

Pseudohomophone Naming and the Word Frequency Effect

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An experiment by McCann and Besner (1987) suggested that non-words that are homophonic with a high-frequency word (e.g. "keap") are named in the same amount of time as non-words that are homophonic with a low-frequency word (e.g. "fome"), despite such pseudohomophones being faster to name than non-pseudohomophones (e.g. "feap", "yome"). Such a result is a challenge to any model of lexical processing that places the word-frequency effect at the stage when the word is being selected from amongst all lexical entries. McCann and Besner propose a complex alternative account where frequency effects arise at a later stage of processing, a stage that is not involved in the naming of pseudohomophones. The purpose of the present study is to look for a frequency effect in the naming of pseudohomophones, controlling for orthographic factors that McCann and Besner ignored. The first experiment, using a homophone decision task, establishes a set of items that produce a clear frequency effect. These items are then used in a naming experiment which also reveals a clear frequency effect for those subjects who make use of a lexical route when pronouncing pseudohomophones. It is concluded from this that the complex model developed by McCann and Besner is unnecessary.

The frequency with which a word occurs in the language is probably the factor that exerts the greatest influence on response times in tasks where words are to be identified, either by naming them or by distinguishing them from non-words in a "lexical decision task" (e.g. Forster & Chambers, 1973; Fredriksen & Kroll, 1976; Monsell, Doyle, & Haggard, 1989; Whaley, 1978). For this reason, models of lexical processing have needed to incorporate an explanation for the effects of word frequency. In most models, word frequency has its influence on that stage of processing where the lexical representation of the word is isolated from all the other can-

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didate representations. Different models suggest different methods by which this selection process takes place.

In "word activation" models such as the logogen model put forward by Morton (e.g., 1969, 1979) and the interactive-activation model of McClelland and Rumelhart (1981), frequency effects arise either from the word detectors for high-frequency words having a higher resting level of activation than those for low-frequency words, or from the response thresholds for high-frequency word detectors being lower than those for low-frequency word detectors. Thus, when sensory information extracted from a stimulus word is fed into the system, activation to response threshold will occur earlier for high-frequency words than for low-frequency words.

According to serial search models (e.g. Forster, 1976; Glanzer & Ehrenreich, 1979; O'Connor & Forster, 1981), the entry for each word in the lexicon, or subset of the lexicon, is scanned in serial order until a match with the stimulus word is made. As the lexical representations of words are listed in order of frequency, those for high-frequency words will be encountered before those for low-frequency words.

In "verification" models (e.g. Becker, 1976; Becker & Killion, 1977; Paap, McDonald, Schvaneveldt, & Noel, 1987; Paap, Newsome, McDonald, & Schvaneveldt, 1982), frequency has its impact at a later stage, though still at a stage where the appropriate candidate is being singled out from other candidates. Verification models involve an initial activation stage where a set of potential candidates is accessed, followed by a verification stage where the candidates are serially checked back against a sensory representation of the presented stimulus, until one of them is determined to be appropriate. The initial development of the set of candidates is unaffected by word frequency. However, information about word frequency is extracted from these candidate lexical entries and taken into account during the serial verification process. High-frequency words are verified prior to low-frequency words.

In more recent times, these "traditional" accounts of word frequency effects have been challenged. Attempts have been made to explain frequency effects at a stage of processing that is subsequent to the isolation of a single candidate, namely, at a stage where the accessing of a unique lexical entry is transformed into a response. If this is the correct approach, it means that lexical representations of rare words are discovered as quickly as lexical representations of common words. Furthermore, it may be possible to find circumstances where the response required in the task is not influenced by frequency. Indeed, the evidence taken as support for this "post-lexical" position are data that suggest that not all tasks do reveal a strong frequency effect.

Balota and Chumbley (1984) found that the time taken to classify a word as belonging to a particular semantic category was not significantly affected by the frequency of that word. Furthermore, the time taken to

initiate its pronunciation (naming time) was not as greatly influenced by frequency as was the time taken to classify the letter string as a word (lexical decision time). They claimed that, if frequency effects arise solely during access to lexical information, both the semantic classification and the naming tasks should exhibit just as large a frequency effect as the lexical decision task. This is because all three tasks require access to lexical information. An effective critique of this work has been given, however, by Monsell et al. (1989).

Monsell et al. firstly demonstrated a strong frequency effect in a semantic categorization task where subjects were required to classify words as belonging to one of two very large categories, either "human" (e.g. "student", "tyrant") or "inanimate" (e.g. "picture", "shawl"). The semantic categorization task used by Balota and Chumbley was rather different. In their task, subjects were required to decide whether or not the target word belonged to a category that was presented immediately beforehand (e.g. "furniture" CHAIR). In Balota and Chumbley's task it was therefore possible to perform the task by generating examples of the category when it was presented and then ascertaining whether or not the target word was one of these examples. If so, the task could be performed without requiring bottom-up access to the lexical entry for the target word. In the task used by Monsell et al. on the other hand, top-down processing would be inexpedient since the categories were so large, and therefore, the effects of bottom-up processing (in particular, frequency effects) could be observed.

Balota and Chumbley's other finding of only a weak frequency effect in the naming task can also be countered. When naming words with a reasonably predictable and regular pronunciation, it is possible to start constructing the pronunciation without having to access its lexical representation. Rather, articulatory output could begin to be set up on the basis of information about the pronunciation of the individual letters. Such a non-lexical contribution to the naming response would therefore weaken any frequency effect. Monsell et al. presented words whose pronunciation did not follow the typical pattern in English—in particular, words whose first syllable was not stressed (e.g. "machine", "cadet"). The correct pronunciation for such words could only be determined from lexical information, and, therefore, there should be as large a frequency effect in naming such "irregular" words as in deciding that they are words. This is what Monsell et al. observed, thus suggesting a non-lexical basis for the reduction in the size of the frequency effect that is found when typical words are named.

In addition, Grainger (1990) has suggested that part of the frequency effect observed in the lexical decision task arises from confusions between words that are only one letter different from each other (i.e. "neighbours"). Such interference to response times arises only when the neigh-

bour of the target word is of higher frequency than the target word, and low-frequency words will therefore be more affected than high-frequency words. As neighbourhood interference effects do not occur in the naming task, the weaker frequency effect observed in this task is explained. In support of this proposal, Grainger demonstrated equivalent frequency effects in the lexical decision and naming tasks when words that had no higher-frequency neighbours were used.

Although they were able to provide counter-evidence to the conclusions drawn by Balota and Chumbley, Monsell et al. were not so readily able to repudiate a further result that can be taken to support the post-lexical account of frequency effects. McCann and Besner (1987) found another task that, they claimed, was insensitive to frequency manipulations. They observed that naming responses to non-words that were pronounced identically to a real word (i.e. pseudohomophones, such as "*keap*") were unaffected by the frequency of that base word, despite the fact that these naming responses were faster than those to non-words that were not homophonic with any word (such as "*feap*"). The pseudohomophone/non-pseudohomophone difference suggests that lexical information can participate in the naming of non-words, yet despite this involvement of lexical information no frequency effect was observed. According to the traditional models, if a lexical item is accessed and a response is based on the information so accessed, then a frequency effect should be found. McCann, Besner, and Davelaar (1988) supplemented the pseudohomophone naming result with the further finding that the frequency of a word did have an influence on response times when the task was to say specifically that a non-word was homophonic with a word (i.e. in a homophone decision task).

The interpretation given to these results by McCann et al. was that frequency plays a role when a YES/NO decision must be made on the basis of lexical information. Access to this lexical information is unaffected by frequency, but the utilization of that information in deciding that a positive response is appropriate is influenced by the "stimulus familiarity". As both the lexical decision task and the homophone decision task require a YES/NO decision based on lexical information, the positive responses in these tasks will be influenced by stimulus familiarity, and this will be manifested as a frequency effect. The non-word naming task, on the other hand, does not entail any decision stage. So, while the non-word naming response may be based upon lexical information about pronunciation, it is unaffected by lexical information about word familiarity and hence produces no frequency effect.

If familiarity is a factor used to discriminate stimuli that require a positive or negative response, one might expect that the negative responses should be influenced by familiarity, just as the positive responses are. The

more familiar the negative stimulus is, the more difficult should it be to make "no" decisions, and therefore, in the case of the lexical decision task, "no" responses should be more difficult to make the more wordlike the non-word is. McCann et al. showed this to be so when the degree of being wordlike was based on rated orthographic similarity of a pseudohomophone to its base word, and so did O'Connor and Forster (1981) in finding that misspelled high-frequency words (e.g. "mohter") were more difficult to classify as non-words than were misspelled low-frequency words (e.g. "bohter"), as determined by error rates. However, when the degree of being wordlike is based on phonological factors, there appears to be no effect of familiarity. In the lexical decision task, neither McCann et al. nor Rubinstein, Lewis, and Rubenstein (1971) found any effect on responses to pseudohomophones of the frequency of the word with which the non-word was homophonic, even though pseudohomophones did take longer to respond to than did non-pseudohomophones.

To explain this finding, McCann et al. suggest that the pseudohomophone/non-pseudohomophone difference arises from pseudohomophones accessing a phonologically represented set of lexical entries (a phonological input lexicon), but that the familiarity judgement, which is involved at the subsequent decision stage of the lexical decision task, focuses on orthographic familiarity rather than on phonological familiarity. Therefore the familiarity of the pronunciation of the pseudohomophone, as determined by the frequency of the base word, has no impact on response times. The explanation for why phonological familiarity does play a role in the homophone decision task is that that task focuses specifically on phonological factors, which therefore become the basis for the familiarity judgment.

So the conclusion is that frequency effects arise from familiarity discriminations involved in YES/NO decisions, though the specific task determines whether familiarity is based on orthographic or phonological factors. However, further elaboration is still needed to account for all of the data. In particular, why is there a frequency effect for words in the naming task? No binary decision is required in this task, and therefore no familiarity judgement should be involved. The explanation given by McCann and Besner (1987) is that the frequency effect resides in the connection between visually accessed lexical entries (the orthographic input lexicon) and their articulatory output (the phonological output lexicon). Such a connection is used in the naming of words but not in the naming of pseudohomophones, as it is the phonological input lexicon that is used in the latter case, not the orthographic input lexicon.

This sort of argument seems quite *ad hoc* and appears to be motivated purely to explain the pattern of results obtained in the naming task. Furthermore, it entails a loss of parsimony in that at least two different

sources of the frequency effect—the familiarity discrimination involved in YES/NO decisions and the connection between the orthographic input lexicon and the phonological output lexicon—must now be postulated.

In point of fact, there is only one result that poses a problem for the more straightforward traditional accounts of word frequency, and that is the failure of McCann and Besner to observe frequency sensitivity in the naming of pseudohomophones. All the other results can be readily accommodated. The frequency effects found for word items in the lexical decision and naming tasks are explained by the activation, search, and verification models in the manner described earlier. The frequency effect obtained for pseudohomophones in the homophone decision task is explained in the same way, except that the lexical representation being sought is a phonological one.

The failure to find a frequency effect for pseudohomophones in the lexical decision task is most readily explained in terms of the search and verification models. In both of these models there is a frequency-ordered search through a set of lexical candidates, at a bottom-up access stage according to the search model, or at a top-down verification stage according to the verification model. If phonological information participates in the matching process between the stimulus and the lexical representation, then the search will pause when the word that is homophonic with the pseudohomophone is contacted. When it is determined that this base word is not the stimulus that was actually presented, the search will continue exhaustively. Thus pseudohomophones will take longer to classify as non-words than will non-pseudohomophones, because the search will have been interrupted in the former case, but not in the latter. However, the frequency of the base word will not affect response times, as, although the interruption will occur earlier when the base word is of higher frequency, the search will always continue to the end of the search set before the response is made. Thus, an early interruption will have the same ultimate effect as a late interruption.

In activation models, the most natural expectation would be that pseudohomophones based on high-frequency words should be more difficult to classify as non-words than those based on low-frequency words. To see why this is so, we must examine how a non-word decision would be reached in an activation system. When the stimulus is a non-word, no word detectors will be activated to threshold. In order to decide that the threshold is never going to be reached, there presumably must be some time-based deadline at which point a non-word classification can be made (e.g. Coltheart, Davelaar, Jonasson, & Besner, 1977). However, if this were the case, all non-words would be responded to in about the same amount of time; responses to wordlike non-words would be as long as responses to unwordlike non-words. So, in order to explain why wordlikeness does influence response times, what can be suggested (e.g. Coltheart

et al.) is that the deadline is variable and depends upon how much activity there is in the system. When a non-word is similar to a word, there will be activation in the detector for that word, and therefore the deadline will be extended. This can explain the pseudohomophone effect, as pseudohomophones will strongly activate the detector for their base word if phonological factors enter into the activation process, whereas non-pseudohomophones will not appreciably activate any word detectors.

Earlier it was pointed out that the frequency effect can be accounted for in more than one way by activation models. If the explanation given is that detectors for high-frequency words have a higher resting level of activation than those for low-frequency words (or are more strongly activated by sensory input), then one would expect the frequency of the base word to influence response times to pseudohomophones. Activation of detectors for high-frequency words will result in a longer extension of the deadline than activation of detectors for low-frequency words, as extension of the deadline depends upon the amount of activation in the system. Hence, pseudohomophones based on high-frequency words should be slower than those based on low-frequency words. This is not what was found.

If, on the other hand, frequency effects are explained in terms of detectors for high-frequency words having lower response thresholds than those for low-frequency words, then the amount of activation in all detectors will be the same, as long as there is not enough activation for even a low threshold to be reached (yet enough activation for the deadline to be extended). This would therefore be consistent with the lack of a frequency effect on lexical decision responses to pseudohomophones.

The point being made is that one does not need a complex model of the sort postulated by McCann and colleagues to handle the results that they obtained using the lexical decision task and homophone decision task. On the other hand, the lack of frequency sensitivity when naming pseudohomophones is a problem for models that presuppose that frequency influences the speed of access to a single lexical representation. As pseudohomophones are named faster than non-pseudohomophones, it must be the case that pseudohomophones are named as soon as the phonological representation of their base word is accessed. If so, the naming response should be sensitive to any factor that influences the speed of access, and therefore a word frequency effect would be expected. It seems, then, that a post-lexical model of the sort offered by McCann and Besner would be required if the lack of frequency sensitivity in naming pseudohomophones cannot otherwise be accounted for.

However, it is possible to provide an alternative explanation for the failure of McCann and Besner to find a frequency effect in pseudohomophone naming. The naming of pseudohomophones can be achieved via one of two different routes: a lexical route or a non-lexical

route. Either the base word is accessed and this is pronounced (the lexical route), or pronunciation is generated on the basis of non-lexical information (e.g. information about the pronunciation of the individual letters or graphemes), just like non-pseudohomophones. The lexical route presumably will only influence responses when it is faster than the non-lexical route. If one assumes that high-frequency base words are accessed before low-frequency base words, it should be the case that there is a correlation between response times and frequency. Indeed, low-frequency base words may not even be accessed before the non-lexical route comes into play and hence may not differ from non-pseudohomophones at all. Of course, this is not what McCann and Besner found. However, frequency is not the only factor that will determine whether the base word is accessed in time. The orthographic similarity between a pseudohomophone and its base word has a strong influence on the access time to the base word (McCann, Besner, & Davelaar, 1988; Taft, 1982), so that if a pseudohomophone is very different to its base word (e.g. "*phocks*" from "*fox*"), pronunciation is likely to be based on non-lexical factors. In addition, the easier the non-lexical route is to use, the less likely the influence of the lexical route. Thus, simple orthographic forms that are easy to pronounce (e.g. "*fome*" from "*foam*") are unlikely to be influenced by the frequency of the base form.

Given that the average time taken to pronounce a non-word on the basis of lexical information is only about 30 msec less than the average time taken to pronounce a non-word on the basis of non-lexical information (as determined by the size of the pseudohomophone/non-pseudohomophone difference), it may well be the case that the task is, indeed, sensitive to frequency, but that this sensitivity is obscured by freely varying orthographic factors. Such orthographic factors were not controlled for in McCann and Besner's examination of frequency, as frequency sensitivity was determined by means of a linear regression performed on a range of pseudohomophones. One might then ask why McCann and Besner were actually able to demonstrate frequency sensitivity using the same materials and the same statistical approach, when employing a homophone decision task. The answer is that orthographic factors are less likely to obscure the frequency sensitivity in this task because the subject is forced to use the frequency-sensitive lexical route, with no non-lexical route to fall back on. The only way a correct decision can be made in the homophone decision task is via the lexical route, and therefore, frequency effects should be observed.

It is very easy to avoid the possible confounding effects of orthographic factors in pseudohomophone naming. All one need do is design pseudohomophones based on high and low frequency words in pairs,

matching them on orthographic factors. This can be achieved by making exactly the same changes to high and low frequency words in order to create pseudohomophones. For example, “*gaim*” is based on the high frequency word “*game*”, while “*daim*” is based on the low frequency word “*dame*”. The two experiments reported in this paper were set up in this way.

EXPERIMENT 1

The first experiment made use of the homophone decision task and simply served as a pilot study for the crucial second experiment, which tested pseudohomophone naming times. As McCann and Besner (1987) found a correlation between homophone decision times and base word frequency, it should be the case that a pseudohomophone based on a high-frequency word would be associated with shorter homophone decision latencies than an orthographically matched pseudohomophone based on a lower-frequency word. If the set of items used in the homophone decision task does reveal a frequency effect, then this set of items is worth subjecting to the naming task.

Method

Materials. Non-words were designed in triplets. Each member of the triplet was a monosyllabic non-word with exactly the same body (vowel plus final consonant cluster), where one member of each triplet was homophonic with a relatively common word as based on the 1971 norms of Carroll, Davies, and Richman (e.g. “*gaim*”, “*rume*”, “*tree*”), one was homophonic with a relatively uncommon word (e.g. “*daim*”, “*lume*”, “*bleet*”), and the third was not homophonic with any English word (e.g. “*raim*”, “*yume*”, “*smeet*”). The orthographic relationship between the body of a pseudohomophone and the body of its base word was the same for the high- and low-frequency conditions (e.g. “*ame*” → “*aim*”, “*oom*” → “*ume*”). There were 30 such triplets, and these are presented in the Appendix. The mean base word frequency in the high-frequency condition was 232.6 occurrences per million; for the low-frequency condition it was 9.2.

Procedure. All items were presented in random order to 20 subjects, who were recruited from the first-year psychology program at the University of New South Wales. Items were presented in upper case on a television screen for 2 sec each, with an inter-item interval of 2 sec. The subjects were told that they would see a series of nonsense words, some of which could be pronounced identically with a real English word and some of which could not. Their task was to classify the items in this way by means

of a button press, YES or NO. Both speed and accuracy in responding were emphasized. Fifteen practice items were given before the experimental items were presented.

Results and Discussion

Mean homophone decision times to the three conditions are presented in Table 1.

Not surprisingly, negative responses took longer to make than positive responses, with the non-pseudohomophones taking significantly longer than either of the two pseudohomophone conditions: $F(1, 19) = 117.9$, $p < 0.001$, over subjects; $F(1, 29) = 134.1$, $p < 0.001$, over items for the pseudohomophones based on high-frequency words (HP) versus the non-pseudohomophones (NP); and $F(1, 19) = 97.7$, $p < 0.001$, $F(1, 29) = 82.3$, $p < 0.001$ for the pseudohomophones based on low-frequency words (LP) versus NP. A number of different explanations could be given for this finding, none of which is of any consequence. For example, when a phonological version of the presented non-word fails to find a lexical representation, as would be the case for the non-pseudohomophones, a re-analysis of the non-word might be attempted in case it can be phonologically encoded in another way.

What is of far greater interest is whether the HP condition is faster than the LP condition. Although it is highly significant on the analysis of subject means, $F(1, 19) = 12.33$, $p < 0.001$, the 70-msec difference was not quite significant on the analysis of item means [$F(1, 29) = 3.73$,

TABLE 1
Experiment 1.
Homophone Decision Latencies Averaged across
Subjects and Percentage Error Rates

<i>Condition</i>	<i>Example</i>	<i>R.T.</i>	<i>% Err</i>
HP	GAIM	1241	12.7
LP	DAIM	1306	24.9
NP	RAIM	1657	5.9

HP = Pseudohomophones based on high-frequency words.

LP = Pseudohomophones based on low-frequency words.

NP = Non-pseudohomophones.

Latencies in msec.

0.05 < p < 0.1], despite the fact that the frequency effect occurred in 21 of the 30 items. In the analysis of errors, both the subject and item analyses were significant: $F1(1, 19) = 23.20$, $p < 0.001$, and $F2(1, 29) = 6.73$, $p < 0.02$, respectively.

It is apparent from these data that HP items are more readily processed than LP items, but it may be problematical to use exactly the same set of items in the possibly less sensitive naming task. The item analysis for reaction times was not significant, despite over two thirds of the items showing the effect, and this suggests a large variability across items. If this set of items is to be used in the naming experiment, it would seem advisable to reduce the variability by eliminating certain items. There were, in fact, three items that stood out as being inappropriate.

The first of these was simply not known to subjects. Only two subjects correctly classified "gerd" as a homophone, presumably because "gird" is such a rare word. There was a 280-msec frequency effect for "berd" vs. "gerd", but the mean response time for the latter was based on only two responses. The other two cases that stood out were HP/LP pairs where the former was over 200 msec slower than the latter. These were "cair"/"snair" and "croo"/"broo". While it is unclear why these two pairs should behave so oddly (perhaps competition from "car" and "crow", respectively), the chance of finding a frequency effect in the ensuing naming experiment would be reduced if these items were to be used.¹ They were therefore eliminated from the materials used in Experiment 2.

There is a further aspect of the design of Experiment 1 that could be improved in the naming experiment. Subjects were presented with each member of an HP/LP/NP triplet and therefore would be exposed to three non-words that had the same body. It is possible that responses to an item are influenced by the prior presentation of another item with the same body, as this has been demonstrated at least in the lexical decision task (e.g. Colombo, 1986; Meyer, Schvaneveldt, & Ruddy, 1974). Although there was nothing systematic about the order with which subjects saw each condition, it would clearly be better in terms of reducing variability if the naming experiment used a design whereby subjects only saw one member of any triplet.

Experiment 2 was therefore set up as a naming task using the same items that were used in Experiment 1, minus the three inappropriate items. In addition, three groups of subjects were used, so that no subject saw more than one member of any triplet.

¹An analysis of items carried out on homophone decision times when these three pairs of pseudohomophones were eliminated did turn out to be significant: $F2(1, 26) = 8.59$, $p < 0.01$.

EXPERIMENT 2

Method

Materials. The items were the same as those used in Experiment 1, except for the triplets "berd"/"gerd"/"lerd", "cair"/"snair"/"sair", and "croo"/"broo"/"snoo", which were eliminated. Thus, 27 triplets were used.

Procedure. There were three groups of 15 subjects, being a mixture of first-year and post-graduate psychology students at the University of New South Wales. Each group was presented with one of three different sets of items. The items were assigned to these sets in such a way that no set included more than one member of each triplet, and each set contained 9 items from each condition. Thus over the whole experiment, 15 response measures were collected for each non-word.

The presentation conditions were the same as in Experiment 1. This time, however, subjects were instructed to read the non-words aloud. The naming response was registered via a microphone suspended above the subject, and the onset of each response triggered a voice-key that served to stop the computer's timer. In this way, naming latencies could be recorded.

As the initial phonemes of the non-words were not controlled and as the voice-key is differentially triggered by different phonemes, the naming task was followed by a naming control task. In a naming control task, the ability of an initial phoneme to trigger the voice-key is supposedly measured without any influence of lexical processing. Subjects were presented with all of the items that they had just seen in the naming task, but this time they did not name the item until 1.5 sec had elapsed, as indicated by the appearance of a line above and below the item to be named. In this way, the time taken to determine the pronunciation of the letter string should have been absent from the naming latency. Therefore, if frequency effects arise at the access stage of lexical processing, this delayed naming task should not produce a frequency effect. In point of fact, although a number of experiments have revealed no influence of word frequency on delayed naming responses (e.g. Forster & Chambers, 1973; Monsell, Doyle, & Haggard, 1989; Savage, Bradley, & Forster, 1990; Taft, 1990), other studies have (e.g. Andrews, 1989; Balota & Chumbley, 1985), though it is difficult to know whether any difference between conditions observed in the naming control task has arisen from lexical factors or differences in the ability of the items to trigger the voice-key. Nevertheless, it is important to include a naming control task when performing naming experiments in order to determine whether it would at least be possible to explain any results obtained in the naming task in terms of the voice-key-

triggering capability of the items. McCann and Besner also included a delayed naming task in their study and actually observed a difference between pseudohomophones and non-pseudohomophones.

Results and Discussion

The mean naming and naming control latencies for the non-words of Experiment 2 are presented in Table 2.

Looking first at the naming control times, it is clear that the conditions did not differ in terms of the capability of their initial phonemes to trigger the voice-key. There were no significant differences between any of the conditions, with none of the *F* values approaching significance.

The failure to find a difference in delayed naming between the pseudohomophones and non-pseudohomophones contradicts what McCann and Besner found in their delayed naming task. Additionally, Savage, Bradley, and Forster (1990) observed a word/non-word difference in the delayed naming task, which parallels McCann and Besner's finding of an effect of lexical status. There is, however, a possible way of explaining why there is sometimes an effect of lexical status on delayed naming and sometimes there is not (as in the present experiment). When no lexical information is accessed, as is the case with non-pseudohomophones, there is likely to be some further processing of the letter string in order to determine whether there is another way to pronounce it. The longer one has to think about alternative pronunciations, the more likely it is that one will come up with them, and hence the more probable that competition between possible pronunciations will occur. Therefore, this component of the lexical status effect may not be eliminated by a delay in the naming response if there is some ambiguity in the pronunciation of the non-word. By this

TABLE 2
Experiment 2.
Naming Latencies and Naming Control Latencies Averaged across
Subjects and Percentage Error Rates

<i>Condition</i>	<i>Example</i>	<i>NL</i>	<i>CL</i>	<i>% Err</i>
HP	GAIM	817	387	5.2
LP	DAIM	840	386	6.5
NP	RAIM	859	392	7.1

NL = Naming latencies.

CL = Naming control latencies

HP = Pseudohomophones based on high-frequency words.

LP = Pseudohomophones based on low-frequency words.

NP = Non-pseudohomophones.

Latencies in msec.

account, the occurrence of a lexical status effect in delayed naming will depend on the number of potential pronunciations the non-pseudohomophones have. Of course, the difference between conditions may alternatively arise simply from differences in initial phonemes. However, as there was no difference between conditions in the present experiment, it is meaningful to turn to the analyses of the naming latencies.

On first appearances, the naming latency data are ambiguous but, if anything, seem to favour McCann and Besner's position. The 23-msec difference between the pseudohomophones based on high-frequency words and the pseudohomophones based on low-frequency words was not significant [$F(1, 42) = 3.85, p > 0.05, F(1, 26) = 0.58, p > 0.1$], whereas the two pseudohomophone conditions together were significantly faster than the non-pseudohomophone condition, $F(1, 42) = 8.25, p < 0.01, F(1, 26) = 5.53, p < 0.05$, and this is exactly the result that would be predicted by McCann and Besner. On the other hand, when the two pseudohomophone conditions are compared to the non-pseudohomophone condition separately, the picture is somewhat different. Although the 42-msec difference between the control non-words and the pseudohomophones based on high-frequency words was clearly significant, $F(1, 42) = 8.49, p < 0.01, F(1, 26) = 5.17, p < 0.05$, the 19-msec difference between the control non-words and the pseudohomophones based on low-frequency words was not, in that the item analysis was not significant [$F(1, 42) = 4.12, p < 0.05, F(1, 26) = 2.81, p > 0.1$]. Therefore, it is only if we ignore the non-significant item analysis for the LP/NP difference that the results can be taken as support for the McCann and Besner position. Should we do this? Further analysis would suggest not.

Consider the alternative account, which involves two routes to pronunciation. According to this position, the pronunciation of a letter string will be generated via a non-lexical method, that is, using information stored about subcomponents of the letter string (e.g. letters, bodies, etc.) unless it is faster for information stored within a lexical entry to be accessed and used. Whether this latter lexical route is indeed faster than the non-lexical route will depend largely upon how quickly the reader can generate the pronunciation of the letter string on the basis of non-lexical information. It is therefore very possible that subjects who are able to pronounce non-pseudohomophones rapidly will not produce frequency effects in naming pseudohomophones, as such subjects are presumably adept at using the non-lexical route. In other words, the frequency effect that was predicted to occur in Experiment 2 would really only be expected to be observed with subjects who are relatively slow at pronouncing non-pseudohomophones.

For this reason, the 15 subjects run in each of the three groups were divided into a fast set and a slow set. The three fast sets comprised the 7

subjects who named the non-pseudohomophones most rapidly in each group, and the three slow sets comprised the 7 subjects who named the non-pseudohomophones most slowly in each group. A separate analysis was then carried out for the fast subjects and the slow subjects. The means for these two types of subject are presented in Table 3.

An analysis of the fast subjects revealed no differences at all, with all F 's < 1 . As the pseudohomophones were named no more quickly than the non-pseudohomophones, it is clear that the fast subjects were manifesting no lexical effects at all. Turning to the slow subjects, we see a very different result. Not only was there a significant difference between the pseudohomophones and the non-pseudohomophones, $F(1, 18) = 11.41, p < 0.01$, $F(1, 26) = 7.76, p < 0.01$, but there was also a significant frequency effect within the pseudohomophones, $F(1, 18) = 4.80, p < 0.05$, $F(1, 26) = 6.30, p < 0.02$. Looking at the two pseudohomophone conditions separately, the HP condition was faster than the NP condition, $F(1, 18) = 11.85, p < 0.01$, $F(1, 26) = 14.43, p < 0.001$, as was the LP condition, though only on the subject analysis, $F(1, 18) = 4.46, p < 0.05$ [$F(1, 26) = 1.12, p > 0.1$].

The results of this post-hoc examination of the data allow us to conclude that the analysis that was carried out over all the subjects, and that had an ambiguous outcome was an inappropriate analysis in that it included a large number of subjects who were not pronouncing the letter strings on the basis of lexical information. When one focuses only on those subjects who would be expected to use a lexical route to pronunciation on account of the difficulty they have in using a non-lexical route, we witness the

TABLE 3
Experiment 2.
Naming Latencies and Naming Control Latencies Averaged Separately
across Fast Subjects and Slow Subjects

Condition	Example	Fast		Slow	
		NL	CL	NL	CL
HP	GAIM	683	430	954	344
LP	DAIM	686	438	1004	341
NP	RAIM	688	428	1040	341

NL = Naming latencies.

CL = Naming control latencies

HP = Pseudohomophones based on high-frequency words.

LP = Pseudohomophones based on low-frequency words.

NP = Non-pseudohomophones.

Latencies in msec.

expected frequency effect. According to the post-access account of frequency effects given by McCann and Besner, when one finds a difference between pseudohomophones and non-pseudohomophones on naming times, one should not find a concomitant frequency difference. Yet one does.

In order to account for this fact, McCann and Besner could argue in the following way. As there were more errors on LP items than on HP items in the homophone decision task of Experiment 1, the fact that LP items were slower than HP items in the naming task could simply reflect the fact that the LP items were more often treated as non-pseudohomophones than were the HP items. Within their framework, McCann and Besner would say that the reason the LP items were treated as non-pseudohomophones more often than HP items was that the low-frequency words were not always lexically stored. A post-hoc examination of the data from Experiment 2, however, suggests that such an explanation for the naming time results cannot be sustained. Specifically, there were 11 cases in the homophone decision experiment where an LP item was within only one error of its matched HP pair: these comprised two cases where there was no difference, seven cases where the HP item produced one more error than its LP pair, and only two cases where the LP item produced one more error than its HP pair. If a frequency effect were observed for the slow subjects of Experiment 2 on these 11 HP/LP pairs, then it could no longer be claimed that the frequency effect occurs because low-frequency words are less often lexically stored than are high-frequency words. The homophone decision data suggest that in these 11 pairs, the high-frequency and low-frequency base words are equally well stored. In point of fact, a significant frequency effect was observed for these 11 item pairs in the naming task, $t(10) = 2.37$, $p < 0.05$, with means of 952 and 1041 for the HP and LP items, respectively, and therefore McCann and Besner's account would seem to be wanting.

The results of Experiment 2 are, on the other hand, entirely explicable in terms of the traditional accounts that say that effects of word frequency emerge during lexical access. To reiterate, a letter string can be pronounced either by assembling a pronunciation from its sublexical components or by using information stored in an appropriate lexical entry. The latter, lexical method will only come into play when the non-lexical method is sufficiently slow relative to the lexical method. Thus it will be an advantage to subjects for whom the non-lexical route is relatively slow to make use of the lexical method. If lexical information associated with high-frequency words is accessed more quickly than lexical information associated with low-frequency words, then the lexical method will be more likely to come into play for pseudohomophones based on high-frequency words than for those based on low-frequency words. Consistent with this is the fact that it was easier for the slow subjects in Experiment 2 to name pseudohomophones

based on high-frequency words than pseudohomophones based on low-frequency words, as well as being easier than non-pseudohomophones. The fact that the difference between the LP and NP conditions was only significant on the analysis of subject means suggests that, even though the non-lexical route might have been slow, the time taken to use the lexical route for the LP items was often no faster. It is seen, therefore, that the account one gives for how pseudohomophones are named does not need to invite the complexities of argument offered by McCann and Besner. The more traditional explanations will suffice.

It is interesting to consider, though, how a pseudohomophone is able to access lexical information about the word on which it is based—that is, how the lexical route to pronunciation is brought into play. The most obvious explanation is that non-lexical procedures are used to convert the letter string into a phonological form, which is then used to access the phonological representation of the base word in the lexicon. However, if a non-lexical procedure is being applied in any case, why is it not used simply to pronounce the pseudohomophonic letter string overtly (in the same amount of time as would be the case for non-pseudohomophones)? One possible answer to this is that articulatory information necessary for the motor response of naming a word may be stored *in toto* within the lexical entry for that word and easily applied, whereas if the non-lexical method is used, such articulatory information needs to be constructed from sub-lexical phonological information, and this takes time. Therefore, accessing lexical information about the motor response can allow an efficient by-passing of the construction of a response from sub-lexical information.

An alternative explanation for how a pseudohomophone gains access to the lexical representation of its base word is that a pseudohomophone might be able to be converted into the base word without the mediation of a phonological representation at all. Taft (1982) has postulated that readers have knowledge about which graphemes (letters that represent single phonemes) are normally pronounced in the same way—for example, “*ee*” and “*ea*”, “*ai*” and “*ae*”, “*oo*” and “*ew*”. Application of such knowledge will allow the reader to access the base word of a pseudohomophone on an orthographic basis; for example, “*gaim*”, “*daim*”, and “*raim*” will be converted into “*game*”, “*dame*”, and “*rame*”, respectively, and the former two will be able to gain access to lexical information. However, when the word is of low frequency (e.g. “*dame*”), this lexical information might take more time to access than it takes for the letter string to be pronounced via sub-lexical information. This would explain why slow subjects name HP non-words more rapidly than LP non-words, which, in turn, are not named significantly more rapidly than NP non-words.

This idea of grapheme–grapheme conversion would be supported if it were to be found that the non-word “*steek*”, for example, is pronounced /steik/, as in STEAK, more often than the non-word “*fleek*” is pro-

nounced /fleik/. In the former case, a conversion of “*ee*” to “*ea*” would allow “*steak*” to be accessed and hence pronounced, whereas in the latter case such a conversion would produce a non-word, “*fleak*”. Consistent with this suggestion is the observation by Taft (1982) of a higher error rate for the former type of non-word compared to the latter type in a homophone decision task. That is, more subjects mistakenly thought that non-pseudohomophones like “*steek*” were pronounced like a real word than those like “*fleek*”. The pronunciation of the body “*ee*” as /eik/ could never arise on the basis of sub-lexical information converting graphemes to phonemes, as “*ee*” is never pronounced /eik/. Additionally, Treiman, Freyd, and Baron (1983) found that subjects said, for example, “*great*” instead of “*greet*” in the sentence, “*George Washington was a greet leader*” on about 11% of occasions, even though the items were always words whose pronunciation could have been determined directly from lexical information.² Such an error would be difficult to explain in terms of sub-lexical phonological recoding as “*ee*” is never pronounced /eit/ in English.

It should be noted that Besner, Dennis, and Davelaar (1985) opposed the notion of grapheme–grapheme recoding. They found that the lexical decision response to a word was facilitated by the prior presentation of a non-word that was homophonic with that word (e.g. LEEF, LEAF), but not by the prior presentation of a non-pseudohomophone that was nevertheless graphemically related to the target word (e.g. DEEF, DEAF). According to a grapheme–grapheme account, “*deef*” should be as related to “*deaf*” as “*leef*” is to “*leaf*” (via an “*ee*”→“*ea*” conversion). There were, however, problems in the definition used by Besner et al. of grapheme–grapheme relatedness. For example, “*grob*” was taken to be graphemically related to “*grab*” in that an “*a*” can be pronounced like an “*o*”, as in “*swab*”. However, this ignores the fact that the “*a*” is only pronounced like an “*o*” when preceded by “*w*” or “*qu*”. When this context-sensitive definition of grapheme–grapheme relatedness is used, it seems that graphemically related items produce as much priming as homophonically related items (see Taft, 1991).

Whether the correct explanation is in terms of grapheme–grapheme translation or grapheme–phoneme translation, the fact remains that the naming of pseudohomophones can be seen as being sensitive to the fre-

²Treiman et al. found an even higher error rate when the misspelt word was irregular, like “*great*” being read as “*greet*” in the sentence “*The hostess came down to greet her guests*”. While one would expect the application of grapheme–grapheme knowledge to be symmetrical, that is, for “*ee*” to be read as “*ea*” as often as “*ea*” is read as “*ee*”, the probability of making a regularization error, like reading “*great*” as “*greet*”, would be magnified compared to an “irregularization” error, like reading “*greet*” as “*great*”, by the fact that sub-lexical phonological recoding of the irregular word would reinforce the incorrect regular pronunciation.

quency of the base word. Of course, McCann and Besner could incorporate this finding into their account by saying that the connection between the phonological input lexicon and the phonological output lexicon is as sensitive to word frequency as is the connection between the orthographic input lexicon and the phonological output lexicon. However, in so doing, the rationale for postulating that frequency effects reside in the connection between lexicons would be lost. There remain no data that cannot be explained by the traditional accounts of frequency effects that place the effects at the stage where a single lexical representation is isolated from the rest of the lexicon.

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APPENDIX

The following are the items used in the two experiments along with their reaction times. HD = homophone decision times obtained in Experiment 1; NT = naming times obtained in Experiment 2; NC = naming control times obtained in Experiment 2.

<i>High-freq. Pseudohom.</i>	<i>HD</i>	<i>NT</i>	<i>NC</i>	<i>Low-freq. Pseudohom.</i>	<i>HD</i>	<i>NT</i>	<i>NC</i>	<i>Non- pseudohom.</i>	<i>HD</i>	<i>NT</i>	<i>NC</i>
brane	1078	784	407	slane	1214	802	364	prane	1754	913	403
milc	999	823	364	silc	1237	857	366	filc	1544	945	423
gole	1233	744	379	fole	1192	930	392	jole	1732	866	373
gaim	1406	814	405	daim	1502	887	413	raim	1661	851	424
whele	1149	960	394	knele	1189	844	385	chele	1674	869	309
poast	1339	815	369	hoast	1226	770	362	woast	1607	920	375
moov	1353	947	369	proov	1189	790	409	troov	1876	907	341
rayne	1071	780	408	gayne	1233	854	384	hayne	1762	811	357
traid	1239	770	403	spaid	1119	841	382	chaid	1696	808	407
tode	1156	752	383	gode	1489	934	313	fode	1557	872	393
rume	1116	798	389	lume	1410	852	382	yume	1838	889	406
maik	1283	777	334	saik	1650	808	393	paik	1745	898	382
hed	1160	826	383	sted	1521	779	415	gled	1657	907	354
groope	1450	862	399	soope	1518	920	443	noope	1769	817	407
keap	1019	862	395	weap	1078	719	381	meap	1585	656	329
stawk	1484	810	396	bawk	1278	820	368	rawk	1525	860	337
blak	1172	810	387	quak	1505	836	416	plak	1610	867	393
hoam	1372	869	380	doam	1344	837	403	voam	1774	953	422
blud	1056	827	396	flud	1221	949	373	slud	1631	783	377
fite	1105	868	405	tite	1202	821	388	pite	1693	854	429
blo	1086	719	338	sto	1286	823	369	clo	1587	846	389
treet	1230	778	393	bleet	1121	688	378	smeet	1751	916	405
hye	1256	822	395	sye	1290	759	366	kye	1525	797	380
cawl	1429	853	414	gawl	1435	760	414	dawl	1541	782	336
shaip	1254	948	409	raip	1296	864	383	laip	1705	864	384
larst	1156	659	383	carst	1408	845	386	darst	1530	912	380
lej	1499	821	400	slej	1514	896	426	bej	1596	872	393
berd	1176	—	—	gerd	1455	—	—	lerd	1426	—	—
cair	1528	—	—	snair	1055	—	—	sair	1716	—	—
croo	1714	—	—	broo	1494	—	—	snoo	1697	—	—