Deaf Children's Spelling: Does It Show Sensitivity to Phonology?

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A written pictures to spelling task was given to two groups of children, 17 deaf children from signing schools (average age = 10.7) and 20 hearing children learning English as a second language (ESL, average age = 10.4). The stimuli were equally divided according to frequency, phonological regularity, and orthographic regularity. We predicted that the deaf group would not differ from the ESL group in the pattern of their responses across word classes, categorized in terms of the effect of frequency and phonological and orthographic regularity. Results showed that broadly this was the case, but more detailed analysis showed that the approach of the two groups was different. More specifically, the deaf children appeared to be sensitive to, but not aware of, phonology in their spelling, whereas the ESL group showed awareness of, as well as sensitivity to, phonology in their spelling.

Evidence suggests that deaf children, at least those with hearing parents, have serious problems in acquiring literacy (Becker, Schildhammer, & Rouss, 1994; Burden & Campbell, 1994; Conrad, 1979; Gregory, 1995; Merrills, Underwood, & Wood, 1994; Webster, 1986). When deaf children leave school in their late teens, they typically have the literacy skills of a 10-year-old.

Several proposed theories give an account of the development of normal reading and spelling. One of the best-known theories is that of Frith (1985), who proposed that children go through three stages in learning to read and spell in English. In the first, *logographic,* stage, children decode words according to their salient visual features, such as length, shape, and distinctive letters. There is as yet no strategy for decoding novel words, and spelling appears to be random, with little or no resemblance to the target word. As the child gains experience, the relationship between sound and spelling becomes less opaque, and the child begins to learn some simple sound-spelling correspondences. In the next, *alphabetic,* stage, children read and spell on the basis of the details of the letter-by-letter structure of written words, together with rules about grapheme-phoneme correspondences. Children typically enter this stage earlier for spelling than for reading, already using an alphabetic strategy for spelling while expanding the set of words that they can read logographically. The final, *orthographic,* stage begins when the child begins to read according to an orthographic strategy. This is based on more detailed knowledge, picked up through experience, of the complex spelling patterns that occur in written English. This stage is typically reached for reading before it is reached for spelling. In the expert reader and speller, phonological and orthographic codes are strongly interlinked, and morphological knowledge begins to emerge.

Other theories of reading (e.g., Bryant & Bradley, 1985; Harris & Coltheart, 1986; Marsh, Friedman, Welch, & Desberg, 1981) differ in detail from Frith's and from one another. It is, however, generally accepted that phonological awareness is of considerable impor-

To maximize the confidentiality of the participants, we have chosen not to name the schools in which the research was carried out. However, we thank all the children and staff for their help. We also thank Alice Thacker for valuable discussion and Dr. R. W. Hiorns for his advice concerning statistical analyses. Ann Dowker would like to thank the ESRC for financial support during the period of the study. Correspondence should be sent to Ann Dowker, Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, England.

tance to both reading and spelling. Phonological awareness begins with awareness of sound-based similarities and differences between words, such as those involved in rhyme and alliteration (e.g., understanding that cat and hat rhyme, and that doll and dog begin with the same sound). At a more advanced level, it also involves the ability to segment words into their component sounds: for example, that the word "cat" is made out of three sounds. Hearing children with normal phonological perception but relative weaknesses in phonological awareness are often poor readers (e.g., Bradley & Bryant, 1983; Bowey, Cain, & Ryan, 1992; Lundberg & Hoien, 1989; Shankweiler, Lundquist, Dreyer, & Dickinson, 1996; Tunmer, Herriman, & Nesdale, 1988). Despite phonological awareness being a strong predictor of reading performance in English, some individuals with very limited phonological awareness can nevertheless read well, by using and perfecting alternative, more logographic strategies (Bruck & Waters, 1988; Campbell & Butterworth, 1985; Frith, 1985). Even such individuals, however, usually have persistent spelling deficits.

It might be suspected that born-deaf children with little or no auditory input would be unlikely to achieve normal progress in reading, and especially in spelling, as they would have no way of obtaining phonological information. The information provided by lipreading is minimal; although canonical vowels are as visually distinct as they are auditorily distinct, consonants are much less clear, and manner of articulation is invisible, as is place of articulation, except at the front of the mouth (Kyle & Woll, 1988; Rodda & Grove, 1987). Furthermore, trying to teach lipreading to deaf people with no residual hearing is "difficult and frustrating," according to Rodda and Grove and "unnatural," according to Kyle and Woll. The speech of many born-deaf people is often intelligible only to close associates and carers. However, deaf people often show patterns of phonological development in their own speech, which, although they are developmentally delayed and extended in time, resemble in some ways those of hearing children (Dodd, 1974; Oller & Kelly, 1974). Whatever happens to the phonological skills of deaf people in spoken language, there will always be gaps, as not all of the phonetic distinctions available through the ear can be naturally perceived, by sight or by any other way. The phonological representations that deaf people are capable of developing are likely to be seriously underspecified.

If deaf children have limited phonological information about the words they are trying to read and spell, they might be expected to read English by using solely logographic strategies, particularly if their primary mode of communication is a form of sign language. The written words would be treated purely as visual patterns, which require a mapping between the written form of the word and the spoken or signed form, where there is no perceived correspondence between the characters and the features of the spoken or signed form. If this is the case, the deaf children would be sensitive to the orthographic regularity of the written form of words; how word-like it is, but not sensitive to phonological regularity; how much it follows the "rules" of letter to sound correspondences. Sensitivity to phonology is here defined to mean that phonological regularity influences the accuracy of spelling. It is contrasted with awareness of phonology, which is here defined to mean explicit knowledge about the phonological composition of words, ranging from the detection of rhyme and alliteration, to the ability to isolate, count, or manipulate the individual sounds in a word. Evidence on this is mixed. Some studies suggest that deaf readers do use primarily visual-orthographic strategies in reading and spelling, whereas others appear to have shown that they are capable of quite sensitive phonological judgments, for example, of rhyme and homophony.

Dodd (1980) found that deaf and hearing 14-year-olds achieved the same overall level of accuracy, but the deaf group made more errors on phonologically regular words and the hearing group made more errors on phonologically irregular words. This finding supports the claim that deaf people are less impaired than hearing people of the same reading ability when spelling words with an unusual relationship between sound and spelling. However, Dodd and Hermelin (1977) found that deaf children made phonetic errors in pronouncing unfamiliar words. Hanson, Shankweiler, and Fischer (1983) found sensitivity to phonological regularity as well as orthographic regularity in the spelling of a group of college-level deaf people of varied educational background, (reading age 15–16 years). In a

study of spelling in French, Leybaert (1992) tested Belgian primary school deaf children and found that they must use sound as a guide to spelling in some way, as they showed a phonological regularity effect.

Other studies, such as Campbell and Wright (1988), showed that deaf people can make rhyme judgments on words and pictures, (also shown by Dodd, 1987; Hanson & Fowler, 1987; Waters & Doehring, 1990), although the deaf people were more confused by "eye rhyme" pairs such as PEAR-FEAR, where two words look as though they should rhyme but do not. Deaf children are also capable of using homophony in some tasks (Dodd, 1987).

Some studies of deaf people's word reading (Merrills, Underwood & Wood, 1994; Waters & Doehring, 1990) have suggested rather less sensitivity to phonological regularity than would be suggested by some of the above studies, especially those of spelling. These somewhat contradictory findings may in part reflect methodological differences and differences between samples. Differences between schools and between educational systems in different countries could, for example, have been a factor; so conceivably could slight differences between samples in degree of hearing loss. Almost all the studies were confined to profoundly prelingually deaf children, and most (e.g., Campbell & Wright, 1988; Dodd 1974, 1980, 1987; Hanson, Shankweiler, and Fischer, 1983; Merrills, Underwood, & Wood, 1994) defined profound deafness as a hearing loss of over 85 decibels in the better ear across the frequencies most relevant to speech (500, 1000 and 2000 Hz). However, a few studies (e.g., Hanson & Fowler, 1987; Leybaert, 1992) defined profound deafness as a hearing loss of over 90 decibels. Of more potential importance is the fact that Leybaert's sample included some children assessed as "severely" rather than "profoundly" deaf, with hearing losses ranging from 70 to 90 decibels; this may have contributed to their ability to use sound to guide spelling. Differences between reading and spelling (Burden & Campbell, 1994) may also have contributed to the different results of the different studies. Studies of hearing children have revealed that it is possible for the same child to read by predominantly "visual" strategies, and spell by predominantly "phonological" strategies; this is especially true of children in the early years of schooling (Bryant & Bradley, 1980; Lightman, 1990) and of children with specific difficulties in spelling (Burden, 1992; Frith, 1985).

Recently, more detailed studies of deaf children's spelling strategies have been carried out. A study by Burden and Campbell (1994) compared orally educated profoundly prelingually deaf 14-year-olds (with a hearing loss of at least 85 decibels in the better ear) with two control groups, one matched for reading age, the other for chronological age. All participants were given a written pictures to spelling task that consisted of 72 items, each representing a specific word. Of the 72 words, they were divided equally into high frequency and low frequency groups. The words were also divided according to their spelling pattern; there were equal numbers of regular words, exception words (which had a common spelling pattern, but an unusual spelling to sound correspondence) and strange words (which had an unusual spelling pattern and a unique pronunciation). Burden and Campbell found that the deaf school leavers fell between the two control groups. They scored better than the reading age-matched group, but worse than the chronological age-matched group. For the older hearing group, only strange-low frequency words were hard to spell, and for the younger group both phonological and orthographic regularity effects were found. For the deaf group, both of the regularity effects were found, and the pattern of errors among the deaf group followed a phonological/lipread pattern. A similar study of Belgian deaf children, by Leybaert and Alegria (1995) found exactly the same thing, namely, that the deaf children's spelling was governed by sensitivity to both phonological and orthographic regularity.

Most of the aforementioned studies of deaf children tested pupils with prelingual hearing losses of at least 85 decibels who were in oral-based education programs, and compared them with children without language difficulties. The purpose of the present study is to examine whether deaf children who are educated in sign language and learn to read and write English follow the same patterns as hearing children learning to read English as a second language (ESL). Thus, the same spelling task (closely based on Burden and Campbell's task) was given both to a group of deaf children and to a group of children of comparable age who were

learning ESL. Although deaf children who are educated in sign vary according to the extent of their exposure to sign language outside school and in the home, the fact that they are trying to master at least two languages, namely, sign and written English, makes it worthwhile to compare them with a hearing group who are also acquiring literacy in a second language. Moreover, ESL children are a useful comparison group, since, like most deaf children, they combine "normal" intelligence and neurological characteristics with a specific deficit in English language use. Although numerous studies have compared the language abilities of deaf and ESL children (e.g., Charrow & Fletcher, 1974; Paul, 1996; Quigley & Paul, 1984, 1987; Swanwick, 1998), none to our knowledge has compared the spelling strategies of these groups.

One study (Wade-Woolley & Siegel, 1997) has, however, looked at 7- to 8-year-old Canadian ESL children's spelling and phonological awareness in comparison with poor and good readers who were native speakers of English. They found that both the poor readers and the ESL children showed deficits on phonological awareness tasks, but that the ESL children's spelling was much better than that of native poor readers. We would suggest that this may indicate different reasons for phonological awareness difficulties in the different populations, with the poor readers having a fundamental problem with general metalinguistic awareness, and the ESL children having not fully mastered the sound system of their second language (i.e., they might have shown higher levels of phonological awareness if tested in their first language), and that the former deficit may cause greater problems with spelling. This explanation is consistent with findings (Bialystok, 1988; Campbell and Sais, 1995) that children acquiring a second language often show *enhanced* phonological awareness when tested in their *first* language. Another possibility is that spelling in a second language is less dependent on oral language knowledge than spelling in a first language, and thus may be less closely related to phonological awareness.

The findings that ESL children can show poor performance in English phonological awareness tasks, while showing relatively unimpaired spelling, suggest that deaf children's phonological limitations *need* not lead to spelling abnormalities. Nonetheless, the extensive evidence that deaf children do often have considerable problems with literacy led us to predict that the ESL children *would* outperform the deaf children in spelling. The purpose of the study was not, however, solely to compare spelling accuracy in deaf and ESL children, but also to investigate (1) whether the patterns of spelling errors would be similar in the two groups and (2) whether the two groups would be similarly influenced by the orthographic regularity of words. Our predictions were that a higher proportion of ESL than deaf children's errors would be phonetically plausible, but that both groups would have sufficient phonological sensitivity to perform better on regular than irregular (exception and strange) words.

It would have been desirable to test the children's performance in reading as well; but this proved to be impractical, as none of the researchers had sufficient competence in British Sign Language (BSL) to administer tests to the deaf children, and it would have placed an excessive burden on the children's teachers to ask them to administer a reading test to each child (the spelling test was more amenable to group administration).

Method

Participants

Two groups of children took part in the experiment: 17 deaf children from two government-funded sign-using schools in the south of England, and 20 hearing children from the ESL program of a middle school in Oxford. The deaf children were between 9.1 and 12.4 years of age, with an average of 10.7, and there was an approximately equal number of boys and girls. The schools used Total Communication (TC) in their teaching, which entailed the use of both BSL and Sign-Supported English, with the aim that the children should become bilingual in English and BSL.

All the deaf children were audiologically diagnosed as being profoundly deaf: they had an average hearing loss of at least 96 decibels in the better ear and had become deaf prior to the onset of language acquisition. They all were described by their teachers as using BSL as their principal communication medium. All children had hearing parents. For reasons of confidentiality, it

was not the policy of the schools to provide detailed information about individual's family backgrounds, IQs, language test scores, or school achievement. However, none of the children had any known associated disabilities such as autism, uncorrected visual impairment, or cerebral palsy; and each was judged by their teachers to be within the normal range of intelligence.

The second language learners were all of Indian, Pakistani, or Bangladeshi origin and were between 9.6 and 10.11 years of age, with an average of 10.4. There was an equal number of boys and girls in the group. Detailed information is not available about the linguistic capabilities of individual children; but children from their schools were usually not assigned to ESL teaching unless they had significant English limitations (demonstrating oral and reading skills at a level at least 2 years below their chronological age).

Stimuli

A stimulus list was produced consisting of 60 pictures corresponding to specific words of established regularity. The list was divided into two groups, high frequency of occurrence (more than 76 per million) and low frequency of occurrence (less than 6 per million), using the norms set out by Kucera and Francis (1967). Within each frequency group the words were divided into three subgroups according to their phonological and orthographic structure (see the appendix for a complete listing). The first group, regular words, have a common spelling and an unambiguous relationship between spelling and sound (e.g., CAT, SPIDER). Exception words also have a common spelling pattern, but contain an ambiguous sound segment that can be spelled in one of several alternative ways. In the case of the exception words, the ambiguous segment has an unusual sound mapping (e.g., BREAD, where the vowel sound is usually represented by E as in BED; LAUGH where the final consonant is usually represented by F or FF as in STUFF). The final word category was strange words (e.g., TONGUE, SPONGE), which have both a unique pronunciation and an unusual letter sequence, according to English positional bigram frequency (Rawlinson, 1976), that is, the frequency with which a pair of letters typically appears in a particular position in a word; for example, the letter pair "ts" is frequent at the end of words, but infrequent at the beginning. There were 10 words of each regularity class in each word-type class. Ten pictures standing for words that were not classified according to frequency or orthography were also included as practice items. The pictures were put together, in a pseudo-random order, to make a 10-page booklet, each with a space for the answer. The practice items preceded the classified items.

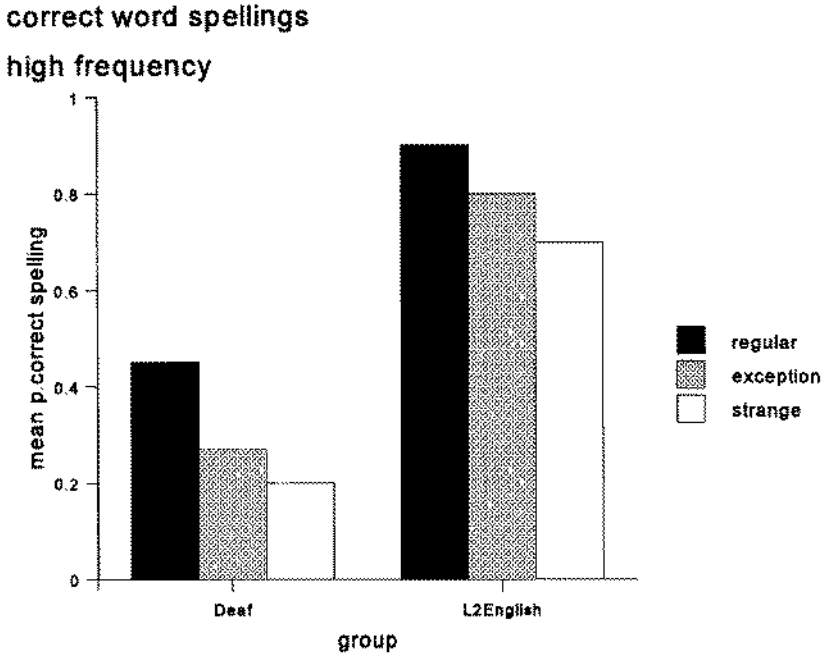
Procedure

Children were tested in three groups, all of the children from one school being tested together. The children were given a copy of the testing booklet and arranged to prevent copying, facing the teacher, who either said aloud the word represented by each picture, or gave the sign for it. The children were told to look at the picture and spell the word the teacher gave. The children had as much time as they needed to make an attempt at the word and were encouraged to guess if they did not think they knew. If necessary, the teacher repeated the word or the sign.

Results

The completed tests were scored in one of two ways. First, the total number of correct responses for each of the 60 classified items was calculated, where only a correct spelling of the word intended was accepted. Figure 1 shows the mean proportions of correct responses by each group to each of the word categories. Table 1 shows chi-square comparisons, for each group separately, between the frequencies of correct responses to the different word categories.

As can be seen, both the deaf group and the ESL group made more errors on low frequency words than high frequency words. Both groups were also better at regular than exception and strange words and better at exception words than strange words, over high and low Frequency. When comparisons were made between the word categories in each frequency group separately, the same pattern of results held with three exceptions. The deaf group did not make significantly more errors on high frequency-exception words than on high frequency-strange words, and they did not make significantly



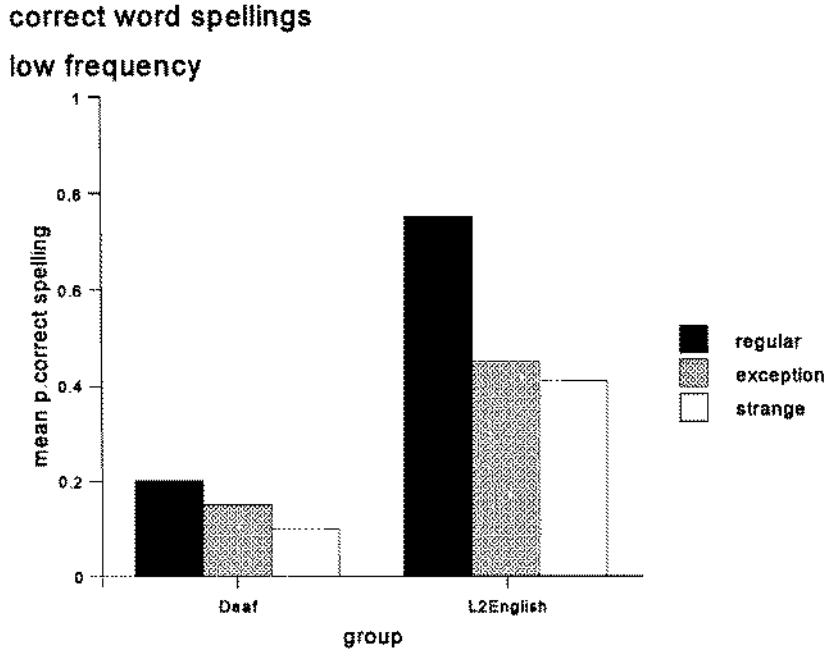


Figure 1 Proportions of correct responses to high and low frequency regular, exception, and strange words.

Table 1 Chi-square comparisons of number correct between word categories for both subject groups

	Deaf children			Second-language learners		
Comparison	χ^2	*df*	*p*	χ^2	*df*	p
Word type (overall)	40.44	2	<.05	84.28	2	<.05
Reg vs Ex	9.45	1	<.05	41.02	1	<.05
Reg vs Str	37.18	1	<.05	83.26	1	<.05
Ex vs Str	4.75	1	<.05	8.17	1	<.05
Word type (high f)	26.65	2	<.05	40.67	2	<.05
Reg vs ex	14.86	1	<.05	10.99	1	<.05
Reg vs str	22.28	1	<.05	39.96	1	<.05
Ex vs str	0.81	1	>0.1 (ns)	10.26	1	<.05
Word type (low f)	17.46	2	<.05	53.58	2	<.05
Reg vs ex	2.99	1	>0.1 (ns)	33.92	1	<.05
Res vs str	17.65	1	<.05	97.30	1	<.05
Ex vs str	6.76	1	<.05	1.23	1	>0.1 (ns)
High vs low f (overall)	45.46	1	<.05	76.65	1	<.05
Reg words	23.49	1	<.05	17.73	1	<.05
Ex words	7.52	1	<.05	44.95	1	<.05
Str words	18.67	1	<.05	22.14	1	<.05

All are significant, except where ns is indicated.

more errors on low frequency-regular words than low frequency-exception words. The ESL group did not make significantly more errors on low frequency-exception words than low frequency-strange words.

The responses for all 60 items were classified and totaled for each of the two subject groups. Correct spellings of unintended as well as intended words were accepted as "Correct," and the types of errors were classified as Phonetic (e.g., NEE for knee; CHARE for chair) or Nonphonetic (e.g., CHMAL for camel). Two further categories of Correct Initial Sound (but nothing else) (e.g., G for gun) and Omission of the word were included as they made up a substantial proportion of the deaf group's responses. The last two categories occurred only in the deaf group. Figure 2 shows the proportion of responses by response type for the two groups.

Chi-square comparisons showed that a very significantly higher proportion of the ESL children's responses than of the deaf children's responses were correct ($\chi^2 = 353.46$; $df = 1$; $p < .01$) or phonetic errors ($\chi^2 = 187.84$; $df = 1$; $p < .01$); while a very significantly higher proportion of the deaf children's responses were nonphonetic errors, ($\chi^2 = 55.03$; $df = 1$; $p < .01$), initial sounds ($\chi^2 = 216.75$; $df = 1$; $p < .01$), or word omissions ($\chi^2 = 435.68$; $df = 1$; $p < .01$).

The Nonphonetic Error category was further broken down into 11 subcategories, adapted from Treiman (1993): Vowel Omissions (e.g., CMAL for camel); Consonant Omissions (e.g., Vowel Substitutions (e.g., TANGE for tongue), Consonant Substitutions (e.g., PECOT for peacock), Reversals (e.g., BURSH for brush), Inappropriate Final "e" (e.g., CAROTE for carrot), Inappropriate Plurals (e.g., DOGS for dog), Other Additions (e.g., AICAX for axe), Syllable Omissions (e.g., BUT for button) and "Nonsense" (e.g., PFDX for hammer). Chi-square comparisons of the two subject groups for each type of response were carried out. Table 2 shows the percentages of nonphonetic errors that fell into each category, and the relevant chi-square values.

There was no significant difference between the two groups for vowel omission errors and consonant substitution errors, but the deaf made significantly more consonant omission errors and the ESL group made significantly more vowel substitution errors. In

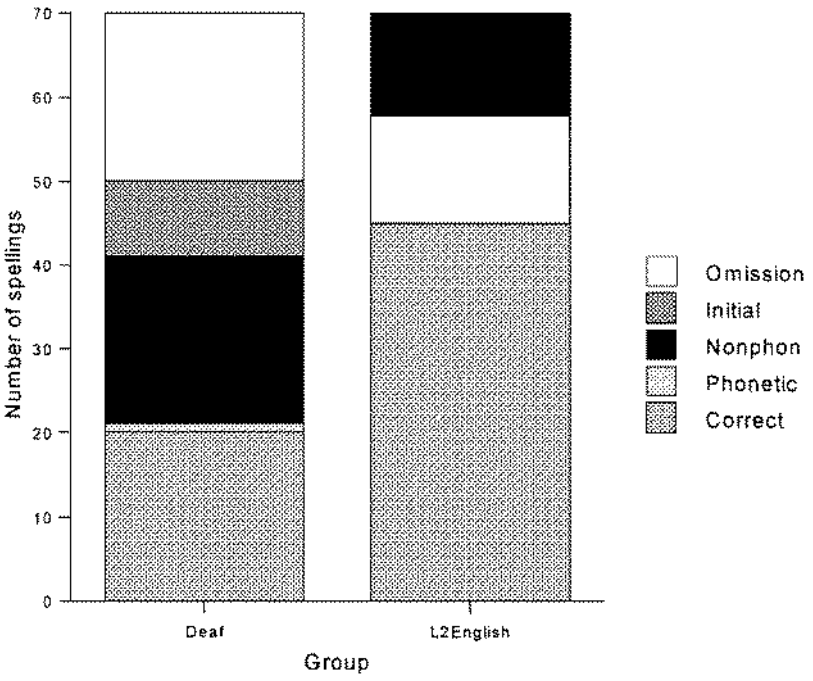


Figure 2 Proportion of responses by response type for the two groups.

Table 2 Number of responses for both subject groups in each subcategory of nonphonetic errors

	Subject group		Comparison between groups	
Type of error	Deaf children	Sec. lang. learners	χ^2	p
Vowel omission	13	16	3.00	>0.1 (ns)
Consonant omission	53	12	14.12	<.05
Vowel substitution	27	59	35.32	<.05
Consonant substitution	53	34	0.03	>0.1 (ns)
Total letter omissions	66	28	4.82	<.05
Total sustitutions	80	93	20.59	<.05
Total vowel errors	40	75	39.28	<.05
Total consonant errors	106	46	8.13	<.05
Reversals	42	25	0.21	>0.1 (ns)
Inappropriate final "e"	5	21	19.09	<.05
Inappropriate plurals	10	4	0.76	>0.1 (ns)
Other additions	28	4	10.62	<.05
Syllable omission	30	0	21.05	<.05
"Nonsense"	39	0	27.86	<.05

Totals of the number of responses for each group will add to more than the total nonphonetic errors, as some errors fit into more than one subcategory. All comparisons are significant, except where ns is indicated.

fact, the deaf made more omission errors overall, but the ESL group made more substitution errors overall. The deaf group made significantly less vowel errors in total and significantly more consonant errors in total than the ESL group. Of the remaining subcategories of responses, there was no significant difference between the groups for reversals or inappropriate plurals, but the deaf showed significantly more syllable omissions, significantly more "other addition" responses, and significantly more nonsense responses.

Discussion

Comparing the two groups' performance across the word types reveals similar effects within each group, despite the expected finding that the ESL group were better spellers overall. The *extent* of the difference in performance level was rather greater than expected and indicates that deaf children's spelling difficulties cannot be attributed solely to the fact that, if their predominant language is a sign language, they are spelling in a second language.

Why did the ESL children perform so much better than the deaf children? One possibility is that they already had greater knowledge of English than the deaf children. Unfortunately, data as to the general English competence of the children in the samples are not available; however, it is known that at least some of the ESL children had very little knowledge of English, and nevertheless performed better than the deaf group.

It is also likely that the ESL children had developed phonological skills and awareness in their first language, which they were able to transfer to their second language, and which supported their spelling. As mentioned, several studies (e.g. Bialystok, 1988; Bruck & Genesee, 1995; Campbell & Sais, 1995) suggest that phonological awareness may be *accelerated* in children who are exposed to more than one language. Most such studies have involved fully or nearly bilingual children, or children who were being tested in their first language, and so do not necessarily apply to children's phonological awareness in a partially acquired second language. The study that did address the latter issue directly (Wade-Woolley & Siegel, 1997) did find lower levels of phonological awareness in children being tested in their second language; but this did not have very deleterious effects on their spelling. It may be that having phonological awareness in one language, even if it does not fully transfer to formal tests of second language phonological awareness, predisposes to success on alphabetic literacy tasks in another language.

Another possibility is that the ESL children were better readers than the deaf children and that this led to better spelling. It is noteworthy that Wade-Woolley and Siegel (1997) found that reading ability strongly predicted spelling ability in both ESL and native English samples. Differences in phonological awareness could still play a role here by causing differences in the *reading* abilities of the groups. In addition, however, the deaf children's reading ability might have been limited by the general language delays that are common in deaf children of hearing parents (Conrad, 1979; Marschark, 1993).

It is also possible that at least some of the ESL children had literacy experience in their first language. Literacy experience in *any* language—especially, though not exclusively, one with an alphabetic writing system—might contribute to spelling skills in English.

The group differences in spelling were not restricted to accuracy levels. The errors made by the deaf and ESL groups were quantitatively as well as qualitatively different. As predicted, a higher proportion of deaf children's errors than of ESL children's errors were nonphonetic, and the extent of this difference was surprisingly large. Moreover, the two groups also differed in the types of nonphonetic error that predominated. The deaf children made more omissions, additions, and more consonant errors; the ESL children made more substitutions and more vowel errors. The ESL group appeared to be more phonologically aware within words; scoring less omissions and additions than the deaf group implies that they know how many sounds there should be in a word, even if they make errors in choosing the right letters. Furthermore, the fact that the deaf children make more consonant errors implies that what phonological awareness they have is based on lipreading. As mentioned earlier, vowels are more visually distinct than consonants, some of the features of which are more or less invisible (Kyle & Woll, 1988; Rodda & Grove, 1974). It is also well worth emphasizing that not only were the deaf children poor spellers, not only did their error patterns differ from those of a chronological age-matched group with limitations in English, but some of their errors were very immature. Random nonsense misspellings, omissions of entire syllables, and productions of only the first letter are all errors that, among hearing children, are virtually confined to complete beginners and are very uncommon even in the middle primary grades (Read, 1986; Treiman, 1993). The importance of the first sound in the spellings of the deaf was indeed remarkable. Nearly a fifth of their responses consisted of noth-

ing but the first letter, and a significant number resembled the correct word only in the initial sound. Neither type of error was found in the ESL group's responses and both appear to be rare even in beginning spellers (Read, 1986; Treiman, 1993). Although these children, as predominant BSL users, did not use lipreading or fingerspelling as their main communication tool, their errors may conceivably reflect both lipreading strategies and fingerspelling: especially where fingerspelling has influenced BSL through the incorporation of initialized signs, where a sign consists of or includes the fingerspelled initial letter of the word.

As predicted, both the deaf group and the ESL group showed a marked frequency effect, high frequency words being spelled consistently better than low frequency words, overall, and for each of the word types. With both frequency classes taken together, both groups showed a phonological regularity effect, with words from the regular type being spelled correctly more often than words from the exception type and the strange type, and a marked orthographic regularity effect, with exception words being spelled correctly more often than strange words. This pattern would put them between Frith's alphabetic and orthographic stages; thus, they would be beginning to spell using an orthographic strategy, but this is still not as effective as an alphabetic strategy. The deaf group appear to be showing phonological and orthographic sensitivity, as did the participants in the studies by Hanson et al. (1983), Burden and Campbell (1994), and Leybaert and Alegria (1995).

The deaf children, then, appear to be showing sensitivity to phonology in spelling; but to make very limited use of spelling strategies that require phonological awareness. More detailed analysis of their performance across word types shows that the picture is not quite so clear. Three of the comparisons between score for word types within the frequency classes were not significant. For low frequency words, the ESL group appeared not to be showing an orthographic regularity effect, as there was no significant difference between their performance on exception and strange words. This could indicate that they are only just beginning to pick up sensitivity to orthographic regularity and move on to an orthographic strategy. They show the effects of the strategy only for those words with which they have most experience, high frequency words. The most curious of the three is that the deaf group's score for exception high frequency words did not differ significantly from their score for strange high frequency words. It would be puzzling if this genuinely represented a lack of orthographic sensitivity for high frequency words. One possible explanation, however, is that this comparison represents a floor effect in the data. Moreover, it must be remembered that standard frequency counts may not fully reflect the familiarity of words to deaf children.

Last, the deaf group did not show a phonological regularity effect for low frequency words; their score for regular words of low frequency was not significantly different from their score for strange words of low frequency. This result could be due to one of two things. First, like the ESL group, the deaf signers need lots of experience with words before they begin to demonstrate sensitivity to the differences among them. As phonological differences are more difficult for deaf people to pick up, it would not be surprising if it took them longer to acquire sensitivity to those differences. This would imply that deaf children are not acquiring spelling according to Frith's stage model, as they have mastered an orthographic strategy before developing phonological sensitivity, which leads to an alphabetic strategy.

Alternatively, the phonological regularity effect for high frequency words could be illusory. The orthographic patterns of the regular words (e.g., -AT in CAT and STR- and -ING in STRING) may actually be more common than the patterns within the exception words (e.g., KN- in KNEE and -UIT in SUITCASE). If this were the case, the deaf group would merely be responding to "word-likeness" in the phonologically regular words, not their actual phonological regularity. This would imply that they are using a completely orthographic strategy. To distinguish between these possibilities, the regular and exception words would need to be divided into two new types according to the frequency of occurrence of their spelling pattern and the number of errors compared for each. If this revealed that the deaf children were scoring more on words with a more common spelling pattern regardless of their

phonological regularity, it would imply little or no phonological sensitivity in the deaf group.

A future study should also control for the possible confounding effects of the signs of a few of the spelling words used in this study. In the signs for some words there is a configuration that resembles the fingerspelling of the first letter of the word. Although there were no words used in the experiment that had obligatory first-letter clues, the signs for CIRCLE, GIRAFFE, and EYE do contain elements of the handshape that resembles the initial letter. Furthermore, the signs for PENGUIN, PIGEON, LEOPARD, and YACHT are typically signed in BSL with a clear initial fingerspelled letter to distinguish them from other more common members of their category, which they would otherwise resemble in sign. This in part may account for why so many of the responses from the deaf group consisted of nothing but the first letter of the word, although this response appeared for many other words and not just those mentioned above. This would probably result in attributing more phonological abilities to the deaf group than they actually possess and is worth considering in further studies relating spelling to sign language.

The implication of this study is that evidence for phonological sensitivity in deaf people, particularly deaf children, should be examined carefully before it is accepted. It should also be noted that whatever their sensitivity to phonology, many deaf children have very poor awareness of it, as evidenced by the types of errors they make. Finally, it indicates the necessity for future studies to investigate interrelationships between reading, spelling, and phonological awareness in deaf children.

Thus, it would be desirable in any future study to obtain data on deaf and ESL children's performance on other tests besides spelling, most crucially on tests of reading and of phonological awareness, and on their levels of previous exposure to English; and to match the groups as closely as possible. Moreover, such further studies should compare a wider variety of groups. Although the ESL children in the study had difficulties with literacy in English, they spelled much better than the deaf children. Therefore, we cannot rule out the possibility that the differences in spelling strategies were simply differences of degree rather than kind: hearing children at as early a stage of spelling as the deaf children might use similar strategies. This seems unlikely, as some of the characteristics of the deaf children's spelling were unlike those observed in young children by Read (1986) or Treiman (1993). However, it would be desirable for future studies to include younger ESL children than those in the present study.

Moreover, the present study is descriptive: it describes the spelling performance and strategies of the deaf children but does not provide a definitive explanation. In particular, the question arises as to whether the atypical spelling strategies and poor spelling performance shown by the deaf children are due to specific phonological deficits, or to the broader language deficits shown by most deaf children from hearing families. Although the children in this study did use sign language as a predominant language, most did not have a great deal of exposure to it at home. This issue should be addressed in the future by including a group of native signing deaf children of deaf parents, who usually do not show language delays (Orlansky and Bonvillian, 1985).

Appendix

Words in Spelling Task

I. High frequency

A. Regular

1. Gun
2. Fish
3. Drum
4. Fish
5. Rabbit
6. Dress
7. Car
8. Chair
9. String
10. Dog

B. Exception

1. Bird
2. Bear
3. Bread
4. Worm
5. Watch
6. Glove
7. Bowl
8. Night
9. Knife
10. Knee

C. Strange

1. Circle
2. Heart
3. Orange
4. Iron
5. Eye
6. Key
7. Sword
8. Scissors
9. Tongue
10. Piano

II. Low frequency

A. Regular
1. Spider
2. Clown
3. Snake
4. Hammer
5. Peacock
6. Elephant
7. Carrot
8. Button
9. Puppet
10. Owl

B. Exception
1. Yacht
2. Axe
3. Worm
4. Swan
5. Onion
6. Monkey
7. Mushroom
8. Vase
9. Camel
10. Suitcase

C. Strange
1. Lettuce
2. Tortoise
3. Yacht
4. Leopard
5. Biscuit
6. Sponge
7. Pigeon
8. Giraffe
9. Guitar
10. Squirrel

D. Words in lists

High frequency

Regular
1. Gun
2. Fish

Strange
3. Yacht
4. Tongue
5. Camel
6. Chair
7. Axe
8. Tongue
9. Wheel
10. String
11. Onion
12. Button
13. Knee
14. Key
15. Worm
16. Cat
17. Leopard
18. Owl
19. Peacock
20. Hammer
21. Carrot
22. Brush
23. Puppet
24. Clown
25. Circle
26. Squirrel
27. Spoon
28. Pencil

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