EXPLORING THE RELATIONSHIP BETWEEN ORAL AND ORTHOGRAPHIC SKILLS IN DEAF INDIVIDUALS

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By

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Abstract

This study examines the relationship between speech production skills and orthographic skills in deaf readers using behavioral indices of word form processing. The Reicher-Wheeler forced-choiced paradigm was used to measure the word and pseudoword superiority effects, which are considered to be measures of familiarity with specific words in a language and familiarity with the orthographic rules of a language, respectively. Eleven deaf individuals took part in this study. Participants completed a background questionnaire, the Reicher-Wheeler task, a pronunciation task and several other measures of phonological and orthographic awareness. The scores from these tasks were correlated in order to determine the degree of relationship that exists between oral and orthographic systems. Results indicate that a well developed speech production system is not necessary for the development of a sophisticated orthographic system. Implications for reading education of deaf individuals are discussed.

INTRODUCTION

Learning to read is one of the most important tasks that children are required to face during their first few years of schooling. With a national literacy rate of 97%, the ability to read is a crucial component of success in our modern society (CIA: World Fact Book, 2005). According to Adams (1990), the normally developing child learns to read by matching the known sounds of the language to the visual forms of letters and words. However, children who are deaf or hard of hearing have a significant disadvantage, as they are not able to use the sounds of language to facilitate reading development. In fact, most deaf individuals read at about a third or fourth grade level (Leybaert, 2000).

Much of the research on reading in the deaf has focused on phonology (e.g., Dyer, MacSweeney, Szczerbinski, Green, & Campbell, 2003; Hanson & Fowler, 1987). The purpose of this study is to investigate word recognition, in particular word form processes, in deaf participants and the contribution of oral skills, a precursor of phonology, to word form mechanisms. Evidence will be reviewed on how individuals process letters and combinations of letters to recognize words and word-like forms according to the rules of their language. Next, research on the role of phonology (the speech sounds of a language with reference to tacit rules governing pronunciation) on the development of orthography (the arrangement of letters into word-like forms based on specific combinatorial rules), and the possible contribution of oral skills, will be discussed. Finally, the present study will be introduced.

Stages of Word Recognition

Most research on word recognition suggests a three-level model (see Grainger & Jacobs, 1994, for a review). The first level of the model consists of analysis of the salient features of letters, such as lines, curves and angles. In the second stage, individual letters and their positions are identified regardless of case, font and physical size. The third level involves the identification of the word form. It is at this level that letter combinations and orthographic regularities are computed. Correspondences between representations in long-term memory (i.e., lexicon) and the whole form of the word facilitate retrieval of further information about word meaning (semantics), morphological and grammatical specifications, and sound (phonology; Grossi & Coch, 2005). Although different reading models disagree on the specific implementation of these stages (e.g., Jacobs & Grainger, 1994; Grainger & Dijkstra, 1996; Perea & Lupker, 2003), experimental evidence from both normal and brain-lesioned (i.e., dyslexic and alexic) individuals supports the existence of these three levels of representation (Grossi & Coch, 2005).

Neuroimaging data have identified some of the brain regions involved in word form analysis. An fMRI priming study by Dehaene, et al. (2004) suggests that the binding of letters into words occurs unconsciously in stages in the left occipitotemporal pathway. This area of the infero-temporal region that responds to the visual presentation of words has been labeled the visual word form area (VWFA) (Cohen & Dehaene, 2004; McCandliss, Cohen & Dehaene, 2003). However, the infero-temporal region also appears to be activated in tasks such as repeating auditory words and manually gesturing in response to meaningless pictures (Price & Devlin, 2003). Thus, some researchers have suggested that the infero-temporal region may be part of a set of regions responsible for the visual analysis of word form (Price & Devlin, 2003). By adopting a different approach, Grossi & Coch (2005) have also offered electrophysiological evidence of the specificity of these systems in terms of their computational properties based on letter identity and letter combinations.

Behavioral Indices of Word Form Processing

Identification of the salient visual features, letter identity, and word forms can occur unconsciously and automatically in skilled readers (Dehaene et al., 2004; Grossi & Coch, 2005). Expert readers are additionally sensitive to the orthographic structure of language, as evidenced behaviorally through lexical decision tasks. When asked to decide whether or not a word briefly presented then masked on a computer is an English word, participants are quicker to reject orthographically illegal strings (e.g., qprt) than orthographically legal strings (e.g., lape) (Hildebrandt, Caplan, Sokol, & Torreano, 1995). Participants are also more accurate in identifying a previously presented and masked letter if it was embedded in a word than if it was embedded in a nonsense string of letters (Reicher, 1969). This effect is known as the word superiority effect (WSE), and it is one of the most widely used behavioral indices of word form processing. For example, if the string of letters presented is WORD and participants are later asked to choose whether the final letter was a "D" or a "K", they would respond correctly more often than if the string of letters was "ORWD" or "XXXD" (letter presented in isolation). This effect was first described by Reicher (1969), who used a forced choice paradigm as described above, briefly displaying a string of letters and then forcing the subject to chose from two options which was the presented letter. This paradigm was also used by Wheeler (1970), so that the forced-choice letter identification paradigm is now referred to as the Reicher-Wheeler task.

The word superiority effect was later divided into two separate effects (McClelland, 1976). The proper word superiority effect (WSE) indicates participants' higher accuracy in identifying letters embedded in words compared to letters embedded in pseudowords (or pronounceable nonwords; e.g., LAPE). The pseudoword superiority effect (PSE) indicates participants' higher accuracy in identifying a target letter if it is part of a string of letters that adheres to the orthographic structure of the language (e.g., LAPE) when compared to letter strings that do not conform to the orthography of that language (e.g., LPAE; e.g., Chase & Tallal, 1990). These two effects purportedly reflect different processes: the WSE is regarded as an index of automatic orthographic processing due to the familiarity with specific stimuli (actual words in the language), whereas the PSE is regarded as an index of familiarity with the orthography of the language (rules that govern whether or not a string of letters are legal in that language) (Grainger & Jacobs, 2004; McClelland, 1976). Both of these effects rely mainly on the orthographic, as opposed to the phonological, regularity of the language (Krueger, 1992). However, as highlighted in the next section, it is difficult to tease apart orthography and phonology.

The Role of Phonological and Oral Skills in Word Recognition

Orthography and phonology are strongly related. Alphabetic systems, such as the English language, have been invented to translate sequences of pre-existing sounds into sequences of written symbols through rules of grapheme-to-phoneme conversion (Ramus, 2005). Therefore, orthographically regular words are pronounceable words (Hanson, 1986). Ontogenetically, speech production precedes phonological awareness, which in turns precedes reading (Perfetti & Sandak, 2000). Phonological awareness plays an important role in learning to read: awareness of rimes (corresponding sounds at the ends of utterances) and single phonemes are the best predictor of the child's future reading abilities (Adams, 1990).

Phonology plays an important role in reading even in expert readers. For example, Chastain (1987) showed that target discrimination accuracy of three letter words and orthographically legal nonwords was inversely correlated with phonological complexity, suggesting that written words are processed through phonological access. Moreover, in lexical decision tasks, participants are generally faster in making lexical decisions with regularly spelled words (transparent relationship between orthography and phonology) compared to irregularly spelled words (opaque relationship between orthography and phonology), at least for low frequency words (Perfetti & Sandak, 2000). However, evidence also shows that expert readers do not always rely on a phonological code to process words (e.g., Ramus, 2005), especially when processing familiar material[1].

A large body of research also exists that examines the development of phonological skills in the deaf population. If learning to read occurs primarily phonologically, then individuals who lack phonological skills, for example deaf and dyslexic populations, should perform more poorly on tasks of phonological awareness and reading than individuals with normally developed phonological skills. Though it has been shown that deaf individuals tend to lag behind their peers in reading level, it has also been shown that deaf individuals do have access to phonological information through means such as speech reading and fingerspelling (Leybeart, 2000). Generally, deaf individuals tend to have poor phonological skills; however, these deficits depend on

[1] This continues to debate the automatic versus controlled activation of phonological information, especially with regard to word familiarity and regularity (Perfetti & Sandak, 2000).

the severity of their hearing impairment and their level of oral education (Harris & Moreno, 2004). For example, research shows that many deaf individuals have an awareness of rhyme (Hanson & Fowler, 1987) but might rely more on orthographic cues than phonological cues in order to make rhyme judgments (Sterne & Goswami, 2000). Other aspects of phonological awareness, such as awareness of syllabic structure and phonological recoding of nonsense words, seem to be also present in some deaf individuals (Dyer et al., 2003; Sterne & Goswami, 2000). In addressing morphology, it appears that deaf students perform more poorly than matched hearing controls at identifying segmented morphemes as well as identifying the meanings of morphemes in printed English (Gaustad, Kelly, Payne & Lylak, 2002).

Spelling errors have also been examined in deaf populations, revealing that most errors were orthographically legal, but phonetically impossible (Olson & Caramazza, 2004). However, Sutcliffe, Dowker, and Campbell (1999) demonstrated that the spelling errors made by deaf children do show sensitivity to phonology, but not necessarily awareness of phonology. Specifically, deaf children showed a word type effect in that they were more accurate in spelling regular words than either exceptional or strange words, but when deaf children made errors, they tended to be phonetically impossible (Sutcliffe et al., 1999).

Harris and Moreno (2004) showed that deaf individuals have approximately the same working memory span as reading age matched controls and that this measure predicted reading ability in the deaf participants. However, this study indicated that deaf participants did not seem to be utilizing phonological coding during these tasks (Harris & Moreno, 2004). Although deaf individuals have been shown to have awareness of phonology and the ability to use phonological information, they also seem to utilize orthographic information when performing tasks involving reading (Sterne & Goswami, 2000).

In summary, previous work on deaf individuals has focused on the role of phonological skills on reading abilities. Not surprisingly, research has shown that deaf individuals lag behind in reading abilities and in some aspects of phonological recoding, although the development of these skills is clearly related to the severity of their hearing impairment and their level of oral education.

Contribution of Speech Production to the Development of Orthographic Representations

Research has shown that oral skills and speech intelligibility are precursors of phonological skills in the deaf. For example, the Stroop effect, which shows that readers take longer to read color words when those words are printed in contrasting colors, is reduced in deaf individuals with poor oral skills compared to deaf individuals with good oral skills (Leybaert, Alegria, & Fonk, 1983; cited in Perfetti & Sandak, 2000). Moreover, better speech production skills have been found to be associated with a better sensitivity to spelling-to-sound and orthographic regularities in a perceptual identification task (Hanson, 1986).

Some authors have stressed the contribution of phonological and oral skills to establishing orthographic representations. According to Share (1995, 1999), orthographic contributions to reading are marginal and most reading occurs phonologically. His research on young Hebrew readers suggests that orthographic knowledge is acquired mainly through self-teaching as a result of phonologically decoding novel letter strings, that is, by deriving speech-based information from printed letter strings (*self-teaching* *hypothesis;* Share, 1995, 1999). Hanson (1986) showed that some aspects of orthography (i.e., sequential redundancy in terms of bigram and trigram frequency) were processed similarly in hearing and deaf adult participants with good oral skills but were processed less proficiently, although present, in deaf individuals with poor oral skills. Hanson (1986) suggested that oral skills might play an important role by allowing the reader to map spoken language into orthographic sequences. This view is similar to the proposal that consistent exposure to spelling-pronunciation correspondences during learning to read (e.g., through the phonics instruction) may allow readers to learn what letter sequences are allowed in a particular language (e.g., Gibson, Pick, Osser, & Hammond, 1962; Venetsky & Massaro, 1979; as cited in Hanson, 1986).

The influence of speech production mechanisms on orthography and word recognition processes is a point of debate. According to other authors, sensitivity to orthography, which is based on recurrent visual patterns, is acquired by visual means, without reference to spoken language (e.g., Baron & Thurston, 1973; Gibson, Shurcliff, & Yonas, 1970; cited in Hanson, 1986). Hanson's (1986) findings that oral skills allow the reader to map spoken language onto the orthography of the language seem to challenge this position but, to our knowledge, have not been replicated to this date. The matter is complicated by the fact that, in some cases, a phonological deficit in hearing individuals may likely trigger reliance on visual aspects of words. For example, Siegel, Share and Geva (1995) showed that dyslexic individuals outperformed normal readers in a test of orthographic awareness, but underperformed normal readers in a task requiring pronunciation of pseudowords. Although these findings do not directly speak to the role of oral skills on orthographic processes, they suggest that phonological deficits might engender more reliance on orthography. Siegel et al. (1995) focused on an explicit measure of orthographic knowledge (orthographic awareness). In the present study, we will focus on an implicit measure of automatic orthographic processing; in order to assess the influence of speech production mechanisms on these processes, the orals skills of deaf individuals will be correlated with the PSE as measured by the Reicher-Wheeler task.

Present Study: Aims and Hypotheses

The question that will be examined in the present study is whether or not performance on a visual task measuring sensitivity to word form representations and orthographic regularities is influenced by speech production skills, defined in terms of speech intelligibility. In order to have a complete picture of the relationship between oral and orthographic skills, phonological skills will also be measured.

Participants will be administered a battery of tests aimed at measuring their orthographic, phonological, and oral skills. Specifically, orthographic skills will be measured by the Reicher-Wheeler task and an orthographic awareness task. Phonological skills will be measured by a picture rhyming task and a pseudohomophone matching task. Finally, oral skills will be measured with a pronunciation task.

In this study, word form processes will be indexed by the WSE and PSE. The PSE score will then be correlated with the intelligibility score from the pronunciation task as a measure of the development of the speech production system. If, as Hanson (1986) posits, the presence of a good orthographic system depends on the presence of a well-developed speech production system, then WSE and PSE should be found in all deaf participants, but the PSE should increase as oral skills increase. If, on the contrary, speech production does not affect the development of orthographic skills, then similar WSE and PSE should be found in all deaf participants, and the PSE should not be modulated by oral skills.

Additionally, this study will examine the relationship between oral, orthographic, and phonological skills with regard to reading ability. Specifically, it will determine whether or not reading ability is a mediating variable in connection with orthographic and phonological awareness as well as oral skills.

The present study will provide important data on two issues. First, it will cast light on the role of oral skills on visual word recognition, specifically on word form processing. Second, it will provide valuable information on how orthographic, phonological, and oral skills interact to influence the development of reading skills in deaf individuals. If oral skills do not affect the development of orthography, education of deaf individuals need not contain an oral element in order to foster good reading skills. If oral skills do affect the development of orthography, it would be advisable that reading education of deaf individuals also focuses on phonological decoding.

METHOD

Participants

There were 11 participants in this study. Of those, four were male and seven were female. Participant's ages ranged from 24-42 years, with a mean of 34 years old. Only one participant was left handed. All participants were severely (2) or profoundly deaf (9), defined as hearing loss greater than 70 or 95 decibels in their best ear, respectively. All participants were diagnosed at or before age two and a half, with the exception of one participant who was diagnosed at age eight. Table 1 contains age, gender, handedness and scores for all measures for each participant. Table 2 contains additional demographic information regarding the participants' use of languages and hearing aid devices.

Participants were excluded for any of the following reasons: diagnosis of cerebral palsy, Down Syndrome, behavioral disorder, psychiatric disorder, seizure disorder, visual impairment, drug or alcohol use by the participant or the participant's mother during pregnancy, or any other handicapping condition.

Recruitment

Deaf participants were recruited from the Albany, NY area, the greater Boston, MA area, and the greater Indianapolis, IN area. Participants were recruited through individual referral within the deaf community, deaf community events, and ads in local newspapers. Additional deaf participants were recruited in the Boston area through Dr. Teresa Mitchell, Asst. Professor of Psychiatry at the Shriver Center, University of Massachusetts, and director of the Perceptual Development Lab, which has been conducting research with deaf citizens and thus has a database of deaf adults in the area.

Materials/Apparatus

A questionnaire was used to collect background data for each participant (see Appendix A). Questions include demographic variables, etiology of deafness, parental hearing status, and parental socioeconomic status.

Reicher-Wheeler Task

Stimuli used in the Reicher-Wheeler forced-choice paradigm were taken from Chase & Tallal's (1990) stimulus list (see Appendix B for list of stimuli). Words (n=40) were 4-letter words selected such that, by changing one letter, another 4-letter word would be formed. There were ten words for each of the four letter positions. The word that was formed by a letter change in one of the four positions determined the alternative letter given in the two-alternative forced-choice task. For example, if PARK was presented, a change in the first position to the letter D would produce another word (DARK); thus, the two choices for the trial were P and D. Chase & Tallal (1990) listed the frequencies (in appearances per million words) for all word stimuli based on Kucera & Francis' (1967) analysis of the use of words in the English language. They also provided word frequencies based on the American Heritage standard for 3^{rd}, 4th, and 5^{th} grade reading levels (see Appendix C for word frequencies at the American Heritage standard 4^{th} grade reading level).

All pseudowords (composed of pronounceable and legal strings of letters) were generated by changing one letter of the stimulus word. For example, changing the last letter of PARK to an L resulted in PARL. Nonwords were generated by rearranging the letters to form an unpronounceable and orthographically illegal string of letters (e.g., RPKA). Therefore, the same critical letters were tested in three different conditions: legal and familiar context (words), legal but unfamiliar context (pseudowords), and illegal and unfamiliar context (nonwords).

Handedness Inventory

Handedness of the participants was established using the Edinburgh Handedness Inventory (Oldfield, 1971). This measure lists several everyday tasks such as writing and brushing teeth, and asks participants to mark which hand they normally use to complete the task. Handedness was established by determining which hand participants use most often.

Reading Level Assessment

All participants completed the Gates-MacGinitie Reading Test, 4th edition (Riverside Publishing). This measure is normed for reading grade levels from kindergarten through 12th grade and also includes an adult postsecondary level. The Gates-MacGinitie Reading Test was chosen specifically because it is normed for higher reading levels. The test contains two subtests, one of which measures vocabulary and assesses decoding skills. The other subtest measures comprehension of words and passages. The combination of the two subtests scores can be reported as a grade-equivalent reading level; however, for greater variability, this study used the combined total raw score instead of the grade level equivalent.

Pronunciation/Speech Skills Assessment

All participants were asked to name aloud ten words from the Boston Naming Test. The words, in task order, were: house, whistle, scissors, comb, saw, broom, pretzel, cactus, hammock, and pyramid. Words were chosen based on the number of syllables, as well as initial and final consonant sounds. Participants were digitally recorded on a laptop computer using WaveFlow software during this task. Three judges blind to the goals of the experiment listened to the audio recordings and rated each word based on intelligibility, which was defined as able to be understood and comprehended (see Appendix G for instruction sheet and Appendix H for rating form). Inter-rater reliability was also assessed, and revealed significant correlations among all three judges (see Table 5 for the correlation matrix of judge's ratings).

Orthographic Awareness Task

This task was based on the design by Siegel et al., 1995. In this task, participants were given a list of seventeen pairs of nonwords and asked to select which of the pair "could be a word in English" (see Appendix D). One nonword of the pair conformed to the orthographic and spelling rules of English such that it could be a word (e.g., lape), the other nonword contained letter combinations and positions not present in the English language such that it could not be a word (e.g., lpae).

Picture Rhyming Task

This task uses the design employed by Sterne and Goswami's second experiment (2000). Participants were instructed about what a rime is, and they were given the opportunity to practice before initiating the matching-to-sample task. Participants were shown three pictures: the target picture was presented above the two choice pictures, and was bounded by a red frame. Each of the choice pictures were bounded by a blue frame. The participants were asked to select which of the choice pictures rhymes with the target picture (e.g., clock-sock). Each participant was presented with 50 rhyme judgments, presented in random order for each subject (see Appendix E).

Distracter items were included that varied from the target in terms of phonological similarity and orthographic similarity to the rhyme item, or shared lip-shape with the target picture. Inclusion of these distracters allows for the experimenters to establish whether or not participants are relying on a certain strategy to make rhyme judgments. Two types of rhyming pairs were used in this task, orthographically similar (e.g. clock-sock) and orthographically dissimilar (e.g. fly-eye). Accuracy for orthographically dissimilar rhyme pairs reveals the participant's level of rhyme awareness.

Pseudohomophone Matching Task

This task uses the design employed by Sterne and Goswami's third experiment (2000). Participants were asked to choose which of four nonsense words is a homophone of the real target word. For example, if the target word was "boys" (represented by a picture of two boys), the nonsense words included: a pseudohomophone (e.g., boiz), and three orthographically similar distracter obtained by changing either the first letter (e.g., roiz), the middle letters (e.g., beiz), or the last letter (e.g., boin). Moreover, half of the pseudohomophones utilized rime units present in English (e.g., shoo) and half utilized rime units not present in English (e.g., boiz). This allowed the experimenters to establish whether or not participants used orthographic strategies to make pseudohomophone judgments. If participants used orthographic cues, the orthographically familiar rime units should prove easier than orthographically dissimilar rime units.

The target word was presented as a picture bounded by a black frame. Under the frame, a question asked, "Which word sounds like the name of this object?" Participants were given 20 pseudohomophone judgments, presented in random order (see Appendix F).

Procedure

After giving informed consent, participants completed the Handedness Inventory along with a general questionnaire to gather demographic information (see Appendix A). Participants then completed the Mac-Ginitie Reading Assessment, picture rhyming task, pseudohomophone matching task, forced-choice letter identification task (Reicher-Wheeler paradigm), and orthographic awareness test, which were given to participants in counterbalanced order. The entire experimental session lasted approximately 2 hours per participant.

For the Reicher-Wheeler task, participants were seated 100 cm directly in front of a 19-inch laptop computer monitor on which stimuli were presented, such that each stimulus subtended 2.5^{o} of horizontal visual angle and 0.5^{o} of vertical visual angle. The sequence of events was as follows (see Figure 1): the word “READY?” appeared at the center of the screen in red letters and served as a warning signal that the new trial was about to begin; participants then pressed either the up or down key of the laptop keyboard to signal the beginning of the trial; a 4-letter string was presented for 50 ms and then masked by a string of 7 consecutive pound keys (#######). The mask was presented for 500 ms and replaced by two letters presented above and below either the second or fourth position of the string. The two letters remained on the screen until the participant chose which of the two letters had appeared in the string at the specified position by pressing either the up or down key on the keyboard. All stimuli were presented in uppercase. Half of the participants saw one member of the stimulus pair (e.g., DARK), and the other saw its complement (e.g., PARK). Accuracy was kept at 75%. This was achieved by adjusting stimulus presentation time based on participant’s accuracy, which was calculated every 12 trials. Specifically, a refresh rate of 17 ms was added to the 50 ms presentation time if the participant’s accuracy is below 75% or subtracted if the participant’s accuracy is above 75%. This procedure ensured that fatigue, practice, and difficulty, as well as floor and ceiling effects, did not affect the results. Accuracy was stressed to the participants. Stimulus presentation was randomized across participants. All participants were debriefed at the end of the experiment.

RESULTS

Reicher-Wheeler Task Analysis

In order to measure the WSE and PSE, a repeated measures ANOVA was conducted using stimulus type as the main factor with three levels (word, pseudowords, and nonwords). Descriptive statistics for each of the three levels of the independent variable may be found in Table 3. The repeated measures ANOVA revealed that stimulus type was significant, $F(2,14) = 5.824$, $p = 0.014$. Within subjects contrasts showed a significant difference in accuracy between real words and nonwords, $F(1,7) = 12.810$, $p = 0.009$, as well as non significant trends between real words and pseudowords and between pseudowords and nonwords, $F(1,7) = 3.398$, $p = 0.108$ and $F(1,7) = 2.626$, $p = 0.149$ respectively (see Figure 2).

Correlations

In order to assess the relationships between the many measures employed in this study, several bivariate correlations were conducted. Descriptive statistics for each of the following tasks may be found in Table 3, and a matrix containing correlation values and significance values may be found in Table 4.

Correlation between Orthographic Processing Measures and Oral Skills

A correlation was conducted between Oral Skills score and the PSE (calculated by subtracting the accuracy on the Reicher-Wheeler Letters stimulus subset from the Reicher-Wheeler Pseudowords stimulus subset). As mentioned, the PSE is considered to be a measure of automatic orthographic processing. The correlation between this difference score and the Oral Skills score was not significant. Additionally, Orthographic Awareness scores did not correlate with Oral Skills scores. These data suggest that there is no significant relationship between orthographic skills (in terms of either automatic processing in visual word recognition or awareness) and oral skills.

Correlation Between Measures of Phonological Awareness

The correlation between the score on the Picture Rhyming task and the score on the Pseudohomophone Matching task was significant, suggesting that these tasks measure the same construct, which we will assume is an awareness of and sensitivity to phonology.

Correlation Between Measures of Phonological Awareness and Orthographic Awareness

Neither the correlation between the score on the Picture Rhyming task and the score on the Orthographic Awareness task nor the correlation between the Pseudohomophone Matching task and the Orthographic Awareness task was significant. These results suggest that the Orthographic Awareness task measures a different construct than the two phonological awareness measures.

Correlation Between Phonological Awareness Measures and Oral Skills

The correlation between the score on the Picture Rhyming task and the score on the Oral Skills task was not significant. However, the correlation between the score on the Pseudohomophone Matching task and the score on the Oral Skills task was significant. This suggests that as oral skills, as measured by pronunciation intelligibility, increase, so does phonological awareness[2].

Correlations between Reading Ability and other experimental measures

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[2] A partial correlation was also conducted to control for reading ability, and the resulting correlations between the score on the Pseudohomophone Matching and the score on the Picture Rhyming with the score on the Oral Skills were not significant (r = .464, p = .295 and r = .198, p = .671, respectively). However, as reading ability does not significantly correlate with either oral skills or orthography, it can be assumed that reading ability is not a mediating variable with respect to those relationships.

The correlation between the score on the Picture Rhyming task and the total reading test score was not significant, but the correlation between the score on the Pseudohomophone Matching task and the total reading test score approached significance. This suggests that there was a trend toward greater phonological awareness being related to higher levels of reading ability.

The correlation between the score on the Orthographic Awareness task and the total reading test score was not significant. Neither was correlation between the score on the Oral Skills measure and the total reading test score.

A measure of the WSE (calculated by subtracting the accuracy for the Reicher-Wheeler pseudoword stimulus subset from the Reicher-Wheeler real word stimulus subset) was added to the correlation matrix for reasons of thoroughness and general exploration. The WSE did not significantly correlate with any other measure in this study.

DISCUSSION

Reading is a complex process, one in which deaf readers have additional difficulties due to their inherent difficulty mapping the sounds of spoken language onto the written words of that language. A body of literature exists on the nature of the reading process in deaf individuals (e.g., Hanson, 1986; Perfetti & Sandak, 2000), and within this, many authors have examined the role that phonology plays in this process (e.g., Hanson & Fowler, 1987; Harris & Moreno, 2004). Less research has focused on the role of orthography in the reading process. A point of debate is whether speech production, or oral skills, influences the development of orthography. Share (1995, 1999) posits that most reading occurs through phonological translation of written words, and that orthographic knowledge is acquired through self-teaching due to exposure to novel letter strings. Hanson (1986) also suggested that oral skills are important to orthography in that they allow the reader to map spoken words onto the orthographic system of the language. In contrast, Baron and Thurston (1973; as cited in Hanson, 1986) argued that orthography is based on recurrent visual patterns, and thus is acquired through purely visual means.

The relationship between oral skills and orthography in the deaf has not been systematically addressed in the literature. In attempt to better understand this relationship, we collected a body of data, including measures of phonological skills, orthographic skills, oral skills, and reading ability, on congenital and profoundly deaf individuals. Although our study consists of only eleven participants, some interesting patterns have emerged in the data, often supporting previous research in the field; thus, we feel that the examination of the present data could offer some valuable exploratory insights on what factors contribute to the development of reading skills in the deaf.

In the Reicher-Wheeler task, analyses revealed a significant main effect for stimulus type, which upon further examination showed a significant difference between real words and letters, and non significant trends for the difference between words and pseudowords as well as between pseudowords and letters (likely due to the small number of participants). The pattern of these relationships parallels that found in both hearing (e.g., Reicher, 1969) and deaf (Hanson, 1986) individuals, and suggests that orthographic processes can develop in deaf individuals.

The main aim of this study was to examine the relationship between oral skills and measures of orthography, in terms of both explicit awareness and automatic processing. Neither of these relationships was significant, which suggests that one does not need a well developed speech production system in order to develop a well-organized orthographic system. This result contrasts with Hanson (1986), who suggested that spoken language is mapped onto written words in the process of learning the orthography of a language. Our data also seem to contradict Share's (1995, 1999) self-teaching hypothesis, which suggests that orthography is learned through the phonological decoding of novel words. Thus, our data support Baron and Thurston (1973; as cited in Hanson, 1986), who stated that orthographical knowledge contains visual information about the language and is acquired through visual means. We found that oral skills were significantly correlated with phonological awareness, but neither of these measures correlated with measures of orthography, suggesting that orthography is not dependent on either of these skill sets. However, the limited number of participants limits the significance of our conclusions.

We also examined the relationships between the phonological awareness measures and the orthographic measures. Both measures of phonological awareness were taken from Sterne and Goswami (2000), who showed that deaf children have an awareness of phonology on several levels, including rhymes and phonemes. In our study, the measures of phonological awareness were highly correlated, as was hypothesized based on Sterne and Goswami's (2000) work. Additionally, neither of these measures correlated with either the measure of orthographic awareness, taken from Siegel et al. (1995), or the PSE difference score (an index of automatic orthographic processing).

A substantial body of literature has been dedicated to examining the relationship between phonological skills and reading ability. Harris and Moreno (2004), as well as Hanson and Fowler (1987) and Dyer et al. (2003), suggested that reading skills in deaf individuals build largely on phonological knowledge and awareness. Additionally, Leybeart (2000) demonstrated that deaf individuals have access to phonological information through channels such as fingerspelling and speech reading. It follows, then, that measures of phonological awareness should correlate with measures of reading ability. Indeed, we found that the correlation between scores on the Pseudohomophone Matching task and Reading test scores approached significance: as the score on the Pseudohomophone Matching task increased, there was a trend for the total reading score to also increase. The relationship between the Picture Rhyming task and the Reading test was also in a positive direction, but was not statistically significant. However, given that the measures of phonological awareness were so highly correlated, we suspect that this relationship also would have at least approached significance given a larger sample size. Therefore, our data corroborate previous literature with respect to the influence of phonological awareness on reading ability.

Sterne and Goswami (2000) suggested that deaf individuals may rely on orthographic information while performing reading related tasks. However, we did not find a significant relationship between reading ability and either the explicit measure of orthographic awareness or the implicit measure of automatic orthographic processing, the PSE. This may suggest that perhaps orthography is relied on more heavily in word form and whole word recognition and decision tasks than in tasks such as vocabulary and comprehension, as is measured by standardized reading tests.

According to Perfetti and Sandak (2000), speech production precedes phonological awareness, which in turn precedes reading. Thus, we expected to find significant correlations between the pronunciation task and the measures of phonological awareness.

In fact, there was a significant correlation between the Pseudohomophone Matching task and the Oral skills task. The correlation between The Picture Rhyming task and the Oral skills task was not significant, but was in the expected direction. The correlation between Oral skills and Reading ability was also in the expected direction, although not significant, with higher Reading ability related to higher ratings of Oral skills.

More research is certainly necessary to tease apart the contributions of phonological, orthographical and oral skills to the reading ability of deaf individuals. Some research has suggested that orthography plays an important role in reading tasks (Sterne & Goswami, 2000), and this may be the case, although we did not find evidence of a relationship between reading scores and orthographic skills in our study. A better characterization of how these different skills develop in the deaf and how they interact, if they do, can have important implications at the educational level. Leybeart (2000) stated that most deaf individuals read at approximately a fourth grade level, which suggests that more work is needed to improve reading in the deaf population. Our data suggest a relationship between oral skills and phonological awareness, and a trend between phonological awareness and reading. Therefore, our data suggest that attention should be paid to oral and phonological of deaf individuals. However, these skills have long been emphasized in deaf education, and even accounting for oral and phonological education the average deaf individual still does not learn to read at an expert level. If orthography is in fact important in reading ability (perhaps more at the level of single word reading than sentence comprehension), and orthography is not dependent on either phonology or oral skills, as the present data suggest, there should be an examination of how to better integrate orthographic knowledge into the process of teaching deaf children to read.

However, we cannot make such bold claims as to the implications of this research without also discussing its shortcomings. As already remarked, our sample size was very small. Only eleven people participated, despite tremendous recruitment efforts. It is likely that many of the correlations we reported as approaching significance or trends (e.g., the correlations between Picture Rhyming task and Oral skills and between phonological awareness measures and Reading test scores) would have been significant with a higher number of participants. In addition to being a very small sample, our sample was also highly selective. Eight of the eleven participants had a reading level greater than 12th grade, which is considerably higher than the general deaf population. This may be due in part to the way this study was advertised. The study was promoted as a study of reading factors in deaf individuals, which may have caused a self-selected sample of only those individuals who felt confident in their reading ability. Moreover, many of the participants had a history of using some type of hearing assistance device, which could have had some impact on their knowledge of the sounds of spoken language.

Other factors must also be considered when discussing the outcomes and implications of this study. One is that the testing environment was different for each participant. This was due in large part to the diverse geographical locations of the participants and thus the inability to test each person in a controlled laboratory setting. Another factor to consider is the fact that our participants had reading levels higher than what Leybeart (2000) reported as normal for the deaf population. This does not seem to have created any ceiling effects, but it did reduce the range of scores used in correlational analyses.

Future research in this area should consider readdressing the relationship between oral skills and orthography, specifically as measured by the PSE. The first step toward accomplishing this goal would be to secure a larger participant pool, preferably in the same geographic area so that a controlled environment can be created for the experiment. Also, a more heterogeneous sample, including a wider range of both reading levels and oral skills would be preferable. In this study, a correlational analysis was used to assess the relationship between oral skills and measures of orthography. A more robust analysis, which would necessitate a larger sample, would be to split the participants into groups based on their level of oral skills (good oral skills vs. poor oral skills). Using the Reicher-Wheeler task as a measure of orthography, a 2x3 mixed model ANOVA could then be conducted to examine the effects of both oral skill level and stimulus type.

Learning to read is a critical and complex process. We have shown, through examination of the current body of literature and this particular study, that there are many interacting factors related to all levels of the reading process, from initially recognizing the word form to expert reading. This study contributes an initial piece to the examination of the relationship between oral and orthographic skills in deaf individuals, but more must be done in order to fully understand both this relationship and the entire process of learning to read in the absence of aural input.

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TABLE 1

Participant	Gender	Age	Dominant Hand	Reicher-Wheeler Real Words	Reicher-Wheeler Pseudo Words	Reicher-Wheeler Nonwords	Reicher-Wheeler Total Score	Orthographic Awareness Percent Correct	Picture Rhyming Percent Correct	Pseudo-Homophone Matching Percent Correct	Reading
1	Male	27	Right	-	-	-	-	88.2	66.0	85.0	91
2	Female	31	Right	-	-	-	-	94.1	100.0	100.0	90
3	Male	37	Right	-	-	-	-	70.6	62.0	75.0	63
4	Female	34	Left	80	72.5	70	74	82.4	86.0	95.0	90
5	Female	35	Right	85	85	70	80	82.4	96.0	100.0	92
6	Female	37	Right	90	80	70	80	88.2	100.0	100.0	87
7	Female	42	Right	85	70	85	80	52.9	94.0	100.0	90
8	Female	35	Right	85	85	62.5	77.5	88.2	62.0	70.	84
9	Male	36	Right	85	78	75	79	100	92.0	95.0	77
10	Female	26	Right	78	83	78	79	94.1	100.0	100.0	90
11	Male	34	Right	80	80	73	77.5	88.2	66.0	85.0	88

Table 2

Participant	When was deafness diagnosed?	What was the cause of deafness?	Hearing Loss	Is English the first language?	Use any other languages?	If so, when was that language learned?	How often is the other language used?	Fluent in that language?	What language was used in school?	Use any devices to aid hearing?	How long have you used them?	How often do you use them?
1	10 months	Unknown	Profound	Yes	ASL	13 months	Only ASL	Yes	ASL/English	None	N/A	N/A
2	< 2 years	Meningitis	Profound	No	French	3 years	Monthly	Yes	English	HA/CI	HA – 26 yrs, CI – 6 mo	Daily
3	Birth	Unknown	Profound	Yes	ASL, Bengali, Hindi, ISL	ASL – 14 years	Daily	Only in ASL	English	HA	10 years	Rarely
4	28 months	meningitis	Profound	Yes	ASL	15 years	Daily	Yes	SEE	HA	32 years	Daily
5	1 year	Sensorineural	Profound	Yes	ASL	22 years	Daily	Yes	English	HA	33 years	Daily
6	2 years	Unknown	Severe	Yes	None	N/A	N/A	N/A	English	HA	childhood	Daily
7	8 years	Cochlear	Severe	Yes	ASL	18 years	Daily	Yes	English	HA	33 years	Daily
8	Birth	Hereditary	Profound	No	ASL	Birth	Daily	Yes	ASL/English	None	N/A	N/A
9	Birth	Unknown	Profound	Yes	ASL, SEE	5 years	Daily	Yes	SEE / TC	HA	25 years	Not anymore Use to be daily
10	Birth	Genetic	Profound	No	ASL, RSL	Birth	Daily	Yes	ASL/English	1 HA	22 years	Daily
11	Birth	Unknown	Profound	Yes	ASL	5 years	Daily	Yes	ASL	HA	childhood	Daily

ASL = American Sign Language, SEE = Signed Exact English, ISL = Indian Sign Language, RSL = Russian Sign Language, TC = Total Communication, CI = Cochlear Implant, HA = hearing aids

TABLE 3

Descriptive statistics for all tasks.

Task	N	Minimum	Maximum	Mean	Standard Deviation
Reicher-Wheeler: Real Word	8	78.0	90.0	83.5	3.89
Reicher-Wheeler: Pseudo word	8	70.0	85.0	79.19	5.53
Reicher-Wheeler: Letters	8	63.0	85.0	72.94	6.66
Reicher-Wheeler: Total Score	8	74	80	78.37	2.05
Orthographic Awareness: Percent Correct	11	52.9	100.0	84.48	12.96
Picture Rhyming: Percent Correct	11	62.0	100.0	84.00	16.42
Pseudohomophone Matching: Percent Correct	11	70.0	100.0	91.36	10.98
Reading: Raw Score out of a possible 93	11	63.0	92.0	85.64	8.62
Oral Skills: Average rating with a possible range of 10-70	11	17	54	35.97	13.49

TABLE 4

Correlation matrix for all tasks.

	Orthographic Awareness	Picture Rhyming	Pseudo-homophone Matching	Reading Ability	Oral Skills	PSE (diff. score)	WSE (diff. score)
Orthographic Awareness	*r* = 1.00 -----	*r* = .111 *p* = .745	*r* = .040 *p* = .907	*r* = .118 *p* = .730	*r* = -.416 *p* = .203	*r* = .630 *p* = .094	*r* = -.525 *p* = .097
Picture Rhyming	*r* = .111 *p* =.745	*r* = 1.00 -----	*r* = .943 *p* < .001	*r* = .435 *p* = .181	*r* = .517 *p* = .104	*r* = -.414 *p* = .308	*r* = .311 *p* = .352
Pseudo-homophone Matching	*r* = .040 *p* = .907	*r* = .943 *p* < .001	*r* = 1.00 ------	*r* = .550 *p* = .079	*r* = .619 *p* = .042	*r* = -.569 *p* = .141	*r* = .349 *p* = .293
Reading Ability	*r* = .118 *p* = .730	*r* = .435 *p* = .181	*r* = .550 *p* = .079	*r* = 1.00 -----	*r* = .467 *p* = .147	*r* = -.138 *p* = .745	*r* = .058 *p* = .865
Oral Skills	*r* = -.416 *p* = .203	*r* = .517 *p* = .104	*r* = .619 *p* = .042	*r* = .467 *p* = .147	*r* = 1.00 -----	*r* = -.472 *p* = .238	*r* = .258 *p* = .443
PSE (difference score)	*r* = .630 *p* = .094	*r* = -.414 *p* = .308	*r* = -.569 *p* = .141	*r* = -.138 *p* = .745	*r* = -.472 *p* = .238	*r* = 1.00 ----	*r* = .258 *p* = .443
WSE (difference score)	*r* = -.525 *p* = .097	*r* = .311 *p* = .352	*r* = .349 *p* = .293	*r* = .058 *p* = .865	*r* = .258 *p* = .443	*r* = .258 *p* = .443	*r* = 1.00 ----

TABLE 5

Correlation matrix for judge's pronunciation ratings.

	Rater 1	Rater 2	Rater 3
Rater 1	r = 1.00 ------	r = .819 p = .002	r = .949 p < .001
Rater 2	r = .819 p = .002	r = 1.00 ------	r = .853 p = .001
Rater 3	r = .949 p < .001	r = .853 p = .001	r = 1.00 ------

Figure 1

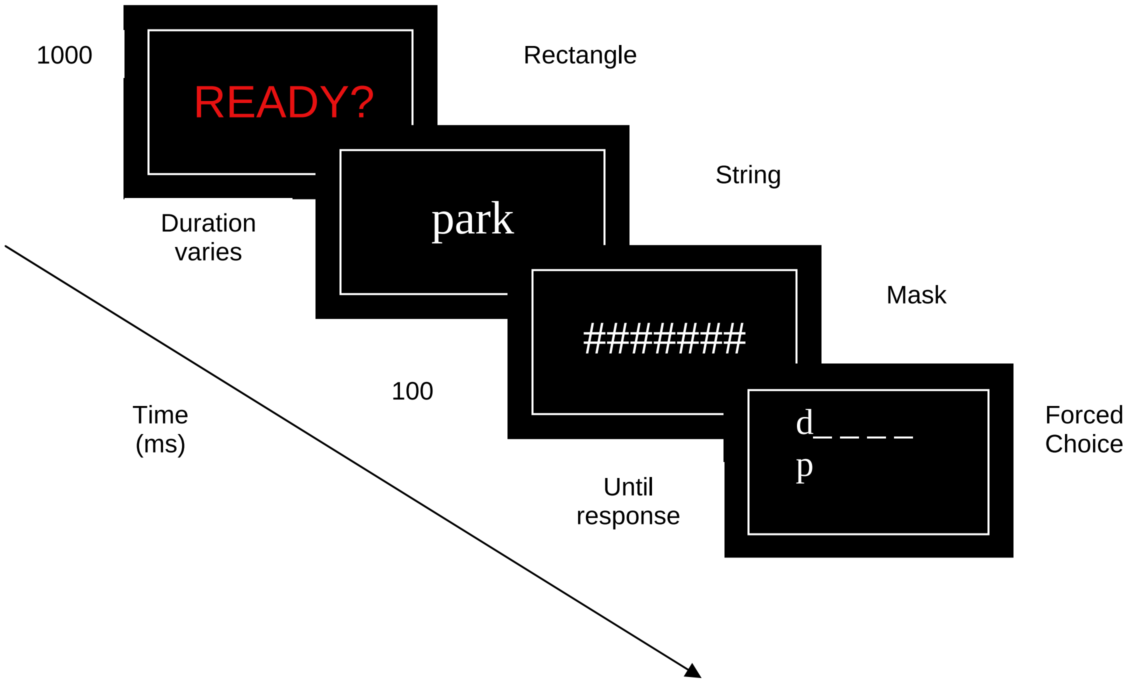

Figure 1: Sequence of event for the WSE forced choice paradigm computer program.

Figure 2

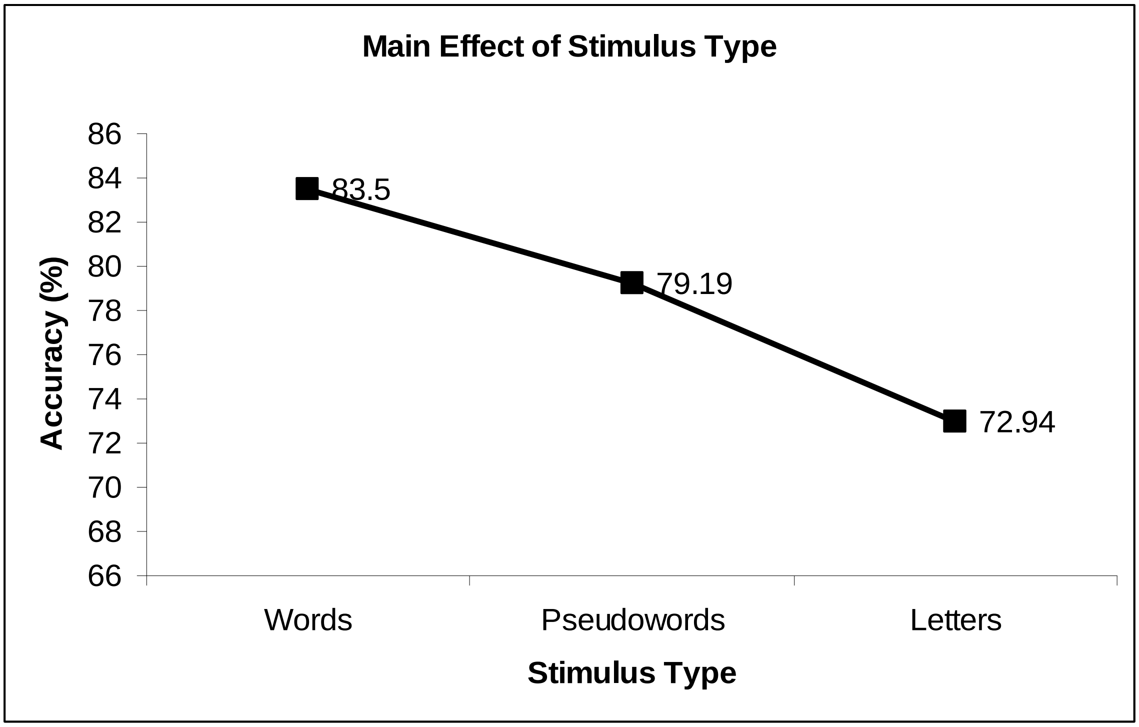

Figure 2: Graph of the relationship between stimulus type for the Reicher-Wheeler task.

APPENDIX A

Adult Background Questionnaire

First Name: ______________________________________

Last Name: _______________________________________

Address: ____

City: ___________________ State: ________ Zip: ___________

Home Phone: _________________ Work Phone: ______________

DOB: ________________________

1. Your current occupation: ____.

2. Your level of education: ____.

3. Have you or any members of your household/family been diagnosed with a language, hearing or visual disability? Please describe. ____
____.

4. Do you speak or sign a language other than English? ________________________________
____.

When did you learn this language? ____
____
_______.

How often do you use this language? Circle one:

Daily Weekly Monthly Rarely

5. What type of school were you enrolled in as a child? _________________________________
____.

What language was used in this school? ________________________________.

6. If you have a hearing loss, when was that hearing loss diagnosed? _________.

What is the degree of hearing loss? Circle one.

Mild (21-40 dB) Moderate (41-70 dB) Severe (71-95dB) Profound (>95 dB).

What was the cause of the loss? ____

_______.

What kind of assistive device(s) do you and have you used? _________________

____.

How long have you used these device(s)? ____

How frequently do you use this device(s)? Circle one.

Daily Weekly Monthly Rarely

7. Have you recently experienced any medical issues? **Yes** or **No**

If your answer was **"Yes"** please give us a brief description of these medical issues:

____

____

8. Have you recently (in the last 6 months) taken medication? **Yes** or **No**

If your answer was "**Yes"** please list these medications:

Name of Medication	**Dates Taken**	**Reason Taken**	**Dosage**

9. Do you have a history of stroke, seizures, brain tumor, head trauma or other neurological or psychiatric diagnosis? **Yes** or **No**

If your answer was "**Yes"** please indicate the diagnosis you were given and when you received it.

Diagnosis	**Date of Diagnosis**	**Age at Diagnosis**

APPENDIX B

List of stimuli for Reicher-Wheeler task.

Real Words

Position 1	Position 2	Position 3	Position 4
dark park	came come	feet felt	band bank
date late	fall full	fine fire	cool cook
deep keep	firm form	hand hard	hear heat
four your	gave give	home hope	mail main
look took	held hold	knew know	mark mary
lord word	list lost	life like	mile milk
much such	love live	made make	pain pair
test rest	mass miss	more move	pool poor
were here	most must	race rate	rich rice
what that	post past	then than	wall walk

Pseudowords

darl parl	camo como	chen chan	cand cank
datu latu	falk fulk	fome fope	cear ceat
deet keet	firp forp	hade hake	dail dain
fous yous	gava giva	heet helt	dall dalk
loob toob	helk holk	kine kire	dile dilk
lort wort	lisk losk	mand mard	jain jair
muct suct	lovi livi	nore nove	sich sice

Pseudowords Continued

tesk resk	masp misp	pnew pnow	sool sook
wera hera	mosp musp	sife sike	nool noor
whab thab	posr pasr	tace tate	tark tary

Nonwords

crea trea	awth atth	ahre ahte	lfla lflu
dmea kmea	cmhu cshu	crhi crei	lhde lhdo
efte lfte	edpe ekpe	imla imna	mcea mceo
ekwn okwn	olko otko	ipna ipra	rfmi rfmo
etnh atnh	rdka rpka	lmei lmki	slti slto
flei klei	rldo rwdo	lwla nbda	smsa smsi
mheo pheo	rwee rhee	nbka lwka	smto smut
nfei rfei	stte srte	oclo ocko	spot spta
nhda rhda	tdea tlea	oplo opro	vgea vgei
rmeo vmeo	ufro uyro	rmka rmya	vleo vlei

APPENDIX C

Frequencies for words used in the Reicher-Wheeler task: American Heritage 4th grade.

Word	Frequency	Word	Frequency	Word	Frequency	Word	Frequency
Band	82	Hand	375	Love	95	Pool	24
Bank	72	Hard	389	Made	1127	Poor	124
Came	942	Hear	418	Mail	35	Post	44
Come	892	Heat	133	Main	121	Race	90
Cook	102	Held	182	Make	1464	Rate	30
Cool	110	Here	783	Mark	246	Rest	215
Dark	231	Hold	223	Mary	217	Rice	68
Date	30	Home	732	Mass	11	Rich	78
Deep	183	Hope	95	Mile	66	Such	457
Fall	141	Keep	482	Milk	103	Test	137
Feet	413	Knew	428	Miss	217	Than	1074
Felt	254	Know	1037	More	1345	That	7019
Fine	212	Late	104	Most	579	Then	2231
Fire	287	Life	321	Move	284	Took	490
Firm	14	Like	1726	Much	830	Walk	140
Form	410	List	351	Must	695	Wall	113
Four	351	Live	437	Pain	31	Were	2781
Full	199	Look	1017	Pair	136	What	2993
Gave	268	Lord	40	Park	74	Word	1336
Give	549	Lost	130	Past	128	Your	2731

APPENDIX D

List of stimuli for the orthographic awareness test. Taken from Siegel et al (1995).

Orthographically Legal (Correct)	Orthographically Illegal (Incorrect)
filk	Filv
tolb	Tolz
powl	Lowp
lund	Dlun
fant	Tanf
miln	Milg
togn	Togd
wolt	Wolg
moke	Moje
jofy	Fojy
crif	Cnif
blad	Bnad
hift	Hifl
gnup	gwup
nilt	nitl
clid	cdil
vism	visn

APPENDIX E

List of words used in the picture rhyming task (Adapted from Sterne & Goswami, 2000).

O+: orthographically legal rhyme pairs; O-: orthographically illegal rhyme pairs

Word Set 1 – distracter items dissimilar to target

Type	Cue	Rhyme	Distracter	Type	Cue	Rhyme	Distracter
O+	sock	clock	bed	O-	fly	eye	hat
O+	snail	tail	bridge	O-	four	door	car
O+	spoon	moon	feet	O-	light	kite	bag
O+	pear	bear	glove	O-	plane	rain	key
O+	ship	zip	heart	O-	drum	thumb	leaf

Word Set 2 – distracter similar in lip-shape to target

Type	Cue	Rhyme	Distracter	Type	Cue	Rhyme	Distracter
O+	boat	coat	moon	O-	whale	snail	stairs
O+	house	mouse	owl	O-	rope	soap	comb
O+	book	hook	man	O-	box	socks	pig
O+	king	ring	cheese	O-	ghost	toast	cloud
O+	phone	bone	van	O-	bear	hair	pie

APPENDIX E (continued)

Word Set 3 – distracter similar initial consonant to target							
Type	Cue	Rhyme	Distracter	Type	Cue	Rhyme	Distracter
O+	wall	ball	witch	O-	goal	bowl	gate
O+	tap	map	ten	O-	bed	head	boat
O+	run	gun	ring	O-	kite	light	key
O+	bag	flag	book	O-	door	four	dog
O+	fan	van	fox	O-	fruit	boot	fish

Word Set 4 – distracter similar initial consonant cluster to target							
Type	Cue	Rhyme	Distracter	Type	Cue	Rhyme	Distracter
O+	snake	cake	snowman	O-	plane	rain	plug
O+	train	chain	tree	O-	shoe	glue	ship
O+	star	car	stool	O-	chair	pear	church
O+	fridge	bridge	frog	O-	three	key	thumb
O+	sweet	feet	swing	O-	cry	tie	cross

Word Set 5 – distracter similar onset vowel to target							
Type	Cue	Rhyme	Distracter	Type	Cue	Rhyme	Distracter
O+	bridge	fridge	bricks	O-	bed	head	belt
O+	clown	crown	clock	O-	chair	pear	chain
O+	star	car	stamp	O-	shoe	blue	shorts
O+	bat	cat	bag	O-	goal	bowl	goat
O+	cake	snake	camel	O-	boot	suit	book

APPENDIX F

List of nonsense word sets used in the pseudohomophone matching task. Taken from Sterne and Goswami (2000).

R+: rime is present in English; R-: rime is absent in English

Practice set

Real Word	Set	Homophone	Initial	Medial	Final
please	R-	pleez	gleez	ploz	pleej
cloud	R-	clowd	glowd	clewd	clowp
six	R+	sics	bics	soocs	sich
bear	R+	bair	sair	boir	baim

Experimental set

Real Word	Set	Homophone	Initial	Medial	Final
door	R+	daw	taw	diw	dak
coat	R+	cote	wote	ciet	coth
rope	R+	roap	goap	riap	roaf
chain	R+	chane	zane	chone	chank
light	R+	lite	yite	lete	licht
leaf	R+	leef	heef	leuf	leem
bird	R+	berd	perd	bord	berb
fly	R+	flie	clie	flae	flid
fruit	R+	froot	droot	froit	froon

APPENDIX F (continued)

Real Word	Set	Homophone	Initial	Medial	Final
shoe	R+	shoo	thoo	shoi	shog
cake	R-	caik	saik	coik	cail
snake	R-	snaik	paik	snoik	snaip
boys	R-	boiz	roiz	beiz	boin
tape	R-	taip	maip	tuip	taid
fox	R-	focs	gocs	fecs	foch
box	R-	boks	toks	biks	bofs
girl	R-	gerl	berl	gorl	gerf
cheese	R-	cheez	deez	chaz	cheel
bridge	R-	brij	grij	bruj	brip
cage	R-	caij	naij	coij	caif

APPENDIX G

Instructions given to judges of the pronunciation task.

Rater Instructions

Thank you for your willingness to help with the data collection for my thesis

You will be given a rating sheet with the numbers 1-110, in a random order.

Each number represents a brief audio file.

This will be followed by a 7 point rating scale & a blank space.

Procedure

1) Look at the first number on your rating sheet then locate that file in the data folder on the computer.

(I will have this folder already open for you)

2) Listen to the audio file **ONLY ONCE**

3) Using the 7 point rating scale, circle the number that represents the intelligibility of the audio clip.

definition: An "intelligible" word is a word that is capable of being understood and comprehended.

example:	**1**	**2**	**3**	**4**		**6**	**7**
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible

4) In the blank space, please write the word you think was spoken on the audio file.

example: <u>CAT</u>

5) Follow the same procedure until you have rated all 110 files.

THANK YOU

APPENDIX H

Sample page from a judge's pronunciation rating sheet. All other sheets follow the same format, with all 110 audio file numbers randomized for each judge.

AUDIO FILE RATING SHEET

Audio File #								What was the word you heard?
72	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
26	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
46	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
20	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
29	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
91	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________
105	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
	Completely Unintelligible			Somewhat Intelligible			Completely Intelligible	___________