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Phonological awareness intervention using a standard treatment protocol for individuals with Down syndrome

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Abstract
This multiple baseline across-participants single case desgin study examined the effect of small group, phonological awareness intervention on the phonological awareness skills of three school-age children with Down syndrome. Each child with Down syndrome was paired with a typical peer to participate in small group intervention, three sessions per week for seven weeks. Lessons from a single unit in the Intensive Phonological Awareness Program were adapted to incorporate repeated exposure to the curriculum and increased opportunities for practice. A functional relation between the intervention and improved phonological awareness skills was not established based on visual analysis of the probe data across the three participants. However, an increasing therapeutic trend following delayed treatment effects as well as an increase in phase means from baseline to intervention was observed for each participant. This investigation provides preliminary guidance for adapting phonological awareness standard treatment protocols for children with Down syndrome by providing repeated opportunities for practice and including peers in small group intervention.

Keywords
children, Down syndrome, efficacy, intervention, phonological awareness

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I Introduction

Children with Down syndrome (DS) typically present with deficits in cognition, speech and language, and academic achievement relative to same-age peers (Chapman, 2003; Laws and Bishop, 2004). Oral language is an area of weakness relative to nonverbal cognition for children with DS (e.g. Chapman, 1997). Contrary to once commonly-held beliefs, recent evidence suggests that learning to read is an achievable goal for many individuals with intellectual disabilities, including children with DS (Allor et al., 2014; Fletcher and Buckley, 2002). Predictors of reading proficiency in individuals with DS include cognitive ability, expressive and receptive language, phonological awareness, and hearing acuity (e.g. Hulme et al., 2012; Laws and Gunn, 2002; Lemons and Fuchs, 2010). For children with DS, there is emerging evidence that phonological awareness is a malleable skill and that changes in phonological awareness are associated with growth in word reading (Goetz et al., 2008; Kennedy and Flynn, 2003). Because phonological awareness is a foundational skill for word decoding, it is essential to explore further the malleability of phonological awareness in children with DS as well as to identify phonological awareness treatment protocols that are effective with children with DS. Given relative strengths in language comprehension and visual processing as well as deficits in working memory and other domains of speech and language, the unique phenotype of DS suggests the need for research specifically with children with DS (Chapman and Hesketh, 2000). That is, findings from typical language learners and from children with intellectual disability but not DS may not generalize to children with DS. Thus, in this study we examined the effect of small group, phonological awareness intervention on the phonological awareness skills of children with DS.

1 Phonological awareness in children without intellectual disabilities

a Development. Phonological awareness – the ability to analyse the sound structure of a language separate from its meaning – is a metalinguistic skill that emerges in the preschool years and continues to develop at least into the kindergarten and early school grades (Lonigan et al., 1998; Mattingly, 1972; van Kleeck, 1994; Wagner et al., 1997). Phonological awareness proficiency has a causal as well as bidirectional role in early reading acquisition, specifically, word decoding (O'Connor et al., 1993; Stahl and Murray, 1994). As a result, deficits in phonological awareness may negatively affect reading development at the word level and associated reading comprehension. Multiple tasks that range in complexity fall under the umbrella of phonological awareness. Phonemic awareness, that is, the isolation of individual sounds (e.g. *Tell me the first sound in FISH*), is most important for reading acquisition (see Schuele and Boudreau, 2008). Implicit as well as explicit learning opportunities contribute to children's phonological awareness development (Justice et al., 2003).

b Intervention. There is a large body of research with children of average intellectual ability that demonstrates that improving a child's phonological awareness leads to gains in word decoding, and that learning to read is associated with further growth in phonological awareness (Bus and Van IJzendoorn, 1999). At present it is likely that all children encounter some experiences in school that promote the development of phonological awareness. However, the extent to which individual children benefit from these experiences varies (Carson et al., 2013; Catts et al., 2005; Kamhi et al., 1985). For children who benefit less, it is not the case that they are unable to learn phonological awareness. Rather, these children need systematic and scaffolded learning opportunities that are sufficient in scope, frequency, and intensity to master phonological awareness (Mathes et al., 2001). Most phonological awareness standard treatment protocols were developed for intervention with children who have average intellectual abilities (e.g. Blachman et al., 2000; Torgesen and Bryant, 2013). It remains unknown whether these treatment protocols are effective for children with intellectual disabilities or in what ways these protocols need to be adapted to be effective with these children.

2 Phonological awareness in children with DS

a Development. In a study of 4- to 6-year-old children with significant language disabilities, some secondary to intellectual disability, O'Connor and colleagues (1993) asserted that although a child's level of cognitive development predicts learning outcomes, cognitive level does not limit the ability to learn phonological awareness. In support of this assertion, based on a systematic review of the literature, Lemons and Fuchs (2010) concluded that children with DS develop and rely on phonological awareness skills in learning to read. However, when compared to preschool children with typical development, individuals with DS (ages 5 to 17 years) perform significantly worse on phonological awareness tasks (e.g. Boudreau, 2002; Lemons and Fuchs, 2010; Næss, 2016). Given the many phonological awareness tasks that range in complexity that have been used in research, it is apparent that children with DS demonstrate a pattern of strengths and weaknesses and that developmental level may be important. For example, Lemons and Fuchs (2010) concluded that children with DS performed more similarly to peers with typical development on tasks measuring early developing phonological awareness skills (i.e. initial phoneme detection) compared to later developing phonological awareness skills (e.g. blending and segmenting sounds). Also characteristic of children with DS are greater difficulties on rhyme tasks compared to more advanced phonological awareness tasks (e.g. Hulme et al., 2012; Næss, 2016; Snowling et al., 2002; Steele et al., 2013) and more difficulty with segmentation tasks compared to blending tasks (van Bysterveldt and Gillon, 2014).

Importantly, van Bysterveldt and Gillon's (2014) cross-sectional study found that older children with DS scored higher on phonological awareness measures than younger children with DS. They interpreted this finding as supportive of growth in phonological awareness over time for children with DS, although it is unknown what impact teaching and/or intervention may have had on this growth. In contrast, in a longitudinal study of school-age children with DS, Kay-Raining Bird and colleagues (2000) concluded that participants did not demonstrate developmental growth in critical phoneme-level skills over a business-as-usual five-year period. Thus, phonological awareness skills may be delayed substantially and therefore, children with DS may benefit from explicit phonological awareness instruction.

Whereas phonological awareness intervention in general and special education has become a focus for struggling readers, it has not been extended consistently to children with DS. Thus, educators and speech-language pathologists do not have a strong evidence base evaluating potential interventions for phonological awareness and word decoding training in children with DS. Though limited, there is some current evidence suggesting that training phonological awareness in DS will facilitate word reading skills. Even when phonological awareness is not explicitly taught, there are data to show that the level of phonological awareness is predictive of children's word reading skills in DS (e.g. Næss, 2016; van Bysterveldt and Gillon, 2014). This evidence implies that improving phonological awareness skills in students with DS will further improve word reading. Thus, these findings support further exploration of instructional methods or standard treatment protocols, if any, that are effective for improving phonological awareness in children with DS. Goetz et al. (2008) suggested that a holistic approach to teaching reading that emphasizes explicit phonological awareness training and includes modifications such as the use of visual supports might result in the greatest gains for individuals with DS.

b Intervention. Several recent studies suggest that intensive phonological awareness intervention is effective for preschool and school-age children with DS (e.g. Lemons et al., 2015). For example, in a randomized control trial of 57 school-age children with DS, Burgoyne and colleagues (2012) found that after 20 weeks of one-on-one language and literacy intervention, the intervention group showed significantly greater progress than the waiting control group on measures of phoneme blending. Næss (2016) found in a longitudinal study conducted in Norway that children with DS who received school-based phonological awareness instruction exhibited greater improvements on all phonological awareness measures compared to nonverbal IQ-matched controls who had not yet entered school. In a multiple probe across behaviors single case research design study with two pre-school children with DS, LeJeune et al. (2018) evaluated the effectiveness of a systematic phonological awareness intervention administered one-on-one that used explicit instruction and a data-based decision-making framework. Interventionists adapted explicit phonological awareness instructional strategies (e.g. scaffolded instruction, multiple opportunities to respond, system of least prompts) and they assessed the children's blending and segmenting syllables, onset-rimes, and individual phonemes. A functional relation between the intervention and improvements in phonological awareness skills was observed for one participant. Although a functional relation was not observed for the second participant, two demonstrations of an intervention effect were observed for blending and segmenting syllables and onset-rimes.

Similar to our goal in the study reported here, Lemons and colleagues (2015) evaluated whether a commercially-available phonological awareness program (Blachman et al., 2000), adapted based on the DS phenotype, would increase children's phonological awareness skills. Results of the single case research design with five school-age children with DS indicated a functional relation between the adapted program, administered one-on-one, and the phonological awareness initial sound identification outcome measure. Four participants demonstrated notable gains in phonological awareness and the final participant demonstrated minor improvement. Note that this program was designed for small group instruction but was adapted to individual implementation. Additional evidence is needed to investigate how phonological awareness instruction can be adapted and delivered most effectively for children with DS, particularly whether group instruction is effective.

II The current study

The purpose of this study was to conduct a preliminary investigation of an adaptation of the commercially-available Intensive Phonological Awareness Program (IPA Program; Schuele and Murphy, 2014) for children with DS. The IPA Program was designed as a small-group intervention for struggling learners in kindergarten and first grade who have average intellectual ability. It is a 36-lesson intervention consisting of 4 units, each 9 lessons in length. The first three units are structured around a similar set of activities but each unit targets a different aspect of phonological awareness – rhyme, initial sounds, final sounds. The reason for having the same activities is to decrease the cognitive load; as new skills are targeted, the activities remain constant. The fourth unit targets segmenting words into sounds and includes blending activities as well. Each lesson is 30 minutes in length and begins with a 3- to 5-minute letter/sound activity to teach and reinforce alphabet knowledge. The remaining 25 minutes are devoted to two or three phonological awareness activities that only in rare instances includes letters, and then only minimally. That is, the IPA Program includes primarily 'pure' phonological awareness activities that focus on the analysis of sounds in words (i.e. phonemes) and not a simultaneous focus on phonemes and the symbols (i.e. graphemes) used to represent phonemes in print. The program is designed as a sequentially-implemented standard treatment protocol. That is, lessons are completed in sequence regardless of child performance. The movement from one lesson to the next is not dependent on a particular level of child proficiency. However, within each lesson scaffolding is aligned with the proficiency of the children in the small group. Thus, the program is not individualized at the level of lesson, but rather at the level of scaffolding.

We asked whether an adaptation of the IPA Program would lead to improved phonological awareness skills for children with DS. To our knowledge, all evaluations of phonological awareness intervention for children with DS have involved one-on-one intervention. Thus, the current study addresses a gap in the literature by evaluating small group intervention. One of the IPA Program features that was of interest to us when delivering the standard treatment protocol to individuals with DS was the small group service delivery method. The small group instruction afforded in the IPA program optimizes opportunities for peer interaction and peer modeling and more closely reflects service-delivery models implemented in the school setting (Brandel, 2020). We addressed the following research question: Is intensive, small group phonological awareness intervention functionally related to improved phonological awareness for school-aged children with DS?

There are multiple IPA Program features that make it suitable for adaptation for children with DS. It is an explicit, systematic phonological awareness intervention. It is possible to extract a particular unit for implementation. As explained below, the adaptation involved implementing only one unit with each child and two repetitions of each lesson. Within each unit, the targeted subskills sequentially increase in complexity across the lessons. For example, an easy initial sound activity involves judging whether two spoken words begin with the same sound, and the most complex initial sound activity involves segmenting the initial sound of a spoken word. Because the phonological awareness activities almost exclusively focus on analysis of phonemes and not relating phonemes to graphemes, the learning task is narrow. Within each lesson there is sufficient repetition and practice to support children's learning. Learning activities are implemented with picture support of verbal stimuli. Within each unit, intervention activities increase in complexity across the weeks. The lesson plans provide soft scripting (e.g. teaching strategies and scaffolding) for the interventionist. Multi-sensory instructional methods are employed, such as encouraging students to feel, look, and listen to the sounds in words.

III Method

The Institutional Review Board at Vanderbilt University approved the study protocol. This study was implemented in the summer when children were not in school. We chose to implement the study then because we wanted to see what progress the participants could make without having the confound of ongoing school instruction. Therefore, we had a finite time period in which to implement the study and ultimately study decisions were driven by the restricted time period.

1 Design

This study utilized a multiple baseline across participants single case research design (Gast and Ledford, 2018). This design allows for evaluation of the effects of an intervention on a non-reversible behavior, such as phonological awareness. For each participant, the intervention lessons implemented (i.e. one unit from IPA Program) related to a phonological awareness skill on which the individual participant demonstrated low and stable performance on the probe task in the baseline phase. Once evidence of experimental control was demonstrated by the first participant's stable increase on the probe task, we planned to introduce intervention for the second participant and subsequently for the third participant, following the same process. We planned to analyse data for level, trend, and stability within conditions (baseline and intervention) as well as immediacy, consistency, and overlap across conditions (baseline to intervention). See Table 1.

Table 1. Data properties analysed via visual analysis.

Visual analysis features assessed within phases:	
Level	The value of the data on the dependent measure at any point in the series
Trend	The direction the data are moving over time (increasing, decreasing, or remaining the same)
Stability / variability	Fluctuations from one data point to the next
Visual analysis features assessed across phases:	
Immediacy	The change in level between the last three data points in one phase and the first three data points of the next. The more rapid (or immediate) the effect, the more convincing the inference that change in the outcome measure was due to manipulation of the independent variable.
Overlap	The proportion of data from one phase that overlaps with data from the previous phase. Larger separation/smaller proportion of overlap = more compelling demonstration.
Consistency	The extent to which there is consistency in the data patterns within the same phase. The greater the consistency, the more likely the data represent a casual relation.

Source. Reprinted from Hessling and Schuele, 2020.

Because phonological awareness includes multiple tasks that range in complexity, we evaluated an array of phonological awareness skills across participants at the eligibility session. We planned to probe any phonological awareness skill that participants demonstrated below-average performance on in baseline. Any phonological awareness skill that met the criterion level (score $\geqslant$ 12 on probe task) for three consecutive sessions in the baseline condition was discontinued and then another skill was probed.

2 Participants

Three children (2 boys, 1 girl) with DS participated in this study and met inclusionary criteria: (1) native English speaker, (2) diagnosis of DS, (3) see and hear well enough to benefit from group instruction, (4) speech as primary mode of communication (as opposed to signing or augmentative and alternative communication), (5) behaviorally attend to instructional sessions lasting approximately 30 minutes (i.e. the length of the planned intervention session, with breaks), (6) standard score more than two standard deviations below the normative mean on the Phonological Awareness subtest of the Woodcock Reading Mastery Tests – 3rd edition (WRMT-III; Woodcock, 2011), (7) nonverbal intelligence score more than 1.5 standard deviations below the normative mean on the Primary Test of Nonverbal Intelligence (Ehler and McGee, 2008), and (8) enrolled in kindergarten through third grade. To describe participants, norm-referenced measures of receptive and expressive vocabulary as well as receptive language were administered. Additional expressive language and word reading assessment was not completed due to time restrictions and concerns about validity related to poor speech intelligibility. Table 2 provides a summary of participant scores on the eligibility and descriptive measures. The participants had comparable standard scores on the phonological awareness measure. Participant 2's scores on other measures exceeded the scores of the other two participants.

Each child with DS was paired with a typical peer to form a small group for the intervention (i.e. three dyads). Three children (2 boys, 1 girl) with typical development participated in this study and met inclusionary criteria: (1) native English speaker, (2) typically developing as reported by parents and verified by a nonverbal IQ score within the average range, (3) see and hear well enough

Table 2. Participant assessment standard scores.

Child	Age (years; month)	Grade	Sex	Nonverbal intelligence (PTONI)	Phonological awareness (WRMT-3)	Receptive language (TACL-4)	Receptive vocabulary (PPVT-4)	Expressive vocabulary (EVT-2)
Participant 1	6;7	1st	female	<46	57	51	65	61
Peer 1	6;5	1st	male	104	–	–	–	–
Participant 2	7;4	1st	male	55	59	69	81	79
Peer 2	4;7	Pre-K	female	112	–	–	–	–
Participant 3	9;2	3rd	male	<46	55*	49	59	72
Peer 3	5;8	K	male	119	–	–	–	–

Note. PTONI = Primary Test of Nonverbal Intelligence (Ehler and McGhee, 2008); WRMT-3 = Woodcock Reading Mastery Test – 3rd edition, Phonological Awareness subtest (Woodcock, 2011); TACL-4 = Test for Auditory Comprehension of Language – 4th edition (Carrow-Woolfolk, 2014); PPVT-4 = Peabody Picture Vocabulary Test – 4th edition (Dunn and Dunn, 2007); EVT-2 = Expressive Vocabulary Test – 2nd edition (Williams, 2007) *standard score reported using 8;11 norms, no norms for 9;2 age.

to benefit from group instruction, (4) speech as primary mode of communication, and (5) behaviorally attend to instructional sessions lasting approximately 30 minutes (i.e. the length of the planned intervention session, with breaks; see Table 2). The construction of dyads was based on family availability for intervention sessions; the peer for Participant 2 was his sibling.

3 Dependent variable

As a result of baseline performance, the measurement system/dependent variable for Participants 1 and 3 differed from Participant 2.

a Participants 1 and 3. The dependent variable for Participants 1 and 3 was the raw score on the Segment Initial Sounds subtest from a dynamic assessment adaptation of the Measure of Phonological Awareness[1] (MOPA; Schuele, 2017). Participants 1 and 3 did not meet the criterion level for initial sound segmentation when it was first probed in baseline. The MOPA is a criterion-referenced assessment with multiple subtests; in the standard format test items are presented with a straightforward prompt designed to elicit independent performance (e.g. *tell me the first sound in moon*; i.e. static assessment) and each response is scored as correct or incorrect. The subtest raw score is the number of subtest items answered correctly. This type of administration may fail to detect subtle or incremental changes in skill for children with disabilities for whom slow progress may be anticipated (Hasson and Joffe, 2017). Thus, for this study, we adapted the MOPA Segment Initial Sounds subtest to create a dynamic assessment version that involved a graduated prompt hierarchy to capture incremental change. Each item was presented initially with the standard MOPA prompt; if the child responded correctly to the standard prompt, 4 points were awarded. If the child did not respond correctly, then prompting with increasing support was initiated and fewer points (0 to 3 points for correct responses) were awarded with each increase in support; see Appendix 1. The highest level of prompting was imitation (0 points). To decrease assessment fatigue, the number of MOPA subtest items was reduced from 10 to 5 items. The maximum score for the probe task was 20 points (5 items, max. 4 points for each item).

b Participant 2. Participant 2 met the criterion level for initial sounds and final sounds. Thus, the dependent variable for Participant 2 was the raw score on the MOPA Segment All Sounds subtest.

The standard administration procedure (i.e. not dynamic assessment) was used as we anticipated that incremental change was not an issue for this child as evidenced by him meeting criterion for the initial two phonological awareness tasks – initial and final sounds – that were probed in baseline. Each item was presented only with the prompt, *Tell me the sounds in [stimulus word]* and a binary scoring system was applied to each item (correct/incorrect). The raw score was the total number of subtest items answered correctly (max. points = 20).

4 Procedures

a Probe assessment. The interventionist placed an iPad, which displayed the stimulus pictures, on the table where she and the participant were seated. The interventionist read the subtest directions, presented the two demonstration items followed by any necessary feedback, and then administered the subtest items. Each administration of the probe assessment was video recorded. The interventionist orthographically recorded online the child's responses to the probe assessment on a paper protocol copy.

An abbreviated version (reduced from 10 to 5 items) of the MOPA Rhyme Generation subtest with dynamic assessment was administered each session prior to the probe assessment, as a warm-up and to orient the participant to providing a verbal response in the probe assessment. The rhyme task was not a dependent measure and thus, responses were not recorded. The probe assessment for Participants 1 and 3 was initial sound segmentation because they did not meet the criterion level for this skill in baseline. The probe assessment for Participant 2 was all sound segmentation because he demonstrated criterion level scores for initial sound segmentation and final sound segmentation in baseline.

b Baseline condition. Baseline sessions took place three times per week. Peers did not participate in baseline sessions. Baseline sessions consisted of administration of the probe assessment to the participants. The interventionist did not provide any phonological awareness instruction in baseline sessions.

c Intervention condition. The IPA Program was adapted in two ways. First, the entire program was not implemented. Rather each small group completed lessons from one unit. Second, each lesson within the unit was repeated twice so as to increase learning and practice opportunities. Instead of repeating lessons back-to-back (e.g. lesson 1, lesson 1, lesson 2, lesson 2), lessons were repeated in a two- or three-lesson cycle (e.g. lesson 1, lesson 2, lesson 1, lesson 2) to allow more time for information retention and memory consolidation before repeating the same material. Intervention intensity, amount of exposure to intervention material, may be critical in whether the child with DS acquires and maintains the skill over time (Faragher and Clarke, 2013). We hypothesized one exposure to each phonological awareness lesson would not be sufficient to yield change for the participants with DS. The small group intervention for Participants 1 and 3 and their typical peers aimed at increasing skills related to segmenting initial sounds of words. Thus, they completed the lessons in the Initial Sound unit of the IPA Program. The small group intervention for Participant 2 and his typical peer aimed at increasing skills related to segmenting and blending sounds in monosyllabic words (CVC, CCVC, CVCC). Thus, they completed the Segment and Blend Sounds unit.

Intervention sessions for each dyad took place three times per week. If the typical peer was absent for an individual session, the session was conducted with only the participant with DS present. All dyads began the intervention phase with two lessons from the Rhyme unit. For dyads 1 and 3 these lessons familiarized the children with the activities albeit with a different skill. For all dyads these lessons acclimated the children to the intervention condition. Thereafter, each dyad

Table 3. Participant 1 lesson progression and attendance.

Intervention session	Lesson	Lesson topic	Attendance
1	Lesson 2	Rhyme Judgment and Rhyme Odd-One-Out	
2	Lesson 5	Rhyme Matching and Rhyme Sorting	
3	Lesson 10	Initial Sound Judgment	
4	Lesson 11	Initial Sound Judgment and Initial Sound Odd-One-Out	
5	Lesson 12	Initial Sound Odd-One-Out and Introduction to Initial Sound Matching	Absent
6	Lesson 10	Initial Sound Judgment	
7	Lesson 11	Initial Sound Judgment and Initial Sound Odd-One-Out	
8	Lesson 12	Initial Sound Odd-One-Out and Introduction to Initial Sound Matching	
9	Lesson 13	Initial Sound Matching	
10	Lesson 14	Initial Sound Matching and Initial Sound Sorting	Absent
11	Lesson 13	Initial Sound Matching	
12	Lesson 14	Initial Sound Matching and Initial Sound Sorting	Absent
13	Lesson 15	Initial Sound Matching and Initial Sound Sorting and Introduction to Initial Sound Segmentation	
14	Lesson 16	Initial Sound Segmentation	
15	Lesson 15	Initial Sound Matching and Initial Sound Sorting and Introduction to Initial Sound Segmentation	Absent
16	Lesson 16	Initial Sound Segmentation	

Note. Lesson number corresponds to numbers in the IPA program manual (Schuele and Murphy, 2014).

completed the IPA Program unit lessons twice, with the individual lessons repeated in a two lesson sequence (e.g. unit lesson 1, 2, 1, 2). See Tables 3, 4, and 5. The probe assessment was administered only to the child with DS. It was administered after the completion of each day's lesson.

d Intervention condition: Settings and materials. Sessions were held in a university lab play room with the interventionist positioned at a table with the participants. For each dyad, two-thirds of the sessions were led by a female clinical speech-language pathology master's student (second author) and one-third of sessions were led by a female PhD student, who is a certified speech-language pathologist (first author). Intervention materials included the book of lesson plans, materials (e.g. picture cards) printed from the multiple downloadable files provided by the publisher, and some additional materials gathered by the end-user (e.g. chips or game pieces). Each lesson plan describes the activities to be implemented, provides a soft script to guide the interventionist, specifies the intervention materials to be used, and provides additional guidance for scaffolding and differentiating instruction and for sequencing instructional stimuli.

e Maintenance condition. The purpose of a maintenance phase is to evaluate the generalization of the skills, or the occurrence of relevant behavior under different, non-training conditions such as setting, people, or time (Peterson, 2009). Ideally, the probe assessment would be administered multiple times in the maintenance condition. Due to time constraints, we were only able to administer the probe assessment to each participant one time in the maintenance condition, about two weeks post intervention phase cessation. Thus, this data point provided only a minimal indication of skill maintenance.

Table 4. Participant 2 lesson progression and attendance.

Intervention session	Lesson	Lesson topic	Attendance
1	Lesson 2	Rhyme Judgment and Rhyme Odd-One-Out	
2	Lesson 5	Rhyme Matching and Rhyme Sorting	
3	Lesson 28	Segmentation of Continuant CV and VC Words; Introduction to Segmentation of Continuant CVC Words	
4	Lesson 29	Segmentation of Continuant CV and VC Words; Introduction to Segmentation of Continuant CVC Words	
5	Lesson 28	Segmentation of Continuant CV and VC Words; Introduction to Segmentation of Continuant CVC Words	
6	Lesson 29	Segmentation of Continuant CV and VC Words; Introduction to Segmentation of Continuant CVC Words	
7	Lesson 30	Segmentation and Blending of Continuant CV, VC and CVC Words; Introduction to Segmentation of Stop CV and VC Words	
8	Lesson 31	Segmentation (Stops) and Blending (Continuants): CVC	Absent
9	Lesson 30	Segmentation and Blending of Continuant CV, VC and CVC Words; Introduction to Segmentation of Stop CV and VC Words	
10	Lesson 31	Segmentation (Stops) and Blending (Continuants): CVC	
11	Lesson 32	Segmentation of CV, VC and CVC Words (Stops and Continuants)	
12	Lesson 33	Segmentation and Blending (Stops and Continuants)	
13	Lesson 32	Segmentation of CV, VC and CVC Words (Stops and Continuants)	
14	Lesson 33	Segmentation and Blending (Stops and Continuants)	

Note. Lesson number corresponds to numbers in the IPA program manual (Schuele and Murphy, 2014).

5 Measurement systems

a Experimental control and functional relation. Following the baseline phase, introduction of the intervention was time-lagged (staggered) across participants. When the first participant entered the intervention phase, the other two participants remained in an extended baseline phase. Data were collected concurrently across all participants to minimize threats to internal validity. According to conventional single case research design standards, a functional relation is established by three replications of the intervention effect (Kratochwill et al., 2013). To conclude that a functional relation was observed in this multiple baseline across participants design, experimental control and demonstration of an intervention effect had to be demonstrated for each of the three participants.

b Interobserver agreement and procedural fidelity. An independent observer (undergraduate student, cognitive studies major) collected agreement data using the video recordings. Prior to conducting interobserver agreement (IOA) for the study data, the observer completed an initial training with the first and second authors that included review of the study procedures, a question and answer session, and group coding and discussion of dependent variable probe videos. The training occurred in week one of the study concurrent with the collection of baseline data. Participant videos of the probe task administration were used in the initial training. One out of every four probe sessions was selected randomly to be coded for IOA and the remaining videos in the set were

Table 5. Participant 3 lesson progression and attendance.

Intervention session	Lesson	Lesson topic	Attendance
1	Lesson 2	Rhyme Judgment and Rhyme Odd-One-Out	
2	Lesson 5	Rhyme Matching and Rhyme Sorting	
3	Lesson 10	Initial Sound Judgment	
4	Lesson 11	Initial Sound Judgment and Initial Sound Odd-One-Out	
5	Lesson 10	Initial Sound Judgment	Absent
6	Lesson 11	Initial Sound Judgment and Initial Sound Odd-One-Out	
7	Lesson 12	Initial Sound Odd-One-Out and Introduction to Initial Sound Matching	
8	Lesson 13	Initial Sound Matching	
9	Lesson 12	Initial Sound Odd-One-Out and Introduction to Initial Sound Matching	
10	Lesson 13	Initial Sound Matching	
11	Lesson 14	Initial Sound Matching and Initial Sound Sorting	
12	Lesson 15	Initial Sound Matching and Initial Sound Sorting and Introduction to Initial Sound Segmentation	
13	Lesson 14	Initial Sound Matching and Initial Sound Sorting	
14	Lesson 15	Initial Sound Matching and Initial Sound Sorting and Introduction to Initial Sound Segmentation	

Note. Lesson number corresponds to numbers in the IPA program manual (Schuele and Murphy, 2014).

Table 6. Average (range) interobserver agreement (IOA) data across conditions and participants.

	Baseline	Treatment	Maintenance	Average
Participant 1	.96 (.94–.98)	.97 (.96–1.00)	.99 (.98–1.00)	.97 (.94–1.00)
Participant 2	.97 (.96–1.00)	.98 (.96–1.00)	.97 (.96–1.00)	.97 (.96–1.00)
Participant 3	.96 (.94–1.00)	.97 (.96–1.00)	.99 (.98–1.00)	.97 (.94–1.00)
Average	.96 (.94–.98)	.97 (.94–1.00)	.98 (.98–1.00)	.97 (.94–1.00)

available for training purposes. The observer independently coded probe videos (four total) until she reached criterion of 90% agreement with the second author.

The second author randomly selected 25% of probe sessions across participants and conditions to be analysed by the independent observer for IOA (Gast and Ledford, 2018; see Table 6). The observer was not blind to the study phase (baseline, intervention, maintenance). We established point-by-point agreement for each MOPA subtest item by dividing the total number of agreements by the total number of agreements plus disagreements and then multiplying by 100. IOA was consistently high; the two scorers demonstrated an average of 97% agreement for the probe task scoring. IOA across conditions for each participant were as follows: Dyad 1: 97% (range: 94 - 100%), Dyad 2: 97% (range: 96 - 100%), Dyad 3: 97% (range: 94 - 100%). IOA results remained above criterion (i.e. 90%); therefore, no retraining of coders was warranted throughout the duration of the study.

The same independent observer collected procedural fidelity data for one third of intervention condition sessions across participants. Sessions coded for procedural fidelity were chosen at random and the interventionists were blind to which sessions were coded for procedural fidelity (see supplemental materials). Average procedural fidelity across sessions and participants was 93% (range: 90 - 94%). Consistently high levels of both IOA and procedural fidelity increase confidence in the study outcomes.

IV Results

The purpose of this study was to determine whether an adaptation of the IPA Program was functionally related to improvements in phonological awareness for children with DS. After five weeks of intervention, all participants demonstrated increasing therapeutic trends based on scores on the phonological awareness probe assessment. Two weeks post intervention, two participants demonstrated maintenance of the individualized phonological awareness skill targeted. As will be shown below, there was not any immediacy once intervention was introduced which precluded us from concluding that experimental control was established. Nevertheless, the results are informative and thus we report three cases without experimental control which inform future studies to improve reading outcomes of children with DS. Results for each participant are described in detail and presented in Figure 1. Table 7 includes intervention dose information, and Table 8 includes baseline and intervention phase means. Phase means are reported as supplemental analyses to support the primary visual analyses of data.

Participant 1

Participant 1 demonstrated low and stable performance on the initial sound segmentation probe task in the baseline phase. Once intervention was introduced, no change was observed in the first six probe sessions, but then delayed treatment effects were observed across the next six probe sessions. A gradual accelerating therapeutic trend was observed after nine intervention sessions and consistently increased until the final intervention session, which demonstrates a latent, but weak effect. However, even Participant 1's highest score was indicative of only minimal change. A significant amount of overlap was observed across phases due to delayed change in level. Not surprisingly, Participant 1's performance returned to baseline levels in the maintenance phase and thus, there was no evidence that even her minimal change maintained.

Participant 2

In the baseline phase, Participant 2 demonstrated a rapidly increasing trend for initial sound segmentation (dynamic probe) that reached the established criterion level (scores $\geqslant 12$ for three consecutive sessions; the fourth consecutive session at criterion was an oversight during data collection). As a result, the next IPA Program phonological awareness skill – final sound segmentation – was probed in baseline. Participant 2 again reached the established criterion level for final sound segmentation (dynamic probe); therefore, the remaining IPA Program phonological awareness skill (all sound segmentation) was probed in baseline and selected as the intervention target. Recall that the probe task for all sound segmentation was a static assessment with 20 items. With a maximum score of 20 for this probe task, the performance of the three participants is easily compared.

Participant 2 demonstrated low and stable baseline performance for all sound segmentation; all baseline scores were at zero. Following introduction of intervention, a score of zero was recorded for six consecutive probe tasks. Thereafter, an accelerating therapeutic trend was observed such that there was no further overlap in the data between the intervention phase and baseline phase. Lack of experimental control precludes us from interpreting a treatment effect for Participant 2.

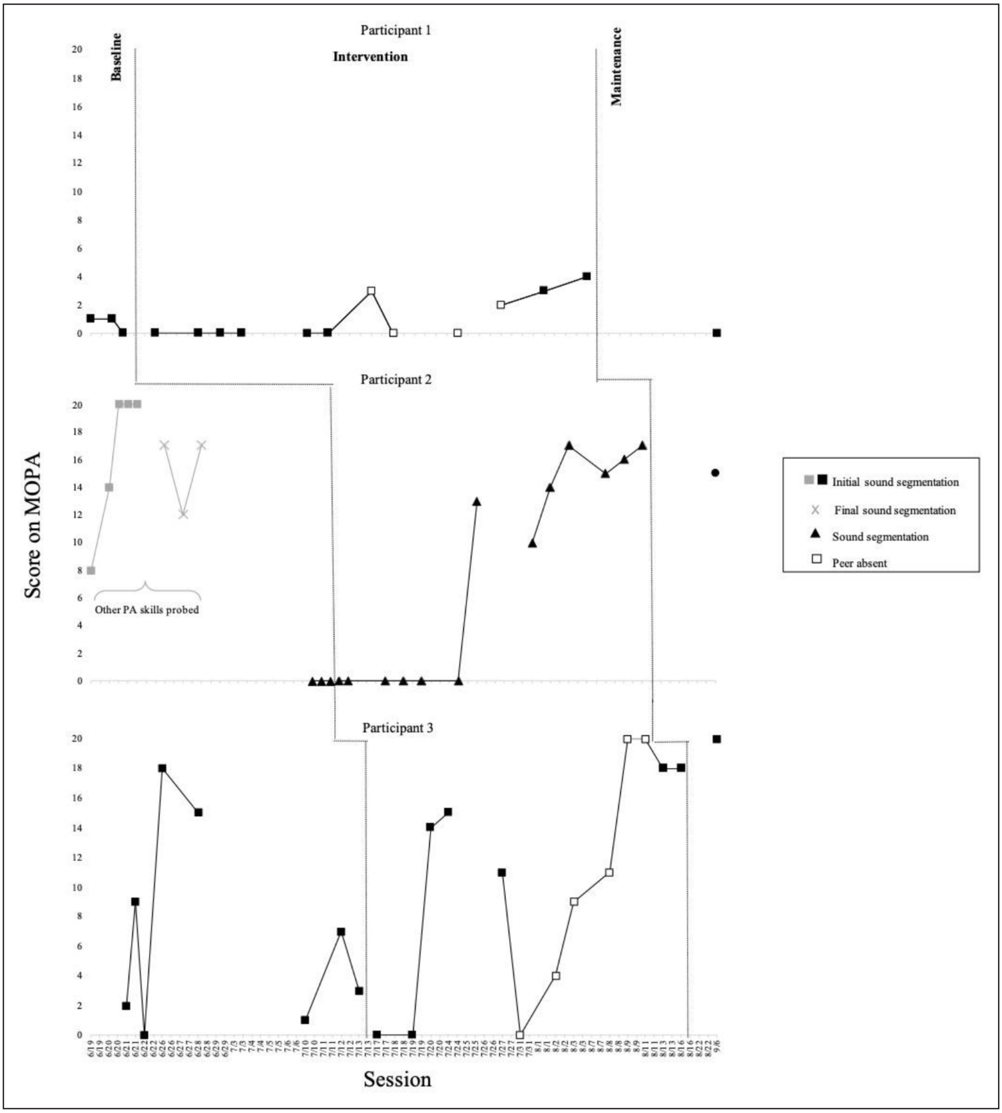

Figure 1. Performance across conditions and participants.
Note. PA = phonological awareness.

Table 7. Intervention dose information for each participant.

	Duration (weeks)	Frequency (sessions/week)	Amount (hours)
Participant 1	6	2	6
Participant 2	5	2.6	6.5
Participant 3	5	2.6	6.5

Note. Duration refers to period of time over which participants were exposed to intervention, frequency refers to how often intervention was provided, on average, over the duration of the intervention condition, and amount refers to the total length of intervention (Voils et al., 2014).

Table 8. Phase means for each participant.

	Baseline	Intervention
Participant 1	0.67	1.00
Participant 2	6.89	10.77
Participant 3	0.00	7.85

The consistent, accelerating therapeutic trend approached mastery level in the final four intervention sessions. Participant 2's performance two weeks post-intervention indicated maintenance of the gains on target skill with a score of 15 out of 20 points.

Participant 3

Participant 3 demonstrated substantial variability in performance on the initial sound segmentation probe task in the baseline phase. Participant 3's tendency to incorrectly respond with a grapheme rather than a phoneme resulted in inconsistent performance in the baseline phase. Intervention was introduced following demonstration of a contra-therapeutic trend in baseline. Participant 3 demonstrated variable performance within the first six sessions of the intervention phase, with substantial (50%) overlap in data across phases. A consistent, accelerating therapeutic trend was observed after session six and performance remained high and stable in the final intervention sessions, with limited overlap between the final four intervention sessions and a single data point in the baseline phase. Participant 3 demonstrated maintenance of the initial sound segmentation skill at two weeks post-intervention.

V Discussion

The purpose of this study was to evaluate the effectiveness of an adaptation of a commercially-available small-group phonological awareness intervention for children with DS. A functional relation between the intervention and improved levels of phonological awareness skills was not observed due to fewer than three replications across participants. Because we did not have experimental control, we report and interpret the results as a series of three cases. As has been observed in other research evaluating speech and language outcomes in children with DS, some participants appeared to demonstrate strong treatment effects and others demonstrated weak or inconsistent treatment effects (e.g. Camarata et al., 2006). Despite variability and overlap in the data, increases in scores on the phonological awareness probe were observed in the intervention phase, and two out of the three children with DS maintained their improved levels after intervention was withdrawn. Although exploratory in nature, this study contributes to the small but growing evidence base that (1) standard treatment protocols can be adapted to effectively teach phonological awareness skills for children with DS and (2) children with DS can benefit from small-group, intensive, and systematic phonological awareness intervention and progress in their development of phonological awareness skills (Næss, 2016).

The adapted version of the IPA Program (Schuele and Murphy, 2014) used in this study included repeating each lesson twice to increase exposure to phonological awareness material. Two out of the three children with DS (Participants 2 and 3) appeared to benefit from repeated exposures and multiple opportunities to practice using multi-sensory methods outlined in the standard intervention protocol; Participant 1, however, needed additional support. Moving forward, we anticipate that there are some children with DS for whom repeating each lesson twice is not enough. Given more time, we likely would have repeated the lessons an additional third time with Participant 1 after observing little to no change, and thus may have realized greater overall change in her phonological awareness skills with increased intensity. In addition, our pattern of repetition may not have been optimal for some children. We completed two or three lessons, repeated that two- or three-lesson sequence, and then moved on to the next two lessons, repeated in the same pattern. For some children, two sequential completions of each lesson (e.g. lesson 1, lesson 1, lesson 2, lesson 2, and so on) may yield better outcomes due to immediate re-exposure to the same material from the preceding lesson; further exploration is warranted. Participant 2's pattern of results mirrors Participant 1 in that delayed treatment effects were observed following no skill observed in baseline. Participant 3 demonstrated variable performance which suggests that he had some initial sound segmenting skill or was beginning to learn this skill, but that the skill was not yet under volitional control (Paris, 2005). As evidenced by his final four intervention data points at or near mastery and evidence of maintained skills, the adapted intervention appears to have resulted in change in the targeted skill for Participant 3.

It may be critical that educators persist with providing phonological awareness intervention for some time given the repetitive nature of the instruction provided and the delayed treatment effects observed in this study. Specifically, it appears that if a child has no skill on the phonological awareness target, he or she may need a substantial amount of intervention before a change in skill is observed compared to baseline. However, if a child has some (whether consistent or not) skill on the phonological awareness target, he or she likely will demonstrate change compared to baseline at a faster rate. If change in skill is realized within the first few sessions, as was the case for Participant 3, then repeating the lessons twice is likely sufficient. Despite what appeared to be lack of progress across multiple sessions, each of the participants eventually demonstrated improved performance following persistent provision of the IPA Program curriculum. It may be that children with DS require additional time in conjunction with repeated exposures to demonstrate consistent change in behavior for academic skills (e.g. Allor et al., 2018). As such, change in level may be a better indicator of learning as compared to immediacy of effect when visually analysing data related to academic skills for children with DS. Taken together, the results from these three cases illustrate multiple ways in which standard treatment protocols can be adapted to maximize outcomes. At the same time, we illustrate how an outcome measure can be adapted to capture incremental change. Lastly, the results can inform clinical decision making, especially when time is not restricted and all the necessary adaptations (e.g. repeating lessons a third time) can feasibly be made.

As is common with academic skills, our dependent variable probe was based on measuring change in an observable behavior. We cannot be certain whether our measurement captured behavior indicative of past knowledge, true development of phonological awareness skills, or simply the ability to consistently demonstrate what was being asked of them. For example, it may be that Participant 2's receptive and expressive vocabulary strengths contributed to his improvements in phonological awareness skills; however, this was not captured in the probe. As an alternative explanation, whenever children with intellectual disabilities show performance at or near the floor of an assessment, the assessment may not adequately capture the child's actual ability (Hessl et al., 2009). Children with intellectual disabilities may have the skills necessary to complete certain tasks, but they may lack the ability to demonstrate those skills on demand. In academic settings, it is expected that children will demonstrate their skills and knowledge on demand, and thus it is an important skill to work on. In absence of this behavior, we cannot accurately identify areas of need.

Additionally, it is important to recognize that our initial sounds outcome measure tapped the child's skills on the desired outcome, segment initial sounds, but this skill was only taught in the lessons 7 – 9. Lessons 1 – 6 focuses on simpler initial sound analysis skills, such as choosing which one of three words does not begin with the same sound as the other two words. Had our outcome measures captured skill across the continuum of intervention tasks leading to segment initial sounds the trajectory of change may have appeared different for Participant 1 and 3. However, we had hypothesized that the dynamic assessment adaptation would compensate for the nature of the measure.

Careful consideration of when to measure progress so that the measurement accurately captures change is critical (Yoder et al., 2018). For instance, each of the participants seemed to demonstrate change in phonological awareness skills by providing correct responses to activities on some occasions within sessions. However, this potential evidence of change was not captured consistently by the probe. Given the intervention context, participants' correct responses within sessions were highly scaffolded. But it is important to note that this closely mapped on to the graduated prompt hierarchy used in the dependent variable probe with dynamic assessment. Further, participants' performance on the dependent variable probe measure may have been impacted negatively due to fatigue because the measure was administered at the end of each session. Children with DS may benefit from sessions that follow a sequence involving a brief warm-up period, the probe or progress monitoring measure, and then intervention. Monitoring progress at the beginning of the session would eliminate the confounding factor of immediately administering the probe assessment following intervention, thus priming participants and potentially overestimating their learning. Or if a proximal measure of progress is warranted, embedding the assessment measure after or within intervention may more accurately capture immediate learning (LeJeune et al., 2018).

In keeping the small group instruction aspect of the IPA Program, each dyad consisted of the participant with DS and a younger, typically developing peer group member. Along with both groups of children gaining exposure to phonological awareness instruction, additional benefits were observed. The peer group members often times served not only as models, but in some cases also as closer-in-age instructors. Based on the interventionists' observations, the participants with DS more actively participated when engaging in intervention doses that involved turn-taking with peers rather than intervention doses that purely involved interventionist-child interchanges (See Warren et al., 2007 for explanation of intervention dose). Similarly, the participants with DS were eager to engage in opportunities to 'be the teacher' and help guide the peer group member through the intervention activities. Anecdotally, Participant 3's behavior and performance were particularly sensitive to whether the peer group member was present in the intervention session; he often times displayed increased willingness to participate when the peer was present (see Figure 1). Further, although not specifically captured in the measure of procedural fidelity, we observed peer compliance with the phonological awareness intervention tasks (e.g. active participation, peer modeling, shared attention among group members) which further supports the benefits of peer-group membership for children with DS. Peer group membership for children with DS is worthy of further careful study.

VI Limitations and future directions

We noted several limitations of this pilot study. First, the participants with DS completed a one-time visit to determine eligibility prior to beginning the baseline phase. Although scores on standardized assessments were obtained in this visit, a more accurate picture of each child's true phonological awareness skills may have emerged given multiple visits to increase familiarity with the environment as well as to allow time to build rapport. For instance, Participant 2's performance in the eligibility session may not have been representative of his phonological awareness abilities which led to probing and rotating through three phonological awareness targets in baseline for this participant. Second, participants' sight word knowledge was not assessed or considered for inclusionary criteria. Given that some research suggests that children with DS develop phonological awareness skills once they have established a substantial sight word vocabulary (Goetz et al., 2008), assessing sight word vocabulary may have been informative in interpreting participants' response to intervention.

Third, we administered the MOPA Rhyme Generation subtest with dynamic assessment prior to each probe assessment as a warm-up and to orient the participant to providing a verbal response. We wanted the participants to understand that if they did not respond correctly then we would provide support, which is an important distinction between dynamic assessment and standardized assessment administration. In hindsight, orienting the participants to the dynamic assessment probe at the outset of each probe session may have not been helpful and may have contributed to the observed delayed treatment effects as well as reported change within the session but not on the probe task. Incorporating an orientation activity only prior to baseline probe assessments so that children know how to respond should be considered in future research. Lastly, administration of the probe at the end of each intervention session required the child with DS to be engaged for up to 35 minutes before the probe was administered. Near the end of many intervention sessions, it was evident that the children with DS lacked focus and had difficulty attending to the probe. Future studies may utilize the following schedule for each intervention session: a brief warm up, collect data to monitor progress, implement the intervention session. In doing so, the interventionists could orient the child to the task and minimize the effects of fatigue.

Replication of the current study is warranted with revised methods as suggested above. Given that it is not common for phonological awareness to be taught to children with DS in school, the study could be replicated and extended during an academic year to avoid the time restrictions we faced. The extent to which participants receive phonological awareness intervention exposure in the classroom during the intervention study would have to be documented however. Regardless of setting, researchers ought to avoid planning studies with time limitations especially for children with intellectual disabilities. Doing so would potentially allow participants sufficient time to demonstrate progress and skill stabilization, despite an initial treatment delay, or at minimum, allow interventionists more opportunities for curriculum repetition to facilitate learning.

Future studies should compare the effectiveness of one-on-one versus group phonological awareness intervention for children with DS. For group intervention, additional investigation of the inclusion of typically-developing peers as group members when implementing intervention for children with intellectual disabilities is warranted. Determining how best to match students for small group instruction, taking into consideration skill level and age, has the potential to optimize outcomes for all participants. Additionally, future work must explore the trajectory and rate by which children with intellectual disabilities learn in order for practitioners to set goals that are realistic and obtainable. Only through controlled studies will researchers and educators better understand how long it takes for a child with disabilities to acquire a specific skill.

VII Conclusions

Although the literature focusing on phonological awareness skill development, assessment, and intervention for individuals with DS is growing, additional research is needed to maximize literacy outcomes for individuals with DS (Kennedy and Flynn, 2003; Lemons et al., 2015). This study sought to evaluate the effectiveness of a commercially-available phonological awareness intervention, The IPA Program (Schuele and Murphy, 2014). Individuals with DS can rely on phonological awareness skills to learn to read and can achieve higher levels of literacy than previously suggested throughout history (Allor et al., 2014; Lemons and Fuchs, 2010). The three case studies from this pilot study combined with existing literature informs educators, including speech-language pathologists, on the feasibility of adapting standard treatment protocols for teaching children with DS phonological awareness skills, a foundational skill for literacy development. Research that can be implemented without time constraints will further evaluate the effectiveness of adapted phonological awareness interventions for children with DS.

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Supplemental material

Supplemental material for this article is available online.

Note

1. The Measure of Phonological Awareness (MOPA) is a criterion-referenced measure of phonological awareness designed to be instructionally informative. The MOPA includes multiple tasks, such as segment initial sounds (10 items), segment final sounds (10 items), and segment all sounds (20 items). Standardized administration procedures are delineated. Readers can request more information at melanie.schuele@vumc.org.

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Appendix 1. Dynamic assessment: Measure of Phonological Awareness (MOPA): Task 3: Segment initial sound.

Prompt level	Prompt procedure	Score awarded
0	No prompt *Fish, tell me the first sound in the word fish.*	4
1	Repeat item and elongate/iterate initial sound *Fish, tell me the first sound in the word fff-ish.*	3
2	Repeat item and elongate/iterate initial sound followed by target word with initial sound segmented (onset-rime) and give visual cue *Fish, tell me the first sound in the word fff-ish, f (point to mouth)-pause-ish*	2
3	Cue child with the first sound of the target word, repeat item *Fish, tell me the first sound in the word fff-ish, Fish starts with the fff sound. Tell me the first sound in the word fish.*	1
4	Prompt immediate imitation of initial sound segmentation, elongate/iterate the first sound and give visual cue *Fish, tell me the first sound in the word fish, tell me fff (point to mouth).*	0

Notes. Measure of Phonological Awareness (Schuele, 2017). Dynamic scoring based on Spector (1992).

Item	Prompt level 2
fish	Point to lips
cape	Point to throat
moose	Point to lips
team	Point to teeth
juice	Point to lips