LANGUAGE AND SPEECH, Vol. 28, Part 3, 1985

MORPHOPHONOLOGY AND LEXICAL ORGANIZATION IN DEAF READERS*

VICKI L. HANSON
Haskins Laboratories
and
DEBORAH WILKENFELD
Haskins Laboratories and The University of Connecticut

Prelingually, profoundly deaf individuals, due to their hearing impairment, would not be expected to have the same access to phonological information as hearing individuals. They might therefore have difficulties in using phonological structure to relate different morphological forms of words. Deaf and hearing readers' sensitivity to the morphological structure of English words was tested in the present study by using a lexical decision (word/nonword classification) task. Target words were primed 10 trials earlier by themselves (e.g., *think* primed by *think*), by morphologically related words (e.g., *think* primed by *thought*), or by orthographically related words (e.g., *think* primed by *thin*). Response times of both hearing and deaf college students to target words were facilitated when primed by themselves and also when primed by morphological relatives. Response times of subjects in neither group were facilitated to targets primed by orthographically related but morphologically unrelated words. These results indicate that deaf readers, like hearing readers, are sensitive to underlying morphophonological relationships among English words.

INTRODUCTION

An appreciation of the morphological structure of English words has been demonstrated experimentally for hearing readers. In reading tasks, it has been shown that responses to words are facilitated by prior presentation of morphologically related words (Fowler, Napps and Feldman, 1985; Murrell and Morton, 1974; Stanners, Neiser, Hernon and Hall, 1979). Thus, for example, the word *walk* is more readily recognized when a morphologically related word such as *walks, walking,* or *walked* precedes it, than when no such morphological relative does. While facilitative effects due to priming by a semantic associate (e.g., *doctor* primed by *nurse*) generally appear not to persist beyond immediate testing (Dannenbring and Briand, 1982; Henderson, Wallis and Knight, 1984), facilitative effects due to priming by a morphological relative have been found to persist for lags of at least 48 items (Fowler *et al.*, 1985). Facilitation due to priming by a morphological relative is plausibly attributed to a particular organization of the reader's

* This research was supported by National Institute of Communicative Disorders and Stroke Grant NS-18010 and by National Institute of Child Development Grant HD-01994. We wish to thank people at Gallaudet College who made it possible for us to conduct this research. We are also grateful to Laurie Feldman, Nancy Fishbein, Carol Fowler, and Rena Krakow for their comments on earlier versions of this manuscript and/or for their help in testing subjects.

internal lexicon in which morphologically related words are stored closely together (Fowler *et al.*, 1985; MacKay, 1978; Stanners *et al.*, 1979; Taft and Forster, 1975).

Not all morphologically related words have a common pronunciation and spelling of the shared morpheme (e.g., *find–found*), yet previous research suggests that hearing readers organize members of such disparate word "families" together in their lexicons (Fowler *et al.*, 1985; cf. Stanners *et al.*, 1979). This is apparently due to their ability, as speakers of English, to make use of the rules of the phonological component of the grammar, which relate underlying forms that are similar at the abstract level of morphophonological representation to forms that are different at the more concrete level of phonetic representation (see Chomsky and Halle, 1968).

The orthographic conventions of English appear to capture similarities at the morphophonological level and to exploit speakers' knowledge of the rules that render differences at the phonetic level. Thus, for example, the orthography represents the vowel in *wide* in the same way as the vowel in *width* (i.e., by the letter *i*) and represents the vowel in *heal* in the same way as the vowel in *health* (i.e., by the letters *ea*), reflecting the fact that at the abstract morphophonological level they are presumably the same. The speaker of English knows that in the first case the letter *i* represents the phone [ay] while in the second case it represents [ɪ]. Note that not all orthographic similarities reflect morphophonological relationships (for example, *cat* is not related to *catalyst*). The evidence indicates that words are not stored closely together by virtue of their orthographic similarity alone in the mental lexicons of hearing readers (Feldman, in press; Murrell and Morton, 1974; Napps and Fowler, submitted).

It may not be surprising that *hearing* readers of English are able to make efficient use of an orthographic system that presupposes a knowledge of the underlying structure of the language. However, it can reasonably be asked whether deaf readers are able to make similarly efficient use of this orthographic system. Since deaf readers do not come to the task of learning to read English with the same experience of English phonology that hearing readers have, it is not clear whether they are able to take advantage of morphophonological relationships captured by the orthography. The present experiment investigates whether prelingually, profoundly deaf readers are able to acquire the knowledge of English phonology necessary to perceive the morphological relationships among written words that are observed in the orthography.

A technique that has been used to study morphological effects on lexical organization is that of repetition priming. This technique requires subjects to make a word/nonword response to each item during continuous presentation of letter strings. Lexical decision response times thus obtained are typically faster to the second presentation of a word than to the first (Forbach, Stanners and Hochhaus, 1974), and are also typically faster to a word that has been preceded by a morphological relative (Stanners *et al.*, 1979). This first type of facilitation will be referred to as identity priming; the second type as morphological priming. The present study uses the repetition priming technique to compare response times (RTs) to the first presentation of a word (e.g., *think*) with RTs to the same word when it has been preceded 10 trials earlier by itself (e.g., *think* primed by *think*), by a morphologically related word (e.g., *think* primed by *thought*) and by an orthographically related word (e.g., *think* primed by *thin*). Although RT facilitation of the sort indicative of lexical effects has not been found when a word is preceded by an orthographically similar word (Napps and Fowler, submitted), it is possible that such will be obtained for deaf readers. In fact, this is exactly what would be expected if deaf readers fail to perform linguistic analyses of words and instead, or in addition, organize words in their lexicons according to orthographic features.

Two types of morphological relatives will be presented in this study: irregularly inflected forms (e.g., *mouse-mice*) and derived forms (e.g., *prove-proof*). Word pairs thus related differ phonetically and exhibit less orthographic overlap than do regularly inflected forms. As a result, readers can rely on neither phonetic nor orthographic similarity exclusively in recognizing the morphophonological relationships that hold between the members of each pair. Access to the underlying morphophonological representations would be necessary. For hearing readers, significant facilitation of words preceded by both irregularly related inflections and derivationally related words has previously been obtained (Fowler *et al.*, 1985).

In the present experiment, the performance of deaf and hearing college students is compared. It should be borne in mind that the deaf college students who served as subjects represent the more advanced readers among the deaf population. These subjects were not tested in order to find out how deaf readers, *in general,* read, but rather to determine whether sensitivity to the underlying morphophonological relationships among words is possible at all in the presence of prelingual, profound deafness. A similar pattern of results for the hearing and deaf subjects would suggest that subjects in the two groups have a similar organization of their mental lexicons.

Method

Stimuli

Word triplets were constructed consisting of a target word paired with both a morphological relative and an orthographically similar but morphologically uhrelated word (e.g., *think* – *thought* – *thin*). The target words (e.g., *think*) and their orthographically similar primes (e.g., *thin*) always had at least the first three letters in common.

Preliminary lists of these triplets were given to four deaf students from Gallaudet College who were asked to indicate any words on the list that they did not know. Final stimulus lists were then constructed that excluded word triplets from the preliminary list having one or more words that were judged to be unfamiliar.

The final list consisted of 24 word triplets. For 14 of these triplets, the morphological relative was an irregularly inflected form. For 10 of the word triplets, the morphological relative was a derivationally related form. The target words were generally high in frequency of occurrence in written English: 14 had a frequency of at least 100 per million words, 3 had a frequency of at least 50 per million and the remaining 7 had a mean frequency of 27.6 per million (Thorndike and Lorge, 1944). A listing of the stimulus words is given in the Appendix.

Throughout the full experiment, each target word appeared once in each of three prime-target conditions. By appearing in each of these conditions, each target word served as its own control. The three prime-target conditions were (1) identity prime, in which the target word served as both target and prime (e.g., *think* being primed by *think*); (2) morphological prime, in which the target word was primed by a morphologically related word (e.g., *think* being primed by *thought*); and (3) orthographic prime, in which the target word was primed by an orthographically similar word (e.g., *think* being primed by *thin*). Although there was obviously some orthographic overlap between the target words and their morphological relatives, the orthographic overlap was less than that between the target words and their orthographic primes. The morphological primes had 2.13 letters in common with the target words (considering only common letters in the same word position); the orthographic primes had 3.42 letters in common with them. This difference was significant, $t(23) = 7.85, p < 0.001$.

Three experimental test lists were constructed so that in each list every target was tested in only one condition. Eight of the target words appeared in the identity prime condition, eight in the morphological prime condition and eight in the orthographic prime condition. Each target followed the prime by a lag of 10 items. In addition, there were 12 filler words per list.

To serve as an index of episodic (memory) effects, nonwords in the experiment were generated by replacing the initial consonant or consonant cluster of each word with another consonant or consonant cluster that made the letter string a nonword. For example, the nonword counterparts of the word triplet *less – least – lesson* were *dess – deast – desson*. In list construction, the nonwords were treated similarly to their word counterparts, with each of the target nonwords preceded 10 trials earlier by an identity prime, a morphological nonword prime, or an orthographic nonword prime. The final lists each contained 120 items, 60 of which were words and 60 nonwords.

A practice list of 30 items was constructed. The structure of the list was consistent with that of the experimental list.

Procedure

Stimulus presentation was controlled by a microcomputer. A trial began with the presentation of a warning signal (a "+") that appeared in the center of a CRT screen for 250 msec. The warning signal was then terminated and, following a 250 msec blank interval, a stimulus item was presented. Stimulus items were presented in upper case letters in the center of the screen until the subject responded or until 5 sec had elapsed. RT in milliseconds was measured from the onset of the letter string.

Subjects were instructed that they would be seeing strings of letters. They were told to indicate as rapidly and as accurately as possible whether or not each letter string was an actual English word by pressing one of two response buttons. If the letter string was a word, they were to press the YES response button. If the letter string was not a word, they were to press the NO response button. The YES button was pressed with the index finger of a subject's right hand and the NO button with the index finger of the left hand. For the deaf subjects, the instructions were signed by a deaf experimenter who is a native signer of American Sign Language (ASL). For the hearing subjects, the instructions were spoken by a hearing experimenter. All subjects were individually

TABLE 1

Mean RTs (in msec) to words as primes and as targets in the three experimental conditions. The mean percentage errors are given in parentheses.

Condition	Subject Group *Deaf*	*Hearing*
Prime	520 (7.4)	482 (5.4)
Target		
Identity Prime	494 (2.4)	458 (5.4)
Morphological Prime	505 (1.8)	467 (3.6)
Orthographic Prime	513 (5.1)	473 (4.2)

morphological prime conditions ($p > 0.05$). RTs to targets preceded by orthographic primes were not significantly facilitated ($p > 0.05$).

The error rates on the target words were low for both groups of subjects, as shown in Table 1. The analysis of the errors was generally consistent with the analysis of the RT data. An analysis of variance performed on the percentage of errors indicated no significant difference in error rates for the two groups in either the subjects or the items analyses (both *F*s < 1). There was a main effect of condition in both the subjects, $F(3, 78) = 5.69$, $p < 0.005$ and the items analyses, $F(3, 138) = 3.95$, $p < 0.01$, which approached significance in the simultaneous consideration of both, $F'\text{min}(3, 211) = 2.33$, $0.05 < p < 0.10$. Post hoc Tukey (hsd) tests indicated fewer errors to targets preceded by identity and morphological primes than to the same words as primes ($p < 0.05$). No other differences were statistically significant (all *p*s > 0.05). There was an interaction of condition X group in the subjects analysis, $F(3, 78) = 3.19$, $p < 0.05$, but not in the items analysis, $F(3, 138) = 2.22$, $p > 0.05$. The fact that this interaction was not significant in the items analysis suggests that the scores of just a few subjects deviated from the general pattern and that these deviant scores were responsible for the significant interaction in the subjects analysis. Inspection of the individual subjects' data supports this hypothesis. The deaf subjects generally produced fewer errors when the common morpheme had been previously accessed (i.e., in the identity and morphological priming conditions), while a few of the hearing subjects broke from this pattern, actually producing more errors to target words in the identity and morphological priming conditions than to priming words.

The nonword counterparts of the four conditions indicated that there was facilitation of nonwords primed by the identical nonword but not of nonwords primed by morphotested.

Each subject saw all three experimental lists, list order being randomly drawn from the six possible orderings of the three lists. Thus, all subjects saw each target word once in each prime-target condition. Prior to testing with the three experimental lists, subjects were tested on the practice list.

Subjects

Deaf subjects were 14 students at Gallaudet College. All were prelingually and profoundly deaf, with a hearing loss of 85 dB or greater (better ear average). All except one had deaf parents. The one subject who did not have deaf parents reported a family history of deafness (i.e., younger sibling, cousin). In all cases, then, the etiology of their hearing losses appears to have been hereditary deafness. The reading level of these subjects was assessed by means of the comprehension subtest of the *Gates-MacGinitie Reading Tests* (1978, Level F, Form 2), which was administered to each subject after completion of the experiment. The median reading grade equivalent of these subjects was 9.5 (Range: grade 3.3 to 12.9+).[1]

Hearing subjects were 14 students at Yale University who reported no history of hearing impairment. The reading test was also given to these subjects, although in all but one case (a subject whose grade equivalent was 12.2), subjects' scores were so high as to be beyond the range for which the test was standardized (grade equivalent 12.9+).

RESULTS

Of interest here are RTs to words as targets in the three prime-target conditions compared with RTs to these same words as primes. Table 1 shows the means of the median RTs in the four conditions.

The median correct RTs were entered into analyses of variance on the within-subjects factor of condition (prime, target in the identity prime condition, target in the morphological prime condition, target in the orthographic prime condition) and the between-subjects factor of group (deaf, hearing). There was a significant main effect of condition in both the subjects, $F(3, 78) = 8.12, p < 0.001$ and items analyses, $F(3, 138) = 5.05$, $p < 0.005$, as well as when both were simultaneously considered, $F'\mathrm{min}(3, 214) = 3.11, p < 0.05$. This effect did not significantly interact with group in either the subjects or the items analyses (both Fs < 1). Post hoc Tukey (hsd) tests indicated the source of this main effect: RTs to targets preceded by an identity or morphological prime were significantly faster than RTs to the same words as primes ($p < 0.05$), i.e., RTs to targets primed by themselves and by morphological relatives were facilitated. There was no significant difference between RTs to targets in the identity prime and

[1] Surveys in the United States and Canada have found that prelingually, profoundly deaf high school graduates generally only read with a grade equivalent of about third grade (Conrad, 1979; Karchmer, Milone and Wolk, 1979). Therefore, the subjects of the present study were quite successful deaf readers, some of them being quite exceptional.

logically related or orthographically similar nonwords for either subject group. An analysis of variance on the RTs to the nonword conditions revealed a main effect of condition, $F(3, 78) = 6.80, p < 0.001$, that did not interact with group, $F(3, 78) = 1.97, p > 0.05$. There was no significant main effect of subject group, $F(1, 26) = 3.09, p > 0.05$. The analysis of the error data indicated no significant main effects of either group, $F < 1$, or condition, $F(3, 78) = 1.69, p > 0.05$ and no significant interaction of the two variables, $F(3, 78) = 1.29, p > 0.05$. The means of the median RTs (and the mean percentage errors), collapsed across subject group, were 575 msec (9.4%), 550 msec (6.3%), 561 msec (9.4%), and 563 msec (7.2%), respectively, for the prime, the target in the identity prime condition, the target in the morphological prime condition and the target in orthographic prime condition. Post hoc Tukey (hsd) tests on the RTs indicated that the main effect of condition was due to faster RTs to nonwords when they served as targets in the identity prime condition than when they served as primes ($p < 0.05$). There was no significant facilitation of nonword targets in the orthographic prime condition ($p > 0.05$). Importantly, there was also no significant facilitation of nonword targets in the morphological prime condition ($p > 0.05$), suggesting that the facilitation obtained with words in the morphological prime condition was due to lexical, not episodic, effects. Moreover, with words in the morphological prime condition, there were fewer errors to targets than primes, while, by contrast, in the nonword error data, the percentage of errors did not significantly vary as a function of condition.

Because there is evidence that highly successful hearing readers/spellers are more sensitive to morphophonological relationships than are average or poor readers/spellers (Fischer, Shankweiler and Liberman, 1985; Freyd and Baron, 1982), the question of whether deaf readers' sensitivity to morphophonological relationships varies as a function of reading proficiency was also examined. Correlations between deaf subjects' degree of priming in each of the target conditions and their grade level reading achievement were consistent with the notion that the better readers were more sensitive to morphological relationships than the poorer readers. Correlations were computed between scores on the comprehension subtest of the *Gates-MacGinitie Reading Tests* (1978) and their RT facilitation in the three target conditions. The measure of facilitation was the RT to primes minus the RT to targets. The correlations with facilitation in the identity prime condition ($r = 0.39$) and the morphological prime condition ($r = 0.41$) approached significance (both $df = 12$, $0.05 < p < 0.10$, one-tailed). There was no significant correlation between reading achievement and amount of facilitation in the orthographic prime condition ($r = 0.09$).

Discussion

The results of this experiment indicate that despite prelingual and profound hearing impairment, it is possible to acquire a sensitivity to the morphophonological structure of English words, even when morphological relations are expressed by orthographically dissimilar representations. In this experiment, deaf subjects, like hearing subjects, were facilitated in their response times to words that had been preceded by a morphological relative. Neither hearing nor deaf subjects were facilitated in their response times to words that had been preceded by an orthographically similar yet morphologically unrelated word.

Several pieces of evidence from the present study suggest that the obtained facilitation to target words in the morphological prime condition reflected lexical, not episodic, influences. Episodic effects could arise in an experiment such as the present one because subjects remember having seen or responded to a particular letter string previously in the experiment. One indication of episodic effects in a repetition priming task is the presence of facilitation on nonwords (Feustel, Shiffrin and Salasoo, 1983). There was, however, no such facilitation to nonword targets in the morphological prime condition, suggesting that the facilitation to target *words* in this condition can be attributed to lexical effects. Moreover, the fact that there was no facilitation to target word RTs in the orthographic prime condition is consistent with this interpretation. The number of common letters was greater in the orthographic than the morphological prime condition and this greater overlap should lead to larger episodic effects; yet, there was no significant facilitation in the orthographic prime condition. The observed facilitation due to inflectional and derivational relationships is therefore consistent with conceptualizations of lexical organization in which morphologically related words are tightly associated (Fowler *et al.*, 1985; Stanners *et al.*, 1979; Taft and Forster, 1975).

Although the facilitation due to morphological priming did not differ significantly in magnitude from that due to identity priming, a look at Table 1 indicates that the facilitation is numerically somewhat smaller in the morphological prime condition. This greater facilitation may have been due, at least in part, to episodic influences acting in conjunction with lexical effects to facilitate RTs to targets in the identity prime conditions (Feustel *et al.*, 1983; Forster and Davis, 1984; Fowler *et al.*, 1985). Evidence supporting this interpretation was obtained in the nonword data where significant RT facilitation occurred to target nonwords in the identity prime condition. Such an episodic influence may therefore have also affected response times to word targets in this condition.

The outcome of this study suggests that deaf readers, whose knowledge of English phonology may not be the same in all respects as that of hearing users of the language, do possess and utilize a knowledge of phonology that serves them well, at least in certain linguistic situations. Studies by other investigators have shown that deaf readers (also college students) are able to segment morphologically complex words into their stems and affixes and are aware that morphologically related words are semantically related (Hirsh-Pasek and Freyd, 1983, 1984; Lichtenstein, in press). The present study extends such findings by indicating that their lexical organization is affected by the morphological composition of words.

Examination of the response time data in the present study reveals a magnitude of identity and morphological priming facilitation that is somewhat smaller here than that in previous studies (Fowler *et al.*, 1985; Stanners *et al.*, 1979). Procedural differences between the present study and earlier ones may account for this difference. In the present study, each target word occurred three times as a target item, once in each of the three experimental lists. Each subject was tested on all three lists. Studies have indicated that effects of identity and morphological priming may be apparent over relatively long time periods (Fowler *et al.*, 1985; Scarborough, Cortese and Scarborough, 1977). With respect to the present experiment, this suggests that response times to target words in the second and third lists tested would be facilitated not only by the priming word on that list, but also by prior presentations of the same and related words on earlier lists. This does not in any way invalidate the results of the present experiment; indeed, the results for the hearing subjects are quite consistent with other studies of hearing readers (Fowler *et al.*, 1985; Stanners *et al.*, 1979). However, the procedure used here would tend to diminish the magnitude of the facilitation effect since the response times to target words were averaged over the three lists.[2] Moreover, it is known that the magnitude of facilitation is greater for infrequently occurring words than for words that occur frequently (Forster and Davis, 1984; Scarborough *et al.*, 1977). The target words of the present study were nearly all of a very high frequency of occurrence in written English, due to the necessity of obtaining words within the vocabulary of all the subjects. This, too, is likely to have had the effect of diminishing the magnitude of any identity or morphological priming compared with other studies in the literature in which less frequently occurring words were used. In any case, even though the effects reported here are numerically somewhat smaller than those reported in previous studies, they are still statistically significant, in spite of the presence of factors that might have masked a larger priming effect.

As in experiments with hearing subjects both here and earlier (Napps and Fowler, submitted), the deaf subjects were not significantly facilitated in their response times to targets following an orthographically related prime. The implication of this result is that words are not, by virtue of orthographic (i.e., visual) similarity alone, closely associated in readers' lexicons. This is apparently the case for deaf as well as hearing readers of English. Although most morphologically related words do overlap orthographically a great deal, the present results suggest that formal similarity alone is not sufficient for organizing words together. Rather, what is required is a morphological relationship.

There was some indication in the present study that the degree of deaf readers' sensitivity to morphophonological relationships was related to their reading ability; specifically, the better readers were more sensitive to this level of linguistic structure than were the poorer readers. This finding is consistent with results reported for hearing subjects (Feldman, 1984; Freyd and Baron, 1982). Freyd and Baron (1982), for example, found that superior fifth grade readers outperformed average eighth grade readers in their ability to decompose morphologically complex words. Thus, the superior readers were better able to use the principles of English morphology. Based on such findings, it has been argued that skill in using the English orthography encompasses an ability to apprehend the morphological structure of words (Fischer *et al.*, 1985; Freyd and Baron, 1982).

[2] One way to eliminate any effect due to presentation of target words in multiple lists would be to examine only the first list on which each subject was tested. However, within each list there were too few instances of each prime-target condition to produce reliable averaged response times. Thus, only the response times averaged over all three lists can be considered a reasonable measure.

In conclusion, it should be noted that this is not the only study in which evidence has been obtained that deaf readers are able to acquire some appreciation of the phonological component of English (see Dodd, 1980; Dodd and Hermelin, 1977; Hanson, Shankweiler and Fischer, 1983). It does, however, extend previous work in finding that the organization of the mental lexicons of deaf readers is affected by morphological relationships captured at an abstract level by the phonological component of the grammar.

Such findings raise the question of the development of morphophonological sensitivity in prelingually, profoundly deaf readers. These readers have available to them some knowledge of the spoken language that they have acquired through experience with speaking and also lipreading. In addition, they have knowledge of word structure that has been acquired through reading and fingerspelling. (Fingerspelling is a manual representation of the orthography.) Each of these factors may contribute in part to the development of morphophonological sensitivity in prelingually, profoundly deaf readers (for further discussion, see Hanson *et al.*, 1983 or Hanson, in press). But it is likely that none of these factors can, by itself, account for the degree of morphophonological sensitivity observed in this experiment: Knowledge of the English sound system obtained without reference to its phonetic aspect is necessarily incomplete and the morphology of English is represented by the orthography in a way that assumes prior familiarity with phonology on the part of the reader. The relative roles of the above factors in the development of the morphophonological sensitivity observed in this experiment remain to be determined, along with the nature of the contribution made by the innate linguistic abilities of deaf readers.

REFERENCES

CHOMSKY, N. and HALLE, M. (1968). *The Sound Pattern of English* (New York).

CONRAD, R. (1979). *The Deaf School Child* (London).

DANNENBRING, G.L. and BRIAND, K. (1982). Semantic priming and the word repetition effect in a lexical decision task. *Canadian Journal of Psychology*, **36**, 435-444.

DODD, B. (1980). The spelling abilities of profoundly pre-lingually deaf children. In U. Frith (ed.), *Cognitive Processes in Spelling* (London), pp. 423-440.

DODD, B. and HERMELIN, B. (1977). Phonological coding by the prelinguistically deaf. *Perception & Psychophysics*, **21**, 413-417.

FELDMAN, L.B. (1984). Structure of the noun system. Paper presented at the meeting of the American Psychological Association, Toronto, Ontario.

FELDMAN, L.B. (in press). Phonological and morphological analysis by skilled readers of Serbo-Croatian. In A. Allport, D. MacKay, W. Prinz and E. Scheerer (eds.), *Language Perception and Production* (London).

FEUSTEL, T.C., SHIFFRIN, R.M. and SALASOO, A. (1983). Episodic and lexical contributions to the repetition effect in word identification. *Journal of Experimental Psychology: General*, **112**, 309-346.

FISCHER, F.W., SHANKWEILER, D. and LIBERMAN, I.Y. (1985). Spelling proficiency and sensitivity to word structure. *Journal of Memory and Language*, **24**, 423-441.

FORBACH, G.B., STANNERS, R.F. and HOCHHAUS, L. (1974). Repetition and practice effects in a lexical decision task. *Memory & Cognition*, **2**, 337-339.

FORSTER, K.I. and DAVIS, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 680-698.

FOWLER, C.A., NAPPS, S.E. and FELDMAN, L. (1985). Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. *Memory & Cognition*, **13**, 241-255.

FREYD, P. and BARON, J. (1982). Individual differences in acquisition of derivational morphology. *Journal of Verbal Learning and Verbal Behavior*, **21**, 282-295.

Gates-MacGinitie Reading Tests (Second Edition) (1978). Prepared by W.H. MacGinitie (Boston).

HANSON, V.L. (in press). Access to spoken language and the acquisition of orthographic structure: Evidence from deaf readers. *Quarterly Journal of Experimental Psychology.*

HANSON, V.L., SHANKWEILER, D. and FISCHER, F.W. (1983). Determinants of spelling ability in deaf and hearing adults: Access to linguistic structure. *Cognition*, **14**, 323-344.

HENDERSON, L., WALLIS, J. and KNIGHT, D. (1984). Morphemic structure and lexical access. In H. Bouma and D.G. Bouwhuis (eds.), *Attention and Performance X: Control of Language Processes* (London), pp. 211-226.

HIRSH-PASEK, K. and FREYD, P. (1983). From print to meaning: Word identification through morphological analysis. Paper presented at the August meeting of the American Psychological Association, Los Angeles, CA.

HIRSH-PASEK, K. and FREYD, P. (1984). Taking the Latin and Greek out of English: Morphological analysis by hearing and deaf readers. Paper presented at the October meeting of the Boston University Conference on Language Development, Boston, MA.

KARCHMER, M.A., MILONE, M.N., Jr. and WOLK, S. (1979). Educational significance of hearing loss at three levels of severity. *American Annals of the Deaf*, **124**, 97-109.

LICHTENSTEIN, E.H. (in press). The relationships between reading processes and English skills of deaf college students: Part II. *Applied Psycholinguistics.*

MACKAY, D.G. (1978). Derivational rules and the internal lexicon. *Journal of Verbal Learning and Verbal Behavior*, **17**, 61-71.

MURRELL, G.A. and MORTON, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology*, **102**, 963-968.

NAPPS, S.E. and FOWLER, C.A. (submitted). Formal relations among words and the organization of the mental lexicon.

SCARBOROUGH, D.L., CORTESE, C. and SCARBOROUGH, H.S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, **3**, 1-17.

STANNERS, R.F., NEISER, J.J., HERNON, W.P. and HALL, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior*, **18**, 399-412.

TAFT, M. and FORSTER, K.I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, **14**, 638-647.

THORNDIKE, E.L. and LORGE, I. (1944). *The Teacher's Word Book of 30,000 Words* (New York).

APPENDIX

Morphological Primes

Target Words	*Inflection*	*Derivation*	*Orthographic Primes*
less	least		lesson
fight	fought		fig
more	most		moral
freeze	frozen		free
catch	caught		cat
rang	ring		ran
feet	foot		fee
teach	taught		tea
grind	ground		grin
find	found		fin
sunk	sink		sun
mouse	mice		mouth
tooth	teeth		too
think	thought		thin
speech		speak	speed
length		long	lend
voice		vocal	void
sale		sell	salad
sight		see	sigh
die		dead	diet
forty		four	fort
choice		choose	choir
singer		song	single
prove		proof	proverb