FINGERSPELLING AS A PHONOLOGICAL CODE FOR DEAF AND HARD OF HEARING STUDENTS

by

LORIANN SCHWARTZ

B.A., Point Loma Nazarene University, 2003

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado at Boulder in partial fulfillment

of the requirement for the degree of

Master of Arts

Department of Speech, Language, and Hearing Sciences

2011

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 - 1346

This thesis entitled:
Fingerspelling as a Phonological Code for Deaf and Hard of Hearing Students
written by Loriann Schwartz
has been approved by the department of Speech, Language, and Hearing Sciences

_____
Brenda Schick, Ph.D.

_____
Anne Whitney, Ed.D.

_____
Jeff Coady, Ph.D.

_____
Willy Moers, M.A.

Date_____

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB protocol # 11-0097

Schwartz, Loriann (M.A., Speech, Language, and Hearing Sciences)

Fingerspelling as a Phonological Code for Deaf and Hard of Hearing Students

Thesis directed by Professor Brenda Schick

Abstract

Phonological awareness (PA), an important skill for learning to read among hearing children, has also been correlated with the reading ability of deaf and hard of hearing (DHH) students. Given the limited auditory input available to DHH children, a number of alternative forms of phonological codes have been proposed, including fingerspelling. This study explored the relationship between fingerspelling and PA, using PA tasks in speech and in fingerspelling to look at the word internal knowledge of DHH students and their ability to manipulate the phonemic components of language through fingerspelling. Further analysis assessed relationships with vocabulary and reading. The Phonological Awareness Test for Deaf and Hard of Hearing (PAT-DHH) was developed for the present investigation, and includes subtests in alliteration, rhyming, elision, and blending words; each in fingerspelling and spoken conditions. Participants were 10 DHH students (kindergarten through fourth grade) attending bilingual educational programs for DHH students. Results confirmed that children are able to demonstrate PA skills in fingerspelling and that they use both "sounding out" as well as "fingerspelling out" strategies. The measure of ASL vocabulary correlated significantly with explicit PA in fingerspelling, but not with the other PA constructs in fingerspelling. Both fingerspelling ability and PA in the fingerspelled condition were predictors of reading ability; however PA in the fingerspelled condition was the stronger predictor of the two, predicting 20% of the variance of reading achievement. This has important implications for the role of fingerspelling in the clinic and classroom settings and in how we teach children to read.

Acknowledgements

I would like to thank my advisor, Dr. Brenda Schick, for her valuable insight into this field of research, and her incredible support and encouragement every step of the way. Thank you for fueling my passion for this research, and for your guidance both professionally and personally.

I am greatly appreciative of my committee, Dr. Anne Whitney, Dr. Jeff Coady, and Willy Moers. They have each brought their own expertise and valuable viewpoints that have helped to shape this thesis into a truly meaningful project. Thank you Annie for your clinical expertise, excellent literature references, and many opportunities to learn from you. Jeff, thank you for your solid research background, for taking the time to teach me, and for empowering me to perform quality analysis on my data. Thank you Willy for your native sign intuition and for providing the fluent American Sign Language stimuli critical to the assessment portion of this project.

My most sincere and heartfelt thanks go out to all of the families who participated in this study and to the administration and faculty of the school for deaf and hard of hearing students that made this study possible. Thank you also to my family, colleagues, and friends. You have a treasured place in my life and your support and prayers have been felt and greatly appreciated.

Finally, and perhaps most importantly, I would like to thank my husband, Brian Schwartz. You have encouraged me to do more than I would have dreamed possible on my own. You are a true blessing and I am forever grateful.

Table of Contents

List of Tables

List of Figures

Fingerspelling as a Phonological Code for
Deaf and Hard of Hearing Students

Introduction

Phonological awareness refers to an awareness of the sound structure, or phonological structure, of words; and the ability to manipulate these sounds at the word, syllable, and phoneme levels. Paul (2007) defines phonological awareness as "the ability to detect rhyme and alliteration; to segment words into smaller units, such as syllables and phonemes; to synthesize separated phonemes into words; and to understand that words are made up of sounds that can be represented by written symbols or letters" (p. 385-387). Phonological awareness has been well documented as an important skill for learning to read among hearing children (Ezell & Justice, 2005; National Institute of Child Health and Development, 2000; Wagner & Torgesen, 1987). These skills develop sequentially in overlapping stages (see review in Scheule & Boudreau, 2008), typically beginning in the preschool years with rhyme and syllable segmentation. These early skills have been referred to as *implicit* phonological awareness (Harris & Beech, 1998). The later stages of segmenting and blending sounds into words, known as *explicit* phonological awareness or *phonemic* awareness (Harris & Beech, 1998), are the foundation for early literacy success and should be developed by early first grade when children begin to receive more direct reading instruction (Schuele & Boudreau, 2008). The beginning reader combines this knowledge of sounds (phonological awareness) with an awareness of print in order to apply phoneme-grapheme correspondence for decoding of new words (i.e. "sounding out" a new word; Ezell & Justice, 2005).

There is less known about the development of phonological awareness among deaf and hard of hearing (DHH) children. It is clear that reading comprehension is a major challenge for

deaf students (Marschark et al., 2009). Improvement in reading ability by DHH students has been shown to average as little as .2- or .3-grades each year (Kyle & Harris, 2010). Based on national norms and performance standards developed for the Stanford Achievement Test, 9th Edition, the median (50th percentile) reading achievement of DHH 18-year-old students is equivalent to that of a typical fourth grader and the 80th percentile score is equivalent to that of a typical seventh grader (Traxler, 2000). Weak phonological awareness skills may be one contributing factor to the low reading achievement, although it is uncertain whether phonological awareness contributes to reading ability in deaf students or if it is reading that contributes to phonological awareness (Kyle & Harris, 2010).

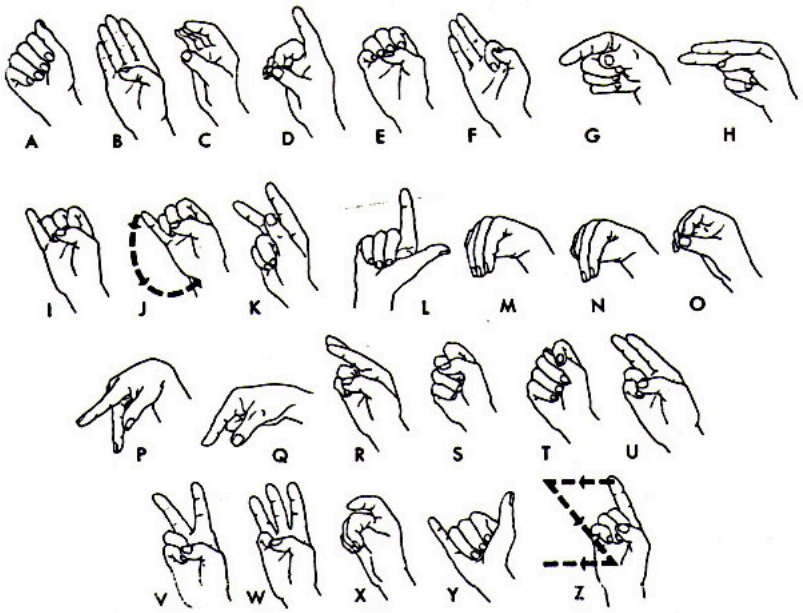
In a meta-analysis of 57 studies, Mayberry, del Giudice, & Lieberman (2010) found that phonological coding and awareness accounted for 11% of the variance in reading ability of severe to profoundly deaf participants. Several additional studies have supported the finding that phonological awareness (primarily measured in rhyming ability) and coding skills strongly relate to measures of reading achievement for DHH children (e.g., Colin, Magnan, Ecalle, & Leybaert, 2007; Dyer, MacSweeney, Szczerbinski, Green, & Campbell, 2003; Harris & Beech, 1998; Harris & Moreno, 2006; LaSasso, Crain, & Leybaert, 2003; see also Leybaert, 1993 for a review). Despite this robust relationship, it appears that the reduced auditory input available to DHH students may limit their development of phonological awareness skills, evidenced by numerous studies showing that hearing students outperform DHH peers on measures of phonological awareness and use of phonological coding (Colin et al., 2007; Dyer et al., 2003; Harris & Beech, 1998; Harris & Moreno, 2004; Miller, 1997; Miller, 2010).

Given the reduced auditory input available to DHH individuals, researchers have proposed that DHH children may rely on different forms of phonological codes in emergent and

early literacy. Such phonological codes include speech reading (Harris & Moreno, 2006; Kyle & Harris, 2010), cued speech (Colin et al., 2007; LaSasso et al., 2003), visual phonics (Guardino, Syverud, Joyner, Nicols, & King, 2011; Narr, 2008; Trezek & Wang, 2006), and fingerspelling (Alvarado, Puente, & Herrera, 2008; Haptonstall-Nykaza & Schick, 2007; Hirsh-Pasek, 1987; Puente, Alvarado, & Herrera, 2006).

Fingerspelling is an integral part of American Sign Language (ASL) and also a direct representation of the English alphabet, with each grapheme manually represented by a single, distinct handshape (figure 1).

Figure 1. Manual alphabet in American Sign Language



Similar to the production of spoken phonemes, fluent fingerspelling also undergoes coarticulation, with manual letters being influenced by the handshapes of both preceding and following letters (Jerde, Soechting, & Flanders, 2003; Wilcox, 1992). Fluent signers seem to perceive a fingerspelled word as a single lexical unit with a distinct contour of shapes (Padden, 1998; Padden, 2006). Padden (2006) goes on to suggest that young signers actually learn to fingerspell twice. They first acquire the skill of recognizing fingerspelled words as lexical units

with a movement of shapes, unaware that there is any connection to the alphabet or a written form. This begins at a very young age – attempts at fingerspelling have been seen in children as young as 13 months of age (Anderson & Reilly, 2002). The child then essentially learns to fingerspell a second time during the period of early literacy when the child discovers that fingerspelled words have internal linguistic patterns made up of handshapes corresponding to the English alphabet.

Fingerspelling has existed since the earliest filmed records of ASL in the early 1900s and continues to play a prominent role in ASL to this day (Padden, 1998). Analyzing 150-sign segments of 18 native signers, Padden & Gunsauls (2003) found that an average of 18% of words were fingerspelled, with some signers fingerspelling as much as 30-39%. Their study further revealed that the vast majority of fingerspelled words were nouns (70%) and very few were verbs (6%). Padden & Gunsauls (2003) point out that "in ASL the use of the manual alphabet is not simply to represent English words but also to borrow and represent *selectively*, that is, mostly nouns, with some representation of other vocabulary under highly constrained contexts" (p. 24). Fingerspelled words have been incorporated into the ASL lexicon in the form of "loan signs", in which certain common words are fingerspelled but look more sign-like with a larger prosodic envelope.

Fingerspelling represents more than just a letter-grapheme correspondence; *it is a phonological code with a cognitively stored linguistic representation*. Studies looking at short-term memory recall in DHH individuals have noted the use of fingerspelling as a strategy for rehearsing and coding (Lichtenstein, 1998; Locke & Locke, 1971).

A landmark study by Hirsh-Pasek (1987) explored the metalinguistic and phonological role of fingerspelling in congenitally deaf students who were native users of ASL. Participants

in the study were 26 students divided between an elementary group ages 5-11 years and a secondary group ages 13-16 years. Three experiments were conducted where a native user of ASL delivered the stimuli (fingerspelled words, loan signs, and signed sentences) that were presented on a video monitor. Results of the study confirm that deaf signers have the metalinguistic ability to attend to individual handshapes within fingerspelled words and that this ability relates to measures of initial reading achievement. The most complex of the first set of three experiments was a phoneme deletion task, which asked students to report the new word after a target letter was removed from either the initial, medial, or final position (e.g., remove *S* from *SEAT* and what's left? *EAT)*. Participants did surprisingly well with this task, answering correctly on average 88% of the time, with even the youngest elementary students responding with 78% accuracy. In a fourth experiment, Hirsh-Pasek conducted a training study and found that training in fingerspelling promotes word identification.

Puente, Alvarado, and Herrera (2006) adapted Hirsh-Pasek's study and looked at deaf Chilean students whose first language was Chilean Sign Language (CHSL). Participants in their study were able to recognize and store fingerspelled words successfully and then recall and write them down. Puente et al. concluded that fingerspelling is related to orthographic skills and can serve as an internal representation of words and supporting mechanism for reading acquisition. Furthermore, training deaf individuals in fingerspelling can increase these effects.

Similarly in a task conducted by Padden & Ramsey (2000), 31 DHH participants across four classrooms (two fourth-fifth grade, and two seventh-eighth grade) watched videotape of a signed sentence with one fingerspelled word and were asked a question to prompt them to write down the item that had been fingerspelled. This ability to mentally store a fingerspelled word in

the context of a sentence and then recall and write it down was positively correlated with reading achievement.

In a study of 21 profoundly deaf participants ages 4-14, Haptonstall-Nykaza and Schick (2007) compared a fingerspelling condition to a sign condition to assess which was the better facilitator of English decoding. They found that students scored higher on all tests when taught in the fingerspelled condition: 10% higher in their recognition of the printed word, 20% higher in their ability to write the word, and 28% higher in their ability to fingerspell the word. The authors concluded, "this study and others indicate that fingerspelling may help to provide a phonological link with print" (p. 181).

The phoneme deletion task conducted by Hirsh-Pasek (1987) was the first study to look directly at the relationship between fingerspelling and phonological awareness and very few have followed. The present study was designed to explore this relationship, using phonological awareness tasks in speech and adapted for fingerspelling, to look at the word internal knowledge of DHH students and their ability to manipulate the phonemic components of language through fingerspelling. Specifically, the following questions were explored:

1) Do DHH students perform differently on phonological awareness tasks when administered in a fingerspelled condition as compared with a spoken English condition?
2) Is fingerspelling ability a predictor of phonological awareness in the fingerspelling condition, vocabulary, and/or reading achievement?
3) Is phonological awareness in the fingerspelling condition a predictor of vocabulary and/or reading achievement?
4) When accounting for the variance in reading achievement, which is the stronger predictor between fingerspelling ability and phonological awareness?

Methods

Participants

Participants for this study were 10 DHH students (4 boys and 6 girls) in kindergarten through fourth grade with no reported disabilities of educational significance. Ages ranged from 5;3 to 10;0 years (M = 7.0; SD = 1.4). Nine of the students attended the same bilingual school for DHH students, where the mode of communication in the classrooms was ASL with English taught primarily through print. The tenth and oldest participant attended a center-based school for DHH students where the primary mode of communication was simultaneous sign and spoken communication (SimCom).

The school did not have audiograms for the majority of the students; however all students had a significant level of hearing loss in order to be placed in the schools they were attending. A measure of speech intelligibility was taken that related to the level of hearing loss. Given their severely limited auditory input, five of the students produced no spoken English. Four of the participants had at least one deaf parent (DoD) and had been exposed to ASL since birth. The remaining six participants had hearing parents (DoH) and the primary language in the home varied as either ASL, gestures, or spoken English. Table 1 shows the demographic information for each subject.

Table 1: Demographic information on the 10 participants

Subject number	Age	Grade	Gender	Speech (Y/N)	Parental hearing status	Home language
1	5;3	K	Female	Y	DoD	ASL
2	5;9	K	Female	N	DoH	ASL
3	5;11	K	Male	N	DoD	ASL
4	6;4	K	Male	Y	DoH	Spoken Eng/ASL
5	6;7	1st	Female	N	DoH	Limited sign
6	6;7	1st	Female	N	DoH	Limited sign
7	7;5	1st	Female	Y	DoD	ASL
8	7;8	2nd	Female	N	DoD	ASL
9	8;3	2nd	Male	Y	DoH	Spoken Eng/ASL
10	10;0	4th	Male	Y	DoH	Spoken Eng/ASL

DoD = deaf children with deaf parents; DoH = deaf children with hearing parents

Measures

Fingerspelling Ability. The measure of fingerspelling ability consisted of four brief tasks. Children were asked to fingerspell their own name, the alphabet, and a series of individual letters as was done in the Harris & Beech (1998) study. For the third task, fingerspelling twelve individual letters (R, E, Q, D, X, B, F, A, U, K, C, P), the letters were selected based on a range of difficulty of handshapes. In the final task, the participants were shown a series of twelve pictures of objects and asked to fingerspell the name for each. The pictures were selected according to common words children of all ages in the study would have learned and seen fingerspelled (see table 2). The words ranged in length with the majority consisting of 3-5 letters and the longest word (caterpillar) consisting of 11 letters. A number of the shorter words selected (e.g., bus) are also common loan signs in which the word is fingerspelled but looks more sign-like with a larger prosodic envelope. When fingerspelling the names of pictures, the children were first given the opportunity to do so on their own, and then were provided a model

and asked to repeat the fingerspelled word. The individual letters and pictures were displayed in PowerPoint on a laptop monitor.

Table 2: Names of pictures in fingerspelling task

Car	Sock
Sun	Cake
Bus	Fish
Dog	Skirt
Foot	Pencil
Bone	Caterpillar

The first task, fingerspelling the child's own name, was given a total weighting of 2 points. The second task, fingerspelling the alphabet, was weighted 0.5 points for each correct letter and 0.25 points for each correct letter in an incorrect position. For the final and most heavily weighted task, the error categories and scoring method were similar to that in the Haptonstall-Nykaza & Schick (2007) and Hile (2009) studies. Each accurate letter was given the value of one point. For each transposed letter, one point was given for the two letters. Similarly, if there was a correct letter in an incorrect position, it was assigned 0.5 points. As a final step, one point was deducted for each missing, substituted, or additional letter. Points assigned to each of the four tasks were summed and divided by the total possible points for a final percentage correct score.

Speech Intelligibility. Speech intelligibility was rated using the scale developed by Allen, Nikolopoulos, Dyar, & O'Donoghue (2001) for the evaluation of cochlear implantation in children (see Table 3). Harris & Moreno (2006) used the scale as a measure of speech intelligibility of deaf children, and their methods were followed for the present study. Teachers were first consulted regarding students who had no known useable speech and those students

were excluded from this task and automatically given a 1 on the speech intelligibility scale (no words can be recognized). For the remaining students, speech intelligibility was rated off-line first by the first author (who administered all testing), and then by an independent rater unfamiliar with the child, using video recordings from the first assessment session. If there was a discrepancy involving ratings 4 or 5, the rating of the inexperienced rater was used because these require intelligibility by all listeners, including those unfamiliar with the speech of the child.

Table 3: Speech Intelligibility Rating (Allen et al., 2001; Harris & Moreno, 2006)

Category	Speech Intelligibility Description
5	Connected speech is intelligible to all listeners. The child is understood easily in everyday contexts
4	Connected speech is intelligible to a listener who has had little experience of a deaf person's speech. The listener does not need to concentrate unduly
3	Connected speech is intelligible to a listener who concentrates and lip-reads within a known context
2	Connected speech is unintelligible. Intelligible speech is developing in single words when context and lip-reading cues are available
1	No words can be recognized

Phonological Awareness. In order to test phonological awareness, the author developed the Phonological Awareness Test for Deaf and Hard of Hearing (PAT-DHH), which consisted of four subtests. Each subtest has two parts – one to be administered in fingerspelling and the second to be administered in a spoken condition for those students who have some level of spoken English ability. Additionally two forms of the test (Form A and Form B) were created to allow for counterbalancing of results. The PAT-DHH Form A and B protocols are provided in Appendices A and B.

The first two subtests (alliteration and rhyming) assessed implicit phonological awareness skills and were modeled after materials from the Kyle & Harris (2006) study (originally

developed by Miller, 1997; and adapted for use by Harris & Beech, 1998). For each item, three pictures were displayed – the item at the top, and the target and distracter at the bottom. All words (including items, targets, and distracters) on the first two subtests were selected because they were rated as being acquired early (see norms from Morrison, Chappell, & Ellis, 1997) and of high frequency (Masterson, Stuart, Dixon, & Lovejoy, 2003) and high imageability. For each of the first two subtests, two practice items were provided with feedback to ensure proper understanding of the task. The first subtest required the child to make a judgment of alliteration (onset) similarity. For example, the item would be "doll", target word "door" and distracter "bone" and the student would identify which of the bottom two words started with the same sound as the top item. The second subtest required the child to make a judgment of rime similarity (i.e., which two words end with the same set of sounds). This subtest was developed such that one third of the trials contained items and targets that were phonologically and orthographically congruent (e.g., "fox" and "box"), one third that were only orthographically congruent (e.g., "five" and "give"), and one third that were only phonologically congruent (e.g., "door" and "four"). This was done to explore any potential differences among the types of rime in the fingerspelling versus spoken conditions.

The final two subtests of the PAT-DHH were adapted from the explicit phonological awareness subtests of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999) – elision and blending words. These subtests of the CTOPP are normed for hearing children ages 5 to 24. The primary adaptation to these subtests was that half of the stimuli would be presented with fingerspelling and the other half would be presented with speech; and the child would be asked to respond in the same manner. Students who were previously identified as not having useable speech were excluded from the spoken segments.

For the spoken portion of subtests 3 and 4, the administration instructions provided with the CTOPP were followed and given by the hearing examiner. Instructions were adapted for the fingerspelling portion of each of these subtests to be provided in ASL by a deaf native signer. For the fingerspelling portion of the elision subtest, instructions provided by the deaf native signer followed this model: "TOOTHBRUSH t-o-o-t-h-b-r-u-s-h. YOU FINGERSPELL. [*Pause*]. T-o-o-t-h-b-r-u-s-h [point first chunk] t-o-o-t-h TAKE AWAY, LEFT WHAT?" (Correct answer: *"b-r-u-s-h"*). For the fingerspelling portion of the blending words task, instructions provided by the deaf native signer followed this model: "CHUNK CHUNK – MOVE-TOGETHER, ONE WORD WHAT? C-a-n … d-y [*nod-forward with you gesture*]".

Figure 2: Screen shot of the blending words subtest video

Vocabulary. The *American Sign Language Vocabulary Test* (ASLVT; Schick, 1997) was administered to test vocabulary. This receptive vocabulary test has been used previously in DHH research and was modeled after the *Peabody Picture Vocabulary Test – Revised* (PPVT-R; Dunn & Dunn, 1981). Schick & Hoffmeister (2011) conducted a study of 98 deaf children, ages 4 to 8;0 years, in which both the ASLVT and the *Expressive One-Word Picture Vocabulary Test – Revised* (EOWPVT-R; Gardner, 1990) were administered. The ASLVT was shown to be a

valid and reliable instrument with strong inter-item correlation with the EOWPVT-R (.755, $p < .01$).

For each test item on the ASLVT, participants were shown a sign and asked to identify the corresponding picture on a page of four pictures. Foils on the ASLVT have been carefully designed to prevent any influence of iconicity in matching a sign to the correct picture, a problem that frequently arises when simply translating a test such as the PPVT-R into ASL.

Reading Achievement. As a measure of reading achievement, the *Developmental Reading Assessment, 2nd edition* (DRA2) scores were obtained from the schools for each of the participants. The DRA2 levels range from 1 to 44 with designated proficiency levels for the end of each grade level (see Table 4).

Table 4: DRA2 end of year proficiency levels

Grade Level	End of year DRA2 proficiency level
K	2
1st	16
2nd	28
3rd	38
4th	40
5th	44

Procedures

Testing for each participant was administered over two 30-minute sessions. For the younger children, breaks were incorporated between tasks as needed to play a brief bowling or ring toss game. The first session tested fingerspelling ability and phonological awareness in the fingerspelling condition; and the second session tested fingerspelling ability in the spoken condition and ASL vocabulary. Reading achievement data was obtained separately from the

school and rating of speech intelligibility was conducted off-line as described above. Testing took place in a small quiet room with one participant at a time. The author, who is hearing, fluent in ASL, and previously a sign language interpreter, was the examiner for all children in all sessions. For the explicit phonological awareness tasks in the fingerspelled condition, in which the level of fingerspelling was critical to the test, a deaf native signer provided all instructions and stimuli via video played on the examiner's laptop. The laptop was also used to present pictured items in PowerPoint for the fingerspelling task and the implicit phonological awareness tasks.

Results

Reliability of the PAT-DHH

The Phonological Awareness Test for Deaf and Hard of Hearing (PAT-DHH) was developed for the present study. The PAT-DHH is comprised of four subtests in each of two conditions: fingerspelling and spoken English. Internal consistency reliability for each of the subtests was calculated using Cronbach's alpha. Table 5 shows the internal consistency reliability using all cases combined (including items from both Form A and Form B). Appendix C includes reliability results when calculated for each form separately. As shown in the table below, all tasks were found to be statistically reliable because they were above the accepted criterion of .70, with the exception of subtest 1a (alliteration in the fingerspelled condition). The low internal consistency on this subtest may be attributed at least in part to a ceiling effect, as participants consistently scored correctly on items leaving little variability across participants. On Form A for this subtest, no participants missed more than 2 out of the 12 items, and the test of internal consistency reliability resulted in negative covariance.

Combining all subtests in the fingerspelling condition into one phonological awareness construct resulted in high internal consistency reliability of .944 and doing the same with the subtests in the spoken English condition resulted in reliability of .957. Subtests 1 and 2 comprised the implicit phonological awareness construct with a reliability of .833 in the fingerspelling condition (subtests 1a and 1b) and .887 in the spoken condition (subtests 1b and 2b). The remaining subtests comprised the explicit phonological awareness construct with a reliability of .821 in the fingerspelling condition (subtests 3a and 3b) and .947 in the spoken condition (subtests 3b and 4b).

Table 5: Internal consistency reliability of PAT-DHH

Subtest	Cronbach's alpha	N of items	N of Cases
PA (All F/S)	.944	50	10
Implicit PA (F/S 1a, 2a)	.833	30	10
Explicit PA (F/S 3a, 4a)	.960	20	10
1a Alliteration (F/S)	.553	12	10
2a Rhyming (F/S)	.821	18	10
3a Elision (F/S)	.943	10	10
4a Blending (F/S)	.907	10	10
PA (All Sp)	.957	50	5
Implicit PA (Sp 1b, 2b)	.887	30	5
Explicit PA (Sp 3b, 4b)	.947	20	5
1b Alliteration (Sp)	.809	12	5
2b Rhyming (Sp)	.732	18	5
3b Elision (Sp)	.936	10	5
4b Blending (Sp)	.893	10	5

PA = Phonological Awareness; F/S = Fingerspelling condition; Sp = Spoken English condition

Phonological awareness tasks in fingerspelling versus spoken English conditions

Paired sample t-tests were conducted for the implicit phonological awareness and explicit phonological awareness constructs and each of the corresponding subtests (alliteration, rhyme, elision, blending) to compare means in fingerspelling versus spoken English conditions. Each of the paired sample t-tests revealed no significant differences between the two conditions. Looking at individual performance, however, there was a trend particularly across explicit phonological awareness and corresponding tasks (elision, blending) that participants performed better across tasks *either* in the fingerspelling condition (participants 1, 7, 9, 10) or in the spoken English condition (participant 4). See tables 6 and 7 for individual performance across tasks.

Table 6: Individual performance across implicit phonological awareness tasks

Subject Number	Age	Allit (F/S)	Allit (Sp)	Rhyme (F/S)	Rhyme (Sp)	Implicit PA (F/S)	Implicit PA (Sp)
1	5;3	83	83	83	89*	83	87*
4	6;4	83	92*	89	94*	87*	83
7	7;5	100*	50	83*	67	90*	60
9	8;3	100	100	100*	94	100*	97
10	10;0	100	100	100	100	100	100

F/S = Fingerspelling condition; Sp = Spoken English condition; PA = Phonological Awareness
*Higher score between conditions
Note. Only participants with speech were able to complete spoken English condition tasks so the five participants with speech are shown here for comparisons between conditions

Table 7: Individual performance across explicit phonological awareness tasks

Subject Number	Age	Elision (F/S)	Elision (Sp)	Blending (F/S)	Blending (Sp)	Explicit PA (F/S)	Explicit PA (Sp)
1	5;3	30*	10	60*	50	45*	30
4	6;4	0	40*	0	80*	0	60*
7	7;5	20*	0	50*	0	35*	0
9	8;3	60*	40	70*	50	65*	45
10	10;0	100	100	100*	80	100*	90

F/S = Fingerspelling condition; Sp = Spoken English condition; PA = Phonological Awareness
*Higher score between conditions
Note. Only participants with speech were able to complete spoken English condition tasks so the five participants with speech are shown here for comparisons between conditions

Role of fingerspelling ability in relation to phonological awareness in fingerspelling, vocabulary, and reading achievement, with controls for background variables

Partial correlations were calculated to explore the relationship between fingerspelling ability and the other measured tasks (implicit and explicit phonological awareness in the fingerspelled condition, phonological awareness as a whole construct in the fingerspelled condition, vocabulary, and reading achievement), controlling for the effects of the two most significant background variables (age and speech ability; see table 8). The partial correlation matrix shows significant relationships between fingerspelling ability and all other measured tasks other than ASL vocabulary. Explicit phonological awareness in fingerspelling also correlated significantly with both ASL vocabulary and reading achievement. The measure of reading achievement interacted significantly with all other measured tasks, the strongest interaction being with the phonological awareness in fingerspelling construct.

Table 8: Partial correlation matrix (controlled for age and speech ability)

	F/S Ability	Implicit PA (F/S)	Explicit PA (F/S)	PA (F/S)	ASL VT	DRA2
F/S Ability	1.00					
Implicit PA (F/S)	.89** (p=.003)	1.00				
Explicit PA (F/S)	.81* (p=.016)	.65 (p=.079)	1.00			
PA (F/S)	.906** (p=.002)	.841** (p=.009)	.959*** (p=.000)	1.00		
ASL VT	.29 (p=.498)	.32 (p=.442)	.71* (p=.047)	.631 (p=.093)	1.00	
DRA2	.71* (p=.049)	.74* (p=.035)	.78* (p=.021)	.838** (p=.009)	.75* (p=.031)	1.00

F/S = Fingerspelling; PA = Phonological Awareness; ASL VT = measure of ASL vocabulary; DRA2 = measure of reading achievement
*p < .05; **p < .01; ***p < .001

In order to determine the predictive value of fingerspelling ability on each of the other four significantly correlated measures, a series of stepwise multiple regression analyses were performed. Results from the multiple regression analyses should be interpreted with caution given the limited sample size (N = 10). The results of the regression analyses are summarized in table 9. In each of the three models, fingerspelling ability was a significant predictor above and beyond age and speech ability. Fingerspelling ability predicted 30% of the variance of implicit phonological awareness in the fingerspelled condition (p = .003), 38% of the variance of explicit phonological awareness in the fingerspelled condition (p = .016), 41% of the variance of overall phonological awareness in the fingerspelled condition (p = .002), and 15% of the variance of reading achievement (p = .049).

Table 9: Multiple regression analysis for fingerspelling ability as a predictor of phonological awareness in fingerspelling and reading achievement

Variable	B	SE B	β	*p*	$R^2\Delta$
Implicit PA (F/S)					
Step 1					.61
Age	5.16	2.84	.46	.112	
Speech (Y/N)	14.97	7.58	.50	.089	
Step 2					.30
F/S Ability	.50	.11	.73	.003**	
Explicit PA (F/S)					
Step 1					.42
Age	17.47	7.85	.68	.061	
Speech (Y/N)	-9.35	20.95	-.14	.669	
Step 2					.38
F/S Ability	1.25	.38	.81	.016*	
Overall PA (F/S)					
Step 1					.50
Age	10.07	4.44	.65	.058	
Speech (Y/N)	55.37	11.85	.13	.664	
Step 2					.41
F/S Ability	.80	.15	.84	.002**	
DRA2					
Step 1					.71
Age	9.76	2.44	.87	.005**	
Speech (Y/N)	-2.54	6.52	-.09	.709	
Step 2					.15
F/S Ability	.34	.14	.50	.049*	

PA = Phonological Awareness; F/S = Fingerspelling
*p < .05; **p < .01

Role of phonological awareness in fingerspelling in relation to vocabulary and reading achievement, with controls for background variables

Referring back to the partial correlation matrix in table 8, the overall phonological awareness construct in the fingerspelled condition interacted significantly with the measure of reading achievement, but not with ASL vocabulary. Implicit phonological awareness in fingerspelling displayed similar interactions. Explicit phonological awareness in fingerspelling was the only phonological awareness construct in the fingerspelled condition to correlate significantly with both reading achievement and ASL vocabulary.

A series of stepwise multiple regression analyses were conducted to determine the predictive value of each of the phonological awareness in fingerspelling constructs on reading achievement. Given the significant correlation between explicit phonological awareness in fingerspelling and ASL vocabulary, this was also included in the analysis. The results of the regression analyses are summarized in table 10. Each of the phonological awareness constructs in the fingerspelled condition was a significant predictor of reading achievement, above and beyond age and speech ability. The overall phonological awareness construct in the fingerspelled condition predicted the greatest amount of variance of reading achievement (20%, $p = .009$). Explicit phonological awareness in fingerspelling, the only significant predictor of ASL vocabulary, predicted 23% of the variance of the vocabulary measure ($p = .047$).

Table 10: Multiple regression analyses for phonological awareness in fingerspelling as a predictor of reading achievement and ASL vocabulary

Variable	B	SE B	β	*p*	$R^2\Delta$
DRA2					
Step 1					.71
Age	9.76	2.44	.87	.005**	
Speech (Y/N)	-2.54	6.52	-.09	.709	
Step 2					.20
Overall PA (F/S)	.46	.12	.64	.009**	
Step 2					.16
Implicit PA (F/S)	.64	.24	.64	.035*	
Step 2					.18
Explicit PA (F/S)	.24	.08	.55	.021*	
ASL VT					
Step 1					.54
Age	6.07	2.11	.79	.024*	
Speech (Y/N)	-5.68	5.64	-.28	.348	
Step 2					.23
Explicit PA (F/S)	.19	.08	.64	.047*	

PA = Phonological Awareness; F/S = Fingerspelling
*p < .05; **p < .01

Comparison of fingerspelling ability and phonological awareness in fingerspelling as predictors of reading achievement

The next set of analyses explored the question: when accounting for the variance in reading achievement, which is the stronger predictor between fingerspelling ability and phonological awareness in the fingerspelled condition? To answer this, stepwise multiple regression analysis was again conducted, with fingerspelling ability and phonological awareness in fingerspelling entered as the predictor variables and reading achievement as the dependent variable (see table 11). Phonological awareness in fingerspelling was the only significant

predictor when entered second, predicting 19% of the variance of reading achievement, over and beyond fingerspelling ability (p = .031).

Table 11: Multiple regression analyses for fingerspelling ability and phonological awareness in fingerspelling as predictors of reading achievement

Variable	B	SE B	β	*p*	$R^2\Delta$
DRA2					
Step 1					.63
F/S Ability	.54	.15	.79	.006**	
Step 2					.19
Overall PA (F/S)	.94	.35	1.29	.031*	
DRA2					
Step 1					.80
Overall PA (F/S)	.65	.12	.89	.001***	
Step 2					.02
F/S Ability	-.29	.33	-.42	.409	

PA = Phonological Awareness; F/S = Fingerspelling
*p < .05; **p < .01; ***p < .001

Discussion

Perhaps most fundamentally, this study confirmed that children are able to demonstrate phonological awareness skills in a fingerspelled condition, even from as young as kindergarten, for all tasks. This skill appears to be developmental as there was a positive correlation between phonological awareness scores in the fingerspelled condition (particularly for explicit phonological awareness) and age.

A trend was seen especially with more advanced phonological awareness tasks (elision, blending) that participants performed better across tasks *either* in the fingerspelling condition or in the spoken English condition. Interestingly, students used both "sounding out" and "fingerspelling out" strategies. As an example of a typical “sounding out” strategy, subject 1 in

the spoken English condition sounded out /b/ to figure out the correct alliteration for 'bread'. The "fingerspelling out" strategy was seen by subject 9 in the fingerspelled condition when he held up "R" with each hand next to the pictures to show the rhyme for 'star' and 'car'. In the spoken English condition he made the observation that "tree doesn't have the y" when making the rhyme 'tree' and 'key'. In the spoken English condition subject 7 sometimes said the rhyming words aloud as you would expect, but at other times she reverted to fingerspelling to figure it out – for example, fingerspelling 'plaid' and 'braid' before responding that they rhymed.

The finding that some students performed better in the fingerspelling condition suggests that fingerspelling may serve as a valuable strategy for supporting DHH students in developing a sense of word internal structure, which for many of these students may be more difficult to establish through speech alone. It would be interesting in further research of a larger sample size to investigate the underlying factors leading students to rely primarily on sounding out or fingerspelling strategies. Potential contributors could be level of hearing loss, sign and/or fingerspelling ability, strategies emphasized in education, or even just individual variability.

One of the most compelling findings from this study was that the measure of phonological awareness in the fingerspelled condition predicted 20% of the variance of reading achievement. This is higher than in the Mayberry et al. (2010) study in which they found that phonological coding and awareness accounted for only 11% of the variance of reading proficiency in deaf students; however, the present study used a unique measure of phonological awareness through fingerspelling. The findings of the present study need to be interpreted with caution given the small sample size; however, it does give cause for further exploration of phonological awareness as being accessible through fingerspelling for DHH students, and its potential contributions to reading ability.

Not surprisingly, fingerspelling ability was a predictor of the phonological awareness constructs in the fingerspelled condition (predicting roughly one third or more of the variance). This is intuitive given the role of fingerspelling in performing the tasks. A more salient finding was that while both fingerspelling ability and phonological awareness in the fingerspelled condition were found to be predictors of reading ability, phonological awareness in fingerspelling was the stronger predictor of the two.

The Phonological Awareness Test for Deaf and Hard of Hearing (PAT-DHH) was developed for this study and it is the first test of its kind, designed to assess the range of implicit and explicit phonological awareness skills in both fingerspelling and spoken conditions. The PAT-DHH was found to have high internal consistency reliability for each of the phonological awareness constructs (implicit, explicit, and overall phonological awareness). Following some revisions (i.e., making the alliteration task more difficult, creating distracters that more closely resemble the target) and further testing of reliability and validity, the PAT-DHH has potential to be a useful tool in assessing the phonological awareness skills of DHH students, particularly for those who are exposed to sign language and fingerspelling in their educational setting.

In sum, fingerspelling has been proposed in previous studies as a phonological code available to DHH students and the present study affirms this role of fingerspelling, further indicating that it can be used both to assess phonological awareness and as a strategy available to DHH students for manipulating the phonological components of the English language (an ability that correlates with reading achievement). These findings support the use of fingerspelling in education programs for DHH students. Padden & Ramsey (2000) have observed that deaf teachers in residential schools make frequent use of chaining strategies in which fingerspelling, print, and signing are all linked together, reinforcing the commonality of a word between the

three modes. They found that the deaf teachers in residential schools used fingerspelling and chaining strategies much more than did teachers of DHH students in other settings. The findings of the present study support the potential value to such fingerspelling and chaining strategies.

In addition to replicating the present study with a larger sample size, further research should assess the role of fingerspelling in education and intervention for both phonological awareness and reading. Studies of reading programs supplemented with visual phonics have revealed improvements of phonological decoding skills of DHH children (Guardino et al., 2011). There is cause for a study to compare the effects of fingerspelling, visual phonics, and cued speech, to identify which strategy serves as the most effective phonological code for development of phonological awareness and potential contributions to reading ability.

Bibliography

Allen, C., Nikolopoulos, T.P., Dyar, D., & O'Donoghue, G.M. (2001). Reliability of a rating scale for measuring speech intelligibility after pediatric cochlear implantation. *Otology & Neurotology, 22*, 631-633.

Alvarado, J.M, Puente, A., & Herrara, V. (2008). Visual and phonological coding in working memory and orthographic skills of deaf children using Chilean Sign Language. *American Annals of the Deaf, 152*(5), 467-479.

Anderson, D., & Reilly, J. (2002). The MacArthur Communicative Development Inventory: normative data for American Sign Language. *Journal of Deaf Studies and Deaf Education, 7*(2), 83-106.

Colin, S., Magnan, A., Ecalle, J., & Leybaert, J. (2007). Relation between deaf children's phonological skills in kindergarten and word recognition performance in first grade. *Journal of Child Psychology and Psychiatry, 48*(2), 139-146.

Dunn, L., & Dunn, L. (1981). *Peabody Picture Vocabulary Test – Revised*. Circle Pines, MN: American Guidance Service.

Dyer, A., MacSweeney, M., Szczerbinski, M., Green, L., & Campbell, R. (2003). Predictors of reading delay in deaf adolescents: The relative contributions of rapid automatized naming speed and phonological awareness and decoding. *Journal of Deaf Studies and Deaf Education, 8*(3), 215-229.

Ezell, H.K., & Justice, L.M. (2005). *Shared Story Book Reading: Building young children's language and emergent literacy skills*. Baltimore, MD: Brookes.

Gardner, M.F. (1990). *Expressive One-Word Picture Vocabulary Test – Revised (EOWPVT-R)*. Los Angeles, CA: Western Psychological Services.

Guardino, C., Syverud, S.M., Joyner, A., Nicols, H., & King, S. (2011). Further evidence of the effectiveness of phonological instruction with oral-deaf readers. *American Annals of the Deaf, 155*(5), 562-568.

Haptonstall-Nykaza, T.S., & Schick, B. (2007). The transition from fingerspelling to English print: Facilitating English decoding. *Journal of Deaf Studies and Deaf Education, 12*(2), 172-183.

Harris, M., & Beech, J.R. (1998). Implicit phonological awareness and early reading development in prelingually deaf children. *Journal of Deaf Studies and Deaf Education, 3*(3), 205-216.

Harris, M., & Moreno, C. (2004). Deaf children's use of phonological coding: Evidence from reading, spelling, and working memory. *Journal of Deaf Studies and Deaf Education, 9*(3), 253-268.

Harris, M., & Moreno, C. (2006). Speech reading and learning to read: A comparison of 8-year-old profoundly deaf children with good and poor reading ability. *Journal of Deaf Studies and Deaf Education, 11*(2), 189-201.

Hile, A.E. (2009). *Deaf children's acquisition of novel fingerspelled words.* Unpublished doctoral dissertation. University of Colorado, Boulder, CO.

Hirsh-Pasek, K. (1987). The metalinguistics of fingerspelling: an alternate way to increase reading vocabulary in congenitally deaf readers. *Reading Research Quarterly, 22*(4), 455-474.

Jerde, T.E., Soechting, J.F., & Flanders, M. (2003). Coarticulation in fluent fingerspelling. *The Journal of Neuroscience, 23*(6), 2383-2393.

Kyle, F.E., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing school children. *Journal of Deaf Studies and Deaf Education, 11*(3), 273-288.

Kyle, F.E., & Harris, M. (2010). Predictors of reading development in deaf children: A 3-year longitudinal study. *Journal of Experimental Child Psychology, 107*, 229-243.

LaSasso, C., Crain, L., & Leybaert, J. (2003). Rhyme generation in deaf students: The effect of exposure to cued speech. *Journal of Deaf Studies and Deaf Education, 8*(3), 250-270.

Leybaert, J. (1993). Reading in the deaf: The roles of phonological codes. In M. Marschark & D. Clark (Eds.), *Psychological Perspectives on Deafness* (pp. 269-311). Hillsdale: Lawrence Erlbaum Associates.

Lichtenstein, E.H. (1998). The relationships between reading process and English skills of deaf college students. *Journal of Deaf Studies and Deaf Education, 3*(2), 80-134.

Locke, J.L., & Locke, V.L. (1971). Deaf children's phonetic, visual, an dactylic coding in a grapheme recall task. *Journal of Experimental Psychology, 89*(1), 142-146.

Marschark, M., Sapere, P., Convertino, C.M., Mayer, C., Wauters, L., & Sarchet, T. (2009). Are deaf students' reading challenges really about reading? *American Annals of the Deaf, 154*(4), 357-370.

Masterson, J., Stuart, M., Dixon, M., & Lovejoy, S. (2003). *Children's printed word database.* Available online: http://www.essex.ac.uk/psychology/cpwd/. Essex, UK: University of Essex.

Mayberry, R.I., del Giudice, A.A., & Lieberman, A.M. (2011). Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. *Journal of Deaf Studies and Deaf Education, 16*(2), 164-188.

Miller, P. (1997). The effect of communication mode on the development of phonemic awareness in prelingually deaf students. *Journal of Speech, Language, and Hearing Research, 40*, 1151-1163.

Miller, P. (2010). Phonological, orthographic, and syntactic awareness and their relation to reading comprehension in prelingually deaf individuals: What can we learn from skilled readers? *Journal of Developmental and Physical Disabilities, 22,* 549-580.

Morrison, C.M., Chappell, T.D., & Ellis, A.W. (1997). Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. *Quarterly Journal of Experimental Psychology, 50A*(3)*,* 528-559.

Narr, R. (2008). Phonological awareness and decoding in deaf/hard-of-hearing subjects who use visual phonics. *Journal of Deaf Studies and Deaf Education, 13*(3)*,* 405-416.

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction* (NIH Publication No. 00-4769). Washington, DC: U.S. Government Printing Office.

Padden, C.A. (1998). The ASL Lexicon. *Sign Language & Linguistics, 1*(1)*,* 39-60.

Padden, C.A. (2006). Learning to fingerspell twice: Young signing children's acquisition of fingerspelling. In B. Schick, M. Marschark, & P.E. Spencer (Eds.), *Advances in the Sign Language Development of Deaf Children* (pp. 189-201). New York, NY: Oxford University Press.

Padden, C.A., & Gunsauls, D.C. (2003). How the alphabet came to be used in a sign language. *Sign Language Studies, 4*(1), 10-33.

Padden, C.A., & Ramsey, C. (2000). American sign language and reading ability in deaf children. In C. Chamberlain, J.P. Morford, & R.I. Mayberry (Eds.), *Language Acquisition by Eye* (pp. 165-189). Mahway, NJ: Lawrence Erlbaum Associates, Inc.

Paul, R (2007). Intervention for developing language. In *Language Disorders: From infancy through adolescence* (3rd ed.) (pp. 383-426). St. Louis: Mosby Elsevier.

Puente, A., Alvarado, J.M., & Herrera, V. (2006). Fingerspelling and sign language as alternative codes for reading and writing words for Chilean deaf signers. *American Annals of the Deaf, 151*(3), 299-310.

Schick, B. (1997). *The American Sign Language Vocabulary Test*. Boulder, CO: University of Colorado at Boulder.

Schick, B., & Hoffmeister, R. (2011). *Going native: ASL skills in deaf children with deaf and hearing parents*. Unpublished manuscript.

Schuele, C.M., & Boudreau, D. (2008). Phonological awareness intervention: beyond the basics. *Language, Speech, and Hearing Services in Schools, 39,* 3-20.

Traxler, C.B. (2000). The Stanford Achievement Test, 9th edition: National norming and performance standards for deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education, 5*(4), 337-348.

Trezek, B., & Wang, Y. (2006). Implications of utilizing a phonics-based reading curriculum with children who are deaf or hard of hearing. *Journal of Deaf Studies and Deaf Education, 11*(2), 202-213.

Wagner, R.K., & Torgesen, J.K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*(2), 192-212.

Wagner, R.K., Torgesen, J.K., & Rashotte, C.A. (1999). *Comprehensive Test of Phonological Processing (CTOPP)*. Austin, TX: Pro-Ed, Inc.

Wilcox, S. (1992). *The Phonetics of Fingerspelling.* Amsterdam: John Benjamins Publishing Company.

Appendix A

Phonological Awareness Test for Deaf and Hard of Hearing
PAT-DHH

- Form A -

Subtest 1a. Alliteration - Fingerspelling

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "PICTURES [CL: 3 pictures]. WORD CL:WORD [point to first part of word] FIRST CL:CHUNK FIGURE-OUT SAME-AS WHICH?" Point to each of the 3 pictures and fingerspell. "FIRST LETTER SAME-AS SAME-AS WHICH? THINK-CAREFULLY [Fingerspell item-target. Fingerspell item-distractor]. "WHICH?"

For test items, fingerspell each picture and ask "FIRST LETTER SAME-AS SAME-AS WHICH?"

Feedback:

If correct: "RIGHT! [Fingerspell Item. Fingerspell Target.] SAME-AS. FIRST LETTER [Fingerspell first letter in neutral space, then next to both pictures. Fingerspell Item. Fingerspell Target].

If incorrect: "THINK-CAREFULLY. [Fingerspell each picture followed by initial letter]. SAME-AS SAME-AS WHICH?" [Allow child response then provide correct answer]. "SAME-AS [indicate item and target are same]. FIRST LETTER [fingerspell first letter]."

			Score (1/0)
A.	Horse	Brown / **House**	PRACTICE
B.	Leg	**Leaf** / Ant	PRACTICE
1.	Nest	Rain / **Nurse**	_____
2.	Doll	**Door** / Bone	_____
3.	Goat	Coat / **Ghost**	_____
4.	Bat	**Bag** / Man	_____
5.	Hat	Fork / **Hand**	_____
6.	Pink	Six / **Pig**	_____
7.	Watch	**Wall** / Belt	_____
8.	Fish	Cup / **Fire**	_____
9.	Cap	Light / **Cap**	_____
10.	Bread	**Brush** / Car	_____
11.	Tail	**Tie** / Bear	_____
12.	Soap	**Sock** / Frog	_____

Subtest 1b. Alliteration – Spoken English

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "We are going to think about beginning sounds to see which words start with the same sound." Point to each of the 3 pictures and provide word. "Which one of these [point to target and distractor] begins with the same sound as [point to and say item]? Think carefully. [Say each pair: item-target? Item-distractor?] Which one begins with the same sound as [item]?"

For test items, label each picture and ask which begin with the same sound.

Feedback:

If correct: "That's right! [Item] and [target] both start with the sound [provide first sound, then say item and target again]."

If incorrect: "Think carefully. [Say each picture followed by initial sound]. Which one has the same sound as [item]? [Allow child response then provide correct answer]. These have the same beginning sound [indicate item and target are same]. The first sound is [provide first sound].

		Score (1/0)
A. Moon	**Mouse** / Box	PRACTICE
B. Dog	Ring / **Deer**	PRACTICE
1. Nose	**Nail** / Bath	_____
2. Desk	Ball / **Duck**	_____
3. Gate	Red / **Gum**	_____
4. Book	**Boat** / Star	_____
5. Hair	Key / **Heart**	_____
6. Pen	**Pear** / Ship	_____
7. Wing	**Web** / Cake	_____
8. Four	Green / **Foot**	_____
9. Comb	**Cow** / Flag	_____
10. Dress	**Drum** / Well	_____
11. Two	**Toy** / Bed	_____
12. Sun	Whale / **Sick**	_____

Subtest 2a. Rhyming – Fingerspelling

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "NOW WORD CL:WORD [point to last part of word] LAST CL:CHUNK FIGURE-OUT SAME-AS WHICH?" Point to each of the 3 pictures and fingerspell. "LAST LETTER SAME-AS SAME-AS WHICH? THINK-CAREFULLY [Fingerspell item-target. Fingerspell item-distractor]. "WHICH?"

For test items, fingerspell each picture and ask "FINAL LETTER SAME-AS SAME-AS WHICH?"

Feedback:

If correct: "RIGHT! [Fingerspell Item. Fingerspell Target.] SAME-AS. LAST LETTER [Fingerspell last letter in neutral space, then next to both pictures. Fingerspell Item. Fingerspell Target].

If incorrect: "THINK-CAREFULLY. [Fingerspell each picture followed by final letter]. SAME-AS SAME-AS WHICH?" [Allow child response then provide correct answer]. "SAME-AS [indicate item and target are same]. LAST LETTER [fingerspell last letter]."

		Score (1/0)
A. Pear	**Hair** / Three	PRACTICE
B. Flag	Nose / **Bag**	PRACTICE
1. Moon	**Spoon** / Bowl	_____
2. Sock	**Clock** / Gum	_____
3. Train	**Rain** / Book	_____
4. Fox	Bath / **Box**	_____
5. Goat	Wing / **Boat**	_____
6. Nail	Deer / **Tail**	_____
7. Bear	**Ear** / Web	_____
8. Bow	Tie / **Cow**	_____
9. Five	**Give** / Toy	_____
10. Deaf	Six / **Leaf**	_____
11. Snow	**Bow** / Fire	_____
12. Stove	**Glove** / Desk	_____
13. Door	Green / **Four**	_____
14. Leg	Sun / **Egg**	_____
15. Blow	**Sew** / Ship	_____
16. Cloud	**Crowd** / Light	_____
17. Shoe	Soap / **Blue**	_____
18. Head	**Bed** / Pen	_____

Subtest 2b. Rhyming – Spoken English

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "Now we are going to think about final sounds to see which words end with the same sound." Point to each of the 3 pictures and provide word. "Which one of these [point to target and distractor] ends with the same sound as [point to and say item]? Think carefully. [Say each pair: item-target? Item-distractor?] Which one ends with the same sound as [item]?"

For test items, label each picture and ask which end with the same sound.

Feedback:

If correct: "That's right! [Item] and [target] both end with the sound [provide final sound, then say item and target again]."

If incorrect: "Think carefully. [Say each picture followed by final sound]. Which one has the same sound as [item]? [Allow child response then provide correct answer]. These have the same ending sound [indicate item and target are same]. The last sound is [provide final sound].

			Score (1/0)
A.	Frog	Ball / **Dog**	PRACTICE
B.	Toe	**Mow** / Cup	PRACTICE
1.	Mouse	Hat / **House**	_____
2.	Star	**Car** / Sick	_____
3.	Ring	**King** / Coat	_____
4.	Bee	**Knee** / Watch	_____
5.	Cat	Fork / **Bat**	_____
6.	Shell	Ant / **Bell**	_____
7.	Comb	**Home** / Arm	_____
8.	Steak	Red / **Cake**	_____
9.	Snail	Duck / **Whale**	_____
10.	Break	**Snake** / Pig	_____
11.	Tree	**Key** / Heart	_____
12.	Eye	Pink / **Fly**	_____
13.	Boot	Wall / **Foot**	_____
14.	Bread	Belt / **Bead**	_____
15.	Have	**Cave** / Two	_____
16.	Bone	**One** / Drum	_____
17.	Plaid	Man / **Braid**	_____
18.	Roll	**Doll** / Cap	_____

Subtest 3a. Elision - Fingerspelling

Basal: Item 1
Ceiling: Discontinue if miss all practice items.
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0. Check whether child was able to completely fingerspell (F/S) the item.

Directions:
"BOTH-OF-US PLAY WORD GAME. YOU WATCH I ASK-YOU. READY?" Play all stimuli on laptop.

Feedback:
If correct: "RIGHT! NEXT."

If incorrect: "SO-SO. *T-o-o-t-h-b-r-u-s-h* TAKE-AWAY *t-o-o-t-h*, LEFT *b-r-u-s-h*."

ITEM	TAKE AWAY	CORRECT	F/S?	Score (1/0)
A. toothbrush	-tooth	brush	_____	PRACTICE
B. airplane	-plane	air	_____	PRACTICE
1. popcorn	-corn	pop	_____	_____
3. spider	-der	spi	_____	_____
E. cup	-c	up	_____	PRACTICE
F. meet	-t	me, mee	_____	PRACTICE
5. bold	-b	old	_____	_____
7. tan	-t	an	_____	_____
9. time	-m	tie	_____	_____
11. powder	-d	power	_____	_____
13. winter	-t	winer, winner	_____	_____
15. sling	-l	sing	_____	_____
18. flame	-f	lame	_____	_____
19. strain	-r	stain	_____	_____

Subtest 3b. Elision – Spoken English

Basal: Item 1
Ceiling: Discontinue if miss all practice items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0. Check whether child was able to completely say the item.

Directions:
"Let's play a word game."
"Say [item]. Now say [item] without saying [take away].

Feedback:
If correct: "That's right! Let's try the next one."

If incorrect: "That's not quite right. [Item] without saying [take away] is [correct].

ITEM	TAKE AWAY	CORRECT	Score (1/0)
C. doughnut	-dough	nut	PRACTICE
D. snowman	-snow	man	PRACTICE
2. baseball	-base	ball	_____
4. hotdog	-hot	dog	_____
G. cup	-/k/	up	PRACTICE
H. meet	-/t/	me, mee	PRACTICE
6. mat	-/m/	at	_____
8. mike	-/k/	my	_____
10. tiger	-/g/	tire	_____
12. driver	-/v/	drier	_____
14. faster	-/s/	fatter	_____
16. snail	-/n/	sail	_____
17. silk	-/l/	sick	_____
20. split	-/p/	slit	_____

Subtest 4a. Blending Words - Fingerspelling

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"LAPTOP WATCH. WILL SEE WORDS FINGRSPELLED CHUNK CHUNK CHUNK. YOU DO-DO? WATCH-CAREFULLY CHUNK CHUNK CHUNK – MOVE-TOGETHER, ONE WORD. READY? GO-AHEAD." Play all stimuli on laptop.

Feedback:

If correct: "RIGHT! NEXT."

If incorrect: "SO-SO. *Can – dy* CHUNK CHUNK – MOVE-TOGETHER, ONE WORD *C-a-n-d-y* CANDY. YOUR-TURN: *Can – dy* CHUNKS-MOVE-TOGETHER, WHAT? NEXT."

ITEM	**CORRECT**	**Score (1/0)**
A. can - dy	candy	PRACTICE
C. s - un	sun	PRACTICE
E. n – o	no	PRACTICE
G. m – a – d	mad	PRACTICE
1. num – ber	number	_____
3. an – swer	answer	_____
5. t – oy	toy	_____
7. sh – e	she	_____
9. m – i – ss	miss	_____
11. m – oo – n	moon	_____
13. j – u – m – p	jump	_____
15. c – ir – c – u – s	circus	_____
17. g–r–a–ss–h–o–pp–e–r	grasshopper	_____
19. u–n–d–er–s–t–a–n–d	understand	_____

Subtest 4b. Blending Words – Spoken English

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"I will say some words in small parts, one part at a time. I want you to listen carefully, and then put these parts together to make a whole word. Ready? Let's try one."
For practice words ask, "What do these sounds make? Can – dy." For test items just provide the stimulus.

Feedback:

If correct: "That's right! Let's try the next one."

If incorrect: "That's not quite right. When you put [item] together, it makes [correct]. You try it: [item] makes _____?" "Let's try the next one."

ITEM	CORRECT	Score (1/0)
B. hamm - er	hammer	PRACTICE
D. t - ake	take	PRACTICE
F. h – i	hi	PRACTICE
H. b – a – d	bad	PRACTICE
2. num – ber	number	_____
4. pen – cil	pencil	_____
6. s – aw	saw	_____
8. n – ap	nap	_____
10. b – o – ne	bone	_____
12. s – t – a – m – p	stamp	_____
14. m – i – s – t – a – k – e	mistake	_____
16. a – l – m – o – s – t	almost	_____
18. t – e – s – t – i – f – y	testify	_____
20. m–a–th–e–m–a–t–i–c–s	mathematics	_____

Appendix B

Phonological Awareness Test for Deaf and Hard of Hearing
PAT-DHH

- Form B -

Subtest 1a. Alliteration - Fingerspelling

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "PICTURES [CL: 3 pictures]. WORD CL:WORD [point to first part of word] FIRST CL:CHUNK FIGURE-OUT SAME-AS WHICH?" Point to each of the 3 pictures and fingerspell. "FIRST LETTER SAME-AS SAME-AS WHICH? THINK-CAREFULLY [Fingerspell item-target. Fingerspell item-distractor]. "WHICH?"

For test items, fingerspell each picture and ask "FIRST LETTER SAME-AS SAME-AS WHICH?"

Feedback:

If correct: "RIGHT! [Fingerspell Item. Fingerspell Target.] SAME-AS. FIRST LETTER [Fingerspell first letter in neutral space, then next to both pictures. Fingerspell Item. Fingerspell Target].

If incorrect: "THINK-CAREFULLY. [Fingerspell each picture followed by initial letter]. SAME-AS SAME-AS WHICH?" [Allow child response then provide correct answer]. "SAME-AS [indicate item and target are same]. FIRST LETTER [fingerspell first letter]."

			Score (1/0)
A.	Horse	Brown / **House**	PRACTICE
B.	Leg	**Leaf** / Ant	PRACTICE
1.	Nose	**Nail** / Bath	_____
2.	Desk	Ball / **Duck**	_____
3.	Gate	Red / **Gum**	_____
4.	Book	**Boat** / Star	_____
5.	Hair	Key / **Heart**	_____
6.	Pen	**Pear** / Ship	_____
7.	Wing	**Web** / Cake	_____
8.	Four	Green / **Foot**	_____
9.	Comb	**Cow** / Flag	_____
10.	Dress	**Drum** / Well	_____
11.	Two	**Toy** / Bed	_____
12.	Sun	Whale / **Sick**	_____

Subtest 1b. Alliteration – Spoken English

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "We are going to think about beginning sounds to see which words start with the same sound." Point to each of the 3 pictures and provide word. "Which one of these [point to target and distractor] begins with the same sound as [point to and say item]? Think carefully. [Say each pair: item-target? Item-distractor?] Which one begins with the same sound as [item]?"

For test items, label each picture and ask which begin with the same sound.

Feedback:

If correct: "That's right! [Item] and [target] both start with the sound [provide first sound, then say item and target again]."

If incorrect: "Think carefully. [Say each picture followed by initial sound]. Which one has the same sound as [item]? [Allow child response then provide correct answer]. These have the same beginning sound [indicate item and target are same]. The first sound is [provide first sound].

		Score (1/0)
A. Moon	**Mouse**/ Box	PRACTICE
B. Dog	Ring / **Deer**	PRACTICE
1. Nest	Rain / **Nurse**	_____
2. Doll	**Door** / Bone	_____
3. Goat	Coat / **Ghost**	_____
4. Bat	**Bag** / Man	_____
5. Hat	Fork / **Hand**	_____
6. Pink	Six / **Pig**	_____
7. Watch	**Wall** / Belt	_____
8. Fish	Cup / **Fire**	_____
9. Cap	Light / **Cat**	_____
10. Bread	**Brush** / Car	_____
11. Tail	**Tie** / Bear	_____
12. Soap	**Sock** / Frog	_____

Subtest 2a. Rhyming – Fingerspelling

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "NOW WORD CL:WORD [point to last part of word] LAST CL:CHUNK FIGURE-OUT SAME-AS WHICH?" Point to each of the 3 pictures and fingerspell. "LAST LETTER SAME-AS SAME-AS WHICH? THINK-CAREFULLY [Fingerspell item-target. Fingerspell item-distractor]. "WHICH?"

For test items, fingerspell each picture and ask "FINAL LETTER SAME-AS SAME-AS WHICH?"

Feedback:

If correct: "RIGHT! [Fingerspell Item. Fingerspell Target.] SAME-AS. LAST LETTER [Fingerspell last letter in neutral space, then next to both pictures. Fingerspell Item. Fingerspell Target].

If incorrect: "THINK-CAREFULLY. [Fingerspell each picture followed by final letter]. SAME-AS SAME-AS WHICH?" [Allow child response then provide correct answer]. "SAME-AS [indicate item and target are same]. LAST LETTER [fingerspell last letter]."

		Score (1/0)
A. Pear	**Hair** / Three	PRACTICE
B. Flag	Nose / **Bag**	PRACTICE
1. Mouse	Hat / **House**	_____
2. Star	**Car** / Sick	_____
3. Ring	**King** / Coat	_____
4. Bee	**Knee** / Watch	_____
5. Cat	Fork / **Bat**	_____
6. Shell	Ant / **Bell**	_____
7. Boot	Wall / **Foot**	_____
8. Bread	Belt / **Bead**	_____
9. Have	**Cave** / Two	_____
10. Bone	**One** / Drum	_____
11. Plaid	Man / **Braid**	_____
12. Roll	**Doll** / Cap	_____
13. Door	Green / **Four**	_____
14. Leg	Sun / **Egg**	_____
15. Blow	**Sew** / Ship	_____
16. Cloud	**Crowd** / Light	_____
17. Shoe	Soap / **Blue**	_____
18. Head	**Bed** / Pen	_____

Subtest 2b. Rhyming – Spoken English

Basal: Item 1
Ceiling: Administer all items
Feedback: Provide feedback on practice items A and B only
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
Show Practice Item A. "Now we are going to think about final sounds to see which words end with the same sound." Point to each of the 3 pictures and provide word. "Which one of these [point to target and distractor] ends with the same sound as [point to and say item]? Think carefully. [Say each pair: item-target? Item-distractor?] Which one ends with the same sound as [item]?"

For test items, label each picture and ask which end with the same sound.

Feedback:

If correct: "That's right! [Item] and [target] both end with the sound [provide final sound, then say item and target again]."

If incorrect: "Think carefully. [Say each picture followed by final sound]. Which one has the same sound as [item]? [Allow child response then provide correct answer]. These have the same ending sound [indicate item and target are same]. The last sound is [provide final sound].

			Score (1/0)
A.	Frog	Ball / **Dog**	PRACTICE
B.	Toe	**Mow** / Cup	PRACTICE
1.	Moon	**Spoon** / Bowl	_____
2.	Sock	**Clock** / Gum	_____
3.	Train	**Rain** / Book	_____
4.	Fox	Bath / **Box**	_____
5.	Goat	Wing / **Boat**	_____
6.	Nail	Deer / **Tail**	_____
7.	Comb	**Home** / Arm	_____
8.	Steak	Red / **Cake**	_____
9.	Snail	Duck / **Whale**	_____
10.	Break	**Snake** / Pig	_____
11.	Tree	**Key** / Heart	_____
12.	Eye	Pink / **Fly**	_____
13.	Bear	**Ear** / Web	_____
14.	Bow	Tie / **Cow**	_____
15.	Five	**Give** / Toy	_____
16.	Deaf	Six / **Leaf**	_____
17.	Snow	**Bow** / Fire	_____
18.	Stove	**Glove** / Desk	_____

Subtest 3a. Elision - Fingerspelling

Basal: Item 1
Ceiling: Discontinue if miss all practice items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"BOTH-OF-US PLAY WORD GAME. YOU WATCH I ASK-YOU. READY?" Play all stimuli on laptop.

Feedback:
If correct: "RIGHT! NEXT."

If incorrect: "SO-SO. *T-o-o-t-h-b-r-u-s-h* TAKE-AWAY *t-o-o-t-h*, LEFT *b-r-u-s-h*."

ITEM	TAKE AWAY	CORRECT	F/S?	Score (1/0)
C. doughnut	-dough	nut	_____	PRACTICE
D. snowman	-snow	man	_____	PRACTICE
2. baseball	-base	ball	_____	_____
4. hotdog	-hot	dog	_____	_____
G. farm	-f	arm	_____	PRACTICE
H. bead	-d	be, bea	_____	PRACTICE
6. mat	-m	at	_____	_____
7. tan	-t	an	_____	_____
10. tiger	-g	tire	_____	_____
12. driver	-v	drier	_____	_____
14. faster	-s	fater, fatter	_____	_____
16. snail	-n	sail	_____	_____
18. flame	-f	lame	_____	_____
20. split	-p	slit	_____	_____

Subtest 3b. Elision – Spoken English

Basal: Item 1
Ceiling: Discontinue if miss all practice items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"Let's play a word game."
"Say [item]. Now say [item] without saying [take away].

Feedback:
If correct: "That's right! Let's try the next one."

If incorrect: "That's not quite right. [Item] without saying [take away] is [correct].

ITEM	TAKE AWAY	CORRECT	Score (1/0)
A. toothbrush	-tooth	brush	PRACTICE
B. airplane	-plane	air	PRACTICE
1. popcorn	-corn	pop	_____
3. spider	-der	spi	_____
E. cup	-/k/	up	PRACTICE
F. meet	-/t/	me, mee	PRACTICE
5. bold	-/b/	old	_____
8. mike	-/k/	my	_____
9. time	-/m/	tie	_____
11. powder	-/d/	power	_____
13. winter	-/t/	winer, winner	_____
15. sling	-/l/	sing	_____
17. silk	-/l/	sick	_____
19. strain	-/r/	stain	_____

Subtest 4a. Blending Words - Fingerspelling

Basal: Item 1
Ceiling: Discontinue if miss all practice items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"LAPTOP WATCH. WILL SEE WORDS FINGRSPELLED CHUNK CHUNK CHUNK. YOU DO-DO? WATCH-CAREFULLY CHUNK CHUNK CHUNK – MOVE-TOGETHER, ONE WORD. READY? GO-AHEAD." Play all stimuli on laptop.

Feedback:

If correct: "RIGHT! NEXT."

If incorrect: "SO-SO. *Can – dy* CHUNK CHUNK – MOVE-TOGETHER, ONE WORD *C-a-n-d-y* CANDY. YOUR-TURN: *Can – dy* CHUNKS-MOVE-TOGETHER, WHAT? NEXT."

ITEM	**CORRECT**	**Score (1/0)**
B. hamm - er	hammer	PRACTICE
D. t - ake	take	PRACTICE
F. h – i	hi	PRACTICE
H. b – a – d	bad	PRACTICE
2. pen – cil	pencil	_____
4. i – t	it	_____
6. s – aw	saw	_____
8. n – ap	nap	_____
10. b – o – ne	bone	_____
12. s – t – a – m – p	stamp	_____
14. m – i – s – t – a – k – e	mistake	_____
16. a – l – m – o – s – t	almost	_____
18. t – e – s – t – i – f – y	testify	_____
20. m–a–th–e–m–a–t–i– c–s	mathematics	_____

Subtest 4b. Blending Words – Spoken English

Basal: Item 1
Ceiling: Discontinue if miss all practice items
Feedback: Provide feedback on practice items A-H and test items 1-6
Scoring: Record correct responses as 1 and incorrect responses as 0.

Directions:
"I will say some words in small parts, one part at a time. I want you to listen carefully, and then put these parts together to make a whole word. Ready? Let's try one."
For practice words ask, "What do these sounds make? Can – dy." For test items just provide the stimulus.

Feedback:

If correct: "That's right! Let's try the next one."

If incorrect: "That's not quite right. When you put [item] together, it makes [correct]. You try it: [item] makes _____?" "Let's try the next one."

ITEM	CORRECT	Score (1/0)
A. can - dy	candy	PRACTICE
C. s - un	sun	PRACTICE
E. n – o	no	PRACTICE
G. m – a – d	mad	PRACTICE
1. num – ber	number	_____
3. an – swer	answer	_____
5. t – oy	toy	_____
7. sh – e	she	_____
9. m – i – ss	miss	_____
11. m – oo – n	moon	_____
13. j – u – m – p	jump	_____
15. c – ir – c – u – s	circus	_____
17. g–r–a–ss–h–o–pp–er	grasshopper	_____
19. u–n–d–er–s–t–a–n–d	understand	_____

Appendix C

Internal Consistency Reliability of PAT-DHH

Subtest	Form	Cronbach's alpha	N of items	N of Cases
PA (All F/S)	A&B	.944	50	10
	A	.943	50	5
	B	.956	50	5
Implicit PA (F/S 1a, 2a)	A&B	.833	30	10
	A	.750	30	5
	B	.905	30	5
Explicit PA (F/S 3a, 4a)	A&B	.960	20	10
	A	.967	20	5
	B	.963	20	5
1a Alliteration (F/S)	A&B	.553	12	10
	A	-6.201E-14	12	5
	B	.649	12	5
2a Rhyming (F/S)	A&B	.821	18	10
	A	.770	18	5
	B	.873	18	5
3a Elision (F/S)	A&B	.943	10	10
	A	.956	10	5
	B	.943	10	5
4a Blending (F/S)	A&B	.907	10	10
	A	.932	10	5
	B	.905	10	5
PA (All Sp)*	A&B	.957	50	5
Implicit PA (Sp 1b, 2b)*	A&B	.887	30	5
Explicit PA (Sp 3b, 4b)*	A&B	.947	20	5
1b Alliteration (Sp)*	A&B	.809	12	5
2b Rhyming (Sp)*	A&B	.732	18	5
3b Elision (Sp)*	A&B	.936	10	5
4b Blending (Sp)*	A&B	.893	10	5

PA = Phonological Awareness; F/S = Fingerspelling condition; Sp = Spoken English condition

*Reliability for tasks in the Spoken English condition was not calculated separately for each of the forms given the limited number of subjects