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A Syllable Segmentation, Letter-Sound, and Initial-Sound Intervention With Students Who Are Deaf or Hard of Hearing and Use Sign Language

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Abstract

This study investigated children's acquisition of three aspects of an early literacy curriculum, *Foundations for Literacy (Foundations)*, designed specifically for prekindergarten students who are deaf or hard of hearing (DHH): syllable segmentation, identification of letter-sound correspondences, and initial-sound identification. Three prekindergarten students with hearing loss, who used some form of signed communication, participated in this multiple baselines across content design study. Phonological and phonics activities are embedded within the Foundations curriculum, which is built around strong visual manipulatives to provide access to phonemic content. A Visual Phonics (VP) strategy was incorporated into two of the three targeted outcomes. Results indicated that the signing DHH students in this study were able to learn syllable segmentation, letter-sound correspondences, and initial sounds.

Keywords

alphabetic principle, deaf/hard of hearing, Foundations for Literacy, initial sound, letter-sound, syllable segmentation, Visual Phonics

After a review of the empirical research on reading instruction, the National Reading Panel (NRP; National Institute of Child Health and Human Development, 2000) identified five instructional components that should be included in reading programs for school-aged children: phonemic awareness, phonics, fluency, vocabulary, and text comprehension. Notably, the NRP found direct and systematic instruction in phonemic awareness to be integral to the development of reading skills, with phonemic awareness being a strong indicator of reading success in the first 2 years of school. For emergent readers, an understanding of the systematic relationship between graphemes (i.e., letters) in written words and phonemes (i.e., sounds) in spoken words provides a foundation for the acquisition of word reading skills (Boyer & Ehri, 2011; Ehri, Nunes, Stahl, & Willows, 2001). To master this relationship, known as the alphabetic principle, young children must develop letter-sound awareness (Byrne & Fielding-Barnsley, 1989). The combined abilities of sound manipulation and automaticity in letter naming have proven to be successful predictors of early reading development for children with typical hearing (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Neuhaus, Foorman, Francis, & Carlson, 2001; Wagner et al., 1997). Kindergarteners with deficits in letter-sound awareness skills are at-risk for developing reading difficulties (Bowey & Francis, 1991). If letter-sound deficits are not identified and treated early with evidence-based interventions, reading difficulties can persist throughout the school years and prevent future academic success (McDonald & Cornwall, 1995). For students with limited access to sound (i.e., for purposes of this study, this is defined as a 55 dB or greater pure tone average [PTA] in the better ear and use of a signed language), phonemic and phonological skills often present a challenge to reading development (Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008; Kyle & Harris, 2011). One study found the median grade level of the high school participants to be at the fourth grade (Traxler, 2000), while 30% of this population may leave school functionally illiterate (Waters & Doehring, 1990). Because this gap in reading begins at such early ages, interventions that provide improved outcomes for deaf or hard of hearing (DHH) students must be developed. One strategy that may be successful with those DHH students who do not have access to sound is the use of an

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early literacy curriculum such as *Foundations for Literacy* (*Foundations*; Lederberg, Miller, Easterbrooks, & Connor, 2011) in conjunction with Visual Phonics (VP). The purpose of the study described herein was to investigate the effectiveness of this curriculum on syllable segmentation, initial-sound identification, and letter-sound correspondences with DHH children who use manual communication and do not have functional hearing.

The Alphabetic Principle and DHH Students

The alphabetic principle is based on phonological awareness, which is the ability to detect and manipulate individual sound units (i.e., phonemes, syllables, onsets, and rimes) within words and is considered a critical skill for proficient reading (Phillips, Clancy-Menchetti, & Lonigan, 2008). Syllable segmentation is the ability to understand that words can be deconstructed and reconstructed based on their syllables. School-aged DHH children are able to learn this skill (Sterne & Goswami, 2003). Initial-sound identification is a key skill in decoding words and is a skill that DHH children with functional hearing are able to master (Miller, Lederberg, & Easterbrooks, 2013). Letter-sound correspondence refers to the knowledge that specific graphemes are related to specific phonemes. Knowledge of letter-sound correspondences correlates strongly with early reading skills in young DHH children (Kyle & Harris, 2011) and is related to improvements in their word identification skills (Trezek & Malmgren, 2005).

Foundations

Foundations (Lederberg et al., 2011) is an early literacy curriculum designed specifically for DHH prekindergarten children that targets the phonological underpinnings of literacy. Prior research on this curriculum investigated children's acquisition of letter-sound correspondence within small group instruction (Bergeron, Lederberg, Easterbrooks, Miller, & Connor, 2009). This study documented that preschoolers with speech perception, or functional hearing, could master letter/sound correspondences. The *Foundations* curriculum was also used to study syllable segmentation, initial phoneme isolation, and rhyme discrimination in five DHH children with functional hearing using a multiple baseline across skills design (Miller et al., 2013). Children in this study demonstrated a functional relationship between the explicit instruction of the curriculum and the three targeted skills. In a study of children who did not have functional hearing, *Foundations* was combined with VP. In this study, four signing preschoolers with average to low-average vocabulary skills were able to acquire letter/sound correspondences (Beal-Alvarez, Lederberg, & Easterbrooks, 2011). A multiple baseline across content design and descriptive analyses were used to verify skill acquisition. Participants acquired all taught correspondences following explicit instruction in phonological content.

VP

VP is a teaching strategy that uses distinct handshapes, one for each sound in the English language, to clarify letter-sound correspondence (Waddy-Smith & Wilson, 2003). Handshapes often mimic aspects of the movements made during oral production of the sound and may link visually or kinesthetically to letter shape. VP establishes a foundation for phonemic awareness through concrete representations of sounds at the phoneme level (Cihon, Gardener, Morrison, & Paul, 2005). The multimodal coding of the phonology of English, that is, through residual hearing and visual support, may become more deeply embedded in the memory as it taps into (a) the visuospatial sketchpad through the visual hand cue, printed text, and the kinesthetic movement; (b) the phonological loop through the articulated sound; and (c) the episodic buffer that integrates information across the visual, spatial, and verbal domains within a chronological sequencing while linking long-term memory and semantic meaning (Baddeley, 2000). Because VP offers distinct hand movements that represent each sound, handshapes may help students clarify confusing features of English phonology (e.g., letters represent more than one sound). VP has social and economic validity in that it is relatively easy to teach and learn, is not grade specific, can be a supplement to existing reading/language curriculums, and requires little to no materials after the initial training.

VP and Literacy Skills in At-Risk Hearing Students

Cihon et al. (2005) investigated the effect of VP on phonemic awareness in hearing students identified as at-risk for reading disabilities. They used a nonconcurrent multiple baseline across participants and sounds with an embedded multielement design to assess the effects of the intervention. Results from Pre/Post Dynamic Indicators of Basic Early Literacy Skills (DIBELS) and Curriculum-Based Measures (CBM) were used to further support findings and to compare correct identification of letter-sound correspondence taught through VP to those taught through participants' regular classroom instruction. The DIBELS benchmark served as one baseline for all participants (intervention and control). Intervention participants took part in curriculum-based baseline measures for each targeted letter-sound correspondence. Correspondences mastered in baseline measures were not taught during the intervention. Pre and post scores on the DIBELS subtests for participants who received VP were compared with those of students who did not. Substantial gains in word use fluency and sound segmentation were seen for intervention participants and were comparable with those of the nonintervention

students. Participants who received VP did not fall farther behind their nonintervention peers. According to CBMs, participants responded correctly on more opportunities to identify letter-sound correspondences taught through VP than correspondences taught through the regular classroom instruction.

VP and Literacy Skills in Students Who Are Deaf and Hard of Hearing

VP has been used to teach students with various levels of hearing loss, a range of phonological and phonemic skills including phonological decoding (Guardino, Syverud, Joyner, Nichols, & King, 2011; Syverud, Gaurdino, & Selznick, 2009; Trezek, Wang, Woods, Gampp, & Paul, 2007); phonological awareness (Beal-Alvarez et al., 2011; Smith & Wang, 2010; Trezek & Malmgren, 2005); letter-sound identification in isolation, letter-sound identification within word, and word reading (Trezek & Malmgren, 2005); reading comprehension (Trezek & Wang, 2006); and speech production (Smith & Wang, 2010). VP combined with the Corrective Reading–Decoding curriculum produced significant gains in letter-sound identification in isolation, letter-sound identification within word, and word decoding on a pre-/posttest design in middle school DHH students regardless of level of hearing loss (Trezek & Malmgren, 2005). Statistically significant improvements for kindergarten and first grade students in beginning reading skills as measured by standardized assessments resulted when VP was combined with LACES (a reading curriculum created by the participants' local school district; Trezek et al., 2007). When coupled with a modified version of the Fountas and Pinnell Kindergarten Phonics Curriculum (Fountas & Pinnell, 2002), VP significantly increased phonological awareness and speech production in a preschool student who used a cochlear implant (Smith & Wang, 2010).

Thus, we have a growing evidence base of VP's effectiveness in teaching a variety of literacy skills to DHH students with various hearing losses across grade levels. We further know that *Foundations* can be used to teach letter-sound correspondence (Bergeron et al., 2009), syllable segmentation, and initial-sound identification to DHH students with functional hearing (Miller et al., 2013) and letter-sound correspondence to DHH students without functional hearing when combined with VP (Beal-Alvarez et al., 2011). However, we do not know whether syllable segmentation can be taught to prekindergarten students without functional hearing when using *Foundations* or whether initial-sound identification can be taught to prekindergarten students without functional hearing when using a combined approach of *Foundations* and VP.

The current study is part of a larger project funded by the Institute of Education Sciences (R324E06035; R324A110101) to develop an early literacy curriculum for DHH preschoolers called *Foundations for Literacy* (Lederberg et al., 2011). This study further extends the current research (Beal-Alvarez et al., 2011; Bergeron et al., 2009; Miller et al., 2013) by investigating the combined effect of VP and *Foundations* on early literacy skills, specifically syllable segmentation, letter-sound correspondence, and initial-sound identification in DHH students who used signed communication with varied levels of speech perception. The researchers of this study explored three research questions:

Research Question 1: What effect does *Foundations* have on word segmentation at the syllable level (i.e., syllable segmentation)?
Research Question 2: What effect does *Foundations* supported by the VP handshapes have on the correct identification of letter-sound correspondence?
Research Question 3: What effect does *Foundations* supported by the VP handshapes have on the correct identification of initial sound in single and multisyllabic words?

Method

Setting and Participants

This study took place in a day school for the deaf in the Southeastern region of the United States. Students and staff all used some form of signed communication (ASL, Pidgin, Simultaneous Communication) as self-reported. The research teacher, the first author of this study, implemented the first 12 units of the *Foundations* curriculum, while the participating classroom teacher observed each lesson. Beginning in Unit 13, the participating classroom teacher took over daily instruction. The researcher and participating teacher used Simultaneous Communication for instruction. The research teacher completed 8 hrs of training in VP prior to the study, while the participating classroom teacher received ongoing training through the certified VP trainer employed by the school. Three children in a self-contained prekindergarten classroom using Total Communication participated in the study. Lucas (all names are pseudonyms) was a 4-year and 5-month-old African American male with a PTA of 53 dB, who wore bilateral hearing aids. His parents were hearing and used spoken English and some sign in the home. An *Early Speech Perception Test* (ESP; Moog & Geers, 1990) was given to each student to determine their level of functional hearing. The ESP assesses pattern and word discrimination and puts children in one of the following categories: no pattern perception (ESP 1), pattern perception (ESP 2), some word identification (ESP 3), and consistent word identification (ESP 4). There are two versions of the ESP, the standard version and the low verbal. Lucas scored a 4 on the ESP standard pretest. Because his score represented the highest level of functional hearing

and his hearing did not change during the study, no posttest was given. Ben was a 4-year and 10-month-old Asian male with a PTA of 103 dB, who wore bilateral hearing aids. Ben's parents were hearing and used spoken English and some sign in the home. His ESP low verbal pretest score was 1, which is equivalent to no functional hearing. Ben was not post-tested as his hearing (stable, profound loss) did not change during the course of the study as documented by yearly audiograms. Josephine, a 5-year and 5-month-old Hispanic female with a PTA of 110 dB wore a unilateral cochlear implant. She was implanted 2 months before the start of the school year at 5 years and 2 months of age. Josephine's parents were hearing and used spoken Spanish in the home. She scored a 1 on the ESP low verbal pretest, which is equivalent to no functional hearing. Her posttest score was a 4, which is equivalent to functional hearing. The development of functional hearing was due to a progressive benefit from a recent cochlear implant.

Research Design

This study used a multiple baseline across content (i.e., syllable segmentation, letter-sound correspondence, and initial-sound identification) design to determine whether a functional relation existed between explicit instruction in phonological and phonemic skills and acquisition of targeted skills. Skills included word segmentation at the syllable level, letter-sound correspondence, and initial-sound identification. The independent variable was explicit instruction in targeted skills using *Foundations* and VP for letter-sound correspondence and initial-sound identification and *Foundations* alone for syllable segmentation. The dependent variables were learned skills (i.e., syllable segmentation, letter-sound correspondence, and initial-sound identification).

Procedures

Baseline and probe assessment. Baseline assessments followed the same protocols for all skills used during the probe assessments with one exception. Baseline assessments for letter-sound incorporated all letters taught during the curriculum, while the individual probes assessed the letters taught during the weekly units and were not cumulative in nature. Progress monitoring not included in this Single-Case design was used to monitor cumulative letter-sound knowledge.

Syllable segmentation. The researcher or teacher presented a spoken word accompanied by the corresponding sign. Child participants were asked to identify the number of syllables in the word. Acceptable answers included the correct number of syllables (Prompt: *hamburger*—Response: *three*) or the Say It/Show It method (Prompt: *hamburger*—Response: Ham–clap, bur–clap, ger–clap). Three words initially given as teaching items became practice items as probes continued, and students became familiar with the task. Ten words were presented as scored items. A modified protocol was used with Ben and Josephine due to their lack of functional hearing.

Researchers created a series of PowerPoint slides to assess syllable segmentation for these participants. The first three slides contained teaching/practice examples and included a picture of the given word and a visual representation of the number of syllables in the word. The subsequent 10 slides were scored items and included a closed set of visual images representing the number of syllables in the given word (Miller et al., 2013). A word was presented in spoken form along with the corresponding sign. Attention was brought to the assessor's mouth, and the spoken word was presented a second time. No sign was used in the second presentation. Students were asked to identify the correct number of syllables from a closed set of items. The closed set always contained two of the following images: one, two, or three like-colored rectangles arranged in a horizontal line. Each rectangle represented a syllable in the target word. For example, if the word had three syllables, students were expected to pick the item with three rectangles to score a correct answer. The assessor stopped using the modified probe for Josephine, as she began to develop functional hearing due to the routine use of a cochlear implant as noted by her performance without modification during instructional sessions. VP was not used to teach or assess syllable segmentation.

Letter-sound correspondence. Index cards with a single lowercase letter (i.e., written letter) were placed on a binder ring. Participants were asked to identify the corresponding sound when each card was presented. For letters with more than one pronunciation (i.e., short and long vowel sounds), students were prompted to provide corresponding sounds if they did not do so initially.

Initial-sound identification. The researcher or teacher presented a spoken word accompanied by the corresponding sign (e.g., *boat* and BOAT). Students were asked to identify the initial sound in the word. Acceptable answers included the spoken production of the sound (e.g., /b/), the VP representation of the sound, or both. The name of the letter was not an acceptable answer. If a child provided the letter name, the researcher prompted the student for the letter sound. The 3 words initially taught became practice items as probes continued and students became familiar with the task. Ten words were presented as scored items. Researchers created a series of PowerPoint slides to assess initial sound. The first 3 slides contained teaching/practice examples. The following 10 slides were scored items. For the standard protocol, each slide had a picture of the target

word and the letter corresponding to the initial sound. The letter on the slide was obscured until the child provided a response. Once the child's response was acknowledged, the assessor revealed the letter and gave the letter sound. For the modified protocol, the picture of the target word was accompanied by a closed set of three letters. The picture and the closed set of letters were visible to the child at all times. The letter corresponding to the correct initial sound was revealed only after the child gave a response. A spoken word was presented along with the corresponding sign. Attention was brought to the mouth and the spoken word was presented a second time. No sign was used in the second presentation. A closed set of three lowercase letters was presented to the students; each sound and corresponding VP handshape was presented. The researcher ensured that letter choices were sufficiently different on the mouth so as not to confuse the children (e.g., *m* and *b* look similar, while *m* and *g* look different). Students were asked to identify the correct initial sound of the given word. Acceptable answers included pointing to the correct letter, producing the correct sound, or producing the correct VP representation of the sound. The name of the letter was not an acceptable answer. However, if the student provided the correct letter name, the researcher prompted the student for the sound. A modified protocol was used for Ben in that the researcher produced the sound for each of the letters in the closed set before asking Ben to identify the initial sound in the target word.

Intervention. The intervention used was *Foundations* combined with VP for the skills of letter-sound correspondence and initial-sound identification and *Foundations* only for syllable segmentation. This study followed the same instructional procedures for implementation of *Foundations* as found in Bergeron et al. (2009), Beal-Alvarez et al. (2011), and Miller et al. (2013). A brief description is provided for readers unfamiliar with the aforementioned studies. *Foundations* is a balanced prekindergarten curriculum, focused on code- and meaning-based early literacy skills. Intervention occurs an hour per day, 4 days per week, for 25+ weeks. The first 4 weeks are used to teach foundational vocabulary to facilitate future learning (e.g., *take apart* and *put together* facilitate students' understanding of syllable segmentation) and acclimate children to the lesson activities and pacing. The remaining 21+ weeks are instructional and contain various combinations of the following: language-rich activities focused on learning letter-sound correspondence used to decode taught words, phonological awareness activities including syllable segmentation, initial-sound identification and rhyming, storybook reading, review and reinforcement of skills, and vocabulary and fluency practice.

Treatment Fidelity

A trained research assistant watched videotapes of the intervention sessions and measured fidelity of intervention implementation for 20% of the sessions using a fidelity checklist. Fidelity was measured by the percentage of observed elements scheduled within each lesson plan divided by the number of total scheduled elements. Fidelity of intervention was 80% averaged across the lessons. Interobserver agreement was calculated by a second trained research observer for 19 sessions using the point-by-point formula. Agreement for syllable segmentation was 100%. Agreement for letter-sound correspondence ranged from 67% to 100% with a mean of 95%. Agreement for initial-sound identification ranged from 90% to 100% with a mean of 95%.

Results

Because assessment occurs at the participant level in Single-Case Design (Kazdin, 2011), as opposed to the group level, we analyzed data for individual participants. In this study, assessment probes were modified (e.g., use of VP, answer chosen from closed set, visual representations of syllabic composition of stimulus words, allowance of unique, consistent approximations of the spoken sound) to meet the individual needs of each student (i.e., level of hearing loss and communication modality).

Lucas

Stability calculations for Lucas' graph (see Figure 1) indicated stable baselines for syllable segmentation (M = 47.3, stability range = 23.6–71.0) and letter-sound correspondence (M = 32.5, stability range = 16.2–48.7). While two points in the initial-sound identification baseline fell outside the range of stability (M = 6.1, stability range = 3.0–9.1), a negative trend was present with the initial and final data points remaining at 0% correct after a slight increase to 20%. A strong immediacy of effect was found across skills including syllable segmentation (M_{BL} = 47.3, M_I = 83.3), letter-sound correspondence (M_{BL} = 32.5, M_I = 837.7), and initial-sound identification (M_{BL} = 6.1, M_I = 57.5). Data paths in all tiers presented increasing positive trends, and mean percentage of overlapping data (POD; Kazdin, 2011) was 0% across all skills.

Ben

Stability calculations for Ben's graph (see Figure 2) indicated a stable baseline (M = 38.9, stability range = 19.5–58.4) in the first tier. The second and third tier baselines were predictable with a mean level of 0 and a flat (or no) trend. A strong immediacy of effect was calculated for letter-sound correspondence (M_{BL} = 0.0, M_I = 44.4) and initial-sound identification (M_{BL} = 0.0, M_I = 30.3). Visual inspection indicated a sharp positive trend in the acquisition of letter-sound correspondence with 100% mastery in the

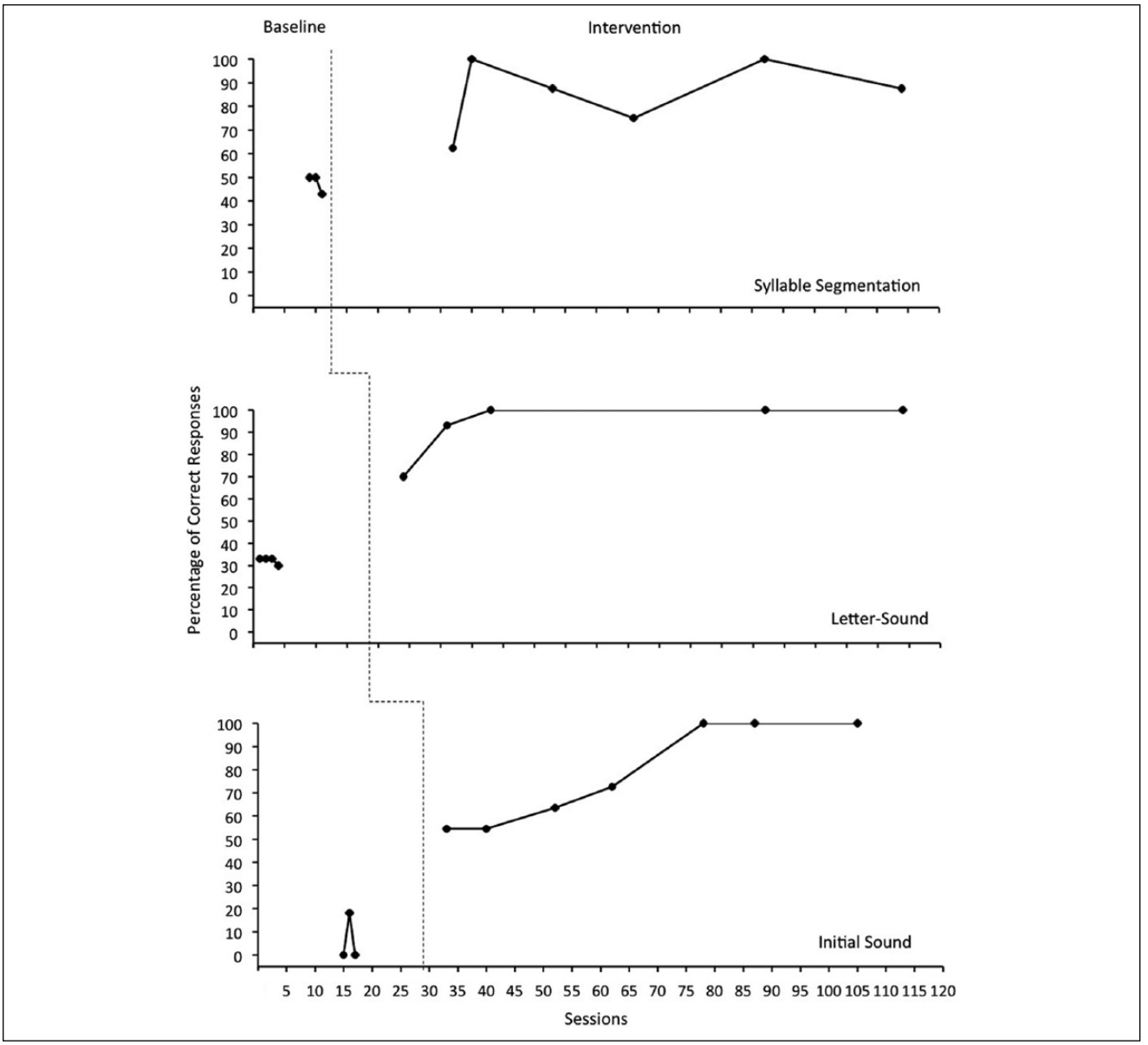

Figure 1. Percentage of correct responses for syllable segmentation, letter-sound correspondence, and initial-sound identification for Lucas.

final data points. Mean POD was 0% for letter-sound correspondence and initial-sound identification.

Josephine

Stability calculations for Josephine's graph (see Figure 3) indicated a stable baseline (M = 38.9, stability range = 19.5–58.4) in the first tier. The second and third tier baselines were predictable with a mean level of 0 and a flat (or no) trend. A strong immediacy of effect was calculated for letter-sound correspondence (M_{BL} = 0.0, M_I = 63.1) with a slightly smaller effect for syllable segmentation (M_{BL} = 38.9, M_I = 63.9). Visual inspection indicated sharp positive trends in the acquisition of letter-sound correspondence and initial-sound identification. Mean POD was 0% for initial sound identification and 16.6% for syllable segmentation.

Social Validity

Social validity was measured through teacher responses in an informal end-of-year meeting. The classroom teacher had the following to say about the *Foundations* curriculum: "I really think the curriculum has a lot of value. The activities were interesting and age appropriate for most DHH students. Experiencing the activity (making airplanes, having a tea party, etc.), helps give students something to hang on to

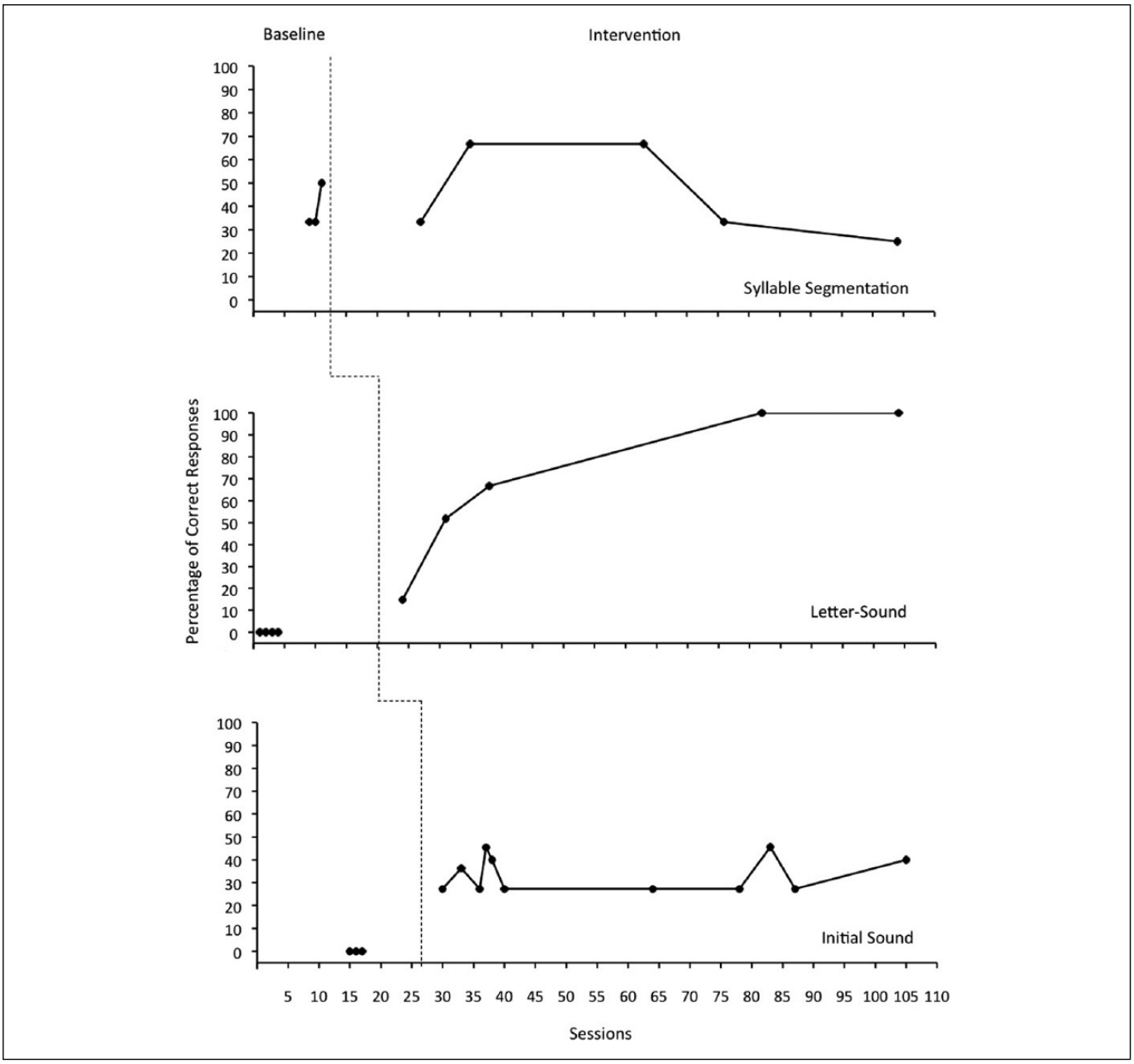

Figure 2. Percentage of correct responses for syllable segmentation, letter-sound correspondence, and initial-sound identification for Ben.

and to connect the visual/sound of the letters. The sequence of activities is basically the same most days, and this provides structure for the students, so that they know what to expect. The teacher can focus more on the information and knowledge rather than the novelty of new activities each day. I think the VP component is vital for DHH students. Without it, the students with profound hearing losses are very limited in the letter sounds they will be able to reproduce. For example, having the VP allows them to see the difference in /c/and t/. All students learned something (e.g., VP), although how much they benefited varied based on hearing loss, attention span, interest, and so on. Again, the frequent repetition with the sound books was very helpful in giving all students the opportunity to learn the sounds and VP hand movements."

Discussion

We asked the following question: What effect does *Foundations* have on the participants' syllable segmentation? To answer this question, we conducted repeated probes to assess participants' ability to correctly identify the number of syllables in one, two, three, and four syllable words through a variety of responses (e.g., giving the number of

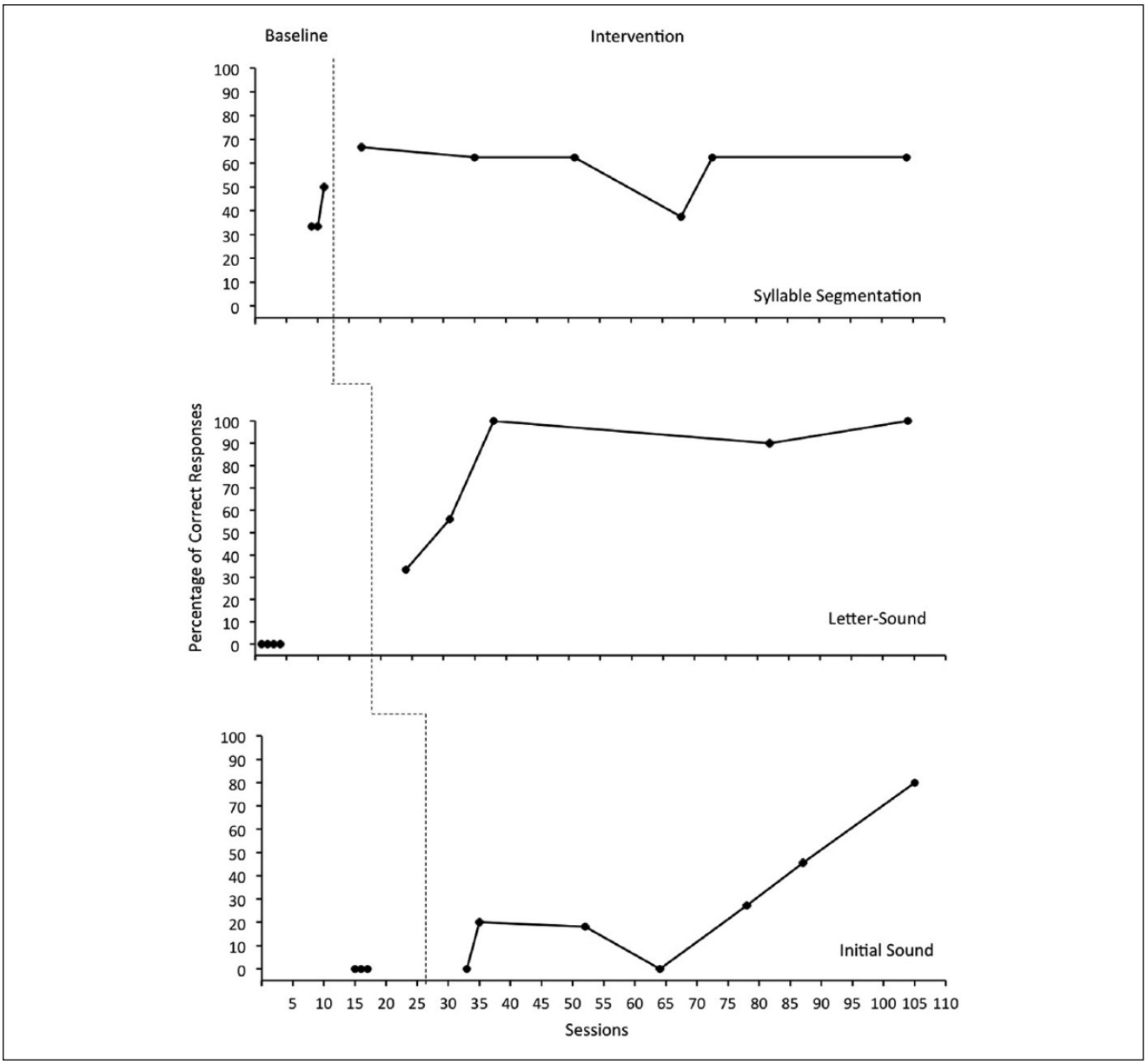

Figure 3. Percentage of correct responses for syllable segmentation, letter-sound correspondence, and initial-sound identification for Josephine.

syllables, clapping, pointing to a visual representation). We found that change in participants' segmentation abilities did occur under the experimental condition. Lucas mastered syllable segmentation. While Josephine made improvement in syllable segmentation, she had not mastered the skill by the end of the study approximately 28 weeks later. Josephine's developing hearing may have been a factor in her acquisition of syllable segmentation. As she relied more on her hearing and less on visual supports (e.g., closed set visuals and speech reading), she began to use her own internal, auditory approximation of the targeted words as an aid in syllable segmentation. If her approximation was grossly dissimilar from the targeted words, she often gave the incorrect response. Ben was not able to master syllable segmentation. While he did make progress, he was unable to sustain it throughout the study. His profound hearing loss and his lack of consistent approximations for the targeted words may have affected his ability to segment. Ben also changed schools close to the end of the study and did not have consistent instruction in the latter part of the curriculum. The last data point was collected at his new school placement.

Next, we asked the question: What effect does *Foundations* supported by the VP handshapes have on the participants' correct identification of letter-sound correspondence? To

answer this question, we conducted repeated probes to measure participants' acquisition of targeted correspondences as they occurred within the individual units. We found that change in participants' letter-sound correspondence did occur under the experimental condition. All three participants mastered all taught letter-sound correspondences.

Finally, we asked the question, What effect does *Foundations* supported by the VP handshapes have on the participants' correct identification of initial sound in single and multisyllabic words? To answer this question, we conducted repeated probes to assess participants' ability to identify initial sound in known and novel words. We found that change in participants' initial-sound identification did occur under the experimental condition. Lucas mastered initial sound. By the end of the school year (approximately 28 weeks later), Josephine had also mastered initial sound. Researchers attribute some of her early variability and later improvement (beginning at the midpoint of the school year) to Josephine's development of functional hearing due to increasing benefit from her cochlear implant. Ben made marked improvements over the course of the school year but did not master initial sound by the end of the study.

Similar to Beal-Alvarez et al. (2011), we found that the children without functional hearing in this study were able to learn letter-sound correspondence, contributing to the discussion of whether children with limited access to sound can learn this skill. Extending the results of Miller et al. (2013), we also found that the children with limited auditory access in this study were able to learn syllable segmentation and initial sound or began to exhibit emergent skills in both areas. For students without functional hearing or those developing functional hearing, slower pacing, repeated practice, and an extension of the curriculum into following school years may be necessary to ensure mastery in the phonological skills of syllable segmentation and initial-sound identification.

Limitations

A limitation of this study is one inherent in all Single-Case designs (Kratochwill et al., 2010)—that is, the small number of participants included. With only three participants, we were unable to generalize the results to all students to show that without functional hearing, they can master all three targeted skills (i.e., syllable segmentation, letter-sound correspondence, and initial sound). Because one student (Ben) changed schools at the end of the study, he missed a portion of the scheduled instruction. It was necessary for the researchers to collect the last data point for all skills at the new school location. This setting change and the loss of instructional time may have negatively affected Ben's performance on the targeted skills.

Future Research

We originally hypothesized that the skills in the current study moved hierarchically from syllable segmentation to letter-sound correspondence to initial sound identification. We expected as children moved across this sequence, the skills were more refined and progressed in a least-to-most difficult manner. While this may be true for students with functional hearing, the student without functional hearing and the student who developed functional hearing had most difficulty with syllable segmentation. This may be explained by the fact that these students do not have or are just beginning to create internal approximations of English words. Future researchers might further examine the hierarchy of phonemic and phonological skills with DHH students without functional hearing who use signed communication, as well as the strategies they use to develop internal (auditory or kinesthetic) approximations of English words. It may be that syllable segmentation is not of great importance to children without functional hearing in terms of early reading ability. It may also be that segmentation of words at the sound level (i.e., initial sound, medial sound, final sound), which looks to be a skill that children developing functional hearing as well those without functional hearing are able to acquire, may be a more effective strategy to teach early decoding and word-attack skills.

Summary

We used a Single-Case Design to examine syllable segmentation, letter-sound correspondence, and initial sound identification in three students with hearing loss who used signed communication, two children with functional hearing (i.e., one began the study with functional hearing, one developed functional hearing over the course of the study due to cochlear implant use) and one without functional hearing. We found that students who used sign language could learn syllable segmentation when taught using the type of explicit instruction found in the *Foundations* curriculum and could learn letter-sound correspondence and initial-sound identification when *Foundations* was supported with VP handshapes. However, the participants with the most residual hearing exhibited greater gains when compared with those with no functional hearing.

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References

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*, 417–423.

Beal-Alvarez, J., Lederberg, A., & Easterbrooks, S. (2011). Grapheme-phoneme acquisition of deaf preschoolers. *The Journal of Deaf Studies and Deaf Education*, *17*, 39–60. doi:10.1093/deafed/enr030

Bergeron, J. P., Lederberg, A. R., Easterbrooks, S. R., Miller, E. M., & Connor, C. M. (2009). Building the alphabetic principle in young children who are deaf or hard-of-hearing. *Volta Review*, *109*, 87–119.

Bowey, J. A., & Francis, J. (1991). Phonological awareness as a function of age and exposure to reading instruction. *Applied Psycholinguistics*, *12*, 91–121.

Boyer, N., & Ehri, L. (2011). Contribution of phonemic segmentation instruction with letters and articulation pictures to word reading and spelling in beginners. *Scientific Studies of Reading*, *15*, 440–470.

Byrne, B., & Fielding-Barnsley, R. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *The Journal of Educational Psychology*, *91*, 403–414.

Cihon, T., Gardener, R., Morrison, D., & Paul, P. (2005). Using Visual Phonics as a strategic intervention to increase literacy behaviors for kindergarten participants at-risk for reading failure. *The Journal of Early and Intensive Behavior Intervention*, *5*, 138–155.

Easterbrooks, S. R., Lederberg, A. R., Miller, E. M., Bergeron, J. P., & Connor, C. (2008). Emergent literacy skills during early childhood in children with hearing loss: Strengths and weaknesses. *Volta Review*, *108*, 91–114.

Ehri, L. C., Nunes, S. R., Stahl, S. A., & Willows, D. M. (2001). Systematic phonics instruction helps students learn to read: Evidence from the National reading panel's meta-analysis. *Review of Educational Research*, *71*, 393–447.

Foorman, B. R., Francis, D. J., Fletcher, J. M., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *The Journal of Educational Psychology*, *90*, 37–55.

Fountas, I. C., & Pinnell, G. S. (2002). *Phonics lessons: Letters, words, and how they work/teaching resources, grade K*. Portsmouth, NH: Heinemann.

Guardino, C., Syverud, S., Joyner, A., Nichols, H., & King, S. (2011). Further evidence of the effectiveness of phonological instruction with oral-deaf readers. *American Annals of the Deaf*, *155*, 562–568.

Kazdin, A. (2011). *Single case research designs: Methods for clinical and applied settings* (2nd ed.). New York, NY: Oxford University Press.

Kratochwill, T. R., Hitchcock, J., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2010). Single-case designs technical documentation. *Psychology Quarterly*, *17*, 341–389.

Kyle, F. E., & Harris, M. (2011). Longitudinal patterns of emerging literacy in beginning deaf and hearing readers. *The Journal of Deaf Studies and Deaf Education*, *16*, 289–304.

Lederberg, A. R., Miller, E. M., Easterbrooks, S. R., & Connor, C. M. (2011). *Foundations for literacy*. Unpublished curriculum, Georgia State University, Atlanta.

McDonald, E. W., & Cornwall, A. (1995). The relationships between phonological awareness and reading and spelling achievement eleven years later. *The Journal of Learning Disabilities*, *28*, 523–527.

Miller, E., Lederberg, A., & Easterbrooks, S. R. (2013). Phonological awareness: Explicit instruction of young deaf and hard of hearing children. *The Journal of Deaf Education and Deaf Studies*, *18*, 206–227. doi:10.1093/deafed/ens067

Moog, J. S., & Geers, A. E. (1990). *Early speech perception test for profoundly hearing impaired children*. St. Louis, MO: Central Institute for the Deaf.

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction* (Reports on the subgroups, NIH Publication No. 00-4754). Washington, DC: U.S. Government Printing Office. Retrieved from http://www.nichd.nih.gov/publications/nrp/report.cfm

Neuhaus, G., Foorman, B. R., Francis, D. J., & Carlson, C. D. (2001). Measures of information processing in rapid automatized naming (RAN) and their relation to reading. *The Journal of Experimental Child Psychology*, *78*, 359–373.

Phillips, B., Clancy-Menchetti, J., & Lonigan, C. (2008). Successful phonological awareness instruction with preschool children: Lessons from the classroom. *Topics in Early Childhood Special Education*, *28*, 3–17. doi:10.1177/0271121407313813

Smith, A., & Wang, Y. (2010). The impact of Visual Phonics on the phonological awareness and speech production of a student who is deaf: A case study. *American Annuls of the Deaf*, *155*, 124–130.

Sterne, A., & Goswami, U. (2003). Phonological awareness of syllables, rhymes, and phonemes in deaf children. *The Journal of Child Psychology and Psychiatry*, *41*, 609–625. doi:10.1111/1469-7610.00648

Syverud, S. M., Guardino, C., & Selznick, D. (2009). Teaching phonological skills to a deaf first grader: A promising strategy. *American Annals of the Deaf*, *154*, 382–388.

Traxler, C. (2000). The Stanford Achievement Test, 9th edition: National norming and performance standards for deaf and hard of hearing students. *The Journal of Deaf Studies and Deaf Education*, *5*, 337–348.

Trezek, B. J., & Malmgren, K. W. (2005). The efficacy of utilizing a phonics treatment package with middle school deaf and hard of hearing students. *The Journal of Deaf Studies and Deaf Education*, *10*, 256–271.

Trezek, B. J., & Wang, Y. (2006). Implications of utilizing a phonics-based reading curriculum with children who are deaf or hard of hearing. *The Journal of Deaf Studies and Deaf Education*, *11*, 202–213.

Trezek, B. J., Wang, Y., Woods, D., Gampp, T., & Paul, P. (2007). Using Visual Phonics to supplement beginning reading instruction for students who are deaf or hard of hearing. *The Journal of Deaf Studies and Deaf Education*, *12*, 373–384.

Waddy-Smith, B., & Wilson, V. (2003). See that sound! Visual Phonics helps deaf and hard of hearing students develop reading skills. *Odyssey: New Directions in Deaf Education*, *5*, 14–17.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., Hecht, S. A., Barker, T. A., Burgess, S. R., . . .Garon, T. (1997). Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology*, *33*, 468–479.

Waters, G. S., & Doehring, D. G. (1990). Reading acquisition in congenitally deaf children who communicate orally: Insights from an analysis of component reading, language, and memory skills. In T. H. Carr & B. A. Levy (Eds.), *Reading and its development* (pp. 323–373). San Diego, CA: Academic Press.