on those days. In addition, parents occasionally submitted videos with poor quality (e.g., materials off-screen, videos cut short) or were unable to film sessions (e.g., camera was not charged). This affected our ability to score all procedures and to maintain a random schedule of data collection.

Implications for Research and Practice

There remain multiple avenues for future research on improving the oral vocabulary of children with DS. First, researchers should continue to investigate vocabulary measures that are appropriate for this population and for single case research (SCR). Such measures must be sensitive to change within a relatively brief time period but robust to the effects of repeated testing. Researchers must also decide how best to evoke children's use of vocabulary words. We included both pictures and spoken prompts in our mastery tests because we were concerned that pictures alone could be interpreted in multiple different ways (especially pictures of verbs [e.g., fast]) and that verbal prompts alone would be too demanding on participants' working memory (Jarrold & Baddeley, 2001). Future studies may compare the utility of multiple measures of content mastery.

Second, we suggest that researchers investigate methods for training parent implementers to make instructional decisions. Although we provided brief ongoing support in this study, we did contact participants each time an instructional change was necessary (i.e., when a participant met mastery criterion). Specific to technology-based interventions like DSL+, researchers could program apps to guide participants through instructional decisions by embedding assessment materials and providing immediate feedback.

Third, an important implication for both research and practice relates to how end users might support parents to

implement vocabulary intervention. Children in this study were enrolled in school, and all had IEPs. Although parents have an integral role in the IEP process, it would likely be challenging for schools to support parents in implementing systematic interventions. Considering the importance of parent–child interactions in vocabulary development (O'Toole et al., 2018), we believe training parents to intervene is worth the effort. Nonetheless, there is a need for researchers and service providers to collaboratively identify personnel with the time and expertise to support parents. This may be accomplished through collaboration with related service providers (e.g., speech-language pathologists) who work in school districts or perhaps through in-home therapy providers (e.g., early interventionists). This process should be informed by an empirical investigation of methods that allow experts to release training/coaching responsibilities to end users—BST models may be appropriate and effective.

We note that DSL+ is not commercially available at the time of this writing, but we believe parents could replicate several components. Considering the lack of functional relations within this study, we recommend parents choose components identified as research-supported within the broader literature base. For example, DSL+ includes multiple exposures to target vocabulary, which is a strategy supported by additional research (e.g., Chapman et al., 2006; Flack et al., 2018). A parent could identify relevant vocabulary words from school-provided lists, ask a librarian to identify books that include those vocabulary words, and then facilitate multiple exposures to that word by locating pictures/videos on the internet and in their community.

Conclusion

The findings from this study demonstrate the potential for parent-delivered interventions to support the vocabulary development of children with DS. Researchers and practitioners should continue exploring ways to effectively and efficiently support parents in providing structured vocabulary experiences to their children. Doing so will ensure that a greater number of children with DS will develop breadth and depth of vocabulary knowledge, which has the promise of providing a solid foundation to support the development of early literacy skills.

Authors' Note

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Supplemental Material

Supplementary material for this article is available on the Topics in Early Childhood Special Education website at http://tecse.sagepub.com.

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