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Grapheme–Phoneme Acquisition of Deaf Preschoolers

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We examined acquisition of grapheme–phoneme correspondences by 4 deaf and hard-of-hearing preschoolers using instruction from a curriculum designed specifically for this population supplemented by Visual Phonics. Learning was documented through a multiple baseline across content design as well as descriptive analyses. Preschoolers who used sign language and had average to low-average receptive vocabulary skills and varied speech perception skills acquired all correspondences after instruction. They were also able to use that knowledge while reading words. On a posttest, the children were able to decode graphemes into corresponding phonemes and identified about half of the words that were included during instruction. However, they did not identify any novel words. Descriptive analyses suggest that the children used Visual Phonics as an effective mnemonic device to recall correspondences and that deaf and hard-of-hearing preschoolers, even those with no speech perception abilities, benefited from explicit instruction in the grapheme–phoneme relationship using multimodality support.

Children who are deaf or hard of hearing (DHH) lag significantly behind their hearing peers in reading skills (Dyer, MacSweeney, Szczerbinski, Green, & Campbell, 2003; Paul, 1998; Traxler, 2000). As early as preschool, children start to show difficulties with early literacy skills and the gap continues to widen with age (Easterbrooks, Lederberg, Miller, Bergeron, & Connor, 2008), some researchers believe that the lack of access to phonological information is the major contributor to low literacy rates (Perfetti & Sandak, 2000; Trezek, Wang, & Paul, 2010).

For hearing children, literacy instruction typically focuses on the auditory-based alphabetic principle, or the idea that phonemes are blended to create words and these phonemes are represented by graphemes (National Reading Panel, 2000; Scarborough & Brady, 2002). Word identification depends on acquisition of the alphabetic principle (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Grapheme–phoneme knowledge, the first step in learning the alphabetic principle, is one of the most important early reading skills at preschool age and a predictor of variance in hearing children with typical reading skills (Anthony & Lonigan, 2004; Lonigan, Burgess, & Anthony, 2000), those with reading disability (Puolakanaho et al., 2008; Wagner, Torgesen, & Rashotte, 1994), and those who are DHH (Easterbrooks et al., 2008; Kyle & Harris, 2011). The latter researchers also documented that DHH children frequently learn very few grapheme–phoneme correspondences (GPCs) during preschool and kindergarten.

The purpose of this research was to investigate the acquisition of GPCs in DHH children using an emergent literacy curriculum developed for DHH preschoolers. Additionally, we investigated how children used Visual Phonics to support their learning and use of GPCs in early reading development.

DHH Spoken Phonology and Reading

The role of the alphabetic principle in DHH children's reading is controversial. Some researchers state that the reading process for DHH readers is "qualitatively similar but quantitatively delayed" compared to their hearing peers (Paul, 1998; Trezek et al., 2010). Because children learn to read a written system that is based on spoken language, these researchers believe that DHH children must learn the alphabetic principle to read well (Perfetti & Sandak, 2000; Schirmer & McGough, 2005; Trezek et al., 2010). DHH children may use various visual and kinesthetic means to access

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spoken phonology and map it onto orthography. Some may use speech reading and production to supplement auditory skills (Harris & Moreno, 2006; Kyle & Harris, 2006, 2010). Others may use devices that provide visual support for spoken phonology (Trezek & Malmgren, 2005; Trezek & Wang, 2006; Trezek, Wang, Woods, Gampp, & Paul, 2007).

On the other hand, other researchers claim that DHH children may vary in how much they use spoken phonology to read (Harris & Moreno, 2006), and this relates to their communication mode (Koo, Crain, LaSasso, & Eden, 2008; Kyle & Harris, 2010). Some DHH readers who only use sign language for communication may not use spoken phonology to read (Koo et al., 2008). Although early intervention and improved technology provide some level of speech perception to a majority of the current generation of DHH children, about a quarter of them still have no access to spoken phonology (Easterbrooks et al., 2008). These two subpopulations of DHH children are likely to acquire literacy through different pathways. Those who have some speech perception and thus spoken phonology prior to learning to read may acquire literacy through a (primarily) auditory path. Those without speech perception may acquire literacy through a (primarily) visual and kinesthetic path (Easterbrooks, 2010; Easterbrooks et al., 2008). For many DHH learners, visual and kinesthetic information about spoken phonology influences speech reading and speech production (De Filippo & Sims, 1995), and speech reading correlates with reading ability (Mohammed, Campbell, Macsweeney, Barry, & Coleman, 2006), although such information is incomplete compared to auditory information available to hearing children (Binnie, Jackson, & Montgomery, 1976).

Evidence for DHH children's access to spoken phonology comes from extensive research on phonological awareness. DHH elementary school children show phonological awareness to a certain degree in tasks that measure rhyme judgment (Dyer et al., 2003; Hanson & McGarr, 1989; Sterne & Goswami, 2000; Wauters & Doehring, 1990), syllable segmentation (Sterne & Goswami, 2000), pseudohomophone picture matching (Dyer et al., 2003; Sterne & Goswami, 2000), reading pseuodowords aloud (Leybaert, 1993; Guardino, Syverud, Joyner, Nicols, & Mauer, 2011; Syverud, Guardino, & Selznick, 2009), and spelling (Campbell, Burden, & Wright, 1992; Leybaert & Alegria, 1995). For young French children, rhyme judgment and generation predicted reading progress a year later (Colin, Magnan, Ecalle, & Leybaert, 2007).

Some researchers have found that spoken phonology may enhance alphabetic knowledge and is related to early reading skills (Kyle & Harris, 2011). Specifically, knowledge of letter–sound correspondences (i.e., GPCs) strongly correlated with early literacy skills concurrently and over time (Easterbrooks et al., 2008; Kyle & Harris, 2011). These skills also correlated with children's hearing loss, speech reading, and production skills, suggesting that children without speech perception may use a nonauditory alternative path to access spoken phonology when acquiring the alphabetic principle (Perfetti & Sandak, 2000; Trezek et al., 2010). Visual Phonics was developed because nonauditory pathways provide an incomplete representation of spoken phonology (Waddy-Smith & Wilson, 2003).

Visual Phonics

Visual Phonics is a multisensory instructional tool designed to clarify the sound–symbol relationship between spoken English and print (International Communication Learning Institute, 1982). Visual Phonics includes 45 handshapes and movements that resemble the articulation of each spoken sound of the English language (Waddy-Smith & Wilson, 2003) with corresponding written symbols. Visual Phonics was created as a tool to improve reading and speech articulation (Waddy-Smith & Wilson, 2003). The link between one grapheme and multiple phonemes is clearly distinguished by modeling each corresponding phoneme with the Visual Phonics handshape and movement. One phoneme is also connected to all corresponding graphemes (e.g., the handshape and movement for /ā/ is identical for "ai," "a_e," and "eigh") and conveys the production of each phoneme within the corresponding hand movement. Thus, Visual Phonics can be seen as both a manual representation of spoken phonemes and as an aid in teaching children to articulate those phonemes.

Hall and Bavelier (2011) proposed a multiple coding hypothesis to explain memory in students who are

DHH. This hypothesis suggests that a speech-based memory code resulted in longer memory span than a sign-based memory code when participants were presented with a span of American Sign Language (ASL) digits, supporting the inclusion of spoken phoneme articulation in the process of GPC acquisition. Furthermore, they suggested that words are stored in both verbal and visual ways, including phonological codes, orthographic codes (Logie, Della Sala, Wynn, & Baddeley, 2000), semantic codes (Martin, 2005; Shivde & Thompson-Schill, 2004), and fingerspelling encoding (Lichtenstein, 1998). Certain phonemes, such as /b/ and /p/, are visually similar yet auditorily distinct, whereas /b/ and /d/ are visually similar but difficult to discriminate auditorily (Massaro, 1998), supporting the use of Visual Phonics. The combination of complementary spoken articulation and Visual Phonics may provide a more complete representation of phonemic distinctions, this facilitating learning of GPCs.

Visual Phonics has been used both in speech therapy (Wilson-Favors, 1987; Zaccagnini & Antia, 1993) and in reading instruction with DHH school-age children. Visual Phonics is most commonly used with DHH elementary students with various curricula for the purpose of phonics instruction, GPCs, word decoding, and word recognition (Narr & Cawthon, 2011). Explicit instruction in the alphabetic principle with existing literacy curricula supplemented by Visual Phonics increased school-aged DHH children's access to GPCs and pseudoword decoding (Trezek et al., 2010) and phoneme production for one preschooler with a cochlear implant (Smith & Wang, 2010). Smith and Wang is the only published study that has examined the use of Visual Phonics with young DHH children receiving emergent literacy instruction. In studies of kindergarten, first-grade, and middle school-aged children, Visual Phonics was combined with existing literacy curricula. The current studies replicate this practice with younger children but combine Visual Phonics with a new curriculum specifically developed to meet the needs of DHH preschoolers. Researchers who investigate GPCs generally do not use the written symbols that correspond with Visual Phonics, and they were not used in the present studies because the curriculum already includes a variety of visual supports. In addition, it provides a description of how and when the children chose to incorporate Visual Phonics.

Present Studies

The present studies were part of a 4-year project to develop a systematic and explicit emergent literacy curriculum for DHH preschoolers called *Foundations for Literacy* (*Foundations*; Lederberg, Miller, Easterbrooks, & Connor, 2011). *Foundations* taught GPCs with multimodal input to supplement auditory input using a semantic association strategy that created a meaningful association for each phoneme. For example, the phoneme /b/ was taught within the context of a story in which children play with a toy boat and say "*b b b*" as they push it around in a tub of water. In addition, children engaged in language experiences directly related to the story, such as pushing their own toy boats in a tub of water while practicing saying /b/. The boat experience provided a meaningful context in which to learn the phoneme /b/, and the semantic experience was connected to the grapheme 'b' through a picture of that displayed the letter 'b' and a boat in a tub. Children experienced multiple opportunities to practice isolated phonemes in engaging contexts supported with embedded language. *Foundations* also focused on phonological skills, vocabulary, language, fluency, and shared reading experiences (for additional information, see Bergeron, Lederberg, Easterbrooks, Miller, & Connor, 2009). *Foundations* included multimodality support on a continuum through a combination of sign language, voice, and visual support tailored to meet the individual needs of children (Bergeron et al., 2009; Morrison, Trezek, & Paul, 2008). Bergeron et al. investigated acquisition of GPCs by DHH preschoolers with some speech perception ability in auditory–oral and sign language settings. They reported a functional relation between the intervention and acquisition of GPCs. All the preschoolers learned all taught GPCs after instruction on correspondences. The efficiency of the intervention was measured by latency, the number of instructional sessions before the first data point of criterion is reached (Kazdin, 2011). Average latencies by child ranged from 1.7 to 7.2 instructional sessions. The present studies extended this investigation to children who required additional multimodal support because of limited or no speech perception, which was provided in three ways: Visual Phonics, speech reading, and speech production.

Study 1

Study 1 included one child. The research question for Study 1 was: Can a DHH preschooler with minimal speech perception skills learn GPCs using Visual Phonics in tandem with the *Foundations for Literacy* curriculum? Although other researchers have described the use of vocalization broadly (Trezek & Wang, 2006; Trezek et al., 2007), our goal was to use Visual Phonics as a tool for supporting children's learning to articulate the spoken phonemes that are associated with a given grapheme, as conceptualized by Waddy-Smith and Wilson (2003).

Methods

Research design. Study 1 occurred across a 10-week period in the spring during the third year of the ongoing larger grant project to determine if one child with minimal speech perception, who did not use vocalized speech, could acquire GPCs after 30-min instructional sessions using components of *Foundations* supplemented with Visual Phonics. A multiple baseline probe design across content (i.e., specific GPCs) was used to determine if a functional relation existed between instruction on a GPC and its acquisition. The independent variable was explicit instruction in GPCs using *Foundations*. The dependent variable was the number of GPCs correctly spoken by the child. Although Visual Phonics was used as an instructional technique, association of correct production of the *spoken* phoneme with the grapheme was the target behavior of the curriculum.

Setting and participant. Study 1 took place in a day school attended by approximately 200 DHH students. All the students and staff used some form of sign language (ASL, Pidgin, Simultaneous Communication) as their mode of communication. The participant in this study, Rosa, was 5 years old (5;0), with a 90 dB unaided/40 dB aided hearing loss, used bilateral hearing aids, and was enrolled in a preschool class at the time of the present study (pseudonyms are used for all children). Spoken Spanish was the primary language used in her home. Rosa had minimal speech perception based on the Early Speech Perception test (ESP 1; Moog & Geers, 1990), used no vocalized speech at the beginning of this study, communicated with sign language, and was language delayed based on the results of the Peabody Picture Vocabulary Test (PPVT) and the Expressive One-Word Picture Vocabulary Test (EOWPVT) (see Table 1). Given her aided hearing level, we expected that Rosa could produce the correct spoken phoneme in combination with Visual Phonics.

Teacher participant. The intervention teacher, the first author of this paper, was an experienced state-certified teacher. She was fluent in ASL, used a mix of ASL and sign-supported speech for instruction, and completed an 8-hr workshop on Visual Phonics prior to this study.

Assessments. Standardized tests were administered to Rosa at the beginning of the school year. These included (a) the ESP test (Moog & Geers, 1990), which assesses pattern and word discrimination of children with hearing loss and places them into the following speech perception categories: no pattern perception (ESP 1), pattern perception (ESP 2), some word

Table 1 Participant assessment scores

			PPVT		EOWPVT		Letter–name		Letter–sound	
Participant	Age (Pre)	ESP	SS	AE	SS	AE	Pre	Post	Pre	Post
Rosa	4 years and 9 months	1	78	3;3	71	2;4	—	—	—	—
Amanda	4 years and 7 months	1	86	3;8	84	3;5	13	21	4	18
Jill	4 years and 7 months	3	97	4;4	92	4;0	16	21	5	18
Spencer	4 years and 4 months	4	94	3;10	81	3;0	11	21	2	20

Note. AE = Age Equivalent Score; EOWPVT = Expressive One-Word Picture Vocabulary Test (mean 100 and SD 15); ESP = Early Speech Perception; PPVT = Peabody Picture Vocabulary Test (mean 100 and SD 15); SS = Standard Score.

identification (ESP 3), and consistent word identification (ESP 4); (b) Peabody Picture Vocabulary Test (PPVT-4; Dunn & Dunn, 1997), a measure of receptive vocabulary presented in simultaneous voice and sign; and (c) EOWPVT (Brownell, 2000), a measure of expressive vocabulary for which the children could say or sign the response. A consistent collection of acceptable sign choices for the PPVT and EOWPVT was established at the beginning of the larger ongoing 4-year research project.

Baseline assessment. Baseline data collection occurred in the first week of the study across 3 days in 30-min one-on-one sessions. Child knowledge of GPCs was assessed in the following manner: single lowercase letters were displayed in the center of 3- by 5-inch index cards. Three occurrences each of nine single letters (m, e, b, o, t, n, i, p, s) were shown in random order. The teacher presented the collection of 27 cards to the child, one at a time, with the prompt: "What sound does this letter make?" A correct response was defined as verbal production of the corresponding spoken phoneme, with or without the corresponding Visual Phonics handcue. If the child made no response, the teacher repeated the prompt. This prompt was repeated for each of 27 instances of letters. The child did not receive feedback during the baseline assessments.

Probes. Immediately prior to instruction for each GPC, another baseline probe was conducted (Kazdin, 2011). For example, the child was asked what sound the letter 'm' makes immediately preceding instruction for /m/. Additionally, a probe containing all 8 GPCs was conducted on the 8th, 20th, 33rd and 37th days of instruction and served as a baseline for untaught GPCs and as a maintenance probe for taught correspondences.

Intervention. Instruction occurred in four 30-min one-on-one sessions each week in a separate classroom. The initial 2 weeks focused on teaching Rosa prerequisite skills for later instruction (e.g., knowledge of same and different) and the remaining 8 weeks involved specific instruction in GPCs in a standard curriculum-based sequence. From the typical hour-long lesson plans, we selected to implement those activities that provided the critical aspects of *Foundations* related to instruction and practice with GPCs. In general, the teacher focused each week on teaching one phoneme and its associated grapheme(s). The sequence of GPCs was as follows: /m/, /ē/, /b/, /ō/, /t/, /n/, /ī/, /p/, and /s/. *Foundations* did not mirror typical curricula because long vowels were introduced before short vowels, as they provide the suprasegmental aspect of duration that provides the student with an optimal chance of perceiving the stimulus (Ling, 2002). Although long vowels are easier to hear, these GPCs are more complex because long vowels correspond to multiple graphemes. Although we assessed single GPCs for the single-subject study, instruction included multiple spellings of phonemes with "silent" letters printed in gray, as illustrated in Figure 1.

Correspondences were introduced on the first day in a meaningful activity-based story, such as a story in which a character is chased by a bee and says "*ō ō ō*." The story was accompanied by a large concept card that contained the semantic cue in the center (e.g., a character being chased by a bee) surrounded by corresponding grapheme(s) and multiple spellings, if appropriate (e.g., "o_e," "ow," "oa," and "oe" for /ō/; see Figure 1). Silent letters, such as those used to represent the /ō/ sound, were noted by gray contrast across printed curriculum materials. The next day Rosa engaged in a language experience activity highlighted in the story (e.g., enacting being chased with a bee puppet) while practicing the corresponding phoneme (e.g., /ō/). The language experience activities were preceded by planning the activity and followed by recall of the activity. On subsequent days, the story was retold while referring to the graphemes on the large concept card. Thus, Rosa was provided with multiple opportunities to produce the GPC in a meaningful context. Additional activities included beginning reading activities (e.g., sounding out simple words such as *me* after taught /m/ and /ē/), practice books (which afforded practice with GPCs and taught words), and relevant phonological awareness activities (e.g., identifying initial phonemes for words that begin with taught phonemes) (see Bergeron et al., 2009, for additional descriptions of activities).

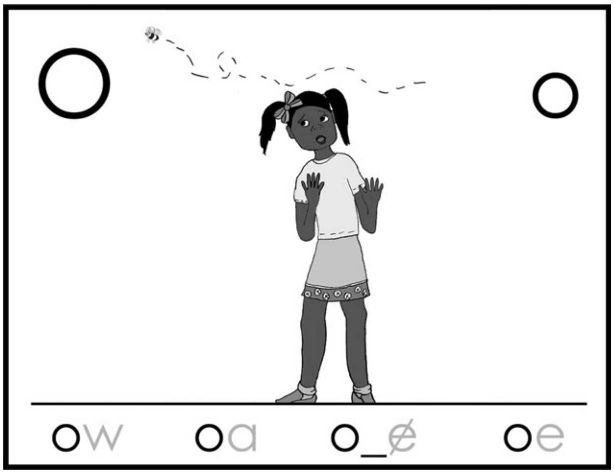

Figure 1 Example of a Large Concept Card.

The teacher provided the Visual Phonics handcues and movements during the initial week of instruction of each GPC for all phonemes. After acquisition, Visual Phonics cues were faded and only used when Rosa needed additional visual support. During grapheme–phoneme instruction, the teacher emphasized her speech production (e.g., cueing attention to her mouth during phoneme production paired with the Visual Phonics prompt) and phoneme production by Rosa (e.g., cueing to her ear and using picture prompts for "sound"). For example, during the bee activity, the teacher modeled /ō/ with the Visual Phonics handcue and movement while producing the phoneme, followed by an immediate request for Rosa to produce /ō/. The large concept card that displayed the semantic cue and six instances of the /ō/ grapheme(s) with multiple spellings was referred to by the teacher during the activity to reinforce the relevant GPCs.

Treatment fidelity. Trained research assistants measured fidelity of intervention implementation during 20% of the intervention sessions using a fidelity checklist for elements of the activities listed above (see Table 2). Fidelity was measured by the percentage of required elements observed during an activity, divided by the number of times the activity was observed. The average for each dimension of fidelity is listed in Table 2.

Intervention assessment. GPC acquisition was assessed daily. Three instances of the target GPC and three instances of any GPCs for which Rosa had not yet met criteria were displayed individually on index cards. Criterion level was defined as three correct responses (out of three instances) for four consecutive days. Reliability of the assessment scores was verified by trained research assistants who observed 17% of the sessions. Interobserver agreement was calculated using the point-by-point formula and agreement ranged from 80% to 100% with a mean of 95% agreement, thus showing strong agreement of whether Rosa had correct spoken production of the phoneme.

Results

Only GPCs that were learned through the intervention were included in all analyses. Rosa knew /ō/ at baseline. Figure 2 displays Rosa's responses during baseline (to the left of the dotted line) and after intervention (to the right of the dotted line). Visual inspection indicated that changes for each GPC occurred consistently following instruction, demonstrating a functional relation. She met criterion and continued to respond correctly on maintenance probes for all eight taught GPCs during the 10-week intervention.

Rosa demonstrated a slow and steady learning curve for most GPCs following instruction. The average latency (the number of instructional sessions before the first data point of criterion was reached) for GPCs for Rosa was 4.5 sessions (range 1–7), meaning that she needed an average of 1 week of

Table 2 Fidelity checklist

Foundations for literacy curriculum elements	Average (%)	
	Study 1	Study 2
Story		
Teacher reads/tells a story that includes phoneme, letter name and is represented by picture on the large concept card.	100	100
Teacher provides written model of target letter.	100	100
Teacher prompts student to imitate her after each production.	100	100
Students attempt to imitate teacher's production.	100	100
Language activity		
Large concept card is visible to students.	75	75
Students engage in activity that is represented in concept cards.	100	80
Teacher models target sound/word during activity.	100	100
Students attempt/produce target sound/word during activity.	100	100
Teacher provides articulatory feedback to students.	75	100
Language activity recall		
Large concept card is visible to all students.	100	—
Teacher and students recall language activity.	100	—
Teacher and students produce target sound/word.	100	—
Story review		
Large concept card is visible to all students.	100	100
Teacher reviews story using story sequencing cards.	100	100
Teacher produces target phoneme.	100	75
Teacher prompts students to produce phoneme.	100	75
Students attempt/produce phoneme.	100	75
Large concept card		
Large concept card is visible to students.	100	100
Teacher prompts students to imitate sound while pointing to letter.	100	100
Students produce sound.	100	100
Teacher provides articulatory feedback to students.	85.7	85.7
Practice books		
Students attempt/produce target sound as student or teacher points to each grapheme.	100	100
Students move from page to page to practice grapheme–phoneme correspondences.	100	100
Key word blending		
Teacher shows small concept cards or letters that combine to make the key word.	100	100
Teacher identifies each phoneme while indicating concept card/ or letter for the word.	75	75
Teacher models blending key word (using continuous blending) while indicating small concept cards/letters.	75	100
Teacher prompts students to imitate.	100	100
Teacher or student points to concept cards with index finger while students blend key word.	100	100

Note. —indicates no available data.

instruction before mastering correspondences. As seen in Table 3, latencies to criterion increased over the 10-week intervention. As is evident in Figure 2, for /n/ and /p/, Rosa produced one or two correct responses after 2 or 3 days of instruction but continued also to produce incorrect responses until 7 days of instruction. Results from our visual analyses were confirmed by the calculation of the percentage of overlapping data (POD; Scruggs, Mastropieri, & Casto, 1987) for each GPC. The range of POD across eight

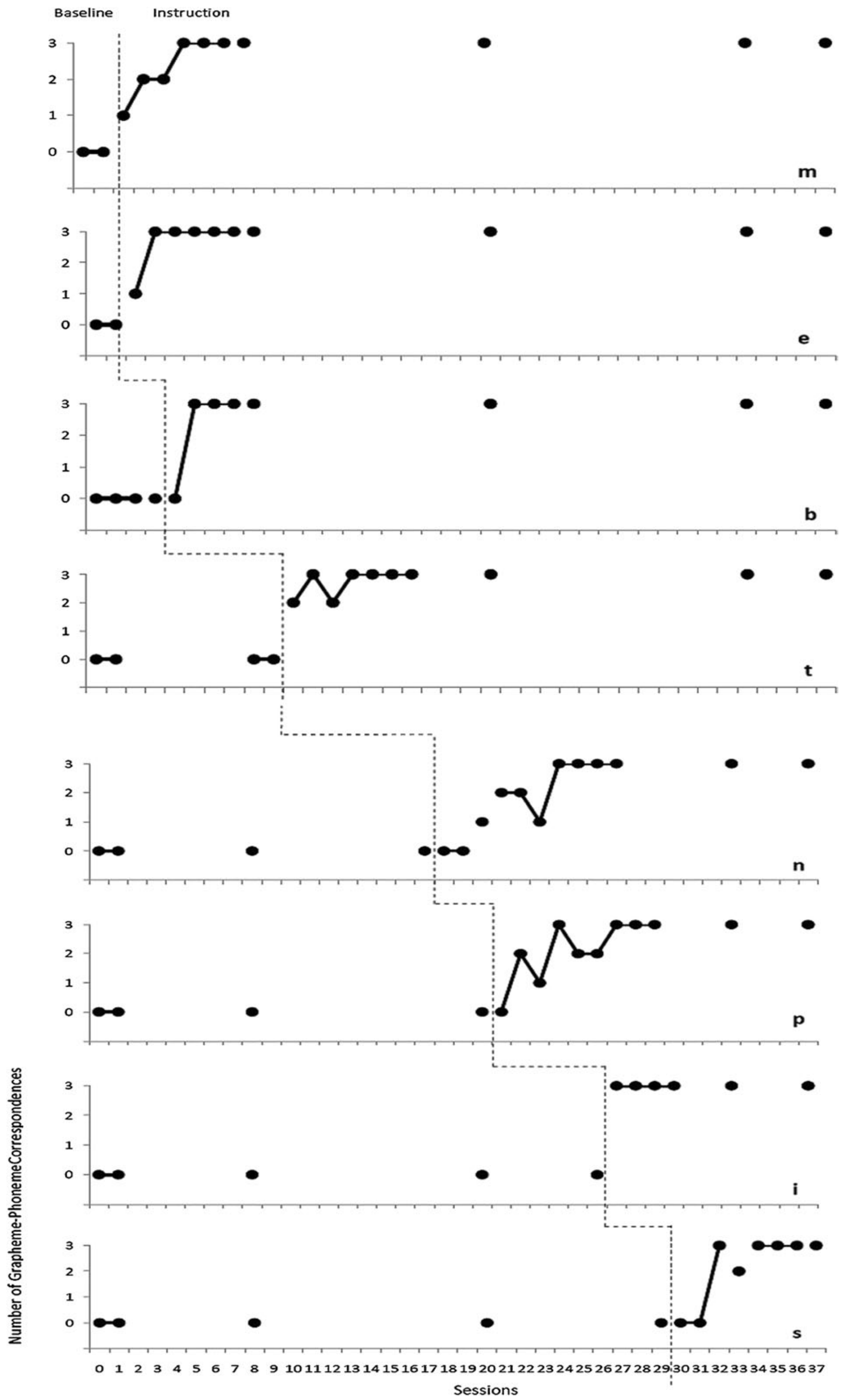

Figure 2 Graph showing acquisition of grapheme–phoneme correspondences for Rosa, a 4 years and 9 months student from a signing program who used no speech to communicate.

Table 3 Number of instructional sessions to latency across children

Grapheme	Rosa	Amanda	Jill	Spencer	Averages by correspondence
m	4	3	1	1	2.25
e	2	3	—	—	2.50
b	3	2	2	1	2
o	—	1	—	—	1
t	4	1	1	1	1.75
n	7	1	1	1	2.5
p	7	1	1	1	2.5
i	1	1	—	—	1
s	3	1	—	—	1
a	—	1	—	—	1
g	—	1	1	—	1
o	—	1	1	2	1.33
k	—	1	1	—	1
w	—	2	1	2	1.67
Averages by student	4.50	1.43	1.11	1.29	1.60

Note. —indicates known correspondence.

phonemes was 0–25% with a mean of 5.9%, showing a strong effect.

Discussion

Rosa identified all taught GPCs and maintained them across the study, providing evidence that a preschooler with minimal speech perception could acquire correspondences. She also learned to produce the correct spoken phoneme for each correspondence. Because Rosa did not vocalize prior to this intervention, learning to use her voice in the instructional setting was a new skill. Latency results for Rosa were similar to those reported by Bergeron et al. (2009) for the children in their Study 1 (average latency of 4.49; range of 1.8–7.2) and Study 2 (average latency of 5.8, range of 4.7–8.0). Rosa appeared to have more difficulty with GPCs as taught phonemes accumulated, a pattern not evident in Bergeron et al. A few factors may have been related to this higher latency. Because Rosa was learning to produce phonemes, as well as associate them with graphemes, she may have needed more instructional time to learn GPCs. Children in Bergeron et al. were in small groups during instruction. Rosa was in a one-to-one instructional setting without the presence of peer modeling and opportunity of incidental learning. Guardino et al. (2011) noted the benefits of peer modeling during direct instruction in GPCs. Regardless of these factors Rosa was able to master all eight GPCs within about 16 hr of instruction across 8 weeks. In summary, this study, in combination with previous research, suggests that DHH children can learn GPCs in preschool, which has been associated with future reading success (Easterbrooks et al., 2008; Kyle & Harris, 2011).

Study 2

The results of Bergeron et al. (2009) suggested that *Foundations* is effective for acquisition of GPCs in small group instruction with DHH preschoolers with speech perception. The results from the present Study 1 suggested that the combination of *Foundations* and Visual Phonics was an effective method to teach GPCs to a DHH preschooler with minimal speech perception. However, children with minimal speech perception may require additional time to acquire and master GPCs. Study 1 was limited by a subset of correspondences in a one-on-one setting. Considering typical small group instruction found in DHH preschool classrooms, the goal for Study 2 was to assess the ecological validity of instruction with a group of preschoolers with various levels of speech perception across a school year using all components of the *Foundations* curriculum.

Visual Phonics has been used to facilitate children's acquisition of spoken phonemes and was created as a tool to improve speech production. However, past research is inconclusive. For example, Trezek & Malmgren (2005); Trezek & Wang (2006) accepted approximations of spoken phonemes when children produced vocalizations as long as the appropriate mouth movements and voiced or unvoiced sensations were produced. We wanted to more closely observe how DHH children used Visual Phonics as a tool in learning to produce spoken phonemes. We also investigated children's use of Visual Phonics during fluent tasks (i.e., fluency chart, described below) and less fluent tasks (i.e., word reading). Finally, we assessed preschoolers' ability to use taught GPCs to decode and identify words.

The research questions we addressed for Study 2 were: What are the effects of instruction in *Foundations for Literacy* and Visual Phonics on acquisition of GPCs by DHH preschoolers who vary in speech perception abilities? Can preschoolers use GPCs to decode and identify words? Finally, how do preschoolers use Visual Phonics and spoken phonemes during reading and fluency activities?

Methods

Research design. In the fall following Study 1, *Foundations* was implemented with Visual Phonics across the school year at the same school as Study 1 with a group of three DHH preschoolers who ranged in speech perception abilities. Three research designs were used. A multiple baseline probe design across content was used to determine if a functional relation existed between instruction on a GPC and its acquisition. The independent variable was explicit instruction in GPCs using *Foundations for Literacy.* The dependent variable was the number of GPCs correctly produced by children. Generalization probes were used to examine changes in the children's abilities to decode and identify words. Finally, we provided a descriptive analysis of children's use of Visual Phonics across reading and fluency activities.

Setting and participants. The setting and participant criteria were identical to Study 1, with the exception that children with and without speech perception were included. Amanda was 4 years and 7 months with a 95dB unaided/80 dB aided hearing loss. Both of Amanda's parents were deaf and ASL was the communication mode used in the home. Amanda had minimal speech perception (ESP 1) and used no speech at the beginning of this study but produced three to five word utterances in sign language. Jill, aged 4 years and 7 months with an 85dB unaided/ 58 dB aided hearing loss, had some word identification abilities (ESP 3) and used a combination of speech and sign language to communicate. One of Jill's parents was deaf. Spencer, aged 4 years and 4 months, with an 80 dB unaided/35 dB aided hearing loss, had consistent word identification (ESP 4) and communicated through a combination of speech and sign language. He had hearing parents. All children used hearing aids daily with varying levels of benefit and had vocabulary scores within 1SD of the mean (see Table 1).

Procedures. ESP, PPVT, and EOWPVT were administered at the beginning of the school year in the same manner as Study 1 (see Table 1). Two tests, developed for research purposes during the larger ongoing research project, assessed alphabetic knowledge at the beginning and end of the school year: (a) *Letter–Name Assessment*, for which children were asked to "name" 23 letters. Either spoken or fingerspelled names were accepted as is typical in research with DHH children (e.g., Kyle & Harris, 2011; the corresponding mouth movement was not required) and (b) *Letter–Sound Assessment*, for which children were asked to supply the correct "sound(s)" for letters for 31 GPCs (including three digraphs) through spoken production.

Baseline and probe assessment. Baseline procedures and criterion for acquisition of GPCs were the same as for Study 1. A total of 18 GPCs were assessed in two sets of nine. Baseline performance was established on the first set of nine phonemes during the first week of instruction and on the second set of nine during the 11th week of instruction. A probe containing the initial nine GPCs was conducted on the 14th, 34th, and 48th days of instruction. A probe containing the second set of nine correspondences was conducted on the 60th and 71st days of instruction for the same purpose.

A correct response was either (a) accurate production of the spoken phoneme or (b) a consistent unchanging verbal approximation of the phoneme when accompanied by Visual Phonics for those instances in which the teacher judged the child was experiencing speech difficulties. Study 2 involved children who had less access to speech compared to Study 1, and therefore, we expected accurate speech production for some phonemes to be difficult. Because our goal was building an articulatory representation of the phonemes and not intelligible speech, we chose to accept approximations if the child maintained consistency across GPCs as correct responses.

Word decoding assessment. A word decoding test was administered at the beginning and end of the school year. The word decoding test contained 13 words with two or three phonemes per word (see Table 4 for word list). All words were composed of GPCs that were taught during the intervention. The assessment contained six taught words, used repeatedly in *Foundations* reading activities (e.g., "eat," "boat"), and seven novel words, composed of taught GPCs (e.g., "weep," "not"). The teacher modeled one-sample test item by pointing to and blending two phonemes to form a word (e.g., "mmm-eee," "me"). Children were shown one word at a time and asked "What is this word?"

Intervention. Foundations is a balanced curriculum, focused on both code- and meaning-based early literacy skills. Intervention occurred an hour per day, 4 days per week, for 23 weeks. After the initial 4 weeks, instruction across the 1-hr sessions was divided into 15-min portions for each of the following: language-rich activities focused on learning GPCs and using them to decode taught words, phonological awareness activities, and storybook reading. Review and reinforcement of skills, as well as vocabulary and fluency practice, were conducted during the remaining 15 min. Words taught within the curriculum were as follows: me, bee, bow, tea, eat, toe, no, bone, Pete, note, pie, bite, tie, see, soap, say, name, feet, face, my, go, goat, game, top, tops, sock, socks, make, cake, bake, wait, and wipe. The sequence of GPCs was the same as Study 1, with six additional GPCs in this order: /ā/, /f/, /g/, /ŏ/, /k/, and /w/. To give children authentic practice in using their GPC knowledge, every week, children were taught a new word to decode that used previously taught GPCs. Words were always written with the special grayed orthography to facilitate decoding of digraphs (see Table 4).

In addition to the relevant activities described in Study 1, intervention included the use of a fluency chart twice per week. The aim of the chart was to increase children's fluent production of learned GPCs in a quick activity that took less than a minute. The chart consisted of a grid that displayed single

Table 4 Word decoding posttest results

Stimuli	Amanda's phonemes	Word response[a]	Jill's phonemes	Word response[b]	Spencer's phonemes	Word response[b]
Eat	ē, t	**Eat**	ē, t	**Eat**	ē, t	**Eat**
Bone	b, ō, n	**Bone**	b, ō, n	—	b, ō, n	Phone
Pie	p, ī	Go	none	**Pie**	p, ī	**Pie**
Go	g, ō	Game	none	**Go**	g, ō	**Go**
Sock	s, ŏ, k	Say	s, ŏ, k	Cake	s, ŏ, k	Phone
Name	n, ā, m	Game	n, ā, m	**Name**	n, ā, m	Game
Weep	w, ē, p	Wait	w, ē, p	—	w, ē, p	Phone
Bike	b, ī, k	—	b, ī, k	Cake	b, ī, k	—
Woke	w, ō, k	—	w, ō, k	Wait	w, ō, k	—
Fog	f, ŏ, g	Game	f, ŏ, g	Feet	f, ŏ, g	Phone
Time	t, ī, m	Feet	t, ī, m	—	t, ī, m	My
Not	n, ŏ, t	Eat	n, ŏ, t	Bear	n, ŏ, t	—
Beef	b, ē, f	Dog	b, ē, f	Feet	b, ē, f	Phone
Correct phonemes	36		32		36	
Total correct words		2		4		3

Note. —indicates no response; bold indicates correct word response.
[a]Amanda signed all word responses.
[b]Jill and Spencer spoke and signed all word responses; Words above the center line were taught words, words below the center line were novel words.

or multiple spellings of different taught phonemes (e.g., "o," "oa"). The multiple spellings were the same as those on the large concept cards and in the practice books. Each fluency chart contained one to three instances of each GPC. Correspondences were included on the chart 2 weeks following instruction. Each chart was randomly arranged and used only once.

The chart was introduced in week 9 and completed twice per week. Each child pointed consecutively to the grapheme(s) and said the corresponding phonemes, moving from left to right and top to bottom. If incorrect, the teacher redirected the child to the grapheme(s), waited for the child to say the correct phoneme, and provided the phoneme if the child incorrectly identified it after the second directive. In week 20, the teacher modeled completing the fluency chart without Visual Phonics to promote Visual Phonics as a bridge to fluent identification of phonemes and prompted each child to use only voice for the phonemes.

The teacher followed the instructional sequence of the curriculum and introduced new GPCs approximately every fourth instructional session (with the exception of the first two correspondences, which were taught on the same day). Although the intervention was designed to teach 18 GPCs, time constraints resulted in instruction on only 14.

Intervention assessment. Assessment was the same as Study 1. Interobserver agreement of the GPC scores was verified by trained research assistants who observed 20% of assessments. Interobserver agreement ranged from 83% to 100%, with a mean of 94.5% agreement.

Treatment fidelity. Procedural fidelity was collected across instructional activities in the same manner as Study 1 and averages for each element are presented in Table 2.

Results

Data were analyzed for each individual child (rather than for the group) because assessment and criterion occurred at that level (and instruction was individualized through extra practice when warranted). At baseline, Amanda did not know any of the 14 GPCs. Spencer and Jill knew seven and five, respectively, and these were removed from the data analysis and the graphs for these two children. Correct production of the spoken phonemes was required of all children, with the exception of Amanda's consistent approximations for four phonemes (/t/, /n/, /g/, /k/) and Jill's consistent approximations for two phonemes (/g/, /k/). During baseline probes, children frequently substituted voiced productions and corresponding Visual Phonics of taught phonemes for untaught phonemes (e.g., /b/ for /p/, /n/ for /h/), suggesting that they were aware of grapheme–phoneme relationships, even if they did not recognize a particular grapheme.

Acquisition of GPCs was similar across children. Participants' individual graphs are displayed in Figures 3, 4, and 5. Visual inspection of the graphs indicated that changes in the GPCs consistently occurred following instruction for correspondences, demonstrating a functional relation across GPCs. All children achieved criteria for all taught correspondences and maintained this performance throughout the intervention, for a period of up to 20 weeks after achieving criteria. In sum, all participants mastered all GPCs after instruction, with a total of 14 GPCs for Amanda, 9 for Jill, and 7 for Spencer.

The children learned GPCs very quickly. Latency for Jill and Spencer was one to two sessions, with a mean of 1.11 for Jill and a mean of 1.29 for Spencer (see Table 3). Latency for Amanda was one to three sessions, with a mean of 1.43 sessions. The mean POD for Amanda was 2.0% (range 0–20%) across 14 phonemes. Mean POD was 0% for Jill across nine phonemes. For Spencer, mean POD was 2.0% (range 0–20%) across seven phonemes. Results suggest that instruction was very effective for these children, with preschoolers learning GPCs after only one or two instructional sessions.

Alphabetic knowledge pretests indicated that children knew many letter names but few GPCs prior to instruction (see Table 1). Posttest assessments showed that all children improved on both tests, increasing their GPC knowledge to the same level as their letter name knowledge. In addition to the 14 GPCs explicitly taught in *Foundations*, the children learned four to six additional GPCs during the school year (as demonstrated

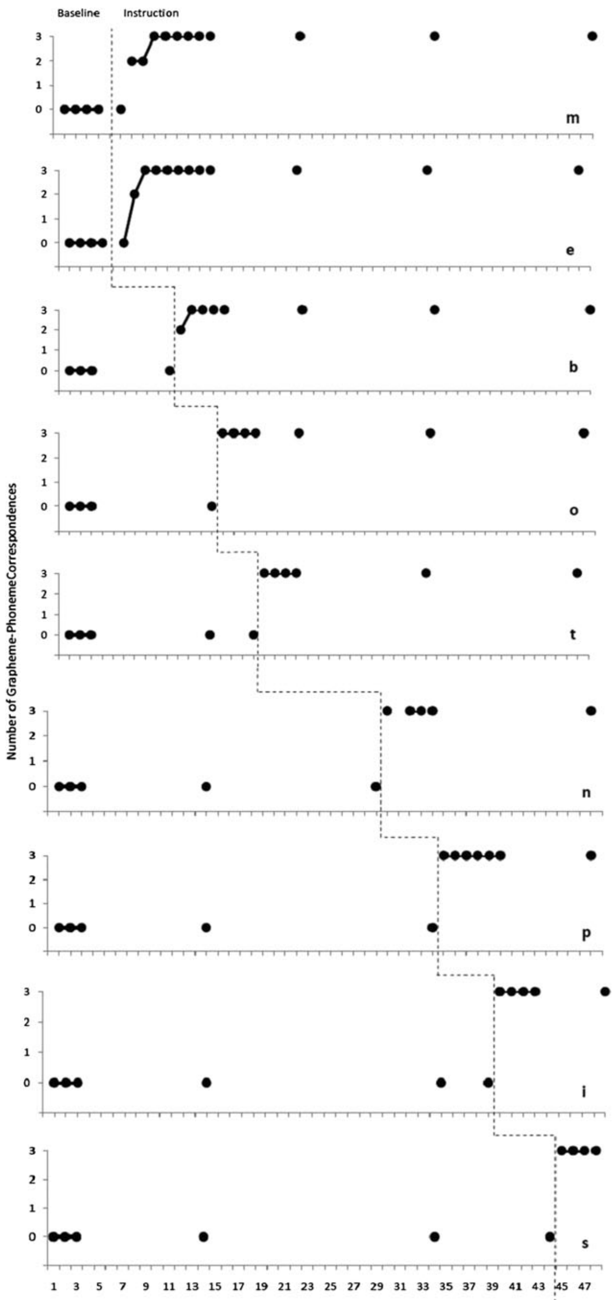

Figure 3 (a and b) Graph showing acquisition of grapheme–phoneme correspondences for Amanda, a 4 years and 7 months preschooler from a signing program who used no speech to communicate.

on the Letter–Sound posttest), suggesting that they may have acquired GPCs from other contexts (e.g., home and classroom instruction) as well as through the *Foundations* intervention.

Word decoding. Children maintained and used GPCs in a functional manner by decoding graphemes in real words on the Word Decoding posttest. Decoding was defined as producing the correct spoken phoneme (or accepted approximation as described above) for each grapheme or digraph. This assessed the accuracy of decoding graphemes within a word and correct identification of the word. On the pretest, none of the children decoded any of the 13 words or any of the graphemes within the words. Jill identified one novel word through a sight word strategy: as soon as she saw

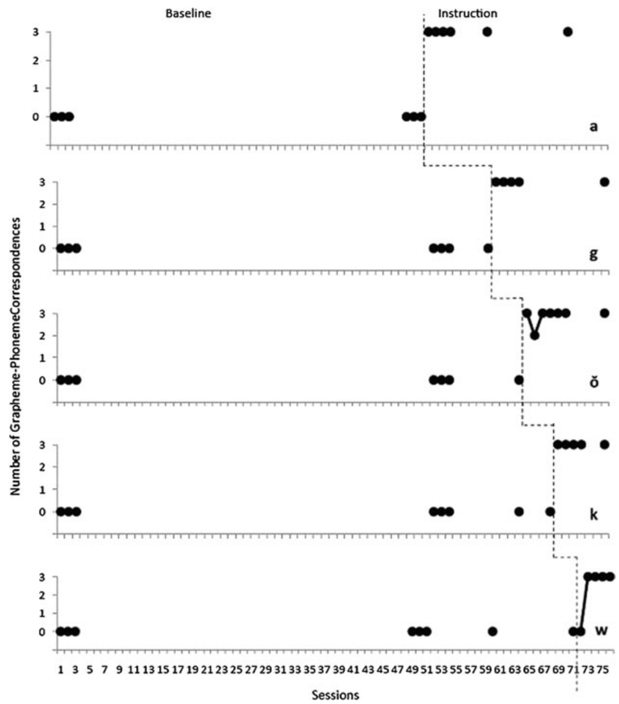

Figure 3 continued.

"cat," she immediately presented the sign for "cat" without the production of any phonemes.

On the posttest, all children accurately decoded 100% of the graphemes. The children used Visual Phonics with their spoken phoneme production throughout this task. Amanda correctly identified two words in sign after decoding the phonemes. Jill identified two words without decoding and two words after decoding. Spencer correctly identified three words after decoding. Jill and Spencer used both speech and sign to identify these words.

Although the children correctly decoded all phonemes in the seven novel words, they did not correctly identify any of the novel words (see Table 4). All children used a strategy for novel words that involved guessing a taught word that shared at least one common GPC with the novel word. Error analysis suggested the children may have been using a partial alphabetic strategy, such as initial or final GPC, to guess unknown words after decoding the graphemes (e.g., "feet" for the test item "fog"). The use of initial GPC occurred six times and use of final GPC occurred three times across the children. Spencer appeared to use a rime strategy for two test items (i.e., "name" for the test item "game" and "phone" for the test item "bone"). The children showed emergent skills in decoding by identification of 50% of taught words but were unable to use these skills to identify novel words.

Fluency chart. Participants were shown fluency charts twice per week throughout the 23 weeks. The charts were used one time each. The total number of graphemes on each fluency chart was 20 with some graphemes presented more than once. The number of different graphemes increased from 6 in week 12 to 11 in week 20. To capture changes across the school year, children's use of Visual Phonics for the fluency chart was coded for weeks 12, 20, 22, and 23. Performance is presented by child.

Amanda consistently used only voice during the fluency chart activity, with the exception of week 12, when she clarified her speech productions with Visual Phonics. In week 20, when the number of GPCs increased to 11, Amanda sought feedback from the teacher on her speech productions. She used Visual Phonics to clarify her voiced productions of /ī/ and /ā/ in week 22. Her average completion time across charts was 39 s

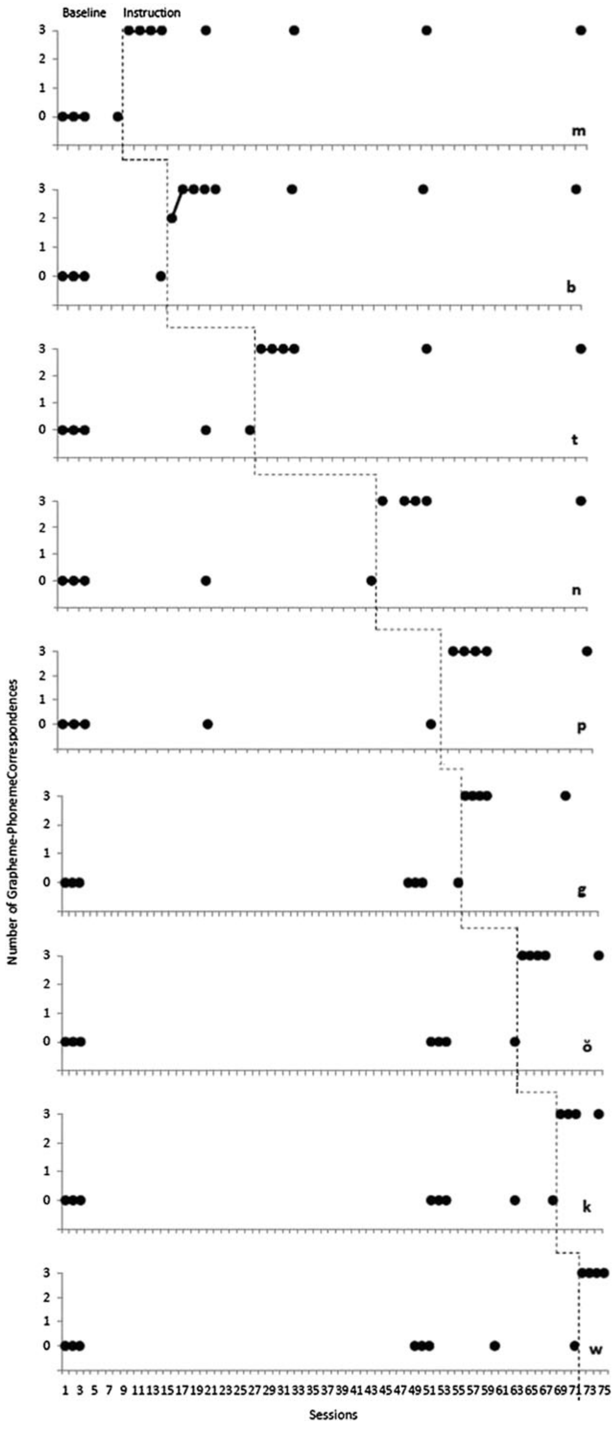

Figure 4 Graph showing acquisition of grapheme–phoneme correspondences for Jill, a 4 years and 7 months preschooler from a signing program who used verbal combination of speech and sign language to communicate.

and her accuracy was 99%. Jill also consistently used only voice during the fluency chart activities, again with the exception of week 12, when she accompanied her voiced productions with Visual Phonics. Her average completion time was about 20 s, with 97% accuracy across the assessments. Spencer, in contrast, used Visual Phonics and voice for all fluency charts. Following teacher modeling in week 20, Spencer repeated the

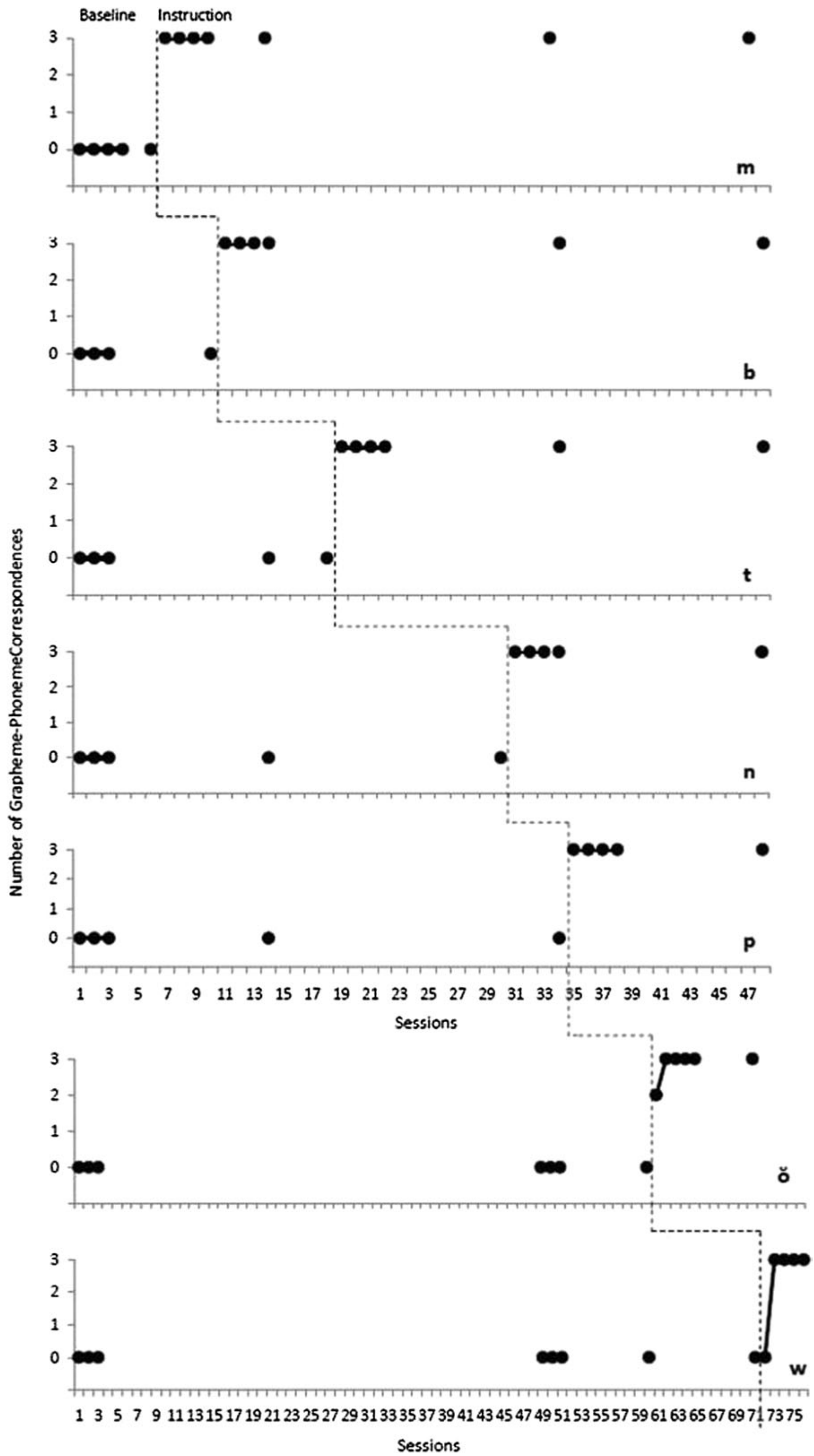

Figure 5 Graph showing acquisition of grapheme–phoneme correspondences for Spencer, a 4 years and 4 months preschooler from a signing program who used speech and sign language to communicate.

fluency chart without the use of Visual Phonics, although he still made a few of the Visual Phonics handshapes with his hands at his sides. He reverted to using Visual Phonics halfway through the assessment in week 23. Spencer's average completion time was 33 s, with 89% accuracy across the fluency charts.

Social validity. Social validity was measured for Study 2 through a teacher survey. The classroom teacher of all three children and their Speech Language Pathologist completed and returned the social validity survey. The mean score for items one through five was 5. The classroom teacher commented that Spencer "started trying to sound out words such as 'will,' 'me,' and a few other words" in her classroom. The classroom teacher also included the following comments:

> I think the work with Amanda is particularly important since she has a profound loss and comes from a Deaf family that uses no speech at home. Her level of deafness (profound) and no apparent benefit from her hearing aids makes her representative of many of our students, and therefore, her progress in the letter/sound recognition reinforces the importance of providing some sort of visual phonics for our students.

Discussion

The results of Study 2 replicated the findings of Study 1, showing that the combination of *Foundations* and Visual Phonics was a very effective method to teach GPCs to preschoolers with limited speech perception who used sign language for communication. Children only needed one or two lessons to learn to produce the correct phonemes for a given grapheme. They also showed a high degree of fluency on charts that included digraphs as well as single letters. The children decoded the GPCs they had mastered within words that contained two or three phonemes and identified about a quarter of all given words.

General Discussion

The purpose of this study was to investigate the ability of DHH preschoolers, with a range of speech perception abilities to learn and use GPCs from explicit instruction combined with Visual Phonics. First, we asked: What are the effects of instruction in *Foundations for Literacy* and Visual Phonics on acquisition of GPCs for DHH preschoolers? After instruction, all children acquired and maintained all taught GPCs across the studies, similar to the results of Bergeron et al. (2009). Visual inspection of graphs shows a clear functional relation between instruction on a GPC and its acquisition.

Based on the results of Study 1, we expected Amanda, who had minimal speech perception and used only sign language to communicate, to need additional time to acquire GPCs. This was not the case. The average latency across Amanda, Jill, and Spencer was 1.28 sessions (range 1.11–1.43), in contrast to an average latency of five sessions across the children in the study by Bergeron et al. (2009). Amanda's latency was similar to Jill and Spencer, who had greater speech perception and used some speech to communicate.

Acquisition did not appear to be related to degree of aided hearing loss for Jill (50 dB), Spencer (35 dB), or Amanda (80 dB). This is consistent with findings for older children who were taught GPCs supplemented with Visual Phonics (Trezek & Malmgren, 2005; Trezek & Wang, 2006). On the other hand, hearing loss may have played a role in the children's ability to accurately represent and produce phonemes, as is evident in Amanda's use of more approximations for GPCs and her use of Visual Phonics for the fluency chart. When she came to the graphemes for /g/ and /k/ she immediately accompanied her verbalizations with the Visual Phonics handcue and movement to distinguish her production. In a nonsense word repetition task, Dodd (1980) reported that certain consonants, including /g/ and /k/, were systematically misrepresented by deaf children because these sounds are not visible during speech reading, which appeared to be the case in the production of /n/, /g/, and /k/ for Amanda and Jill. Visual Phonics appeared to allow Amanda to build differentiated representations of these difficult phonemes.

It was very surprising that children in this study who had weaker speech perception skills learned GPCs faster than those in the study by Bergeron et al. (2009). A number of factors may account for this. The children in the current studies had additional visual access to spoken phonology via Visual Phonics, unlike those of Bergeron et al. They also had better language skills. The mean PPVT standard score for Bergeron et al.'s children in Study 2 was 75 (range 66–97), whereas the mean PPVT score in the current Study 2 was 92 (range 86–97) (PPVT scores were not available for Bergeron et al.'s children in Study 1). Children in this study had average or low-average language skills, and two of the children were native signers. This may have facilitated their ability to learn GPCs quickly, especially when taught through a language-rich meaningful context such as a story.

Despite variation in hearing levels, speech perception, and receptive language skills, DHH preschoolers acquired GPCs when given explicit instruction using a curriculum developed for DHH preschoolers accompanied by Visual Phonics. Easterbrooks et al. (2008) reported that preschool children learned an average of four GPCs across the school year given "business as usual" at a variety of preschools. Kyle and Harris (2011) also found that children aged 5–6 years only knew an average of 2.5 GPCs. In contrast, 30–60 min of daily explicit instruction during the present studies resulted in mastery of all taught GPCs and ceiling scores on post assessments of letter names and sounds. The latter results also suggest that, given explicit instruction on GPCs, children may transfer this knowledge to other instructional contexts. On the posttest, the children knew some additional GPCs that had not yet been taught in *Foundations*. These results reinforce previous findings that some DHH children can acquire GPCs (Trezek & Malmgren, 2005; Trezek & Wang, 2006; Trezek et al., 2007), replicate these findings at the preschool level (Bergeron et al., 2009; Smith & Wang, 2010), extend these findings to preschoolers with limited speech perception, and suggest that explicit instruction at the preschool level is successful for most DHH children. This is an especially important result given research that suggests letter–sound knowledge (but not letter name knowledge) predicts later reading in DHH children (Kyle & Harris, 2011).

Word Decoding

Our next research question was: Can preschoolers use GPCs to decode and identify words? All the children in Study 2 demonstrated an increased ability to decode and identify words from pretest to posttest, although identification was limited to words taught within the intervention. The children accurately decoded all the taught phonemes within taught and novel words. This was surprising given these words included digraphs and did not conform to more typical consonant-vowel-consonant patterns. However, the children did not necessarily decode them meaningfully by signing or saying the correct word. Once children decoded the words into phonemes, they had to blend the phonemes and recognize the word. Thus, accurately producing the GPCs in a word only resulted in correct identification if it was a word with which the child was highly familiar.

There are several reasons why decoding novel words may have been difficult for the children. Identification of novel words may require children to blend phonemes into a spoken word form and then recognize that word form. Blending phonemes is a difficult skill for all young children, hearing or not. Therefore, the ability to use GPC knowledge to identify novel words may only become apparent in older children. Recognition of a novel spoken word also requires that signing children have a spoken representation of the novel word in their lexicon. Children who have minimal spoken word abilities may be unlikely to identify new printed words through phonological recoding.

When children are unable to connect the orthographic representation to a spoken representation of a word they have in their lexicon by sounding out and then blending sounds for unfamiliar printed words, they cannot engage in self-teaching. Share (1995) has postulated that the ability to make this connection is a powerful tool hearing children use. The children in Bergeron et al. (2009), who had greater speech perception skills, decoded 60% of the taught words and 30% of the novel words. It is possible that Bergeron et al.'s children had acquired more words incidentally that they could blend based on their phonological representation of those words. Whereas some children may be more readily able to engage in self-teaching (Share, 1995), others may need instruction that explicitly builds these phonological representations (through auditory and/or visual means) in order to recognize a word after decoding it.

Jill and Spencer tended to make phonologically related mistakes during the word identification task. Dodd

(1980) reported that deaf children were better at determining the initial than final sounds for a word production task. This is consistent with our children who used an initial GPC strategy five times during word decoding, compared to the use of final GPC three times. Finally, one child resorted to guessing halfway through the assessment, precluding strategy analysis. Guardino et al. (2011) reported that DHH children in first and fifth grades also resorted to guessing when they did not know a word based on phonological decoding.

In the current study, the children produced the sign in addition to the phonemes for identified words from printed text. This suggests the children may have a representation of words based on a connection between phonology and sign, in contrast to the finding of Mayer and Moskos (1998) that some DHH children represent written words by the first letter of initialized signs. It seems that children of this age need multiple exposures within semantic contexts to decode familiar words with learned GPCs. Although the preschoolers in this study produced all taught phonemes in all test items, they were not able to blend those phonemes in order to recognize the word when they had not already practiced such blending. Perhaps decoding novel words is not developmentally appropriate for preschoolers who are DHH.

Use of Visual Phonics

Finally, we asked: How do preschoolers use Visual Phonics and spoken phonemes during reading and fluency activities? The use of Visual Phonics seemed to be applied flexibly and in contexts where children needed extra support in recalling a phoneme. During the daily GPC assessments, all children used Visual Phonics during initial acquisition but faded their use as they acquired the spoken phoneme. During the fluency chart, Amanda and Jill dropped the use of Visual Phonics. Guardino et al. (2011) also found that elementary school children gradually stopped using Visual Phonics as they learned GPCs. This supports the conclusion of Waddy-Smith and Wilson (2003) that use of Visual Phonics fades as children internalize the sound–symbol code of English. However, this fading was not observed for Spencer. Recall that Spencer had an aided hearing loss of 35 dB, whereas Amanda's aided loss was 80 dB. Even though Spencer had more residual hearing, he relied on visual and kinesthetic support to reinforce his recall of phonemes. When the teacher modeled completion of the chart without the use of Visual Phonics and prompted Spencer to do the same, he did not complete the chart any faster. Spencer's use of Visual Phonics did not appear to interfere with his fluency. Rather, it appears that Spencer had a lower degree of fluency than Amanda and Jill. Because of this lower fluency, he may have needed Visual Phonics as a mnemonic device to help him recall the phonemes.

In contrast to the fluency chart, all children used Visual Phonics with voice during the word decoding posttest. As the difficulty level of the task increased, it seems possible that the children relied on additional supports beyond only spoken phonology. Visual Phonics appeared to function as a mnemonic device when working memory was increasingly taxed.

These findings suggest that spoken phonology may be recalled differently across DHH preschoolers with varied levels of hearing loss as fluency with information increases, regardless of speech perception ability. Zaccagnini and Antia (1993) speculated that some handcues aided recall of sounds by a 9-year-old child. Finally, word decoding and fluency chart results suggest more fluent recall of GPCs may result in more fluent reading. Jill identified six words and completed the fluency chart in the shortest amount of time, whereas Spencer identified three words and needed the most time to complete the fluency chart.

Limitations and Future Research

A potential limitation to this study may be that all GPC data were collected by the teacher, also the first author of this study. However, we attempted to control for this through the collection of interobserver reliability by trained research assistants. Although the current study was limited by a small sample size, the children served as their own controls through the research design. A functional relation was demonstrated between instruction in *Foundations* with Visual Phonics and acquisition of GPCs across phonemes with multiple replications. This investigation addressed an expansion of GPC research to DHH preschoolers with minimal speech perception abilities and supports previous findings of GPC acquisition in DHH preschoolers (Bergeron et al., 2009; Smith & Wang, 2010). Because of the diversity within the DHH population, future research should include larger intervention groups of DHH preschoolers and comparison groups who receive "business as usual" to confirm the results of this current study and previous research. We cannot determine if acquisition of GPCs was unique to *Foundations* or the use of Visual Phonics. Future research that compares the effects of *Foundations* alone and *Foundations* in conjunction with Visual Phonics should be investigated. In addition, future research should investigate if and how other DHH preschoolers use GPCs to help them read and to develop instructional strategies to help children create a spoken phonological representation of words in order to decode them.

Conclusions

Explicit instruction in GPCs using the multisensory approach of *Foundations* in conjunction with Visual Phonics may provide additional access to spoken phonology for children who have limited speech perception through speech production cues and memory aides (Morrison et al., 2008). This instruction may improve the children's abilities to speech read phonemes, a skill that Harris and Moreno (2006) reported is related to reading for DHH children. Alphabetic knowledge provides a foundation for later reading success (Farrar, Ashwell, & Maag 2005; Puolakanaho et al., 2008) and explicit instruction in GPCs is essential for children in general education settings (National Early Literacy Panel, 2009). The development of these skills in DHH children at a young age may establish a foundation for the alphabetic principle to prevent further reading delays. Based on the results of the current study, the combination of *Foundations for Literacy* and supplemental support through Visual Phonics may result in GPC acquisition for DHH preschoolers with limited speech perception.

Supplementary Data

Supplementary material is available at http://jdsde.oxfordjournals.org/.

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Conflicts of Interest

No conflicts of interest were reported.

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