JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR **23**, 383–404 (1984)

When Does Irregular Spelling or Pronunciation Influence Word Recognition?

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Four experiments examined how irregularities in spelling or in the correspondence between spelling and sound influence two reading tasks, naming and lexical decision. The words studied included regular (e.g., *must*), exception (*have*), regular inconsistent (*gave*), and "strange" (words with unusual spelling patterns such as *aisle* or *fuel*). The results indicate that the two factors have separate effects on recognition. Irregular spelling influences performance on both tasks, while irregular spelling–sound correspondences only influence reading aloud. However, all of these effects are restricted to lower frequency words. The processing of both high and low frequency words, as well as the task differences, can be accommodated by a model that considers the time course of the activation of orthographic and phonological information.

Research on the functions of phonological information in reading can be seen as attempting to provide an explanation for the fact that writing systems have evolved so as to represent this information (Hung & Tzeng, 1981). This historical fact would be difficult to explain unless phonological information had a function either in skilled reading or in learning to read. Orthographies vary in the extent to which they encode phonological information (see Henderson, 1982); the extremes are represented by writing systems such as Japanese Kana (entirely regular correspondence between orthography and phonology) and Chinese logographs (very indirect or arbitrary correspondence, depending on the character). English lies roughly between these extremes, in that the correspondence between spelling and sound is systematic but nontransparent (Chomsky & Halle, 1968). The written forms of some English words indicate their pronunciations more directly than others. The variation between *orthographies* in the extent to which they encode phonological information is thus analogous to that seen between *words* in English.

An important question is whether variations in the correspondence between spelling and sound influence the reading of different words. A skilled reader of English knows the systematic relations between spelling and sound. However, readers must also cope with the fact that the pronunciations of a significant pool of English words are arbitrary, irregular, or otherwise unpre-

This research was supported by NSF Grant IST 80-12439, NICHD Grant HD 16019-01 (both to Wayne State University), NSERC Grant 7924, and Quebec Ministry of Education Grant FCAC EQ-2074 (both to McGill University). Michael Tanenhaus is now at the University of Rochester, Rochester, NY, and Marcia Barnes is at McMaster University, Hamilton, Ontario, Canada. Some of the results were presented at the 1982 meeting of the Psychonomic Society. We are very grateful to Jay McClelland, whose comments proved to be enormously helpful in clarifying the task differences. Send reprint requests to M. S. Seidenberg, Department of Psychology, 1205 Docteur Penfield, Montreal, Quebec H3A 1B1, Canada

dictable. These words are often termed *exceptions*. A number of studies (e.g., Baron & Strawson, 1976; Bauer & Stanovich, 1980; Coltheart, 1978; Glushko, 1979; Parkin, 1982; Stanovich & Bauer, 1978) have suggested that words with regular pronunciations are easier to read than exception words. These results imply that readers use their knowledge of spelling–sound correspondences in reading, even though this is not logically required by the task.

Some representative findings were reported by Glushko (1979). He found that college student subjects' pronunciation latencies for regular words (such as *luck*) were significantly faster than those for exception words (such as *have*); this outcome will be termed the exception effect. Pronunciation latencies were also longer for so-called regular inconsistent words such as *gave*. These words have predictable pronunciations, but there are also words in English with similar spellings and irregular pronunciations. Other examples of regular inconsistent–exception pairs are *dive–give, foe–shoe,* and *leaf–deaf.* The regular inconsistent effect implied that the "regularity" of a word cannot be defined merely in terms of its own pronunciation, but rather must refer to the pronunciations of other words with similar spellings. This result suggested that the inconsistencies in the mapping between spelling and sound in English have more pervasive effects on reading than previously thought.

Glushko (1979) also interpreted the regular inconsistent effect as mediating against the traditional view that readers learn rules governing spelling–sound correspondences (Venezky, 1970), and apply them in reading words and pseudowords. Coltheart (1978) has labeled these grapheme–phoneme correspondence rules, although this knowledge may involve orthographic and phonological units larger than simple graphemes and phonemes. This is often termed the "nonlexical" route to sound in reading. Glushko noted that the regular inconsistent effect is difficult to reconcile with the notion of spelling–sound rules because the pronunciations of both regular and regular inconsistent words would be correctly specified by a felicitous set of rules. Nonetheless, the regular inconsistent words showed latencies very similar to *exception* words, rather than to regular words.

As an alternative, Glushko developed an "activation–synthesis" model of recognition, in which the difficulty associated with recognizing a word depends on the consistency of the pronunciations of words that share its basic spelling. A word is recognized by discriminating it from a set of alternatives or cohorts which defines the word's "neighborhood." For a regular word, all neighbors have a similar spelling (e.g., the same final three letters) and rhyme. For exception and regular inconsistent words, the neighborhood contains words with similar spellings but different pronunciations. The inconsistent information provided by the neighbors with different pronunciations was thought to be related to the longer naming latencies observed. This process was construed as pronunciation through analogy to other words. McClelland and Rumelhart (1981) have developed a model of visual word recognition which provides explicit mechanisms by which the neighbors of a word could influence recognition (see also Paap, Newsome, McDonald, & Schvaneveldt, 1982), and suggest that it could be extended to account for Glushko's (1979) results. Their view is that the same word recognition processes needed to account for facts about visual word recognition will account for the effects of spelling–sound irregularity as well.

The present studies were motivated by a number of concerns. It appeared to be difficult to handle Glushko's results within either a spelling–sound rule or a activation–synthesis model. Glushko found that regular inconsistent (RI) and exception (EXC) words showed comparable naming latencies, and that both were longer than those observed for regular (REG) words (i.e., the ordering of latencies was REG < RI = EXC). Simple spelling–sound rule models cannot account for the REG < RI result. However, it is also difficult to see how the activation–synthesis model would predict the outcome RI = EXC. The neighborhood for a regular inconsistent–exception pair such as *gave–have* contains many more rhymes for *gave* than for *have*. Even building in some necessary assumptions about frequency coding, this asymmetry suggests that it should be easier to synthesize the pronunciation for *gave* than *have*.[1]

We were also concerned about the effects of different reading tasks. Glushko's studies and many others used the naming task, which explicitly requires subjects to access phonological information under time pressure. As this differs in obvious ways from the demands of silent reading, we compared performance on the naming task to that on a silent reading task, lexical decision. The existing literature on these tasks is somewhat unclear. While exception words have consistently yielded longer naming latencies than regular words, this outcome has been observed in some lexical decision experiments (e.g., Stanovich & Bauer, 1978), but not in others (Coltheart, 1978).

Experiment 1

In this experiment, the stimuli included regular and exception words, as well as several other types. Two kinds of regular inconsistent words were used. Recall that regular inconsistent words are those (a) for which there is a regular pronunciation, and (b) for which there exist other words with a similar spelling but a different pronunciation. The activation–synthesis model suggests that the difficulty in recognizing a regular inconsistent word should be related to the salience of the matched exception word. We included regular inconsistent stimuli for which the matched exception is of much higher frequency than the regular inconsistent word itself (e.g., *goes* is a regular inconsistent word for which the exception, *does,* is of much higher frequency), or much lower frequency (e.g., *few* is a regular inconsistent with the lower frequency exception *sew*). If either recognizing or pronouncing a word is affected by the inconsistent neighbors, regular inconsistent words with higher frequency exceptions should show longer latencies than those with lower frequency exceptions.

We also included words that contained spelling patterns associated with several frequently used alternate pronunciations. Exception words are those for which the pronunciation is unusual, given the spelling pattern. Typically, only one or two words have the alternate pronunciation; for example, there are many more words with the regular pronunciation of *-ave* than the exceptional one. However, for spelling patterns such as *-own* or *-ove,* there are many words with each of the pronunciations. These will be termed ambiguous spelling patterns. Described in terms of spelling–sound correspondences, these words have multiple rules associated with a single orthographic pattern, but the rules are comparable in terms of both absolute and relative frequency. In contrast, the spelling pattern for a regular inconsistent–exception pair is also associated with two pronounciations, but one ocurs much more frequently than the other. The ambiguous stimuli provide a way to investigate whether it is the fact that a spelling pattern has multiple pronunciations which is relevant, or the frequencies with which they occur. The final class consisted of homographs such as *tear* and *wind,* which have two correct pronunciations associated with different meanings. Here each application of two alternate spelling–sound rules yields

[1] Although the regular inconsistent and exception words in Glushko's Experiment 1 showed similar naming latencies, the exceptions produced more errors. Thus, the exceptions actually may have been more difficult to process.

TABLE 1
STIMULUS WORD CLASSES, EXPERIMENT 1

Regular inconsistent	
Higher frequency exception	*Goes*
Regular inconsistent	
Lower frequency exception	*Few*
Exception	*Have*
Ambiguous	*Blown*
Homograph	*Wind*

TABLE 2
NAMING LATENCIES (IN msec), EXPERIMENT 1

Condition	Test	Control	Difference
Regular inconsistent, higher exception	681	693	−12
Regular inconsistent, lower exception	680	675	+5
Exception	727	691	+36
Ambiguous	687	682	+5
Homograph	732	656	+76

Note. The only errors were mispronunciations of *Pint* (4), *Caste* (3), and *Soils* (1).

a word. Longer reaction times in this condition would indicate that both pronunciations had been retrieved.

In this experiment, as in the three to follow, task (pronunciation or lexical decision) was included as a between-subjects variable. The same stimuli were used for both tasks, except that pronounceable nonwords (pseudowords) were added in the lexical decision condition.

Method

Subjects. Thirty-four McGill University undergraduates volunteered or were paid two dollars, 18 for the lexical decision task and 16 for the pronunciation one. All were native speakers of English. All of the subjects in subsequent experiments were also drawn from this population, and subjects only participated in one experiment.

Stimuli. The stimuli consisted of monosyllabic words from the classes described above; examples are given in Table 1. There were 12 stimuli in each group, each matched with a regular word of similar frequency and length (Appendix A). For the lexical decision task, 60 pronounceable nonwords such as *hane* were included. They were derived from regular words by changing the initial letter. The stimuli were typed in lowercase letters onto translucent acetate and centered on 2 × 2-in. slides.

Procedure. Stimuli were presented singly on a slide projector tachistoscope, rear projected onto a screen in the subject's room. Stimulus presentation and timing of responses were controlled by Digibit logic units. Each stimulus was presented for a maximum of 2 seconds. In the pronunciation condition, the subject's task was to read the word aloud as quickly and accurately as possible. In the lexical decision condition, subjects indicated whether the stimulus was a word or nonword. Timing was initiated with the opening of the shutter (Lafayette Model 43011-16) and was halted either when the subject read the word into a microphone connected to a voice key (Lafayette Model 63040) or when a key was depressed, indicating the lexical decision. The experimenter recorded the latency data and noted any errors.

Results

Analyses of variance with both subject and item means as units were computed. Analyses were performed on both raw and log-transformed data, which showed very similar results; only the former are reported. MinF' statistics were calculated, and are reported when they were significant; otherwise, the significant F statistics for the subject and item analyses are reported. The above procedure was used for each of the experiments reported in this paper.

Pronunciation task. Subject means and error rates are reported in Table 2. The analyses included the factors Type of word (5 classes) and Condition (test item vs matched regular controls). There was a main effect of Type in the subject analysis, $F(4,60) = 7.27$, $p < .001$; a main effect of Condition, min$F'(1,19) = 4.88$, $p < .05$; and a Type × Condition interaction, min$F'(4,59) = 3.34$, $p < .05$.

TABLE 3
LEXICAL DECISION LATENCIES (IN msec) AND PERCENT ERRORS, EXPERIMENT 1

Condition	Test	Control	Difference
Regular inconsistent, higher exception	605 (2.9)	594 (3.7)	+11
Regular inconsistent, lower exception	586 (0.9)	580 (0.0)	+6
Exception	630 (2.3)	598 (1.4)	+32
Ambiguous	606 (0.9)	605 (1.9)	+1
Homograph	607 (1.9)	614 (2.8)	−7

T tests based on both subject and item means were performed as planned comparisons of the differences between test and control stimuli. In both analyses, differences greater than 35 milliseconds are significant at the .05 level or better (two tailed). The only differences to reach significance were for the exceptions and homographs. Exception words took 36 milliseconds longer to read than regular controls; homographs took 76 milliseconds longer than controls. None of the other differences, which ranged from 5 to 12 milliseconds, approached significance.

Lexical decision task. The results are presented in Table 3. Nonword decisions were longer than in all the word conditions and were excluded from further analyses. In the subject ANOVA, there was a main effect of Type, $F(4,68) = 5.90$, $p < .001$, and a marginal interaction between Type and Condition, $F(4,68) = 2.43$, $p < .06$. No other effects reached significance. The only difference between test and control stimuli to reach significance was for exception words; this difference (32 milliseconds) was significant on a t test based on subject means, $t(68) = 2.75$, $p < .01$. The effect was not significant in the test based on item means. Inspection of the item means revealed that the effect only reached significance in the subject analysis because it was largely due to three lower frequency items, *caste, broad,* and *pint*.

Discussion

Results from the pronunciation task are considered first. The longer latencies for the exception words replicate Glushko (1979), showing that words with irregular pronunciations take longer to read aloud. The homograph results show that a word is difficult to read aloud when two pronunciations are possible. This suggests that both pronunciations were available to subjects before they made their responses. Having to make a choice between them apparently produced longer latencies.[2]

Although the exception effect was replicated, the regular inconsistent effect was not. Neither of the two classes of regular inconsistent words showed reliably different pronunciation latencies than matched controls. Frequency of the exception relative to the regular inconsistent word did not have a reliable effect, lending no support for the hypothesis derived from the neighborhood model. Finally, ambiguous words (such as *flown*) also showed no difference relative to regular controls. Thus, the mere fact that a spelling pattern has multiple pronunciations does not seem to be relevant, nor is the number of inconsistent neighbors. Only when a pronunciation is unusual, as with exceptions, is there an increase in naming latency.[3] These null

[2] We matched homographs to regular words of similar frequency; the resulting comparison is not ideal, because the frequencies of the component meanings, which could control recognition latencies, are lower than the overall estimated frequency. Nonetheless, the latencies for the homographs are quite long, and it is doubtful that frequency differences in the range in question could wholly account for this result.

[3] Although the ambiguous words did not differ from regular words in this study, they did differ for beginning readers in a developmental study by Backman, Bruck, Hebert, & Seidenberg (in press). For younger subjects, ambiguous words are easier to process than exceptions, but harder than regulars.