University of Alberta

Word Reading Strategies of Signing Deaf Adults

by

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Abstract

Response accuracy and response latency data from a lexical decision task were examined to determine whether skilled deaf readers use phonological information during word recognition. The participants were 16 adults with a severe or profound hearing loss who used American Sign Language as a primary means of communication, and 14 hearing University students who served as control participants. Results showed that skilled deaf readers did not access knowledge of spelling-sound correspondence and consistency to the same extent as skilled hearing readers. The conclusion that skilled deaf readers do not use phonological regularity and consistency information implies that other strategies may be utilized during word recognition and that more research is needed to determine the best practices for reading instruction of deaf individuals.

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Chapter 1

Introduction

Decades of reading research conducted with deaf learners evidence a staggering deficiency in reading achievement. Most students with hearing loss leave high school with reading skills comparable to an average ten year old child with normal hearing (see review in Paul, 1998). Numerous studies have documented the importance of phonological processing skills for hearing readers' reading development (see review in Adams, 1990); thus, it is not surprising that difficulties arise in reading development for learners with impeded access to the sound system of English. A small minority of deaf students, however, do learn to read fluently, with approximately 8% of deaf high school graduates leaving school with age-appropriate reading levels (Holt, Traxler, & Allen, 1997). How some deaf readers manage to achieve age-appropriate reading levels while the majority does not is unclear. Research findings in the area of phonological knowledge of skilled deaf readers are contradictory, with some studies finding the use of phonology in various word recognition (e.g., Hanson & Fowler, 1987) and reading tasks (e.g., Hanson, Goodell, & Perfetti, 1991), and others finding little use of phonological knowledge (e.g., Burden & Campbell, 1994; Chamberlain, 2002; Waters & Doehring, 1990) in the deaf populations tested.

The current study used an improved lexical decision task to investigate the word reading strategies of skilled deaf adult readers. Specifically, the study sought to overcome the discrepancies in past research and to determine whether skilled deaf readers use phonology during word reading. To determine whether phonological regularity and/or consistency effects were present in skilled deaf readers, word regularity and consistency were manipulated. The performance accuracy and reaction time data of skilled deaf readers and skilled hearing readers were compared across different word conditions.

Regularity was defined as the tendency of words to follow English grapheme-to-phoneme correspondence (GPC) rules. To examine regularity effect, analyses compared the accuracy and reaction time data of regular, irregular, and strange words. Regular words, such as *came*, follow GPC rules. The *e* at the end of the word makes the previous vowel have a long sound. Irregular words, such as *break*, do not follow GPC rules, although they do have regular orthography. According to the GPC rules, this word would be pronounced /brik/. Strange words contain unusual or atypical spelling patterns and often have irregular spelling-sound correspondence. For example, the strange word *aisle* contains irregular orthography (i.e., the silent *s* in the middle of the word) and does not follow GPC rules for the *ai* vowel combination.

Consistency was defined as the tendency for neighbouring words (defined as words containing the same orthographic rime) to have consistent spelling-sound relationships. To examine consistency effect, analyses compared the accuracy and reaction time data of consistent, semi-consistent, ambiguous, and inconsistent words. Consistency was determined by the number of "friends" and "enemies" each word had. A "friend" was defined as a word containing a similar spelling pattern in the rime with similar pronunciation, as found in the friends *rest* and *best*. An "enemy" was defined as a word containing a similar spelling pattern in the rime but having a different pronunciation. For example, the word *great* would be an enemy to the word *seat*. Consistent words, such as *big*, have many friends (*pig*, *wig*, *dig*, etc.) and no enemies.

Semi-consistent words have many friends, but also enemies, or exceptions to the rule. An example of a semi-consistent word would be *new*. Its friends are in abundance, including *blew*, *stew*, and *dew*; but there exists an exception, or an enemy: *sew*. Ambiguous words contain a body that is pronounceable in two or more ways, and have approximately the same number of friends and enemies. The body *own* can be found in *shown* and *blown* but also in *brown* and *town*. Inconsistent words are the exceptions found in the semi-consistent category, like *sew* from the example given above. They have mostly enemies, but may have a small number of friends.

In what follows, a brief review of the word reading literature as it pertains to hearing readers, both beginning and skilled adult readers, is given. Next, literature regarding the word reading strategies of deaf readers is reviewed, focusing on the research involving skilled deaf adult readers, as well as the ongoing debates as to whether deaf readers use phonology during word recognition tasks. Finally, the study goals and proposed hypotheses of the present research are discussed.

Literature Review

Mastery of higher level reading skills presents people with more career options, opportunities for greater societal contribution, and higher levels of personal independence, accomplishment, and success. Improvement in literacy skills is one of the main instructional goals for both elementary and secondary schools. There exist several methods of teaching reading and literacy skills to both children and adults. Top-down approaches emphasize using contextual clues and prior knowledge to discern word meaning whereas bottom-up approaches focus on using components smaller than the word (e.g., phonemes) to extract meaning. Interactive approaches draw upon both types of processing.

A critical component of skilled word reading in hearing students seems to be a good understanding of "the link between the phonemes of speech of a phonetic language and the graphemes of print" (Paul, 1998, p.78). Phonological processing, which refers to the use of "phonological information – information about the sound structure of our language – in processing written and oral language" (Wagner, 1986, p. 623), would by its very definition be compromised by hearing loss. The phonological deficit model of reading disabilities proposes that the lack of understanding of this link may contribute to lower reading levels in poor readers, both hearing and deaf (Paul, 1998).

Word Reading for Hearing Readers

Word recognition is defined as the ability to see a printed word and retrieve the meaning from the mental lexicon (Hoover & Gough, 1990). Skilled word recognition is crucial to reading development, and the ability to recognize and read words "quickly, accurately, and effortlessly, is critical to skillful reading comprehension" (Adams, 1990, p. 3). Word level reading may be accomplished in various ways. Readers may use grapheme to phoneme correspondence rules (e.g., Coltheart & Rastle, 1994), direct lexical access (e.g., Coltheart, Laxon, Keating, & Pool, 1986), visual/orthographic analogies (e.g., Glushko, 1979), sound/phonological analogies (e.g., Coltheart et al, 1986; Davelaar, Coltheart, Besner, & Jonasson, 1978), meaning/morphological analogies (see review in Carlisle, 2003), or combinations of any of these.

In the dual route model of word recognition, orthography and phonology make up two distinct access routes to the mental lexicon and to word meanings (e.g., Coltheart, Davelaar, Jonasson, & Besner, 1997). An orthographic route to meaning follows a direct path from the visual input. A phonological route follows an indirect path from the visual input to phonological information to meaning. In contrast to the dual route theories, connectionist theories argue that the interaction between phonological, orthographic, and semantic knowledge are more pertinent to word identification. Connectionist models of reading theorize that words are recognized at a sublexical level by a single process that is largely dependent on reading experience (Plaut, McClelland, Seidenberg, & Patterson, 1996).

From a dual route perspective, it is argued that the phonological route is critical for decoding purposes for beginning readers (Bruck, 1990; Jorm & Share, 1983; Merrills, Underwood, & Wood, 1994). For skilled readers, it is argued that the orthographic route is more efficient and therefore dominant, and that the phonological route acts as a backup mechanism for reading more problematic words (Barron, 1986; Merrills et al., 1994). From a connectionist perspective, skilled hearing readers use orthographic knowledge about letter patterns and sequences, spellings, and associations between letter units, as well as phonological knowledge about spelling-sound relationships when processing print. Adams (1990) points out that the visual access to a word leads to the automatic activation of phonological knowledge and that this knowledge increases both word recognition speed and comprehension of less familiar words. For the skilled reader it is argued that orthographic, phonological, and semantic processes do not operate independently of each other, and that skilled reading reflects the synergistic knowledge of all three coordinated systems.

Word Reading for Deaf Readers

The majority of deaf high school students are reading well below their hearing counterparts, and well below their grade level. Several factors must be brought to the task of reading, including a primary language base, which leads to the development of a syntactic system, and life experience, which gives reference to a semantic system. Typically, language is learned naturally through others native or fluent in its use. The primary language of the Deaf community is American Sign Language (ASL), a complete, linguistically complex, and natural visual-gestural language with no written counterpart (Stokoe, 1976). Deaf children from deaf families have the advantage of a primary language base. ASL has a full phonological system that "is not based on sound; rather it involves hand movements, positions, and shapes" (Paul, 2001, p. 306). Although ASL has a phonological system, it cannot be directly mapped onto English (Goldin-Meadow & Mayberry, 2001), as the two languages exist independently of each other. Ninety percent of deaf children are born to hearing parents (Goldin-Meadow & Mayberry, 2001; Musselman, 2000) who have little, if any, connection with the Deaf community or experience communicating in a natural signed language. Many deaf children are instead faced with learning English as a first language through other means, such as manually coded English systems, Cued Speech, or through the use of any residual hearing. Access to the phonological code of spoken language is not easy for the deaf population (Goldin-Meadow & Mayberry, 2001), as speech sounds may not be fully accessible or intelligible through hearing aid use. Passive listening activities that contribute to incidental learning and subsequently lead to knowledge of the world are often compromised (Flexer, 1999). Deaf children from hearing families who are exposed to ASL often have limited access to language models with native-like fluency, or may be exposed to less accurate language (syntactic or semantic) input.

As with any group of people who are the focus of reading research, there are a number of individual factors that could confound the results of investigations, such as the total number of years of schooling, gender, dominant hand use, and the presence of learning disabilities. In addition to these factors, the deaf population is a unique group of learners to study for several reasons. Impeded auditory access to the English language is just one confounding factor of research investigations. There are different degrees of hearing loss, ranging from mild to profound, affecting different frequency regions. Even among hearing losses of similar degree there can be differing access to sound through cochlear implant technology or the use of hearing aids. Sound access may also depend on the type of hearing aids, the specific benefit, the number of hours hearing aids are worn in an average day, and the number of years they are used (Flexer, 1999). The age of onset of deafness is also a confounding factor, as a pre-lingual hearing loss (prior to age two) may have different effects on later reading ability than a post-lingual hearing loss. Identification of hearing loss may have occurred at different ages, possibly resulting in later language input. General acceptance within a family unit as well as the ability to communicate effectively with family members is yet another confounding factor (Padden & Ramsey, 1998; Schlesinger & Meadow, 1972).

There are a variety of educational and language approaches for deaf children, and today's deaf adults may have been exposed to a combination of any of these. Some educational settings include residential schools, special programs, and integration within hearing schools (with and without interpreters, transliterators, or general student assistance). Language instruction may have included oral methods such as various forms of speech training, Cued Speech, or Auditory Verbal Therapy, and/or sign methods like ASL or signing systems such as Signing Exact English, Conceptually Accurate Signed English, or Pidgin Sign. Unlike ASL, these forms of manually coded English are not languages but systems used to teach English to deaf students.

Due to the nature of hearing loss, it is possible that deaf readers have a variety of internal representations of English phonology that differ from those of the average hearing reader. Phonological misrepresentations of English have been blamed for deaf students' problems in reading achievement (Conrad, 1979; Lillo-Martin, Hanson, & Smith, 1992). Poorer phonological processing efficiency of deaf skilled readers in comparison to reading level matched hearing peers (e.g., Treiman & Hirsh-Pasek, 1983) suggests that deaf readers may reach the same levels of reading performance through alternative means of support. Phonological knowledge of ASL (e.g., Shand, 1982; Treiman & Hirsh-Pasek, 1983), and increased reliance on orthographic (e.g., Hanson, 1982; Lichtenstein, 1998; Merrills et al., 1994) and morphological knowledge and strategies (e.g., Gaustad, Kelly, Payne, & Lylak, 2002; Hanson, 1993; Hanson & Feldman, 1989; Hanson & Wilkenfeld, 1985) may aid deaf readers. Increased use of contextual information (e.g., Kelly, 1996) may also support skilled deaf adult readers in word recognition tasks. There are reports that at least some deaf readers, usually the very good deaf readers, do seem to know something about the phonological system of English (e.g., Hanson & Fowler, 1987). However, their use of phonological information in word recognition tasks is lower than their reading levels would predict (e.g., Hanson & Fowler, 1987; Waters & Doehring, 1990). Whether this group is in fact using phonological information during reading has been much debated.

Several studies have produced results indicating that skilled deaf readers employ phonological coding in reading tasks. Hanson et al. (1991) examined the use of phonology by deaf adults with a median reading level of grade 8.7 using a semantic acceptability judgement task. Using sentences that contained same-grapheme tongue twisters, mixed-grapheme tongue twisters, and control sentences, the researchers found that both hearing and deaf adults made more errors in judging both types of tongue twister sentences than they did in judging the control sentences. They concluded that the "phonetic loading" (p. 327) of the tongue twister sentences made them more difficult to judge than the control sentences, and concluded that phonological coding was used during reading for comprehension.

Hanson and Fowler (1987) used a lexical decision task to determine whether skilled deaf college students and hearing control participants used phonological coding in word recognition tasks. They used orthographically similar and phonologically similar word pairs (O+P+ rhymes; e.g., *save* and *wave*), orthographically similar but phonologically dissimilar word pairs (O+P-; e.g., *cave* and *have*), and two sets of orthographically and phonologically dissimilar control word pairs (O-P-; e.g., *mark* and *paid*). They found facilitation for rhyming pairs for both groups, and concluded that the deaf group was using phonological information during word recognition. However, the researchers also used a rhyme judgement task and found that the deaf group was considerably less accurate than the hearing group on judging whether two words rhymed, indicating that phonological information was not necessarily accessed for that task. Had the researchers used orthographically dissimilar yet phonologically similar word pairs (O-P+; e.g., *rope* and *soap*) in their lexical decision task, their results may have been further clarified.

Kelly (1993) tested a group of skilled deaf readers using an abbreviation of Hanson and Fowler's (1987) task. Like Hanson and Fowler, he concluded that the skilled deaf readers did access phonological information in the lexical decision task. However, the correlation between that data and the data he collected on accuracy of verbatim recall and processing during comprehension, was not high. Kelly concluded that these readers were not exclusively using phonology, and that the results from the lexical decision task do not uphold the claims of the critical importance of phonological recoding in deaf readers.

Several studies have found little evidence for the use of phonological processing in skilled deaf readers' reading. Treiman and Hirsh-Pasek (1983) found evidence of phonological coding in ASL, but not in English, in deaf signing adults with a median reading level of grade 7.0. Deaf readers' performance on grammatical acceptability judgement tasks was compared with that of hearing readers. The stimuli included tongue twister and control sentences, and hand twister and control sentences. The hand twisters developed for the research were sentences "that when rendered into sign contained many formationally similar signs" (p. 56). While the hearing readers made more errors on the tongue twister sentences than on the control sentences, indicating use of English phonological coding, the deaf readers did not. Likewise, while the deaf readers made more errors on the hand twister sentences than on the control sentences, indicating ASL phonological coding, the hearing readers did not.

A few studies have looked at phonological spelling-sound correspondence (regularity) and spelling-sound consistency with deaf readers. Waters and Doehring (1990) used a lexical decision task with three groups of oral deaf students, ages 7-11, 12-15, and 16-20, having mean passage comprehension scores of grade 3.1, 6.0, and 8.1 respectively. The researchers used pseudowords and five conditions of real words. Regular words (e.g., *must*) were defined as having consistent pronunciation with other words containing the same spelling pattern. Regular inconsistent words (e.g., *gave*) were defined as having neighbours with mostly the same pronunciation as themselves. Irregular/exception words (e.g., *have*) were the exceptions; or the neighbours with the inconsistent pronunciation. Ambiguous words (e.g., *town*) were defined as containing spelling patterns with ambiguous pronunciation, and strange words (e.g., *yacht*) were defined as having both unusual spelling patterns and pronunciations that do "not follow from the spelling – sound correspondences of English" (p. 343). The second lexical decision task used paired words that were either O+P+ (e.g., *hold* and *gold*), O-P+ (e.g., *fight* and *bite*), O+P- (e.g., *couch* and *touch*), or O-P- (e.g., *chair* and *white*). Participants had to determine if both the letter strings were English words. After examining accuracy and latency data, the researchers concluded that phonological regularity effects were not found for any of the age groups, even though word recognition became faster and more accurate as age increased. When the data were analyzed across reading levels (below grade 3, between grades 3 and 6, and above grade 6), the same result was found. Waters and Doehring have been criticized for using only high-frequency words (Burden & Campbell, 1994), which may not show regularity or consistency effects due to possible repeated print exposure to the stimuli.

Burden and Campbell (1994) used a lexical decision task to examine regularity effects in a group of orally educated deaf readers (mean chronological age 14.5 years, mean reading age 9.5 years). Three conditions of real words, each at high- and low-frequency, as well as pseudowords were used. Regular words (e.g., *chant*) had "a common spelling pattern and an unambiguous relationship between sound and spelling" (p. 336). Exception words (e.g., *love*) were defined as having a common spelling pattern but unusual sound to letter mappings. Strange words (e.g., *aisle*) had both unusual spelling patterns and unusual sound to letter mappings. Two hearing groups, one matched on chronological age (CA) and having age-appropriate reading skills, and the other matched on reading age (RA), served as controls. All groups showed frequency effects, and for both hearing groups, regularity effects were significant (Regular < Exception < Strange), but for the deaf group there was no main effect of regularity. None of the groups showed regularity effects for high-frequency words. For low-frequency words, the CA match and the deaf showed orthographic regularity effects (differences were restricted to strange words). The RA match showed both orthographic and phonological regularity effects, with significant differences between the reaction times of all three word types. The researchers concluded that in lexical decision, "the deaf closely resembled their chronological-age peers…who appear to have based lexical decisions on a visual-orthographic strategy that is highly sensitive to word frequency" (p.345).

Merrills et al. (1994) used a lexical decision task with prelingually profoundly deaf children (median reading age 8.2 years) to examine sensitivity to spelling sound correspondences. They defined regularity in terms of a word's tendency to follow grapheme to phoneme correspondence rules. Using regular (e.g., *mint*) and exception words (e.g., *pint*), and pseudowords and nonwords, the researchers found that sensitivity to spelling sound irregularity was not demonstrated in the deaf readers tested. However, since the deaf children had slower and less accurate responses to pseudowords than to nonwords, the researchers concluded that phonological information was used during pseudoword decoding. By changing the presentation of the stimuli to include both uppercase and lowercase words in order to examine visual reliance, the researchers found that the deaf participants were dependent on visual processing strategies, and persisted in using them even when it was inefficient to do so.

Chamberlain (2002) was the first to investigate spelling-sound correspondence effects with signing deaf adults, using a lexical decision task with two groups of deaf adults, good and poor readers, and a hearing control group. She examined all groups' response accuracy and reaction time data for both high- and low-frequency words at four levels of spelling-sound correspondence and consistency. Chamberlain used stimuli category distinctions developed by Plaut et al. (1996) that were based on the average numbers of friends and enemies each word had. Regular consistent words (e.g., *must*) had many friends and few enemies. Regular inconsistent words (e.g., *bone*) had several friends and a few enemies. Ambiguous words (e.g., *town*) had several friends and several enemies, and exception words (e.g., *done*) had a few friends and many enemies. Chamberlain hypothesized that "If deaf readers use a phonological code for reading as do hearing readers, then both the Good and Poor Readers will show spelling-sound correspondence effects" (p.125). A significant frequency effect was found for all groups, but only the hearing readers had a significant regularity effect. This regularity effect was not well established, as it was only found in the response accuracy data and not in the response latency data. It was concluded that neither the good nor poor deaf readers were accessing phonology, since no regularity effects were found in either the reaction time or accuracy data for either group of deaf readers. Chamberlain's findings may not be accurate for a few reasons. The stimuli were problematic, as there were four times as many words as nonwords, likely producing a positive response bias in the data. As will be further discussed in the methodology section, there were also problems with the frequency classification system used to separate high- and low-frequency words. In addition, presentation order was not fully random, and the response latency data were not cleaned and trimmed for misleading outliers.

In sum, the research regarding the use (and the extent of use) of phonological information by deaf readers is inconsistent at best, with some researchers claiming that skilled deaf readers do use phonological knowledge in lexical decision tasks (e.g., Hanson & Fowler, 1987), others reporting that the deaf do not exclusively use phonology (e.g., Kelly, 1993), and still others reporting that phonological knowledge is not used during word reading (e.g., Burden & Campbell, 1994).

Overview of the Present Study

The purpose of the present study was to investigate the word reading strategies of skilled deaf adult readers who use ASL as a primary means of communication. The major questions addressed were whether phonological regularity and/or consistency effects were demonstrated by the deaf group in comparison to the control group.

For this study, the stimulus words were initially divided into five categories: regular consistent (RC), regular semi-consistent (RS), ambiguous (A), irregular inconsistent (II), and strange (S). Each category was further separated into high- and low-frequency words, resulting in ten conditions of real words. Much of the previous research in spelling-sound correspondence and consistency has used the same word conditions as this study but has given the conditions different names. Plaut et al. (1996) referred to their categories as regular consistent, regular inconsistent, ambiguous, and exception. Their category of regular inconsistent corresponds with the condition called regular semi-consistent in the present study. The name was changed for the current study to clarify for the reader that the words in this category, although containing rimes shared with the exceptions to the GPC rules, are in fact consistent with most of their neighbours. Naming the category "inconsistent" may lead to the incorrect interpretation that these words are themselves inconsistent. The second category name change for the present study was from exception to irregular inconsistent, to provide the reader with more clarity regarding the relationships between the word conditions. The words in this condition are the ones that are inconsistent with their neighbours.

To examine regularity effect, analyses will compare the accuracy and reaction time data of regular words (RC and RS combined; or R), irregular words (II), and strange words (S). These comparisons have the potential to show both phonological and orthographic processing in word reading (Burden & Campbell, 1994). Faster or more accurate responses to regular words than to irregular words (R < II) would indicate a phonological regularity effect, since both word types have regular orthographic patterns but only the irregular words have irregular spelling-sound correspondence. Faster or more accurate responses to irregular words than to strange words (II < S) would indicate an orthographic regularity effect, since both have irregular spelling-sound correspondence but only the strange words have irregular orthographic patterns.

To examine consistency effect, analyses will compare the accuracy and reaction time data of consistent words (RC), semi-consistent words (RS), ambiguous words (A), and inconsistent words (II). Faster or more accurate responses to consistent words than to semi-consistent and inconsistent words, and faster or more accurate responses to semi-consistent words than to inconsistent words (RC < RS < II) would indicate a phonological consistency effect. Semi-consistent words and their exceptions, inconsistent words, contain the same bodies; therefore, a reaction time difference between the two would indicate that knowledge of phonology was utilized. Although past research in computer simulation showed that ambiguous words acted similarly to semi-consistent words (Plaut et al., 1996), research with hearing adults showed that ambiguous words acted similarly to consistent words (Chamberlain, 2002). Ambiguous words are likely to be visually very familiar (Adams, 1990); and it is possible that a word having several possible and plausible pronunciations (ambiguous) results in a reaction time similar to a word having only one possible pronunciation (consistent), as one would not hesitate during recognition. Recognition of a word having either a likely (semi-consistent) or unlikely (inconsistent) pronunciation, on the other hand, may be slower. Therefore, ambiguous words with response latencies similar to consistent words would indicate orthographic effects, whereas faster reaction times for consistent words would indicate phonological effects.

The continuing debate over the use of phonological information by deaf readers presents several possible scenarios: that skilled deaf readers use phonology, that they have deficient use of phonology, or that they do not use phonology during word recognition tasks. Analyses of the response accuracy and response latency data will be performed to compare the deaf group with the control group in order to provide support for one or more of these claims. Good hearing readers should show regularity and consistency effects with low-frequency words in lexical decision tasks, although these effects can be somewhat less pronounced than in naming tasks (Jared, McRae, & Seidenberg, 1990; Waters & Seidenberg, 1985). Using spoken language naming tasks with deaf participants, however, is problematic due to the heterogeneity of speech characteristics of deaf individuals (Chamberlain, 2002). If no significant differences are found between the control and deaf groups, it can be concluded that the deaf group had a similar word reading pattern as the hearing group, meaning that they are most likely using phonological processing strategies when reading words.

Hypotheses for the current research include finding a main frequency effect for both groups. It was hypothesized that no regularity effects would be found for high-frequency words in either of the groups. It was further hypothesized that both phonological and orthographic regularity effects would be found for the control group on low-frequency words. The deaf group was hypothesized to show orthographic regularity for low-frequency words since reliance on orthographic information may aid the reading process (e.g., Hanson 1982; Lichtenstein, 1998; Merrills et al., 1994). It was unknown whether the deaf group would demonstrate a phonological regularity effect on low-frequency words as phonological effects have not been shown in several earlier word reading tasks with deaf readers (e.g., Burden & Campbell, 1994; Campbell & Burden, 1995; Chamberlain, 2002), but have in others (e.g., Hanson & Fowler, 1987). It was hypothesized that no consistency effects would be found for high-frequency words in either of the groups. It was further hypothesized that consistency effects would be significant for the control group on low-frequency words. Faster or more accurate responses to consistent words than to semi-consistent words, and faster or more accurate responses to semi-consistent words than to inconsistent words, were expected. Ambiguous words were hypothesized to act similarly to either the consistent or the semi-consistent conditions (Chamberlain, 2002; Plaut et al., 1996). It was unknown whether the deaf group would demonstrate a significant consistency effect for low-frequency words. Although a consistency effect was not found with the deaf adults in Chamberlain's (2002) study, the methods and stimuli were problematic and may have confounded the results.

Chapter 2

Methodology

Participants

A total of 30 participants volunteered for the present study. The deaf group consisted of 16 adults with a pre-lingual severe or profound hearing loss who use ASL as a primary means of communication. All had completed a minimum of thirteen years of education. Appendix A provides the questionnaire form completed by all deaf participants. A total of 14 hearing adults participated in the control group. Recruitment methods for all participants included announcements made in undergraduate lectures and through Specialized Support and Disabilities Services at the University of Alberta, posters and fliers, and personal invitations extended to members of the Deaf community.

All participants had normal or corrected-to-normal vision. Table 2-1 provides summary information of the basic characteristics for both groups, including age, total years of schooling, and non-verbal IQ as measured by Raven's Progressive Matrices (Raven, Court, & Raven, 1998). Chi square tests indicated that there were no significant differences between the groups on dominant hand use or gender. Two standardized reading measures were taken: the Test of Silent Word Reading Fluency (Mather, Hammill, Allen, & Roberts, 2004), which measured word reading efficiency, and the reading comprehension subtest of the Nelson Denny Reading Test (Brown, Fishco, & Hanna, 1993), which provided information on reading comprehension and reading rate.

Table 2-1
Basic Characteristics of Control and Deaf Groups

Background Information	Group		*F* Value (1, 29)
	Control (n = 14)	Deaf (n = 16)	
Age			
Mean	24.50	40.38	12.30**
SD	5.06	16.23	
Min	18.00	18.00	
Max	33.00	65.00	
Total Years of Schooling			
Mean	16.79	17.72	0.90
SD	2.92	2.48	
Min	13.00	13.00	
Max	22.00	22.00	
Raven's Progressive Matrices			
Mean (Raw)	55.86	54.50	1.68
SD	2.14	3.37	
Min	52.00	48.00	
Max	60.00	60.00	

Note. ** $p < .01$

The number of correct responses in proportion to attempted responses was also calculated to examine untimed comprehension. Reading level information for both groups is presented in Table 2-2.

Analysis of variance tests were used to examine between group differences on background scores, including nonverbal IQ, total years of schooling, age, word reading efficiency, reading rate, and reading comprehension scores (both raw and proportion correct). No significant differences were found for Raven's Progressive Matrices, $F(1, 29) = 1.68, p = .206$, for total years of schooling, $F(1, 29) = .90, p = .352$, or for reading rate, $F(1, 29) = 1.65, p = .210$.

A significant difference was found for age, $F(1, 29) = 12.30, p = .002$. Table 2-1 shows that the deaf group was significantly older than the control group. A significant difference was also found for word reading efficiency, as measured by the Test of Silent Word Reading Fluency, $F(1, 29) = 10.50, p = .003$. Table 2-2 shows that the control group had a higher level of word reading efficiency than the deaf group.

Table 2-2

Reading Level Information for Control and Deaf Groups

Reading Test	Group: Control (n = 14)	Group: Deaf (n = 16)	*F* Value (1, 29)
Test of Silent Word Reading Fluency			
Mean (Raw)	181.50	148.81	10.50**
Mean (SS)	120.57	103.50	
SD (SS)	11.69	18.43	
Min (SS)	98.00	74.00	
Max (SS)	134.00	128.00	
Nelson Denny Comprehension Subtest			
Accuracy			
Mean (Raw)	61.14	40.25	11.60**
Mean (SS)	227.36	194.69	
SD (SS)	18.47	31.46	
Min (SS)	188.00	157.00	
Max (SS)	251.00	245.00	
Rate			
Mean (Raw)	276.64	310.13	1.65
Mean (SS)	217.36	227.50	
SD (SS)	17.86	24.09	
Min (SS)	188.00	188.00	
Max (SS)	254.00	271.00	
Proportion correct			
Mean	87.29	70.44	11.81**
SD	10.73	15.34	
Min	66.00	46.00	
Max	100.00	95.00	

Note. ** $p < .01$

Reading comprehension differences were also significant, $F(1, 29) = 11.60, p = .002$. Table 2-2 shows that the control group had higher comprehension than the deaf group. The effect of reading comprehension as measured by correct responses in proportion to attempted answers was also significant, $F(1, 29) = 11.81, p = .002$. Table 2-2 shows that the deaf group had lower proportions correct than the control group.

Despite the effort to sample only skilled readers with some university experience, the groups were not perfectly matched. To control for possible effects of reading ability, subsequent analyses were replicated with smaller groups matched on the scores of silent word reading efficiency. A sub-sample of 10 participants was selected from each group based on the individual Test of Silent Word Reading Fluency raw scores. Analysis of variance tests re-examined the differences in both background and reading level information between the altered groups. It was found that the only significant differences existed in the conditions of age, $F(1, 19) = 8.10, p = .011$, and reading rate, $F(1, 19) = 10.30, p = .005$. The deaf group was significantly older than the control group, and the reading rate of the deaf group was significantly faster than that of the control group. Chi square tests were used to examine if the groups differed significantly in dominant hand use or gender. There were no significant differences between groups on either factor.

It is possible that phonological effects could develop as a result of having a strong language base in ASL, through residual hearing with the use of hearing aids, or through speech reading and/or speech use. Despite the effort to sample as uniform a deaf group as possible, several background factors differed among participants. Among the differing factors were age of acquisition of ASL (ranged from birth to age 24), degree of hearing loss (ranged from severe to profound), self-reported use of speech (ranged from beginner to fluent), and self-reported understanding of speech reading (ranged from beginner to fluent). Pearson correlation analyses were used to determine if the aforementioned factors had significant relationships with the reading measures taken. It was found that the background factor of degree of hearing loss correlated with the Nelson Denny reading measure of correct responses in proportion to attempted responses. The participants with severe hearing losses had higher proportion scores than the participants with profound hearing losses. Subsequent analyses were repeated with the subgroup of profound hearing loss cases only to control for possible effects of sound access.

Tasks

Test of Silent Word Reading Fluency. Word reading efficiency, or speed of word recognition, was measured by Form B of the Test of Silent Word Reading Fluency (Mather et al., 2004) which required participants to recognize printed words. Participants were presented with rows of words (spaces omitted) and were instructed to draw lines between word boundaries within a three minute time limit. There were 2 practice rows and 32 test rows. Testing was discontinued after three minutes. The test is primarily used as a screening tool to identify poor readers, and is generally used in research with children aged 6-18, yielding raw and standard scores, age and grade equivalents, and percentile ranks. Mather et al. reported test-retest reliability of 0.91 for Form B for children aged 7.0 through 17.11.

Nelson Denny Reading Test, Comprehension Sub-test. Comprehension accuracy and reading rate were measured by the comprehension sub-test (Form G) of the Nelson Denny Reading Test (Brown et al., 1993) which required participants to read passages of unfamiliar text and answer the multiple choice questions that followed. For the measurement of comprehension accuracy, participants were given twenty minutes to read passages and answer questions. There were no practice items. There were 7 passages and a total of 38 questions, each with 5 possible choices. The comprehension questions are both literal and interpretive, and draw from humanities, sciences, and social sciences texts at the high school and college levels. Testing was discontinued after twenty minutes. For the measurement of reading rate, participants were instructed to record the 3-digit number corresponding with the line they were reading after the first minute had passed. The test has been used in research as a screening tool for identifying both superior and poorer reading skills. The test yields raw and scale scores for both rate and accuracy, as well as grade equivalents. To allow for the possibility that not all questions were answered in the twenty-minute time frame, the number of correct responses in proportion to the number of attempted responses was considered as an untimed reading comprehension measure for all participants.

Lexical Decision Task. Three hundred monosyllabic stimuli, listed in Appendixes B and C, were presented in random order to each participant. The list contained both high- and low-frequency words of varying degrees of regularity and consistency. There were an equal number of words and nonwords. The list was adapted from Plaut et al. (1996). As Plaut et al. did not include strange words in their list, several strange words were taken from other sources (Burden & Campbell, 1994; Waters & Doehring, 1990; Waters & Seidenberg, 1985; Waters, Seidenberg, & Bruck, 1984; Seidenberg, Waters, Barnes, & Tanenhaus, 1984) to create the strange condition. As Plaut et al. included nonwords matched to only one category, the numbers of words and nonwords were not equal. Therefore, the results found by Chamberlain (2002) may have had a positive response bias. For this study, more nonwords were generated to create a balance between real words and nonwords. Plaut et al. separated their list into high- and low-frequency words, based on Kucera and Francis (1967). Closer examination of the stimuli revealed several problems with the frequency classification system. For example, a word with a frequency count as low as 27 ("flew") was included as "high-frequency", whereas a word with a frequency count as high as 87 ("touch") was included as "low-frequency." In order to eliminate the overlap, several words were deleted and new words were added to the list. Plaut et al. had a range of 0-7289 for high-frequency words and a range of 0-87 for low-frequency words. The modified list had a range of 36-923 for high-frequency words and 0-19 for low-frequency words. With the exception of the strange high-frequency condition, all high-frequency words had a Kucera-Francis written frequency count ≥ 60, and low-frequency words had a Kucera-Francis written frequency count ≤ 19 (Informatics Division Science and Engineering Research Council, 1987). Enough high-frequency strange words could not be found, so four had a Kucera-Francis written frequency count between 36 and 50.

Word regularity was defined as the tendency to follow English grapheme-to-phoneme correspondence rules, and consistency was defined as the tendency for neighbouring words (words containing the same rime) to have consistent spelling-sound relationships. Consistency was determined by the number of "friends" and "enemies" each word had. A "friend" was defined as a word containing a similar spelling pattern in the rime with similar pronunciation, as found in the friends *came* and *same*. An "enemy" was defined as a word containing a similar spelling pattern in the rime but having a different pronunciation. For example, the word *leaf* would be an enemy to the word *deaf*. Jared et al. (1990) used the summed frequency counts of friends and enemies when determining consistency, whereas Plaut et al. (1996) used the number of friends and enemies. For the present study, the number of friends and enemies was weighted depending on the frequency count of each word. If a word had a Kucera-Francis frequency count of 0-59 it counted as one friend/enemy. If a word had a frequency count of 60 or more it counted as two friends/enemies since its effect would be expected to be greater.

For this study the number of friends and enemies was determined by compiling a list of all the neighbours of each word stimulus using the MRC Psycholinguistic database (Informatics Division Science and Engineering Research Council, 1987). Each neighbour's pronunciation was compared to the stimulus word. If the two words had a similar rime pronunciation, the neighbour was counted as one or two friends, depending on the Kucera-Francis written frequency count. If the pronunciation of the rime differed, the neighbour counted as one or two enemies. Some neighbours appeared in the list as not having a frequency rating. These words were entered into a second database, the English Lexicon Project Web Site (Balota, Cortese, Hutchison, Neely, Nelson, Simpson, & Treiman, 2002), which reported another frequency count called the HAL frequency count (Balota et al., 2002). If this second frequency count was also zero, the neighbour was excluded altogether.

As previously stated, the stimulus words were divided into five categories: regular consistent (RC), regular semi-consistent (RS), ambiguous (A), irregular inconsistent (II), and strange (S). Each category was further separated into high- and low-frequency words, resulting in ten conditions of real words. Regular consistent words followed GPC rules and had a minimum of 7 friends and had 0 enemies. Regular semi-consistent words also followed GPC rules and had at least 4 more friends than enemies, and had between 1 and 3 enemies. Ambiguous words had at least 10 friends and 10 enemies or their number of friends and their number of enemies differed by 3 or less. Irregular inconsistent words did not follow GPC rules and had a maximum of 2 friends and their number of enemies exceeded their number of friends by a minimum of 4. Strange words had an irregular orthography and had 0 friends and had a maximum of 3 enemies. Appendix B provides additional information on the number of friends, number of enemies, and frequency count for each of the words used. Plaut et al. (1996) provided information regarding the numbers of friends and enemies for each of their word conditions. Regular consistent words had an average of 10.7 friends and 0.04 enemies, the condition that corresponded with regular semi-consistent words had an average of 7.8 friends and 2.1 enemies. Ambiguous words had an average of 8.6 friends and 8.0 enemies, and the condition that corresponded with irregular inconsistent words had an average of 0.73 friends and 9.2 enemies. The list developed for this research further separated the conditions with respect to friends and enemies, although the numbers of friends and enemies were determined in a different way. Collapsing across high- and low-frequency, regular consistent words had an average of 14.30 friends and 0 enemies, and regular semi-consistent words had an average of 10.93 friends and 1.67 enemies. For the purpose of examining regularity, the conditions of regular consistent and regular semi-consistent were pooled to form a condition of regular words. Ambiguous words had an average of 7.97 friends and 7.80 enemies, and irregular inconsistent words had an average of 0.60 friends and 11.37 enemies.

The nonwords consisted of 120 pronounceable pseudowords and 30 illegal nonwords. The pseudowords were created by changing the onset of the existing words in both the high- and low-frequency categories of the following conditions: regular consistent, regular semi-consistent, ambiguous, and irregular inconsistent. The nonwords (vowels omitted) were created to match the number of words in both the high- and low-frequency strange condition. The complete list of nonwords used is provided in Appendix C.

Procedure

All participants were tested individually in a quiet room. Deaf participants were given instructions in ASL by a deaf signing research assistant, with the exception of two participants who were instructed through an experienced interpreter registered as a member of the Association of Visual Language Interpreters of Canada. Hearing participants were given instructions in spoken English by the hearing researcher.

The lexical decision task was presented on a Dell OPTIPLEX GX270 desktop computer with a Dell flat screen 17 inch monitor, using DirectRT Precision Timing Software (Jarvis, 2004). Participants were seated approximately 60 cm from the monitor, and were instructed to place their left index finger on the key labeled NO and their right index finger on the key labeled YES. Participants were told that they would see a string of letters appear on the screen and they were to decide, as quickly and as accurately as possible, if the letter string made up a real English word, and to press the key corresponding to their choice. The sequence of the trials was as follows: written instructions repeated what had been told to each person, then a fixation mark "+" appeared for 1000ms to signal where the stimuli would appear on the monitor, followed by the target stimulus which remained on the screen until the participant responded, and finally the next fixation mark appeared to signal the next target stimulus. Two short breaks were given; one after each 100 presentations.

Chapter 3

Results

Lexical Decision Response Accuracy

To examine regularity effect, participant means were calculated by first assigning a "1" for each correct response and a "0" for each incorrect response, and then totaling the scores for each participant in each condition. Two new conditions were created by combining the words from the regular consistent (RC) and regular semi-consistent (RS) word categories, each with 30 stimulus words: high-frequency regular words and low-frequency regular words. Table 3-1 presents the mean accuracy scores and standard deviations for the two participant groups across word conditions. Overall, the accuracy was high and there was a considerable ceiling effect; subsequently, no analyses were conducted on the mean accuracy scores.

Table 3-1

Response Accuracy Means and Standard Deviations of Control and Deaf Groups

Condition (15 Stimuli)	Group							
	Control (n = 14)				Deaf (n = 16)			
	High		Low		High		Low	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Regularity:								
Regular[a]	29.71	0.47	29.43	0.65	29.81	0.75	28.69	1.40
Irregular	14.86	0.36	14.07	0.83	14.88	0.34	13.50	1.71
Strange	14.79	0.43	13.21	1.12	14.88	0.34	12.75	0.93
Consistency:								
Consistent	14.93	0.27	14.86	0.36	14.94	0.25	14.56	0.81
Semi-consistent	14.79	0.43	14.57	0.65	14.88	0.50	14.13	1.09
Ambiguous	14.64	0.74	14.79	0.43	14.81	0.54	14.06	0.68
Inconsistent	14.86	0.36	14.07	0.83	14.88	0.34	13.50	1.71

Note. [a] 30 stimuli

Lexical Decision Response Latency

To analyze the response latency data, participant means were calculated for correct responses only. Each word that a minimum of 10 (33.33%) of the participants responded to incorrectly was deleted due to possible problems with the particular stimulus. The words removed included one low-frequency irregular inconsistent word; *wad*, and three low-frequency strange words; *phlegm*, *fugue*, and *sieve*. Once the particular words had been deleted, outliers in individual reaction times were removed. This was accomplished by first calculating the mean and standard deviation for each participant in each condition. Any stimulus reaction time that was more than two standard deviations away from the participant's mean reaction time was deleted as an outlier, and a new mean score was calculated. To examine regularity effect, two new conditions were created by combining the words from the regular consistent (RC) and regular semi-consistent (RS) word categories, each with 30 stimulus words: high-frequency regular words and low-frequency regular words (R). The means for these conditions were calculated following the same method. Response latency means and standard deviations for the two participant groups are presented in Table 3-2.

Regularity Effect. To examine the regularity effect, a repeated measures ANOVA was calculated for the participant means with Regularity (3; regular, irregular, and strange) and Frequency (2; high and low) as within-subject factors. These analyses were first completed separately for the deaf and control groups, followed by a mixed model ANOVA that included Group (2) as the between-subject factor.

The control group showed significant main effects of Frequency, $F\,(1, 14) = 13.00, p = .003$, and Regularity, $F\,(2, 14) = 4.82, p = .017$. The Frequency by Regularity interaction effect was not significant, $F\,(2, 14) = 1.67, p = .208$. Table 3-2 shows that the reaction times to high-frequency words were generally faster than reaction times to low-frequency words. A test of within-subject contrasts indicated that reaction times to regular words were significantly faster than reaction times to strange words. There were no significant differences between the reaction times to regular and irregular words, or between the reaction times to irregular and strange words.

The deaf group showed a main effect of Frequency, $F\,(1, 16) = 15.34, p = .001$. The main effect of Regularity was not significant, $F\,(2, 16) = 2.23, p = .125$. The Frequency by Regularity interaction effect was also not significant, $F\,(2, 16) = 2.02, p = .150$. Table 3-2 shows that reaction times to high-frequency words were generally faster than reaction times to low-frequency words.

The mixed model ANOVA indicated that the main effect of Group, $F\,(1, 30) =$

Table 3-2
Response Latency Means (in milliseconds) and Standard Deviations of Control and Deaf Groups

Condition (15 Stimuli)	Group							
	Control (n = 14)				Deaf (n = 16)			
	High		Low		High		Low	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Regularity:								
Regular[°]	582	71.85	655	81.38	713	228.32	892	366.28
Irregular	610	93.73	658	99.65	743	285.79	775	202.41
Strange	637	85.68	664	115.70	719	184.23	903	473.48
Consistency:								
Consistent	596	88.15	626	63.10	735	269.08	837	341.92
Semi-consistent	576	71.14	682	101.58	697	193.88	939	355.59
Ambiguous	600	71.37	670	71.55	755	276.74	872	471.74
Inconsistent	610	93.73	658	99.65	743	285.79	775	202.41

Note. [°] 30 stimuli

4.15, $p = .051$, approached significance, with deaf participants generally responding more slowly than the control participants. Frequency by Group interaction effect was significant, $F(1, 30) = 4.60, p = .041$, whereas Regularity by Group, $F(2, 30) = 1.97, p = .150$, and Frequency by Regularity by Group, $F(2, 30) = 1.77, p = .180$, were not. Figure 3-1 shows the mean reaction times for high- and low-frequency words for the control and deaf groups. The significant Frequency by Group interaction effect indicates that there was a greater reaction time difference between high- and low-frequency words for the deaf group than there was for the control group.

To examine whether the observed between-group differences were related to reading skill differences, the analyses were repeated with deaf and control subgroups matched on word reading efficiency. A mixed model ANOVA with Regularity (3; regular, irregular, and strange) and Frequency (2; high and low) as within-subject factors, and Group as the between-subject factor indicated that the main effect of Group, $F(1, 20) = 0.51, p = .487$, was not significant. The Regularity by Group interaction effect was significant, $F(2, 20) = 6.28, p = .005$. No significant results were found for Frequency by Group interaction effect, $F(1, 20) = .01, p = .968$, or Frequency by Regularity by Group interaction effect, $F(2, 20) = 8.41, p = .440$. Figure 3-2 shows that the significant Regularity by Group interaction effect resulted from very different response patterns across the groups. The mean reaction time for regular words was slower than for other word types for the deaf group, and the mean reaction time for strange words was faster than for other word types. The opposite was true for the control group, who followed the general pattern of having a faster reaction time mean for regular words and a slower reaction time mean for strange words.

Because a significant Regularity by Group interaction effect was found for the

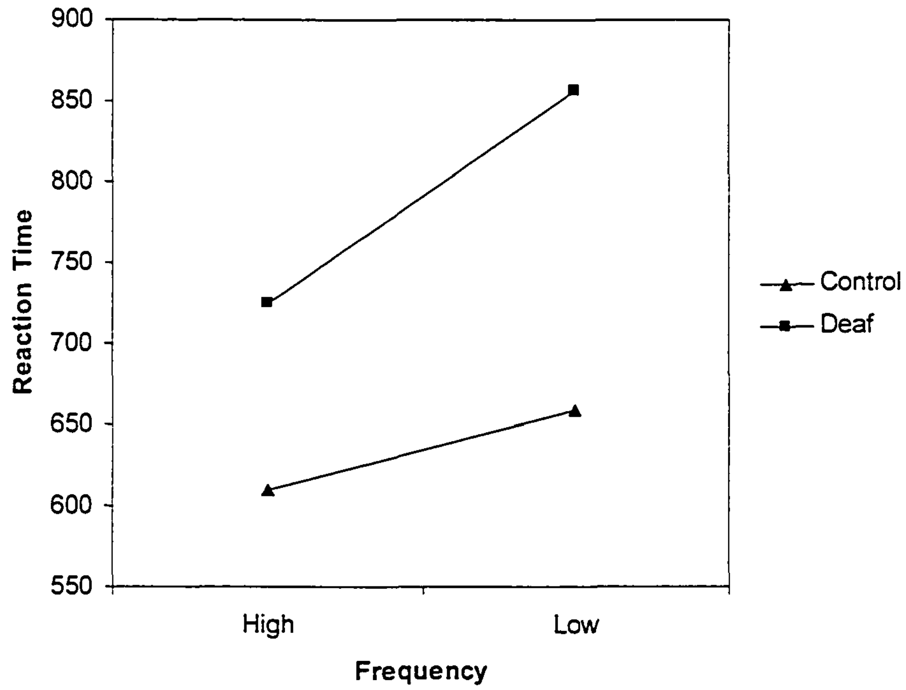

Figure 3-1. Mean reaction times for high- and low-frequency words for the control (n = 14) and deaf (n = 16) groups.

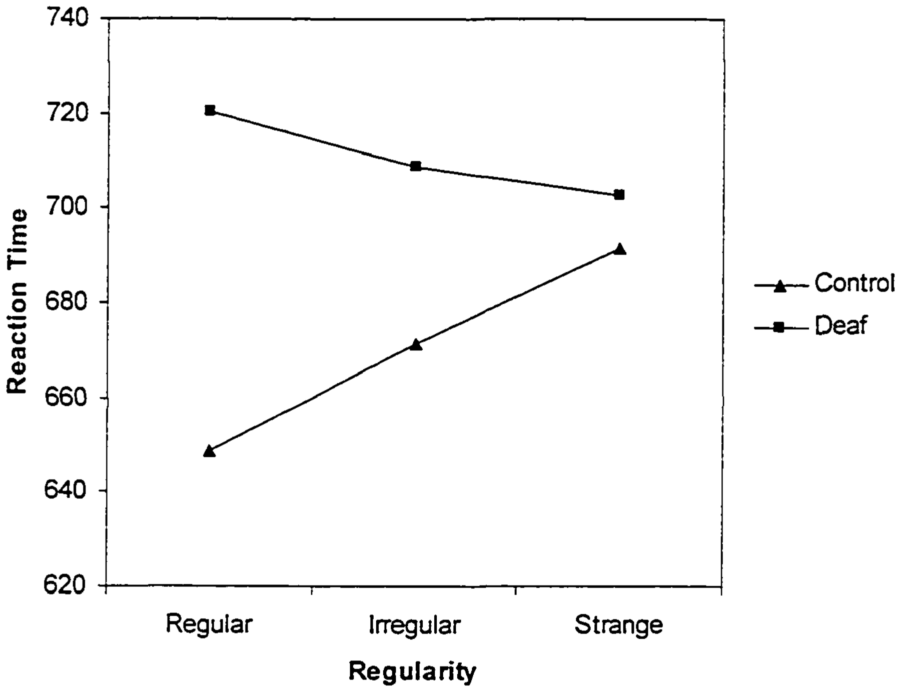

Figure 3-2. Mean reaction times for regular, irregular, and strange words for the control (n = 10) and deaf (n = 10) groups matched on reading ability.

groups matched on reading ability, a repeated measures ANOVA was calculated to determine the within-group differences. The control group still showed significant main effects of Frequency, $F(1, 10) = 13.13, p = .006$, and Regularity, $F(2, 10) = 5.12, p = .017$. Reaction times to high-frequency words were significantly faster than reaction times to low-frequency words, and reaction times to regular words were significantly faster than reaction times to strange words, and were generally faster than reaction times to irregular words, although this difference only approached significance. There was no significant difference between reaction times to irregular and strange words. The Frequency by Regularity interaction effect was not significant, $F(2, 10) = 1.28, p = .303$.

The deaf group also showed a main effect of Frequency, $F(1, 10) = 14.48, p = .004$, with reaction times to high-frequency words significantly faster than reaction times to low-frequency words. The main effect of Regularity was not significant, $F(2, 10) = 1.41, p = .270$. The Frequency by Regularity interaction effect was significant, $F(2, 10) = 4.23, p = .031$. Figure 3-3 indicates that regular words had the greatest difference between the high- and low-frequency conditions, followed by strange words. Irregular words had a considerably smaller mean reaction time difference between the high- and low-frequency conditions. Post hoc analyses showed that the mean reaction time difference between high- and low-frequency words was significant for both the regular and strange conditions, but not for the irregular condition. Post hoc analyses also showed that the Regularity effect was significant for low-frequency words, $F(2, 10) = 6.02, p = .010$, but not for high-frequency words, $F(2, 10) = 1.20, p = .324$. Post hoc pairwise comparisons indicated that reaction times to low-frequency regular words were significantly slower than reaction times to both low-frequency irregular words and low-frequency strange

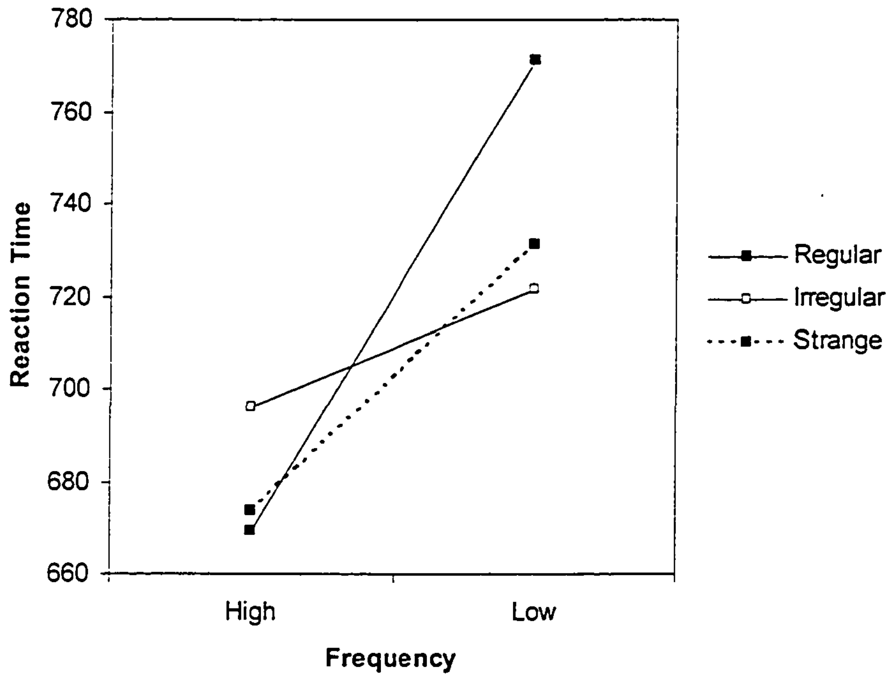

Figure 3-3. Mean reaction times for high- and low-frequency words for the deaf (n = 10) group matched on reading ability.

words. Overall the deaf group showed response patterns of II < R and S < R for low-frequency words. No other reaction time differences were significant.

In order to rule out the alternative explanation of sound access for phonological development in the deaf group, analyses were repeated with the deaf subgroup of profound hearing loss cases only. To examine the regularity effect when the severe hearing loss cases were removed, a mixed model ANOVA was calculated for the participant means with Regularity (3; regular, irregular, and strange) and Frequency (2; high and low) as within-subject factors, and Group as the between-subject factor. The mixed model ANOVA indicated that the main effect of Group, $F\,(1, 26) = 4.82, p = .038$, was significant, with deaf participants generally responding more slowly than the control participants. Frequency by Group interaction effect was still significant, $F\,(1, 26) = 6.86$, $p = .015$. No significant results were found for Regularity by Group, $F\,(2, 26) = 2.35, p = .106$, or Frequency by Regularity by Group, $F\,(2, 26) = 2.06, p = .138$.

In sum, the analysis of the reaction time data indicated that the deaf and control groups were different in their reaction times to the word conditions pertaining to regularity. The control group was generally faster than the deaf group, although this difference only approached significance. There were no significant regularity by group or frequency by regularity by group interaction effects, but there was a significant frequency by group interaction effect (see Figure 3-1). When analyzed separately, both groups did show the expected significant main frequency effect of faster reaction times for high-frequency words than for low-frequency words, most likely due to repeated print exposure. However, only the control group showed a significant regularity effect, and the only significant difference occurred between regular and strange words (R < S). Neither the control nor the deaf groups showed significant frequency by regularity interaction effects.

When the groups were matched on reading ability, analyses revealed clear differences. The main effect of group was not significant. The interaction effect of regularity by group, however, was significant (see Figure 3-2). Because of the different pattern exhibited by the reading matched subgroups, each subgroup was analyzed separately. Both groups still showed a significant frequency effect with faster reaction times to high-frequency words than to low-frequency words. The control group still showed a significant regularity effect (R < S), whereas the deaf group did not. The frequency by regularity interaction effect was still not significant for the control group, but was significant for the deaf group. Regularity was only significant for low-frequency words, as depicted in Figure 3-3, with reactions to both low-frequency irregular and strange words significantly faster than reactions to low-frequency regular words, (II < R and S < R). Frequency differences were significant for regular and strange words; there was no significant difference between high- and low-frequency irregular words.

When the severe hearing loss cases were removed from the deaf group, analyses revealed a pattern similar to the original results, with the difference that the main effect of group was now significant, with the deaf group generally responding slower than the control group. There were no significant regularity by group or frequency by regularity by group interaction effects, but there was still a significant frequency by group interaction effect, with a greater difference between high- and low-frequency words for the deaf group than there was for the control group.

Consistency Effect. To examine the consistency effect, a repeated measures ANOVA was calculated using participant means with Consistency (4; consistent, semi-consistent, ambiguous, and inconsistent) and Frequency (2; high and low) as within-subject factors. These analyses were first completed separately for the deaf and control groups, followed by a mixed model ANOVA that included Group (2) as the between-subject factor.

The control group showed a significant main effect of Frequency, $F(1, 14) = 37.50, p < .001$. The main effect of Consistency was not significant, $F(3, 14) = 1.87, p = .151$. The Frequency by Consistency interaction effect was significant, $F(3, 14) = 5.94, p = .002$. Table 3-2 shows that reaction times to high-frequency words were generally faster than reaction times to low-frequency words. Figure 3-4 shows the mean reaction times for high- and low-frequency words across the different consistency conditions for the control group. The order for speed of recognition was quite different for high- and low-frequency words. Figure 3-4 indicates that semi-consistent words had the greatest difference between the high- and low-frequency conditions, followed by ambiguous and inconsistent words. Consistent words had a considerably smaller mean reaction time difference between the high- and low-frequency conditions. Post hoc analyses showed that the mean reaction time difference between high- and low-frequency words was significant for the semi-consistent, ambiguous, and inconsistent conditions, but only approached significance for the consistent condition. Post hoc analyses also showed that the main effect of consistency was significant for low-frequency words, $F(3, 14) = 4.75, p = .006$, but not for high-frequency words, $F(3, 14) = 1.93, p = .140$. Post hoc pairwise

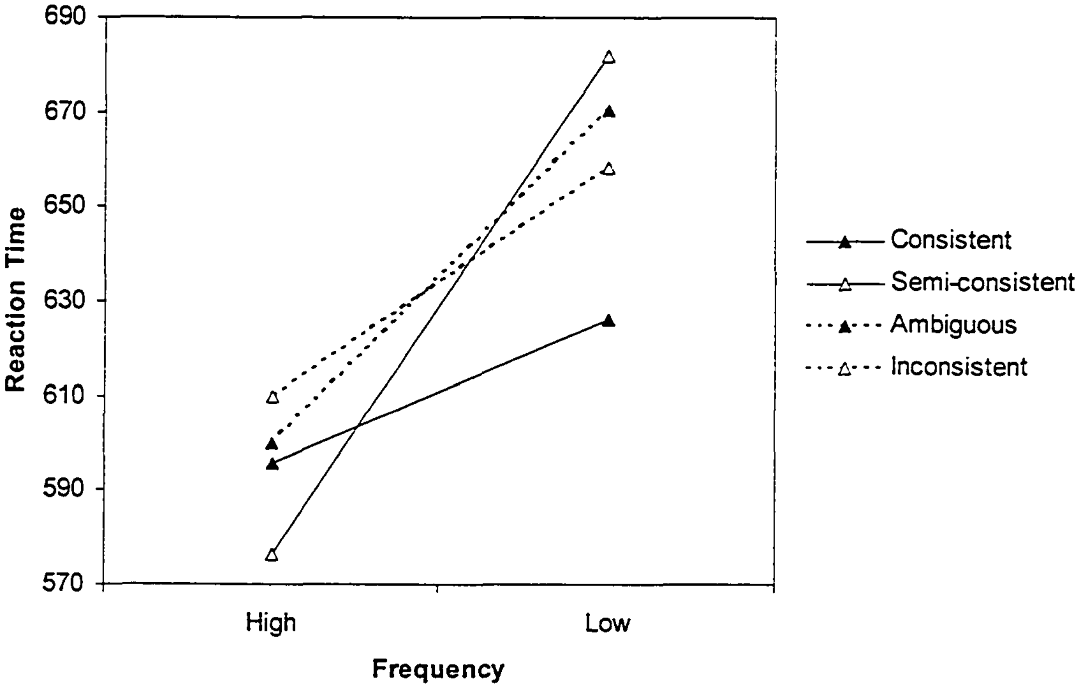

Figure 3-4. Mean reaction times for high- and low-frequency words across the different consistency conditions for the control group (n = 14).

comparisons indicated that reaction times to low-frequency consistent words were significantly faster than reaction times to both low-frequency semi-consistent words and low-frequency ambiguous words. Reaction times to low-frequency consistent words were generally faster than reaction times to low-frequency inconsistent words, but this difference only approached significance. Reaction times to low-frequency inconsistent words were significantly faster than reaction times to low-frequency semi-consistent words. Overall the control group showed response patterns of RC < RS, RC < A, and II < RS for low-frequency words.

The deaf group showed a significant main effect of Frequency, $F(1, 16) = 18.62$, $p = .001$. The main effect of Consistency was not significant, $F(3, 16) = 1.19, p = .325$. Table 3-2 shows that there were generally faster reaction times for high-frequency words than for low-frequency words. A significant Frequency by Consistency interaction effect was found, $F(3, 16) = 3.40, p = .026$. Again, the order for speed of recognition was quite different for high- and low-frequency words. Figure 3-5 indicates that semi-consistent words had the greatest difference between the high- and low-frequency conditions, followed by consistent and ambiguous words. Inconsistent words had a considerably smaller reaction time mean difference between the high- and low-frequency conditions. Post hoc analyses showed that the difference between high- and low-frequency words was significant for the semi-consistent and consistent conditions, but only approached significance for the ambiguous condition. The reaction time difference between high- and low-frequency words was not significant for the inconsistent condition. Post hoc analyses also showed that at high frequency, the main effect of Consistency approached significance, $F(3, 16) = 2.37, p = .084$. At low frequency, the main effect of Consistency was not significant, $F(3, 16) = 2.21, p = .100$. Post hoc pairwise comparisons also

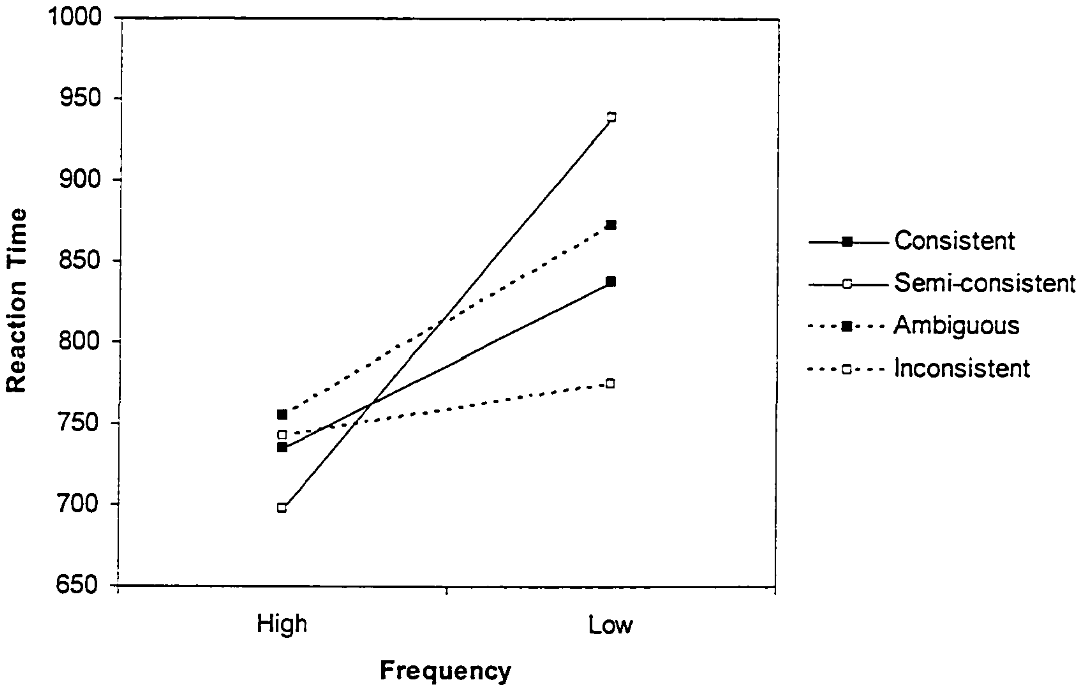

Figure 3-5. Mean reaction times for high- and low-frequency words across the different consistency conditions for the deaf group (n = 16).

indicated that reaction times to high-frequency semi-consistent words were significantly faster than reaction times to high-frequency ambiguous words.

The mixed model ANOVA indicated that the main effect of Group, $F(1, 30) = 4.61, p = .041$, was significant, with deaf participants generally responding more slowly than control participants. The Frequency by Group interaction effect approached significance, $F(1, 30) = 3.42, p = .075$, whereas Consistency by Group, $F(3, 30) = 1.04$, $p = .378$, and Frequency by Consistency by Group, $F(3, 30) = 1.47, p = .230$, did not. There was a trend for the deaf group to have a greater mean reaction time difference between high- and low-frequency words than there was for the control group, similar to the effect shown in Figure 3-1.

To examine whether the observed between-group differences were related to reading skill differences, analyses were again repeated with deaf and control subgroups matched on word reading efficiency. A mixed model ANOVA was calculated using participant means with Consistency (4; consistent, semi-consistent, ambiguous, and inconsistent) and Frequency (2; high and low) as within-subject factors and Group (2) as the between-subject factor. The mixed model ANOVA indicated that the main effect of Group, $F(1, 20) = 1.06, p = .318$, was not significant. Frequency by Group, $F(1, 20) = .07, p = .791$, and Consistency by Group, $F(3, 20) = 1.40, p = .253$, interaction effects were not significant. Frequency by Consistency by Group interaction effect only approached significance, $F(3, 20) = 2.38, p = .080$.

In order to rule out the alternative explanation of sound access for phonological development in the deaf group, analyses were repeated with the deaf subgroup of profound hearing loss cases only. A mixed model ANOVA was calculated using participant means with Consistency (4; consistent, semi-consistent, ambiguous, and inconsistent) and Frequency (2; high and low) as within-subject factors and group as the between-subject factor. The mixed model ANOVA indicated that the main effect of Group, $F(1, 26) = 5.19, p = .032$, was significant, with deaf participants generally responding more slowly than control participants. Frequency by Group interaction effect, $F(1, 26) = 6.53, p = .017$, was significant, whereas Consistency by Group, $F(3, 26) = 1.18, p = .322$, and Frequency by Consistency by Group, $F(3, 26) = 1.84, p = .147$, were not.

In sum, the analysis of the reaction time data indicated that although the control group was significantly faster then the deaf group, there were no significant consistency by group or frequency by consistency by group interaction effects. The frequency by group interaction effect approached significance, similar to the effect shown in Figure 3-1, and there was a greater reaction time difference between high- and low-frequency for the deaf group than there was for the control group. When analyzed separately, both the control and the deaf groups showed the expected significant frequency effect, with reaction times to high-frequency words being faster than reaction times to low-frequency words, and neither group showed a significant consistency effect. Both groups, however, did show significant frequency by consistency interaction effects. For the control group, consistency was significant only for low-frequency words (see Figure 3-4). Reactions to low-frequency consistent words were significantly faster than reactions to both low-frequency semi-consistent and ambiguous words (RC < RS and RC < A), and reactions to low-frequency inconsistent words were significantly faster than reactions to low-frequency semi-consistent words (II < RS). Frequency differences were significant for semi-consistent, ambiguous, and inconsistent words. The difference between high- and low-frequency consistent words only approached significance. For the deaf group (see Figure 3-5), consistency approached significance for only high-frequency words, with the deaf group displaying faster reaction times to high-frequency semi-consistent words than to high-frequency ambiguous words (RS < A). Frequency differences were significant for both consistent and semi-consistent words. The difference between high- and low-frequency ambiguous words only approached significance. The difference between high- and low-frequency inconsistent words was not significant.

When the groups were matched on reading ability, analyses revealed only a slightly different pattern. The effect of group was not significant. The interaction effects of frequency by group and consistency by group were not significant. The interaction effect of frequency by consistency by group approached significance.

When the severe hearing loss cases were removed from the deaf group, analyses revealed a pattern similar to the original results. The effect of group was still significant, with the deaf group responding more slowly than the control group. Neither consistency by group nor frequency by consistency by group interaction effect was significant. The frequency by group interaction effect was significant, with a greater difference between high- and low-frequency for the deaf group than there was for the control group.

Chapter 4

Discussion

In the current study, reaction time data from a lexical decision task was analyzed using repeated measures and mixed model analyses of variance in order to examine the phonological regularity and consistency effects in skilled deaf and hearing adult readers. The examination of regularity effect included high- and low-frequency regular, irregular, and strange word conditions. The examination of consistency effect included high- and low-frequency consistent, semi-consistent, ambiguous, and inconsistent word conditions. All analyses were repeated with participants matched on word reading efficiency to control for the possible effects of reading skill, and with the deaf subgroup of profound hearing loss cases only to control for the possible effects of sound access on phonological development.

Regularity

Earlier studies with deaf readers have produced conflicting results regarding the phonological regularity effect. Waters and Doehring (1990) found no evidence of phonological regularity in any of their three age groups of oral deaf students. When they separated the groups based on reading level rather than chronological age, they again found no evidence of phonological regularity. Burden and Campbell (1994) tested signing deaf teens and found similar results. Their study indicated that orthographic, but not phonological, information was utilized by the deaf. In a study of deaf children, Merrills et al. (1994) found no evidence for phonological coding with real words, but did for pseudowords. Chamberlain's (2002) study of signing deaf adults yielded no evidence for phonological coding in either the good or poor deaf readers. Hanson and Fowler (1987), however, also tested signing deaf adults with good reading skills. They found that the deaf participants were facilitated in their responses to rhyming word pairs consisting of two regular words (e.g., *cave* and *save*) as opposed to pairs consisting of a regular and an irregular word (e.g., *cave* and *have*), indicating that phonological information was used.

In the current study, both the control and deaf groups showed the hypothesized main effect of frequency, yet neither group showed significant frequency by regularity interaction effects. In addition, the critical group by regularity interaction was not significant. It was hypothesized that the control group would show this interaction effect as previous research has indicated that regularity effects are often only present within low-frequency words. The control group did show a main effect of regularity, but the only significant difference occurred between the reaction times to regular and strange words. Recall that, according to the dual route perspective, a significant difference between regular and irregular words would indicate phonological regularity effects, as both word types have regular orthographic patterns but only the irregular words have irregular spelling-sound correspondence; and that a significant difference between irregular and strange words would indicate orthographic regularity effects, as both word types have irregular spelling-sound correspondence but only strange words have irregular orthography. The pattern exhibited by the control group indicates that regularity information was used during word recognition, but it is difficult to tease apart phonological and orthographic influences.

When the groups were matched on reading ability, the main effect of group was not significant, but regularity by group interaction effect was now significant. The groups exhibited very different response patterns, as illustrated above in Figure 3-2. The control group showed a trend to recognize regular words faster than irregular words, indicating phonological effects, as well as the significant difference between regular and strange words. The deaf group's response pattern indicated that they were not using information about word regularity in a way similar to that of the control group. Since regular words follow the English grapheme-to-phoneme correspondence rules, it is peculiar that these yielded the slowest reaction times for the deaf participants. If phonological regularity information was utilized by the deaf group, these words should have had the fastest reaction times. If orthographic regularity information was utilized by the deaf group, reactions to strange words should have had the slowest times. The different results for the subgroups matched on reading ability indicate that the results for the larger samples may have been related to reading level differences. The removal of the reaction time data of four deaf participants with lower word reading efficiency scores may have cleared up some of the problem.

Regularity effects have been much more pronounced in naming than in lexical decision tasks (Jared et al., 1990; Waters & Seidenberg, 1985). In lexical decision tasks, these effects have depended on the response criteria of the participants and on the pressure to respond quickly (Waters & Seidenberg, 1985) which was not controlled for in the present research. While irregular spelling has been found to influence performance on both naming and lexical decision, spelling-sound correspondence has been found to influence only naming. These effects have been found with only low-frequency stimuli (Seidenberg et al., 1984).

To summarize the regularity reaction time data, it seems that there are differences in the way that the control and deaf groups responded to words. The comparisons of the original groups and the comparison with only the profound hearing loss cases indicate that regularity information was used by the control group, but not by the deaf group. Like Chamberlain (2002), the expected regularity effect (R < II < S) for the control participants was not firmly established in the current study, however there were trends indicating that the effect may have been present. When the groups were more carefully matched based on reading skill, the group difference of speed of reaction time disappeared, and in its place there was a significant regularity by group interaction effect that indicated different response patterns of the two groups. Because regular low-frequency words had slower reaction times than either irregular or strange low-frequency words for the deaf group, it can be concluded that regularity information was not utilized, or was utilized quite differently in the deaf group than is normally found with hearing participants. These findings support earlier claims by Burden and Campbell (1994), Merrills et al. (1994), and Chamberlain (2002) that phonological regularity information is not used during word recognition by signing deaf readers. The task used by Hanson and Fowler (1987), who did find evidence of phonological coding, may have been flawed as the researchers failed to include any rhyming word pairs that were not orthographically similar.

Consistency

Earlier studies in the area of consistency have indicated that deaf readers do not show spelling-sound consistency effects. Neither oral deaf children (Waters & Doehring, 1990) nor signing deaf adults (Chamberlain, 2002) used information regarding spelling-sound consistency during word recognition. Although both studies had similar conclusions, there were problems with each stimuli list. Waters and Doehring used only high-frequency words, and Chamberlain had an unequal number of words and nonwords, as well as some frequency classification problems.

In the current study, both the control and deaf groups showed the hypothesized main effect of frequency, yet neither group showed a significant main effect of consistency. Both groups showed a significant frequency by consistency interaction effect, which was hypothesized for the control group but not for the deaf group. The control group's performance followed the expected pattern of demonstrating consistency effects only on low-frequency words, with consistent words significantly faster than both semi-consistent and ambiguous words. However, their reaction times to inconsistent words were unexpectedly faster than their reaction times to semi-consistent words. This difference was unexpected as semi-consistent words have many friends and only a few enemies, whereas inconsistent words have many enemies and only a few, if any, friends. For the deaf group, the main effect of consistency approached significance for high-frequency words, but not for low-frequency words, which was unexpected due to the likely repeated exposure of the high-frequency words. The only significant difference within the high-frequency words was that reaction times to semi-consistent words were significantly faster than reaction times to ambiguous words, which was not hypothesized. The main effect of group was significant, and the frequency by group interaction effect approached significance. There was a greater reaction time difference for low-frequency words between the two groups than there was for high-frequency words, indicating that, as hypothesized, there were some differences in how the control and deaf groups recognized the words.

The reading matched groups did not show a significant group difference, nor did they show any significant group interaction effects, although frequency by consistency by group approached significance. When the severe hearing loss cases were removed, results were almost the same as those obtained with the original groups, with a significant main effect of group and a significant frequency by group interaction effect.

Although a significant consistency effect was found for the hearing participants for low-frequency words, the expected pattern (RC < RS < II, with A = RC or A = RS) was not obtained. The control group had faster reaction times to consistent than to semi-consistent words, similar to the accuracy data on Chamberlain's hearing adults (2002). On low-frequency words, Chamberlain's hearing group was more accurate on consistent than on semi-consistent words, which she claimed demonstrated a consistency effect. The control group also demonstrated that ambiguous words had similar reaction times to semi-consistent words, as hypothesized by Plaut et al. (1996), but their reaction times to inconsistent words were surprisingly faster than their reaction times to semi-consistent words. The semi-consistent words have regular pronunciations and are consistent with most of their neighbours, whereas the inconsistent words are the exceptions to the rule. That the inconsistent words would yield the faster reaction times is peculiar. The deaf group, however, had a very different response pattern than the control group, showing consistency effects for only high-frequency words, and only between semi-consistent and ambiguous words (RS < A). The deaf participants in the current study did not show any of the established consistency patterns. The one significant reaction time difference was odd, since ambiguous words should have had reactions similar to either consistent or semi-consistent words, but not slower than reactions to semi-consistent words. Like the studies by Waters and Doehring (1990) and Chamberlain (2002), the current research found no conclusive evidence of spelling-sound consistency effects with deaf participants.

Limitations of the Current Study

The sample of deaf adults in the study differed in a variety of background factors that could have confounded the results in various ways. The reading level information, the range of hearing losses, and the varying ages of ASL acquisition in the participants should have been more tightly controlled, by either having more stringent participation qualifications or by considerably enlarging the sample size. The deaf group was significantly older than the control group, which may have confounded the results.

Sign familiarity and the age of acquisition of signs are often not taken into consideration in word reading studies involving deaf participants. It is possible that the familiarity one has with a sign in ASL or the age at which one acquired the sign as part of the lexicon may affect the speed at which the particular word is recognized in print. Standard sign familiarity and age of acquisition word banks do not yet exist, but would have been beneficial to this study, and others involving deaf participants who use ASL. As well, it should be noted that there are some words in English that do not have a one-to-one match with ASL signs. These words may be fingerspelled using the manual alphabet, and their recognition may occur by a different process than that of words with a single sign match. The stimuli list used for the current study was not examined for words that may be fingerspelled in ASL.

Another problem with the stimuli used in the current study was with the condition of ambiguous words. Many words in this category had the same rimes. In particular, the rimes "-own", "-ive", and "-one" were used repeatedly, as there were limited choices for ambiguous words with approximately the same numbers of friends and enemies. The repetition of certain rimes may have caused a priming effect within the ambiguous condition.

Possible regularity problems with particular stimuli included the low-frequency irregular inconsistent word *spook*, as the English GPC rules state that *oo* can be pronounced as it is in *spook* but also as it is in *look*. Other possible regularity problems could occur with the low-frequency strange word *bulb*, and the high-frequency strange words *guard*, *guide*, and *soul*. The word *bulb* follows GPC rules for the pronunciation of each letter. The words *guard* and *guide* were originally considered to contain bodies beginning with *u*, which could be argued to be part of the onset *gu* in order to make the hard *g* sound. The word *soul* follows the GPC rules as it contains a long *o* sound. Item analyses were used to determine whether these words had significant response time differences from other words in the same category and whether they should be subsequently removed. Group mean reaction times and standard deviations for each word stimulus were calculated, using the data that had only been cleaned of false responses. It was found that all of the above words were within two standard deviations of the group means for each of the three groups, and therefore none were deleted. Although the suspected problematic stimuli were shown not to have had a significant effect, it is possible that the data may have been affected in some other way. The stimuli list would be improved if none of these exceptions were included, and if more fitting stimuli were found and used in their place.

Since the control group did not show exactly the expected patterns of regularity and consistency effects, and the deaf group did not follow exactly the same patterns as the control group, it is difficult to conclude whether or not the deaf group is using phonological processing during word reading. It is possible that problems exist within the design of the experiment or with the stimuli separation into the different word conditions, which may have resulted in the control group's slight deviation from the expected results. If that is the case, nothing can be conclusively reported about the word recognition skills of skilled deaf adult readers. However, the methods were tightly controlled and the control group, although not exhibiting the expected significant regularity pattern (R < II < S), did exhibit part of it, namely R < S, and an added trend (although only approaching significance) of R < II within the reading matched subgroup. As well, although not exhibiting the expected significant consistency pattern (RC < RS < II, with A = RC or A = RS), the control group did exhibit part of it, namely RC < RS, with A = RS. It is possible that the deaf group's responses to both the regularity and consistency conditions were genuinely different than those of the control group.

The use of phonological knowledge during reading by deaf readers has divided much past research. If such research had incorrectly found evidence of phonological coding, then it could be argued that the stimuli in the current study might have been improved to the point of getting more accurate results. An alternative explanation also exists. If past research had correctly found use of phonological knowledge, then in altering the stimuli lists and cleaning the data in the current research, too much information may have been lost or deleted, and it would be difficult to accurately determine whether phonology was used.

Conclusions and Future Directions

Current, largely unsuccessful, reading instruction methods for deaf students are based on information gained from research with hearing readers. Knowledge of the reading strategies of skilled deaf readers increases our ability to design reading programs and interventions that optimally support reading skill development for all deaf learners. In addition, awareness of the strategies used by deaf readers who demonstrate limitations in phonological knowledge has the potential of informing reading research and theory in general. The current study indicates that skilled deaf adults do not use phonological information during word reading. If these results are replicated in future studies, they will have some important consequences. Because much of the teaching of reading to deaf students is based on research with hearing readers, it may not be indicative of best practice. If the findings from the current research are valid, there are strong implications that new ways of teaching reading to deaf students need to be tried and assessed.

Although the current study examined information specific to successful deaf learners, much more research is needed.

Results from a larger sample of deaf and control participants should be collected and analyzed, to determine whether a larger group would show the expected response patterns. Groups should be strictly matched on the basis of word reading efficiency, as more analysis is needed, in particular, for those group interaction effects regarding regularity. The accuracy and reaction time data from the pseudoword and nonword lexical decisions from the current study should be examined to determine whether phonological information was utilized by the deaf group.

The question of how words are represented in the mind is composed of two parts: the representation of a pattern that allows recognition and the ability to access such a representation from a printed stimulus (Perfetti, 1992). Incomplete phonological representations and/or problems accessing the representations could be to blame for the phonological deficits of not only deaf readers, but also of adult dyslexic readers. Results from the current study should be compared to those of adult dyslexics, a group that shows limitations and/or deficits in their use of phonological knowledge (Bruck, 1990; Bruck, 1992; Apthorp, 1995). Comparing deaf skilled readers and high-achieving adult dyslexics could offer some insight into reading with absent or deficient phonological processing skills. If no significant differences were found between the deaf and dyslexic groups, it could be concluded that the deaf group had qualitatively similarly reading processes to the dyslexic group. If significant differences exist between the two groups, it could be concluded that the deaf read differently than the dyslexics, using limited or deficient phonology in a different way, or possibly not using phonological knowledge at all.

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Appendix A

Consent and questionnaire form for deaf participants

Project Title: Reading Strategies of Signing Deaf Adults

Research Team: Gillian French, Graduate Student, Deafness Studies Program, University of Alberta
Lynn McQuarrie, Assistant Professor, University of Alberta
Rauno Parrila, Associate Professor, University of Alberta

About the Study

Reading is an important skill as it presents people with more career opportunities, personal independence, and academic success. Many Deaf children, however, struggle with learning to read. Current reading programs for Deaf students are based on research with hearing readers who use spoken language to communicate. Little is known about the skills and strategies used by Deaf adults who use American Sign Language as a primary language. It is my hope that information gained by this study will support researchers and teachers in developing new programs that specifically address the needs of signing Deaf children. Your help would be greatly appreciated.

My research project, *Reading Strategies of Signing Deaf Adults*, will provide information specific to successful deaf readers. I will investigate the various word reading strategies used by skilled Deaf adult readers who use ASL as a primary language.

I am a graduate student in the Deafness Studies Program at the University of Alberta. This project is supported, in part, by a Master's Scholarship from the Social Sciences and Humanities Research Council of Canada. This project has been reviewed and approved by the Faculties of Education and Extension Research Ethics Board (EE REB) at the University of Alberta.

Procedure

I am inviting you to participate in the study. If you are interested, please sign this consent form and return it to the university when you come to participate. The knowledge you will share regarding your reading strategies as a successful Deaf reader will provide much insight and will have the potential to better inform researchers and teachers in the field of Deafness Education.

As you know, ASL and English are very different. This study will provide information on the reading strategies of Deaf people who use sign language, and will give researchers more knowledge about successful Deaf readers.

As a participant in the study, you will be asked to complete a background questionnaire. You will be asked to come to the University of Alberta to complete a variety of reading activities that will be presented both on paper and on a computer screen (for example, you will read short passages and answer questions about each passage). A Deaf adult will administer all test instructions in American Sign Language. The tasks are expected to take 1-2 hours for completion. You will have a brief hearing screening. A $20 honorarium will be given to you.

Privacy and Confidentiality

- Your privacy will be respected. All results will be kept confidential.

Background Information Questionnaire

General:

1. Name: ____

2. Date of Birth (year/month/day): ______________________________

3. Age: ____

4. Sex (please circle): **MALE** **FEMALE**

5. Occupation: ____

6. Do you prefer to use your right or left hand for writing? **RIGHT** **LEFT**

7. Do you have normal vision? **YES** **NO**

   If *no*, do you wear glasses or contact lenses? **YES** **NO**

8. Were you born deaf? **YES** **NO**
   If *no*, when did you become deaf? **BEFORE AGE 2** **AFTER AGE 2**

9. Do you wear hearing aids? **YES** **NO**

   If *yes*, for how long? ________________ One or both ears? ________________

   If *no*, have you ever worn hearing aids? ____ Between what ages? ______________
   One or both ears? ________________

10. What is your audiological hearing loss? ___ Mild (26dB – 40dB)
    ___ Moderate (41dB – 70dB)
    ___ Severe (71dB – 90dB)
    ___ Profound (91dB and greater)

11. Is your mother Deaf, hard of hearing, or hearing? **DEAF** **HH** **HEARING**

12. Is your father Deaf, hard of hearing, or hearing? **DEAF** **HH** **HEARING**

13. Do you have other Deaf family members (please list; e.g. uncle, sister, grandmother)?

____

____

____

Education:

1. What age did you start school? ___________________________

2. Have you ever been diagnosed with a learning disability? ______________

3. What type of school program did you attend? (Please write a number in each category using the code below.)
   Hearing school (mainstream class with no interpreter) = 1
   Hearing school (mainstream class with interpreter) = 2
   Hearing school (self contained classroom with other Deaf students) = 3
   Deaf school (day student) = 4
   Deaf school (residential student) = 5
      Preschool ___
      Elementary (K-6) ___
      Junior High (7-9) ___
      High school (10-12) ___
      Post secondary ___

4. What was the school's educational approach (language of instruction)? (Please write a number in each category using the code below.)
   Oral = 1
   Signed English = 2
   ASL = 3
   Other (please describe) = 4
      Preschool ___
      Elementary (K-6) ___
      Junior High (7-9) ___
      High school (10-12) ___
      Post secondary ___

5. What was the highest level of schooling you completed?
   ___ High School
   ___ Some college
   ___ Some university
   ___ Vocational Training - Area: ___________________________
   ___ College diploma - Major: ___________________________
   ___ University undergraduate degree - Major: ______________
   ___ University graduate degree - Major: __________________
   ___ Other (please describe): ___________________________

6. How many years of schooling have you had in total? ______________

Communication:

1. Do you know any languages other than ASL and English (please list)? ______________________________

2. What age did you start learning ASL? ______________________________

Please rate your communication skills in the following areas (circle the best response on the scale of 0-4):

3. Use of ASL:
Fluent **Beginner**
0______1______2______3______4

4. Understanding of ASL:
Fluent **Beginner**
0______1______2______3______4

5. Use of fingerspelling:
Fluent **Beginner**
0______1______2______3______4

6. Understanding of fingerspelling:
Fluent **Beginner**
0______1______2______3______4

7. Use of signed English:
Fluent **Beginner**
0______1______2______3______4

8. Understanding of signed English:
Fluent **Beginner**
0______1______2______3______4

9. Understanding of lipreading:
Fluent **Beginner**
0______1______2______3______4

10. Do you use speech at all? **YES** **NO**
If *yes*, please rate your use of speech:
Fluent **Beginner**
0______1______2______3______4

Reading:

1. How well do you READ English?

Fluent **Beginner**

0______1______2______3______4

2. How well do you WRITE English?

Fluent **Beginner**

0______1______2______3______4

3. Which of the following most nearly describes *your* attitude toward reading as a child?

Very positive **Very negative**

0______1______2______3______4

4. When you were in elementary school, how much reading did you do for pleasure?

A great deal **Some** **None**

0______1______2______3______4

5. During secondary school what was your attitude toward reading?

Very positive **Very negative**

0______1______2______3______4

6. When you were in secondary school, how much reading did you do for pleasure?

A great deal **Some** **None**

0______1______2______3______4

7. What is your current attitude toward reading?

Very positive **Very negative**

0______1______2______3______4

8. How much reading do you do for pleasure?

A great deal **Some** **None**

0______1______2______3______4

9. Please describe any strategies you remember using to help you with reading (e.g. using a dictionary, writing summaries of what you have read, translating text into ASL, etc.). ______________________________

____

10. Please describe some of the factors you believe contributed to your successful reading development.

____

____

____

(Adapted from McQuarrie, 2005; Parrila, Corkett, Hein, & Kirby, 2004; Chamberlain, 2002; Boudreault, 1999; Tractenberg, 1997; and Nemeth-Sinclair, 1992)

Appendix B

Table B-1

High-frequency words used in lexical decision task

Regular Consistent				Regular Semi-consistent				Ambiguous				Irregular Inconsistent				Strange			
Word	KF	F	E	Word	KF	F	E	Word	KF	F	E	Word	KF	F	E	Word	KF	F	E
came	622	14	0	paid	145	8	3	brown	176	9	11	work	760	0	6	eye	122	0	0
place	571	13	0	speak	110	11	3	shown	166	10	11	both	730	0	5	corps	109	0	0
page	66	9	0	flat	67	22	3	town	212	9	11	great	665	0	20	sign	94	0	0
big	360	15	0	small	542	18	1	stood	212	4	7	put	437	0	13	view	186	0	0
week	275	12	0	cool	62	9	1	known	245	10	11	word	274	0	7	young	385	0	0
tell	268	18	0	few	601	26	1	good	807	4	7	shall	267	0	20	world	787	0	0
soon	199	9	0	bad	142	12	1	down	895	9	11	foot	70	0	9	once	499	0	1
dark	185	11	0	class	207	12	1	your	923	5	3	touch	87	0	6	friend	133	0	1
stop	120	17	0	camp	75	12	1	four	359	5	3	broad	84	0	5	front	221	0	2
main	119	21	0	land	217	14	1	how	834	11	24	gross	66	0	10	court	230	0	0
write	106	13	0	look	399	11	2	slow	60	21	13	phase	72	1	6	heard	247	0	1
broke	72	12	0	hard	202	7	1	drove	62	10	8	watch	81	1	9	guide	36	0	0
trip	81	21	0	cut	192	11	2	drive	105	8	5	break	88	1	13	soul	47	0	2
team	83	10	0	part	500	11	2	five	286	8	5	move	171	1	17	guard	48	0	0
take	611	18	0	list	133	6	2	death	277	1	2	come	630	2	6	worse	50	0	3
Mean	249.20	14.20	0	Mean	239.60	12.67	1.67	Mean	374.60	8.27	8.80	Mean	298.80	.40	10.13	Mean	212.93	0	.67
SD	201.49	4.00	0	SD	180.39	5.47	.82	SD	317.27	4.56	5.49	SD	269.97	.63	5.29	SD	206.23	0	.98

Note. KF = Kucerà Francis written frequency count; F = number of friends; E = number of enemies.

Table B-2

Low-frequency words used in lexical decision task

Regular Consistent				Regular Semi-consistent				Ambiguous				Irregular Inconsistent				Strange			
Word	KF	F	E	Word	KF	F	E	Word	KF	F	E	Word	KF	F	E	Word	KF	F	E
sank	18	26	0	mouse	10	6	2	hood	7	5	7	wad	0	0	14	phlegm	0	0	0
wing	18	19	0	cord	6	7	2	pour	9	6	3	worm	4	0	4	beige	1	0	0
wax	14	7	0	mush	0	11	3	blown	9	11	11	swamp	5	0	14	seize	6	0	0
ripe	14	7	0	tint	1	9	1	stove	15	11	8	wand	1	0	16	aisle	6	0	0
swore	14	24	0	hoe	0	8	1	strive	7	7	5	sew	6	0	28	yacht	4	0	0
pump	11	15	0	rave	0	13	2	lone	8	12	10	wool	10	0	11	axe	6	0	0
trunk	8	13	0	fowl	1	8	1	prone	14	12	10	pint	13	0	10	bulb	7	0	0
deed	8	16	0	lash	6	20	1	zone	11	12	10	spook	0	1	12	choir	8	0	0
float	3	9	0	rut	1	12	2	gown	16	10	11	rouse	2	1	8	gauge	12	0	0
slam	3	18	0	slant	3	9	2	leaf	12	1	1	swarm	3	2	6	debt	13	0	0
peel	3	9	0	hoot	9	7	3	thrive	1	7	5	doll	10	2	8	fugue	0	0	0
grape	3	10	0	toss	9	9	2	wreath	8	1	3	bush	14	2	12	weird	10	0	0
stunt	1	8	0	growl	4	8	1	hive	2	7	5	flood	19	2	10	limb	5	0	1
ditch	10	10	0	paste	10	5	1	drone	3	12	10	swat	0	2	24	ache	4	0	1
kit	2	25	0	beast	7	6	1	sheath	4	1	3	plaid	1	0	12	sieve	1	0	1
Mean	8.67	14.40	0	Mean	4.47	9.20	1.67	Mean	8.40	7.67	6.80	Mean	5.87	.80	12.60	Mean	5.53	0	.20
SD	5.97	6.68	0	SD	3.89	3.73	.72	SD	4.64	4.20	3.43	SD	5.99	.94	6.32	SD	4.09	0	.41

Note. KF = Kucera Francis written frequency count; F = number of friends; E = number of enemies.

Appendix C

Nonword Stimuli for Lexical Decision Task

	Pseudowords derived from RC	Pseudowords derived from RS	Pseudowords derived from A	Pseudowords derived from II	Illegal nonwords
High	rame	gaid	thown	sork	cthn
	flace	pleak	glown	coth	brps
	yage	smat	jown	breat	ygnk
	hig	grall	plood	vut	gwmd
	feek	vool	wrown	dord	fngpy
	nell	snew	lood	krall	hrld
	poon	nad	cown	joot	jcfng
	jark	prass	rour	youch	stndb
	brop	mamp	wour	thoad	plrtk
	sain	jand	fow	whoss	lhrt
	drite	fook	frow	slase	mgrd
	ploke	zard	spove	natch	ndvsc
	glip	dut	glive	treak	pllmg
	weam	sart	zive	yove	sdrh
	zake	nist	zeath	gome	trsbf
Low	pank	kouse	jood	jad	tgmy
	hing	pord	zour	torm	vgdn
	vax	yush	spown	plamp	rzyhr
	bipe	bint	slove	pand	ylsj
	clore	poe	plive	plew	mcht
	yump	bave	wone	sool	dxjnp
	blunk	gowl	frone	kint	zlbr
	meed	nash	jone	trook	stkr
	droat	lut	pown	vouse	mhyg
	fram	prant	teaf	plarm	kbtwd
	beel	doot	flive	soll	hgpr
	thape	coss	steath	fush	drdl
	thunt	thowl	sive	drood	cmby
	kitch	gaste	trone	glat	jchg
	vit	veast	gleath	thaid	vtvd

Note. RC = Regular Consistent; RS = Regular Semi-consistent; A = Ambiguous; II = Irregular Inconsistent