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## Fingerspelling and Print: Understanding the Word Reading of Deaf Children

JESSICA A. SCOTT, SARAH G. HANSEN, AND AMY R. LEDERBERG

Fingerspelling and its relationship with literacy skills among deaf and hard of hearing children who use American Sign Language is an increasingly popular research topic. However, there is limited research on whether reading interventions that systematically include fingerspelling are more effective for improving literacy skills than reading interventions that do not. In an adapted alternating-treatment single-case study, the authors contrasted the number of words learned under three conditions: a productive fingerspelling condition, in which word reading was taught through activities that emphasized productive fingerspelling; a chaining condition, in which teachers chained written words with receptive fingerspelling; and a sign-to-print condition, in which fingerspelling was not used. Five of the 6 participants learned most of the words taught with no differentiation by condition. Participants could recognize and fingerspell taught words, even if those words were not taught via fingerspelling.

**KEYWORDS:** Deaf education, American Sign Language, fingerspelling, reading, literacy

Although there is increasing research in deaf education addressing questions of language and literacy development, there is little evidence on specific interventions to improve the literacy skills of deaf and hard of hearing (DHH) students (Cannon, Guardino, Antia, & Luckner, 2016). There is evidence to suggest that reading outcomes are improving among some groups of DHH learners (Easterbrooks & Beal-Alvarez, 2012), but identification of the route to print access used by these learners remains unclear. For example, deaf education research is divided on such issues as the relative contribution of phonology both within and between modalities (i.e., spoken language and signed language; Holmer, Heimann, & Rudner, 2016; Mayer & Trezek, 2014), and the

potential contribution of alternate coding systems such as fingerspelling (letters of the alphabet represented through hand-shapes), visemes (representations of speech sounds as seen on the lips and mouth during speaking), or handshapes (hand positions that are used in the execution of individual signs) for word recognition and reading (Elliott, Braun, Kuhlmann, & Jacobs, 2012; Haptonstall-Nykaza & Schick, 2007; Sehyr, Petrich, & Emmorey, 2016). Specifically for those students who use American Sign Language (ASL) to communicate, more research is needed on the relative contribution of such coding systems to reading development. In the present study, we examined one such coding system—fingerspelling—and whether and how the use of fingerspelling enhanced

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signing DHH children's ability to learn novel words.

### DUAL-ROUTE CASCADED MODEL OF READING

The dual-route cascaded (DRC) model of reading was initially proposed by Coltheart, Rastle, Perry, Langdon, & Ziegler (2001). According to this model, phonemic and lexical routes to word reading provide increasing cues to facilitate word recognition; this conceptualization is in contrast with the previously held notion that visual and auditory input must reach a certain threshold before the reader is able to identify the written word. Per the DRC model, when presented with a printed word, the reader may follow one of two routes: The first is a direct route, which allows the reader access to the meaning of the word she is reading directly from the print. The second route relies on sublexical information sources before arriving at the phonemic representation of the word. In essence, one route to reading brings the reader directly from the printed letters to the pronunciation of the spoken word, while the other involves retrieval of lexical information via orthographic and semantic data. The DRC model has been found by some to have better explanatory power for skills such as pronunciation of nonwords (Pritchard, Coltheart, Palethorpe, & Castles, 2012), oral reading, and visual word recognition (Coltheart et al., 2001). There is also evidence that the DRC model aligns with reading approaches that are effective for students with dyslexia (Ziegler et al., 2008).

There has been limited research on the application of the DRC model to DHH readers. In the only study of its kind, Elliott et al. (2012) argued that deaf adults in Germany utilize a modified version of the DRC model in which the sublexical route these readers take to word reading includes

not only drawing upon orthographic and semantic information but also accessing knowledge of German Sign Language lexicon and spoken-German visemes. For the indirect route, Elliott et al. argued that rather than access phonology directly, the deaf adults in their study accessed phonology via means of acquiring visemic information such as speechreading. Others have examined the role of phonology for deaf adults reading in French, finding that study participants favored an orthographic route to word reading (Bélanger, Baum, & Mayberry, 2012). Though valuable, both studies considered the word reading of deaf adults rather than children, and thus were more likely to reflect the word reading process for more fluent readers, which may differ from the word reading process of developing readers.

### FINGERSPELLING AND LITERACY

Evidence has been mounting in support of the importance of fingerspelling in the language and literacy development of DHH children (Allen, 2015; Emmorey, McCullough, & Weisberg, 2015; Haptonstall-Nykaza & Schick, 2007; Mouny, Pucci, & Harmon, 2014; Stone, Katheiser, Hauser, Pettito, & Allen, 2015). Because of its through-the-air representation of orthography, fingerspelling has been thought of as a potential link between ASL and English (Mouny et al., 2014). Indeed, there is even neuroscientific evidence that print words and fingerspelled words are processed similarly by deaf readers (Emmorey et al., 2015). However, there is not yet sufficient research on how these relationships may be applied to teaching practice.

A number of researchers have found a relationship between fingerspelling and literacy skills at various ages. Fingerspelling has been found to predict emergent literacy among young DHH children (Allen, 2015).

Fingerspelling has also been correlated with reading comprehension ability and English vocabulary knowledge among adult DHH readers (Emmorey & Petrich, 2011; Stone et al., 2015). In fact, fingerspelling appears to contribute to scores on a measure of reading proficiency over and above the effects of ASL proficiency—in other words, it is not ASL proficiency in general, but the specific skill of fingerspelling, that may be important to the development of reading skills of signing DHH readers (Lederberg et al., 2019; Stone et al., 2015).

On the whole, these studies suggest both that DHH children make connections between fingerspelled and written words and that explicit instruction that includes fingerspelling may support literacy development. However, the use of fingerspelling as a bridge to word reading is not without its critics. Some have rightly criticized the field for failing to provide sufficient evidence that DHH learners could use either fingerspelling or signs to connect with the written word without also having sufficient phonological knowledge or through reliance on spoken phonology (Wang, Trezek, Luckner, & Paul, 2008). In the present study, we attempt to contribute to the knowledge base in this area.

#### WORD READING INTERVENTIONS WITH DHH LEARNERS

Though there are few word reading interventions that are designed for DHH learners, those that exist can be divided into approaches that use a direct route to reading words and those that use an indirect route. Reading Milestones (Quigley, King, McAnally, & Rose, 1981) is a commonly used literacy intervention for DHH students. In this approach, children are exposed to words multiple times and are expected to learn to associate the word meaning and sign with the

printed word without explicit instruction in sublexical structures such as phonology or fingerspelling. Similarly, a sight word intervention using a single-case design demonstrated that systematic repeated exposure to sight words supported kindergarten-age DHH children in their acquisition of these words (Davenport, Konrad, & Alber-Morgan, 2018). However, there is evidence that DHH children may learn words better in conditions that emphasize orthographic patterns; such evidence suggests that an indirect route emphasizing sublexical structures may be a more successful way to teach DHH children to read words (Reitsma, 2008).

There are interventions that focus on the indirect route and attempt to teach DHH children to decode written words via spoken phonology. For instance, Fairview Learning (Ausbrooks-Rusher, Schimmel, & Edwards, 2012) is a commonly used literacy intervention that teaches children to read words through sight word instruction (the direct route) and through phonology instruction (the indirect route). Similarly, the Science Research Associates (SRA) Direct Instruction (DI) program is a word reading intervention that is based on traditional phonological decoding (Patker, 1997). To make spoken phonology more visually accessible for DHH learners, researchers have used Visual Phonics alongside DI programs (Trezek & Hancock, 2013). Visual Phonics represents sounds with hand movements that mimic articulation (International Communication Learning Institute, 1996). In studies that used pretest/posttest design, children instructed with DI using Visual Phonics increased their ability to decode words and nonwords (Trezek & Hancock, 2013).

An emerging body of literature suggests that literacy instruction using fingerspelling may be an indirect route to word reading that holds promise for DHH children

(Haptonstall-Nykaza & Schick, 2007; Humphries & MacDougal, 2000; Stone et al., 2015). There are a number of ways that fingerspelling may be used in connection with print. Two such approaches are *chaining* and *sandwiching*. Chaining involves making a series of connections between meaningful representations of words, that is, the printed word, the sign, a picture, and its fingerspelled form. Sandwiching uses fingerspelling and signs, with one form “sandwiched” between another to connect them. The target word is either fingerspelled, signed, and fingerspelled or signed, fingerspelled, and signed. Both instructional approaches are used by deaf teachers to make connections between printed words, fingerspelling, and ASL signs (Humphries & MacDougal, 2000). Building on these approaches, Haptonstall-Nykaza and Schick (2007) taught children words either by directly connecting the print with the ASL sign (direct route) or through chaining that linked fingerspelling, the English print, and the ASL sign (indirect route). Haptonstall-Nykaza and Schick found evidence that students learn words better by the indirect route than by the direct route. This seems to suggest, much as Stone et al. found (2015), that fingerspelling may facilitate children’s formation of associations between signs and print.

As a response to the findings of Haptonstall-Nykaza and Schick (2007), the Fingerspelling Our Way to Reading program (FOWR; Schick, Lederberg, Bridenbaugh, Boll, & Burke, 2018) was developed as a supplemental intervention for young signing DHH children. It was based on the Words Their Way spelling intervention, which uses a word family approach to instruction (Bear, Invernizzi, Templeton, & Johnston, 2015). The FOWR intervention focused on building a fingerspelled representation of a word by making explicit connections between the fingerspelling of a word and its meaning,

and later connecting fingerspelling with English print. It differed from chaining and sandwiching by not only exposing children to the fingerspelled forms of words, but also by asking them to *produce* fingerspelling. This intervention included activities that required children to identify sublexical components of words through analysis of fingerspelled representations (see Appendix A).

In the present study, we aimed to add to the existing literature about the role of fingerspelling in learning to read words through an adapted alternating-treatment single-case research design study. We hypothesized that the presence of fingerspelling in instruction would result in better word learning, and that an approach that both exposed students to fingerspelled forms of words and asked them to produce fingerspelled forms of words would be more effective for word learning than a condition that did not include fingerspelling. We tested this hypothesis in three conditions: two that incorporated fingerspelling and one that did not.

The first fingerspelling condition was an instructional approach adapted from FOWR that included receptive and productive fingerspelling, as well as fingerspelling activities inspired by phonological awareness—for example, combining individually fingerspelled letters to make one word (a technique known as *word blending*) and fingerspelling words by separating letter groupings, such as /c/ and /at/ (a technique known as *chunking*). The second fingerspelling condition was an instructional approach that included *only* receptive fingerspelling by incorporating chaining and/or sandwiching (i.e., presenting target English print words via linking signs, fingerspelling, pictures, and print). The final approach, which did not incorporate any fingerspelling, made direct connections between signs and English print.

## METHOD

### Participants

Six children between the ages of 6 years 0 months and 9 years 4 months were recruited from two self-contained deaf education classrooms at an elementary school in the southeastern United States to participate in the present study. Classrooms were selected if they reported that they used ASL as the primary mode of communication and had students who were identified by their teachers as early readers (reading at approximately kindergarten to first grade level). All students from participating classrooms were included. All students qualified for free or reduced-price lunch. Students participated in two different groups, divided by age and grade level. The first group consisted of three students ages 6–7 years who were enrolled in kindergarten (hereafter Kindergarten Group). The second group comprised three students ages 8–10 years who were enrolled in first grade (hereafter First-Grade Group). See Table 1 for information on participants. (To protect the participants' privacy, their real names are not used.)

Manuel, Sam, and Chris made up the Kindergarten Group. They ranged in age from 6 years 0 months to 6 years 4 months. This is slightly higher than the average age for kindergarten enrollment. All three had

binaural cochlear implants, which both Manuel and Sam were reported to use consistently at home and at school. Both Chris and Manuel had been identified in infancy as having congenital hearing loss. Sam had been identified with a hearing loss between the ages of 2 and 3 years.

Dorothy, Nick, and James made up the First-Grade Group. Being more than 9 years old, two of these students were slightly above the average age for first-grade students. All three of the first graders wore bilateral hearing aids; both Dorothy and Nick were reported to wear them consistently. Dorothy was identified as having a hearing loss at age 6 years. Nick and James were identified as having a congenital hearing loss in infancy. James's mother was deaf, and he had deaf siblings. His family communicated primarily through simultaneous spoken English and sign language. James also had a diagnosis of attention deficit hyperactivity disorder, for which he did not take medication.

### Setting and Interventionist

All sessions took place in the students' classrooms during school hours. Located in a major metropolitan area, the school was a public elementary school with a well-established deaf education unit. DHH

**Table 1.** Attributes of the Study Participants ( $N = 6$ )

Name <sup>a</sup>	Group	Age <sup>b</sup>	Gender	Race/ethnicity	Mode of amplification	Home language
Manuel	K	6.0	M	Hispanic/Latino	CI	Spanish
Sam	K	6.4	M	African American	CI	English
Chris	K	6.4	M	Hispanic/Latino	CI	Spanish
James	1	9.7	M	African American	HA	English and sign
Dorothy	1	9.4	F	Caucasian	HA	English and Spanish
Nick	1	7.10	M	African American	HA	English

Notes. K = Kindergarten Group. 1 = First-Grade Group. CI = cochlear implant. HA = hearing aid.

<sup>a</sup> All names have been changed to protect the participants' privacy.

<sup>b</sup> Years.months.

children from all over the county attended this program. It featured classrooms that primarily used ASL and others that primarily used spoken language. The present study took place only in the two classrooms using ASL. Sessions were conducted by a research associate employed at a public research institution. The interventionist had a master's degree in deaf education and experience with classroom teaching and deaf education research. Her ASL skills, rated on the basis of her score on the Sign Language Proficiency Interview (SLPI), were at the advanced level. The interventionist had received training from one of the professionals who designed FOWR.

### Measures

The interventionist administered initial assessments to the children in ASL, without voicing, prior to the start of intervention. Correct responses were accepted in either voice or sign. Measures included three tests of language and literacy. The first was the Woodcock Johnson–III Letter-Word Identification subtest, which assesses knowledge of letters and sight words (WJ-III LWID; Woodcock, Mather, & McGrew, 2001). Next, expressive vocabulary was assessed by means of the Expressive One-Word Picture Vocabulary Test (EOWPVT; Martin & Brownell, 2010). This assessment asks children to provide a signed word matching a picture prompt. Previous modifications used successfully with DHH children included administration in sign and a list of acceptable sign responses generated by deaf and child of deaf adult (CODA) researchers, which were both used in the present administration (Lederberg et al., 2019). Finally, two subtests of the Schick Fingerspelling Assessment (Schick, 2012) were used to assess the children on their fingerspelling ability. One subtest required the children to imitate fingerspelled words of

increasing length. For this subtest, the children viewed a video of a signer fingerspelling simple words such as *sun*, *bus*, and *dog* through longer words such as *pencil* and *caterpillar*. The children were then asked to spell the same word as the one in the video. The second subtest required the children to blend fingerspelled words that were presented in two or three chunks. For example, the interventionist might fingerspell *sun* as /s/ (pause) /un/. The children were then asked to blend the letters together through fingerspelling to create a word. Scores on this assessment are reported as percent correct across items.

Three kindergarteners and one first grader scored within the average range on letter and word knowledge as measured by the WJ-III LWID, while two of the children in the First-Grade Group earned a standard score that was significantly below average (see Table 2). It is important to note, however, that the demands of assessment were much higher for the older children than for the younger ones. Kindergarteners were required primarily to identify letters, while the older children were required to read words of increasing difficulty. This change in level may partially account for the lower scores among the older children. On the EOWPVT, all of the children scored two standard deviations below the mean. In terms of fingerspelling ability, all of the students in the Kindergarten Group scored 0 on both Schick Fingerspelling Assessment subtests, while two participants in the First-Grade Group had average to above-average scores. This jump in fingerspelling ability between the Kindergarten Group and the First-Grade group may have been an effect of age and exposure to fingerspelling in the classroom setting.

### Experimental Design and Analysis

An adapted alternating-treatment single-case research design was used in

**Table 2.** Participants' Assessment Results

Name <sup>a</sup>	Age <sup>b</sup>	WJ-III LWID standard scores	WJ-III LIWD age/grade equivalents	EOWPVT standard scores	EOWPVT age equivalents	Schick Fingerspelling Assessment: fingerspelling ability	Schick Fingerspelling Assessment: PA blending words
Manuel	6.0	105	6.3/1.0	65	3.0	8%	0%
Sam	6.4	88	5.8/K.4	63	3.1	8%	0%
Chris	6.4	88	5.8/K.4	66	3.3	8%	0%
James	9.7	45	5.11/K.6	63	4.8	46%	25%
Dorothy	9.4	65	6.9/1.5	<55	3.5	62%	50%
Nick	7.10	90	7.2/1.9	64	4.0	77%	63%

Notes. WJ-III = Woodcock Johnson-III Tests of Achievement. LWID = Letter-Word Identification subtest. EOWPVT = Expressive One-Word Picture Vocabulary Test. PA = phonological awareness.

<sup>a</sup> All names have been changed to protect the participants' privacy.

<sup>b</sup> Years.months.

the present study. Adapted alternating-treatment designs allow for comparison between conditions using sets of functionally equivalent responses (i.e., word families at the same or a similar level of difficulty). Adapted alternating-treatment designs protect against carryover effects between conditions by using different sets of responses that are hypothesized to be equivalent (Ledford & Gast, 2018). This type of design does not require a baseline to meet What Works Clearinghouse standards but does require at least four alternations between conditions (Horner et al., 2005). Thus, the present study met WWC standards with reservations: Because of constraints of the curriculum and the available time, we only had three alternations between conditions. Therefore, findings from this study contribute to the evidence base but should be considered with reservations.

The leading data point in the graphed adapted alternating-treatment designs was collected prior to the beginning of instruction. Additional pre/post data were collected and are reported separately. Data were collected for three experimental conditions: fingerspelling, chaining, and sign-to-print (described in detail below).

Graphed data were analyzed in keeping with standard procedures for analysis of alternating treatment designs, including identification of visual separation between conditions. Table 3 shows the words used across conditions for both groups.

## THE INTERVENTION

The present study adapted FOWR, an existing supplemental literacy intervention designed for DHH children (Schick et al., 2018). Each unit in the original FOWR intervention consisted of six 25-minute lessons and included interactive instruction around either five words (entry level, kindergarten) from one word family or eight words (1A level, first grade) from two word families. To fit the single-case design and time requirements on the part of participating classrooms, units were reduced in duration and reorganized, and certain intervention components, including review sessions, were eliminated. These modifications resulted in reduction of the intervention from six to four lessons per unit, which were implemented over the course of a week in 30-minute (rather than 25-minute) sessions.

**Table 3.** Words Used Across Conditions for Both Groups

	Set 1, Unit 1 FS	Set 1, Unit 2 C	Set 1, Unit 3 SP	Set 2, Unit 4 SP	Set 2, Unit 5 FS	Set 2, Unit 6 C
Kindergarten Group	Bed, fed, led, red, wed	Can, fan, man, pan, van	Bow, cow, mow, row, tow	Get, met, pet, vet, met	Dot, hot, not, pot, rot	But, cut, nut, put, out
First-Grade Group	Bake, lake, make, take, came, game, name, same	Cash, dash, mash, rash, wash, dish, fish, wish	Fail, pail, mail, sail, tail, boil, foil, soil	Hide, ride, side, wide, dice, mice, nice, slice	Back, black, pack, rack, sack, lock, rock, sock	Cold, fold, gold, hold, told, child, mild, wild

Notes. FS = fingerspelling condition. C = chaining condition. SP = sign-to-print condition.

## General Procedures

The intervention took place over 6 weeks, with each condition being implemented in random order once in the first 3 weeks (set one) and again in the second 3 weeks (set two). The Kindergarten Group was taught one word family per unit with five words that followed the C-V-C pattern. The First-Grade Group was taught eight words per unit from two different word families. Words were assigned to 1 of the 6 weeks of intervention, and then that week was randomly assigned to a condition within a set to mitigate order effects. Set one provided instruction in the fingerspelling condition, then in the chaining condition, and finally in the sign-to-print condition. Set two presented words first in the sign-to-print condition, then in the fingerspelling condition, then in the chaining condition (order based on randomization, see Table 3).

All three conditions used explicit instructional strategies to teach children to connect print words to signs, either using an indirect route to reading (via fingerspelling) or a direct route to reading (via ASL). Each condition followed the same basic format, including an introduction of the words, opportunities to read and write the words, and age-appropriate games and activities to practice the words. Appendix A provides a description of each activity across the four days of instruction for

each condition. We maintained activities across conditions so that the instruction only differed on the basis of the presence or absence of receptive and/or productive fingerspelling.

## Conditions

### *Fingerspelling Condition*

The fingerspelling condition featured 2 days with no exposure to print through activities that used only the fingerspelled and signed versions of the word. The second 2 days of instruction systematically introduced the written word and made explicit connections between the fingerspelled and written forms of the target words. Throughout the four lessons, the interventionist prompted students to fingerspell target words. The interventionist also included activities that required students to focus on onset and rimes of fingerspelled target words.

### *Chaining Condition*

The chaining condition included print throughout all 4 days of the intervention. The interventionist presented target words through a chain of fingerspelling, sign, and print. Students were *not* explicitly prompted to respond using fingerspelling, nor did the teacher provide instruction on concepts such as onset and rime, but fingerspelled responses were accepted, and

children were exposed to fingerspelled representations of words.

### *Sign-to-Print Condition*

The sign-to-print condition did not include fingerspelling in the presentation of target words at any point. Print was present for all days of this condition. The interventionist showed the children printed words and made direct connections with the ASL sign without using fingerspelling. If students responded to a prompt with fingerspelling, they were redirected to provide the sign for the target word.

### Pretest, Baseline, and Data Collection

Pretest data were collected across all word families the week before intervention began. Students were shown a print version of a word and asked to provide the sign. They were also shown picture cards of the same words and asked to fingerspell them.

For both baseline and intervention data, the interventionist presented the students with each word from the current unit in print and asked for the corresponding sign. Baseline data were taken on the first day of each unit prior to instruction. Intervention data points were taken at the end of lessons two, three, and four. Additionally, on day 4 the interventionist assessed children's ability to fingerspell the target words following the procedures from pretest.

The same procedures were used to collect maintenance data for word reading and fingerspelling after each set. As a result, even though the intervention itself took 6 weeks, the study lasted 9 weeks:

Week 1: pretest

Weeks 2, 3, and 4: first set

Week 5: maintenance data collection for the first set of words

Weeks 6, 7, and 8: second set

Week 9: was maintenance data collection for the second set of words

### Procedural Fidelity and Interobserver Agreement

To establish procedural fidelity, a research associate who was not the interventionist viewed 30% of instructional sessions for each group, randomly selected (blocked for condition). She used a 12-item checklist created by the research team with items predefined as expected to occur differentially across condition (see Appendix B). Procedural fidelity was calculated using point-to-point agreement (i.e., the number of expected items observed + the number of expected items not observed). Procedural fidelity was 77% in the sign-to-print condition (range: 67%–83%), 85% in the fingerspelling condition (range: 75%–92%), and 92% in the chaining condition (no range). According to Ledford and Gast (2018), procedural fidelity should reach 85% over at least 20% of sessions. Only the sign-to-print condition was slightly below the desired fidelity level.

The same research associate also scored the word assessments from video-recordings for 100% of pre- and postassessments and 20% of intervention assessments (randomly selected). There was 100%, 97.5% and 98.0% agreement, respectively, between the interventionist and the research associate. Point-to-point interobserver agreement was ascertained with the formula [(agreements + disagreements) – disagreements]/total x 100.

### RESULTS

On the target word pretest, students in the Kindergarten Group scored an average of 25% correct on tested words (range 0%–40% accuracy). In the First-Grade Group, students had an average of 38% correct (range 0%–75%). Nick had higher pretest scores, which influenced the scores of the group. The other students in this group averaged 25% accuracy, a finding that suggest

that for most of them the majority of words were unfamiliar before instruction.

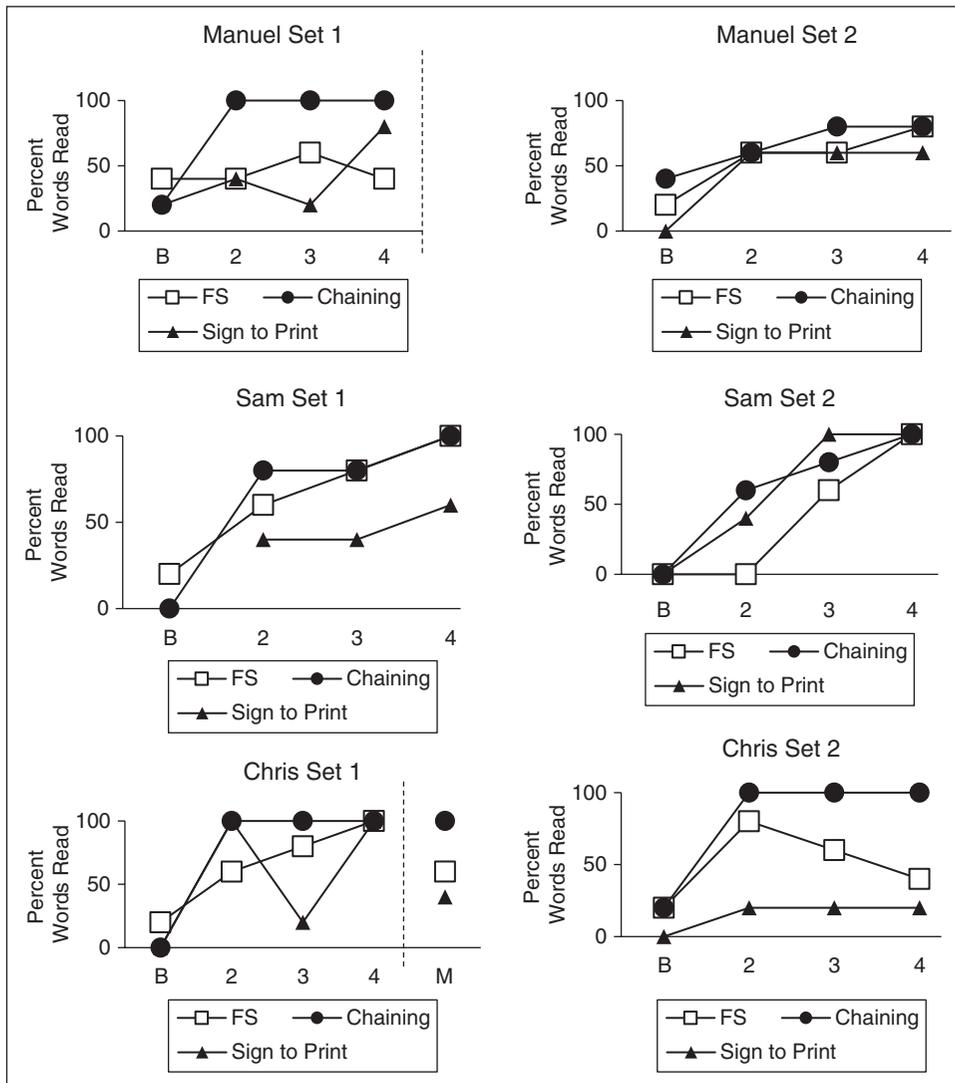
For each child, we present the results in two graphs corresponding to the two sets (Figures 1 and 2). The first data point (B) indicates the baseline assessment taken immediately prior to instruction. The lines extending from B to points 2, 3, and 4 represent the child's word reading across the three days of intervention. Missing data points occurred when children were absent from school.

Adapted Alternating-Treatment Results

Kindergarten Group

*Manuel.* Set one data show an increasing trend for the chaining condition only, with variable responding in the sign-to-print and fingerspelling conditions (see Figure 1). There is clear separation between the chaining condition and all other conditions, with minimal overlap following the first data point. Set two data indicate

Figure 1. Kindergarten Group's Word Learning Across Conditions



Notes. All names have been changed to protect the participants' privacy. FS = fingerspelling.

an increasing trend for all conditions, no separation evident within conditions, and overlapping data between conditions.

*Sam.* Set one data indicate an increasing trend in the chaining and fingerspelling conditions and steady responding in the sign-to-print condition (see Figure 1). There is separation between the fingerspelling and chaining conditions and the sign-to-print condition, but no separation evident between the fingerspelling and chaining conditions. Set two data indicate minimal separation between conditions and an increasing trend in all conditions.

*Chris.* Set one data do not indicate clear separation between any two conditions (see Figure 1). All conditions show an overall increasing trend, except for the third data point in the sign-to-print condition, which appears to be an outlier. Set two data indicate an increasing trend within the chaining condition, a decreasing trend within the fingerspelling condition, and low and steady responding in the sign-to-print condition. There is clear separation between all conditions, with no overlapping data paths.

#### *First-Grade Group*

*Dorothy.* Set one data indicate an increasing trend across all conditions, but no clear separation between conditions (see Figure 2). In set two, the sign-to-print condition shows an increasing trend and clear separation from both fingerspelling and chaining. The fingerspelling condition appears low and steady, and the chaining condition has a small increasing trend before returning to zero levels on the fourth data point.

*Nick.* Set one data show high levels of correct responses from the start of intervention (see Figure 2). All three conditions are fairly stable, and there is no clear separation between conditions. Set two data show an increasing trend across all three conditions, but no clear separation

between conditions. Nick had frequent absences, including absences for three of the four sign-to-print sessions in the second word set.

*James.* Within set one, James shows low and steady responding with no clear separation between conditions. Set two data again shows low responding, with no separation, no clear trend, and high rates of overlapping data (see Figure 2).

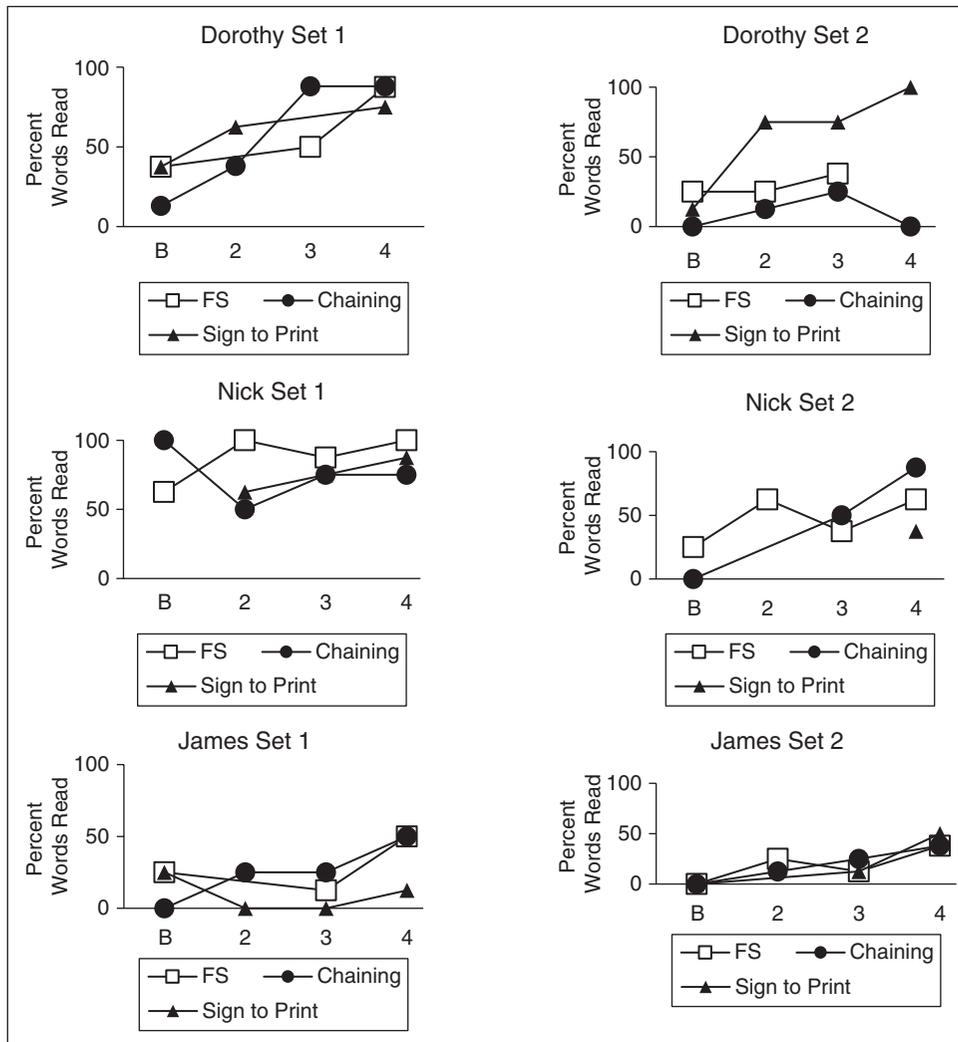
#### Pretest and Maintenance Results Across Conditions

Across participants, increased acquisition of target words is evident between pre- and maintenance probes for all experimental conditions across sets (Table 4). There were no clear trends in acquisition of target words between conditions. For example, Manuel showed the greatest acquisition in the chaining condition, as did Chris, but Dorothy consistently demonstrated better acquisition of target words in the fingerspelling condition. Some participants appeared to learn uniformly across conditions (e.g., Sam). However, every student made gains from pretest to posttest. Overall, the pretest mean was 17.96% correct and the posttest mean was 49.57%.

#### *Production of Fingerspelled Words*

At the end of each unit, participants were assessed on their ability to produce fingerspelling of target words. Figure 3 shows the rate of correct production of fingerspelled words for each participant at pretest (beginning of the study), end of instruction (on day 4 of each unit), and at maintenance. Table 4 also presents end-of-instruction data on fingerspelling across conditions and sets. There is evidence that participants were able to produce fingerspelling for taught words even in the sign-to-print condition (in which they were not exposed to fingerspelling). In

Figure 2. First-Grade Group's Word Learning Across Conditions



Notes. All names have been changed to protect the participants' privacy. FS = fingerspelling.

the fingerspelling condition, the children on average were able to fingerspell 77.88% of words at the end of instruction. In the chaining condition, the children were able to fingerspell on average 62.38% of words at the end of instruction. In the sign-to-print condition, the children were able to fingerspell on average 66.67% of words at the end of instruction. However, there was a lower level of maintenance of fingerspelled words in the sign-to-print condition (26.5%) compared to the chaining

(38.2%), and fingerspelling (40.1%) conditions.

*Social Validity*

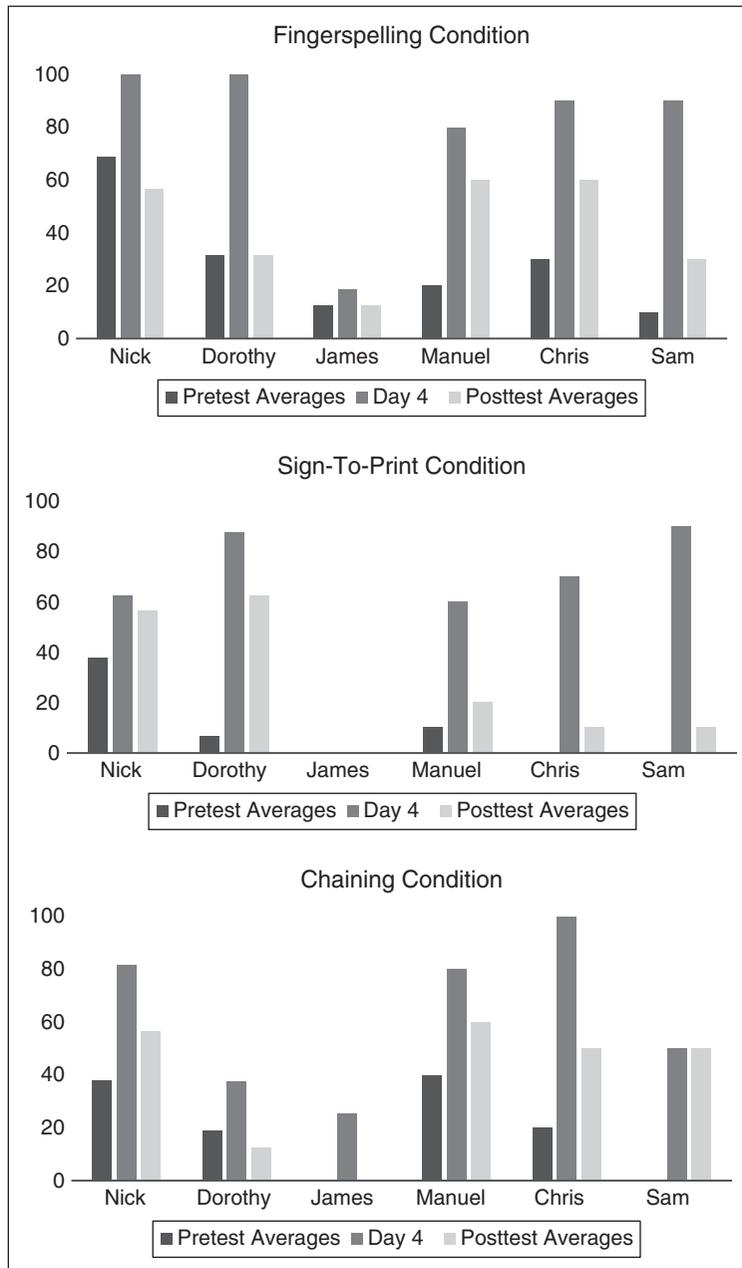
The two teachers whose students participated in the intervention study completed a researcher-created measure of social validity. The measure was a 1-to-5 Likert scale questionnaire regarding the intervention itself and the efficacy of fingerspelling as a tool for supporting word learning. Mean results for each question are

**Table 4.** Pre- and Posttest Results (Percentage Correct) for Children Across Experimental Conditions

Name <sup>a</sup>	Set 1, Unit 1 Fingerspelling			Set 1, Unit 2 Chaining			Set 1, Unit 3 Sign to print			Set 2, Unit 4 Sign to Print			Set 2, Unit 5 Fingerspelling			Set 2, Unit 6 Chaining		
	Pre	Post	FS	Pre	Post	FS	Pre	Post	FS	Pre	Post	FS	Pre	Post	FS	Pre	Post	FS
Manuel	20.0	40.0	60.0	40.0	80.0	80.0	20.0	60.0	40	0	80.0	100	40.0	60.0	80.0	20.0	20.0	80.0
Sam	20.0	60.0	100	0	60.0	0	0	60.0	80	0	60.0	80.0	0	60.0	100	0	60.0	100
Chris	20.0	60.0	100	20.0	100	100	0	40.0	80	0	80.0	80.0	40.0	20.0	100	20.0	60.0	60.0
James	25.0	12.5	12.5	0	12.5	12.5	0	12.5	-	0	25.0	25.0	-	25.0	38.0	0	12.5	0
Dorothy	37.5	37.5	100	25.0	62.5	50.0	0	75.0	75	13.0	0	-	37.5	75.0	25.0	62.5	25.0	100
Nick	62.5	87.5	100	62.5	75.0	100	25.0	75.0	25	50.0	37.5	100	75.0	62.5	62.5	12.5	50.0	100
<b>Ave.</b>	<b>30.9</b>	<b>63.9</b>	<b>78.75</b>	<b>24.5</b>	<b>65.0</b>	<b>57.1</b>	<b>7.5</b>	<b>53.8</b>	<b>60</b>	<b>10.5</b>	<b>47.1</b>	<b>77.0</b>	<b>32.1</b>	<b>50.4</b>	<b>67.6</b>	<b>19.2</b>	<b>37.9</b>	<b>73.3</b>

<sup>a</sup> All names have been changed to protect the participants' privacy.

Figure 3. Productive Fingerspelling Results Across Conditions for Each Participant



Note. All names have been changed to protect the participants' privacy.

presented in Table 5. The teachers strongly agreed that fingerspelling was important and that the intervention was important for literacy. The relatively low score for “This intervention was beneficial to the students” may be due to the lack of teacher

involvement in the intervention. The teachers found the intervention feasible and appropriate for DHH children. They also believed fingerspelling to be an important element of reading instruction for signing DHH students.

**Table 5.** Teachers' Social Validity Ratings

Statement	Mean rating
It is important to use fingerspelling in the classroom with deaf children.	5.0
Fingerspelling aligns with some of the literacy goals for deaf students.	4.5
This intervention was beneficial to the students.	3.5
It is feasible for this intervention to be implemented by teachers of deaf children.	4.5
This intervention should be implemented in the classroom with deaf children.	4.5

Note. A 5-point Likert scale was used, with 1 = strongly disagree and 5 = strongly agree.

## DISCUSSION AND IMPLICATIONS

Though many have speculated about effective literacy instruction for DHH children (e.g., Cannon, Fredrick, & Easterbrooks, 2010; Trussell & Easterbrooks, 2014), there has not been satisfactory exploration of how students learn to recognize English print and how instruction may support the development of word reading skills. The present study used an adapted alternating-treatment single-case research design to evaluate the difference in word reading gains resulting from a literacy intervention designed for elementary-age DHH children in three different conditions: fingerspelling, chaining, and sign-to-print. We hypothesized that the presence of fingerspelling would support word learning among participating DHH children. This hypothesis was not supported: There was no clear separation of learning across treatment conditions.

In our data, no individual condition showed better results for individual children or across groups of children. That is, when we looked across both sets, there was no consistent pattern of learning pointing to the superiority of one condition over another. With the exception of James (whose case is explored further below), all children seemed to benefit from the intervention regardless of whether fingerspelling was present and how it was used. These findings speak to the importance of

explicit instruction to the literacy development of DHH children. This assertion is based on the gains made by most of the children in most conditions. Others have found explicit instruction to be an essential component of an appropriate education for DHH children, especially for the acquisition of early literacy skills and phonological awareness (Trezek & Wang, 2006), vocabulary (Cannon et al., 2010; Guardino, Cannon, & Eberst, 2015; Trussell & Easterbrooks, 2014), morphological awareness (Trussell & Easterbrooks, 2015), reading comprehension (B. R. Schirmer, Schaffer, Therrien, & T. N. Schirmer, 2012), and writing (Wolbers et al., 2015). Explicit teaching was a likely key for word learning in the present study.

### Fingerspelling and Print Recognition

Most of the children in the present study were able to fingerspell target words when given a picture prompt, even for words in the sign-to-print condition. This suggests that although the children who participated in this study were in early elementary school and still developing early reading skills, they may already have established a connection between fingerspelled letters and English print. For most, these gains persisted into posttest. However, the children recalled fewer words in the posttest from the sign-to-print condition than in other conditions. It is possible that

the use of fingerspelling during instruction lent itself to maintaining learned words over a longer time. Although it is not clear from these data whether learning a word in one form (print or fingerspelled) directly supports the acquisition of that word in the other form, the data do suggest that a relationship between the two exists and should be further explored.

Given the finding by Lederberg et al. (2019) that fingerspelling among early readers had a .99 correlation with reading, we expected to find a relationship between the ability to understand and produce the fingerspelled forms of a word and the ability to read that word in English print. The complex relationships between print English and fingerspelling require further research. The findings presented here suggest that for participants in the present study, there was not a consistent benefit of instruction on English words that used fingerspelling compared to instructional conditions that did not use fingerspelling. This may be evidence of the notion that instruction around orthography (rather than or in addition to phonology) can be an effective tool for teaching DHH children to identify print (e.g., see Miller, 2010).

### The Case of James

Although James did not appear to benefit from any condition, observation of instructional sessions and feedback from the interventionist suggest that this lack of benefit was strongly influenced by behavioral difficulties. Given his diagnosis of ADHD, for which he used no medication, we believe that his lack of growth may have been directly related to additional disabilities (besides deafness) and their effects on learning. Learning disabilities (LD) are common among DHH children (Mitchell & Karchmer, 2011), though it can be extremely challenging to diagnose a DHH

child with LD (Caemmerer, Cawthon, & Bond, 2016). The difficulty James experienced with learning words even with explicit instruction in small groups demonstrates the strong need in the field for both improved means of identifying LD in the DHH population and research identifying practices more likely to be successful for teaching DHH students with LD. Unfortunately, without more detailed observation of James's home language environment, it is difficult to say with certainty the cause of his difficulty, and we do not believe that James's outcomes would be typical for a DHH child coming from a home with a deaf parent and signing siblings.

### Limitations of the Study

There are limitations of the present study that should be acknowledged. First, all six of the participants either used primarily sign or a mix of sign and speech in their home and school lives, and thus do not represent children who use primarily or only spoken language. All six of them also experienced language and literacy delays, and students who have average or above-average language and literacy may not respond the same way to treatment as this group. As several of the children who participated in this study earned a score of 8% or less across the subtests of the Schick Fingerspelling Assessment, it is possible that the effects of the fingerspelling intervention on their literacy and fingerspelling skills was undetectable due to a floor effect. Replication of this study with children who are not experiencing a delay in this area is necessary to disentangle these complex skills. Additionally, we selected the adapted alternating-treatment design to reduce the effects of behavioral carryover between conditions; however, there may be evidence of carryover of learning across conditions.

Its limitations aside, the present study is one of the first to examine differences between instructional use of receptive and productive fingerspelling, chaining, and sign-to-print conditions in the individual word reading of DHH children who are acquiring early literacy skills. Additionally, explicit instruction, regardless of the presence or absence of fingerspelling, appeared to be a significant feature of instruction in word reading. In this intervention, some students appeared to do better when fingerspelling was added to instruction. This finding supports the notion that the DRC model of reading is potentially applicable to DHH children as soon as the early elementary school grades. Children acquiring literacy skills at this age may access words through an intermediary sublexical structure such as fingerspelling (an indirect route to reading), or connect the word in print with its meaning (a direct route to reading).

## NOTES

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## Appendix A

### Overview of Activities Across Conditions

	Fingerspelling condition	Chaining condition	Sign-to-print condition
Day 1	<p><b>Assess</b> target words</p> <p><b>Introduce words</b> using sign and fingerspelling. Ask children to imitate.</p> <p><b>Show picture cards</b> and prompt students to sign and then fingerspell. Model signing and fingerspelling.</p> <p><b>Play lily pad game</b> by showing a target word picture card. The child jumps to a lily pad with the picture and fingerspells the word.</p>	<p><b>Assess</b> target words.</p> <p><b>Introduce words</b> using sign and fingerspelling. Ask children to imitate signs.</p> <p><b>Show picture cards</b> and prompt students to sign. Model signing and fingerspelling.</p> <p><b>Play lily pad game</b> by showing a target word picture card. The child jumps to a lily pad with the picture. The teacher asks the child to sign or fingerspell the word.</p>	<p><b>Assess</b> target words.</p> <p><b>Introduce words</b> using signs only. Ask children to imitate signs only.</p> <p><b>Show picture cards</b> and prompt students to sign. Model signing.</p> <p><b>Play lily pad game</b> by showing a target word picture card. The child jumps to a lily pad with the picture and signs the word.</p>
Day 2	<p><b>Show an ASL story.</b> Ask comprehension questions on the target words and emphasize fingerspelling.</p> <p><b>Support phonological awareness</b> by asking students to fingerspell target words and identify the first letter and last chunk of the word.</p> <p><b>Play fishing game.</b> Fingerspell a word to student and ask for sign. Ask student to “fish” for the matching picture.</p> <p><b>Assess</b> target words.</p>	<p><b>Show an ASL story.</b> Ask comprehension questions on the target words using chaining.</p> <p><b>Support word recognition</b> by showing picture cards of target words and chaining. Ask students to sign target words and match the picture and print cards.</p> <p><b>Play fishing game.</b> Fingerspell and show a print word to student and ask for sign. Ask student to “fish” for the matching picture.</p> <p><b>Assess</b> target words.</p>	<p><b>Show an ASL story.</b> Ask comprehension questions on the target words using signs.</p> <p><b>Support word recognition</b> by showing picture cards of target words. Ask students to sign target words and match the picture and print cards.</p> <p><b>Play fishing game.</b> Show a print word to student and ask for sign. Ask student to “fish” for the matching picture.</p> <p><b>Assess</b> target words.</p>

(continued)

	Fingerspelling condition	Chaining condition	Sign-to-print condition
Day 3	<p><b>Link fingerspelling to print</b> by showing students a target picture, English print, and fingerspelling. Build phonological awareness by asking for the initial letter and last chunk of the word.</p> <p><b>Use sentence strips</b> that contain the target words. Ask students to read the sentences and use fingerspelling to decode target words.</p> <p><b>Build word</b> with magnetic letters based on a picture card. Ask students to fingerspell the word.</p> <p><b>Assess</b> target words.</p>	<p><b>Link fingerspelling to print</b> by showing students a picture, English print, and fingerspelled word. Ask students to sign each word.</p> <p><b>Use sentence strips</b> that contain the target words. Ask students to read the sentences. Chain any target words they do not recall.</p> <p><b>Build words</b> with magnetic letters based on a picture card. Use chaining to confirm or correct. Ask students to sign the word.</p> <p><b>Assess</b> target words.</p>	<p><b>Link signing to print</b> by showing students a picture, English print, and sign. Ask students to sign each word.</p> <p><b>Use sentence strips</b> that contain the target words. Ask students to read the sentences. Sign any target words they do not recall.</p> <p><b>Build words</b> with magnetic letters based on a picture card. Correct errors through signing and modeling using the magnetic letters. Ask students to sign the word.</p> <p><b>Assess</b> target words.</p>
Day 4	<p><b>Play matching game</b> with picture word cards. Students sign and fingerspell the matched words.</p> <p><b>Practice writing</b> words using a writing sheet.</p> <p><b>Play bingo</b> with picture cards. The teacher fingerspells words, and if the student has the word on their bingo card they get a chip.</p> <p><b>Assess</b> target words.</p>	<p><b>Play matching game</b> with picture word cards. Students sign the matched words.</p> <p><b>Practice writing</b> words using a writing sheet.</p> <p><b>Play bingo</b> with picture cards. The teacher signs words, and if the student has the word on their bingo card they get a chip.</p> <p><b>Assess</b> target words.</p>	<p><b>Play matching game</b> with picture word cards. Students sign the matched words.</p> <p><b>Practice writing</b> words using a writing sheet.</p> <p><b>Play bingo</b> with picture cards. The teacher signs words, and if the student has the word on their bingo card they get a chip.</p> <p><b>Assess</b> target words.</p>

Note. ASL = American Sign Language.

## Appendix B

### Procedural Fidelity Document

Teacher behavior <sup>a</sup>	Conditions expected <sup>b</sup>
<i>Teacher presentation/modeling</i>	
Teacher modeled fingerspelling of target word in connection with picture or sign (days 1 and 2).	FS
Teacher modeled fingerspelling of target word in connection with print (days 3 and 4).	FS
Teacher chained (fingerspelling + print + picture) when presenting words.	C
Teacher chained (sign + print + picture) when presenting words.	SP
<i>Prompting</i>	
Teacher prompted students to provide fingerspelled word.	FS
Teacher prompted students to provide initial letter of fingerspelled word.	FS

(continued)

Teacher behavior <sup>a</sup>	Conditions expected <sup>b</sup>
Teacher prompted students to provide last chunk of fingerspelled word.	FS
Teacher prompted students to provide the sign for printed target words.	FS, C, SP
Teacher prompted students to write or build the target word using letter tiles.	FS, C, SP
<i>Feedback</i>	
If the student fingerspelled or read the word incorrectly, the teacher modeled how to fingerspell the word and prompted the student to fingerspell the word.	FS
If the student fingerspelled or read the word incorrectly, the teacher chained the fingerspelling and the sign and prompted the child to sign the word.	C
If the student fingerspelled or read the word incorrectly, the teacher chained the print word and/or picture and the sign, and prompted the child to sign the word.	SP

<sup>a</sup> An item was scored as present if the interventionist exhibited this behavior 70% of opportunities during each instructional session.

<sup>b</sup> FS = Fingerspelling condition. C = Chaining condition. SP = Sign-to-print condition.