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Equal Homophonic Priming With Words and Pseudohomophones

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The hypothesis that the earliest representations in visual processing of print are activated word-specific units leads to the expectation that homophonic priming (HP) should be greater for word pairs than pseudohomophone pairs. Ten experiments with naming disconfirmed this hypothesis. At interstimulus intervals of 0, 129, 516, and 930 ms, HP for pseudohomophones (e.g., *HOEZ–hoze* vs. *HOGZ–hoze*) equaled HP for words (e.g., *KNOWS–nose* vs. *KNEES–nose*). The complementary finding of negative HP with pseudohomophones relative to positive HP with words was found in an additional investigation of lexical decision. The results confirm a critical early stage in visual word recognition, in which words are represented in purely phonological form, and implicate equal speeds in dual-route models for nonlexical and lexical processing.

The processing influence of one letter string on a subsequent letter string by virtue of shared phonological structure is referred to as *phonological priming.* If the two letter strings are identical in phonology, and if that phonology is the phonology of a word, then the priming can be referred to more precisely as *homophonic priming* (HP). A demonstration of such priming patently requires controls for the potential influences of other kinds of similarities between the two letter strings, such as their visual and semantic relatedness.

In our view, the significance of HP lies in its unique ability to reveal the design of the visual word recognition system. Reasonable intuitions about what that design should include are easy to come by. With little forethought, a layperson might suggest that there are processes that relate the letters composing the word to knowledge of the word's meaning or meanings, to knowledge of how the word is spoken, to knowledge of how it would sound if spoken, and to knowledge of how it would look if written or printed. In contrast, intuitions about the temporal ordering and general necessity of these processes are much less easy to come by. The layperson might puzzle over whether the recovery of meaning leads the recovery of sound, or vice versa, and whether evoking a word's sound is necessary once proficiency in reading has been achieved. Resolving such puzzles to the satisfaction of students of visual word recognition is the promise of HP.

Rastle and Coltheart's (1999a) Perspective on HP

The value of investigations of HP for adjudicating among theories of visual word recognition was highlighted by Rastle and Coltheart (1999a). They remarked that a nonword's ability to prime a homophonic nonword is "relevant to the general issue of the role of phonology in visual word recognition" (p. 471). In experiments directed at addressing this issue, using long prime-to-target interstimulus intervals (ISIs), they found that naming a target was facilitated by a phonologically identical prime only when either the prime or the target was a word or when both were words.

The observed lexical dependency of HP was taken by Rastle and Coltheart (1999a) as evidence against an early stage in visual word recognition in which words are represented as purely phonological patterns. In their view, the observed lexical dependency favored theories in which the earliest representations are activated word-specific units. The prime implementation of such theories is the dual-route cascaded (DRC) model (Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart & Rastle, 1994; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). In accordance with the DRC model, "when words are involved in the prime–target pairing, more HP will occur because these prime–target pairs may benefit from the effects of residual activation in systems of representation that are denied to nonwords: the lexicons" (Rastle & Coltheart, 1999a, p. 465). The lexicons in question are an input orthographic lexicon and an output phonological lexicon. The expectation from the DRC model is that "when the prime is a word homophone of the target, activation of the target phonology in the phonological output lexicon reaches a much greater value than when the prime is a pseudohomophone" (p. 473).

Behind the preceding view of HP is a key feature of the DRC model: Words activate their corresponding representations in the orthographic input lexicon over a fast lexical route. Pseudohomophones typically engage a slower nonlexical route, which leads to rule-based activation of phoneme units and, subsequently, to activation of units in the phonological and orthographic lexicons. This nonlexical route tends to produce lower levels of excitation of phonemes and of units in the phonological and orthographic lexicons than those produced by the lexical route (Rastle & Coltheart, 1999b). Although pseudohomophones and other nonwords can also engage the faster and more strongly activating lexical route, their ability to activate entries in the orthographic lexicon by this route is limited. The degree of a given pseudohomophone's excitation of the orthographic lexicon depends on the degree to which it shares the spellings of words (Coltheart & Rastle, 1994).

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Whatever the level and whatever the source, activation from the orthographic input lexicon is transferred to the corresponding whole-word phonological representation in the phonological output lexicon, and from there to the phoneme system. The latter provides the basis for the naming response. Thus, from the input orthographic lexicon, activation cascades down to induce and/or amplify activation at the level at which individual phonemes are represented. At any prime-to-target ISI, and especially at long prime-to-target ISIs, HP with words exceeds HP with pseudohomophones because the orthographically based activation in the phonological output lexicon is initially higher and remains substantially higher for a word prime than for a pseudohomophone prime.

An Alternative Perspective on HP

The backdrop for Rastle and Coltheart's (1999a) research was two sets of studies conducted by Lukatela and Turvey (1994a, 1994b), one concerning associative priming by appropriate words, homophones, and pseudohomophones (1994a), and the other concerning phonological priming by homophones and pseudohomophones (1994b). In interpreting the priming effects observed in these studies with English language materials, Lukatela and Turvey adopted the account found necessary for explaining the results obtained in investigations of word processing in Serbo-Croatian (Lukatela, Feldman, Turvey, Carello, & Katz, 1989; Lukatela, Turvey, Feldman, Carello, & Katz, 1989; for a review, see Lukatela & Turvey, 1998). The key feature of this latter account is the leading role assumed by a rapidly assembled (computed) phonological code. Whether the letter string is a word or a nonword, this purely phonological code is the primary constraint on the processes by which the letter string's name is determined and its meaning (if any) is recovered.

Results of experiments on phonological priming in Serbo-Croatian motivated Lukatela and Turvey's (1994a, 1994b) interpretation of pseudoassociative and phonological priming in English. Of particular significance were the experiments of Lukatela, Carello, and Turvey (1990). The primes and targets in these experiments differed in alphabet and case (e.g., prime in lowercase Cyrillic and target in uppercase Roman). Furthermore, they differed in almost all consonants and vowels or only in the final consonant. They were, therefore, visually dissimilar and phonemically dissimilar or visually dissimilar and phonemically similar. (True homophones are not possible in Serbo-Croatian.) This latter contrast was implemented for word–word, word–nonword, nonword–word, and nonword–nonword prime–target pairings. On the basis of Lukatela, Turvey, et al. (1989) and Lukatela and Turvey (1990), it was expected that naming the target would benefit from the prior presentation of a similar sounding prime relative to a dissimilar sounding prime, and do so to the same degree regardless of the lexicality of prime and target. The expectation was confirmed.

An Experimental Test: Is HP Better With Words?

In experimental terms, the contrast between Lukatela and Turvey's (1994a, 1994b) view and Rastle and Coltheart's (1999a) view translates into whether the lexical status of the prime or target matters. For Rastle and Coltheart, HP must always be greater when the prime–target pair includes a word than when the pair does not include a word. For Lukatela and Turvey, neither prime nor target needs to be a word. Lukatela et al. (1990) found that nonword primes facilitated phonologically similar nonword targets as effectively as word primes facilitated phonologically similar word targets.

The view of Lukatela and Turvey (1994a, 1994b) can be aptly expressed through a straightforward modification of the DRC model. In its standard mode of operation, the DRC model imposes a delay on the start of processing on the nonlexical route relative to the lexical route, and assigns lower weights to activation on the nonlexical route relative to the lexical route (see Table 1 of Rastle & Coltheart, 1999b). If the preceding relations were reversed, then the nonlexical route would lead the lexical route, and the activation of phoneme units would both lead and be the major constraint on activation of lexical units. Given these reversed relations, the possibility arises that over the nonlexical route, both words and pseudohomophones would activate the orthographic lexicon through the phonological lexicon, ahead of the activation of the orthographic lexicon by letters. The role of the lexical route would then be primarily that of an orthographic verification process—reinforcing appropriately activated lexical entries and inhibiting inappropriately activated lexical entries (e.g., Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994a, 2000; Luo, 1996; Van Orden, 1987). Evidence of equivalent magnitudes of HP for prime–target pairs consisting of words and prime–target pairs consisting of pseudohomophones would favor the preceding variant of the DRC model, a variant in which nonlexical processes play the leading role.

Experiments 1–5: HP With Irregular Words and Pseudohomophones as a Function of ISI

Rastle and Coltheart (1999a) underscored the significance of using long ISIs in the evaluation of HP with words and pseudohomophones. As they remarked,

> If there is a difference in the extent to which HP priming occurs for lexical and nonlexical items, then that difference should be clearly exposed in a long ISI condition in which residual activation in the phoneme system may have decayed entirely while residual activation in the phonological lexicon may persist. (Rastle & Coltheart, 1999a, p. 466)

Rastle and Coltheart (1999a) reported simulations of the DRC model in respect to the degree of HP in the word and pseudohomophone conditions. They summarized these simulations in their Figure 3. This figure plots the amount of priming in each condition as a function of decay period in cycles, with decay period functionally equivalent to ISI. In the simulations, the decay of the prime's activation is applied gradually, with a specific small proportion of decay occurring on each processing cycle for many successive processing cycles. Two notable features of Rastle and Coltheart's (1999a) Figure 3 are (a) greater priming by word pairs than by pseudohomophone pairs at each length of decay or ISI, and (b) significant priming for pseudohomophone pairs at intermediate (and presumably short) ISIs, but not at long ISIs. In respect to feature (a), Rastle and Coltheart (1999a) noted that "in every simulation of the word–word condition and the pseudohomophone–pseudohomophone condition that we carried out, which varied proportion of decay and length of decay, word items showed more priming than pseudohomophone items" (p. 472). In respect to feature (b), the disappearance of HP with pseudohomophones at long ISIs in the simulation confirms their intuition that the HP difference should "be clearly exposed" (p. 466) at long ISIs.

In Experiments 1–5, we directly compared HP produced with primarily irregular words and HP produced with pseudohomophones. Following Rastle and Coltheart (1999a, p. 466), irregular targets were chosen so that the use of the lexical route, and thus the phonological output lexicon, would be encouraged." The comparison of the word and pseudohomophone conditions was conducted within a five-field sequence of mask-prime-mask-target-mask. The preceding sequence is a simple extension of that used by Humphreys, Evett, and Taylor (1982) in their influential investigation of phonological priming. For a fixed prime duration, the duration of the postprime, pretarget mask determines the ISI. For ISI = 0 ms, the postprime, pretarget mask is deleted, rendering the presentation sequence identical to that of Humphreys et al.

Experiments 1–5 were distinguished by the magnitude of the ISI between the offset of the prime (exposed for 129 ms) and the onset of the target. These ISI values were 930 ms (Experiment 1), 515 ms (Experiment 2), 129 ms (Experiments 3 and 4), and 0 ms (Experiment 5). The distinction between Experiments 3 and 4 was in the proportion of homophonic stimuli. This proportion was reduced by half in Experiment 4 to check on the robustness of the observed priming effects.

On the basis of Rastle and Coltheart's (1999a) interpretation of HP, there were two major expectations. First, HP in the pseudohomophone condition should become less evident as ISI increases. That is, HP should be highly significant in Experiment 5, much less so in Experiment 1, and of intermediate significance in Experiments 2–4. Second, HP in the word condition should be greater than HP in the pseudohomophone condition in each experiment, that is, at each ISI.

Method

Participants. In each experiment, there were 20 participants, none of whom participated in any other of the five experiments. All were undergraduates at the University of Connecticut. They participated in partial fulfillment of the course requirements in Introductory Psychology.

Materials. If the number of homophonic pairs were excessively large, and if the prime–target stimulus onset asynchrony (SOA) was sufficiently long, participants could have developed a general strategy of using phonological information provided by the prime to anticipate the target. Given this concern, the total number of homophonic prime–target pairs seen by a participant was restricted to less than 20% of the total number of pairs. An additional concern was the degree to which long words would be fully processed within the limited prime duration. In response to this concern, the letter strings in all pairs were restricted to a maximum length of five letters.

With the latter constraints in mind, we assembled 48 homophonic test pairs of words and 48 nonhomophonic pairs of words as controls (Appendix A). Most of these pairs were borrowed from Rastle and Coltheart's (1999a) Appendix A. The targets in their word pairs were all irregular words. The mean frequency of the targets was 57.62 and the mean frequency of the primes was 90.83 according to Kucera and Francis (1967).[1] We borrowed pseudohomophone pairs from Rastle and Coltheart's (1999a) Appendix E, but fewer because they did not satisfy our five-letters criterion. We created a set of 48 homophonic nonword pairs (test pairs) and a set of 48 nonhomophonic nonword pairs with the same targets (control pairs, see Appendix A). The mean frequency of the source words for the test primes and targets was 72.73 and the mean frequency of the source words of the control primes was 32.04.

In summary, prime–target pairs of the following four kinds were created: (a) Each target word was preceded by a homophonic word to create 48 word pairs (e.g., *KNOWS–nose*); (b) Each target word was preceded by a nonhomophonic word to create 48 nonhomophonic word pairs (e.g., *KNEES–nose*); (c) Each target pseudohomophone was preceded by a homophonic pseudohomophone to create 48 homophonic pseudohomophone pairs (e.g., *HOEZ–hoze*); (d) Each target pseudohomophone was preceded by a nonhomophonic pseudohomophone to create 48 nonhomophonic pseudohomophone pairs (e.g., *HOGZ–hoze*).

There were, in addition, 155 filler pairs. In each filler pair, the prime and the target were two different nonhomophonic letter strings. The filler pairs were highly diversified to make the development of any specific response strategy unlikely. They consisted of 24 word–word pairs with the prime and target associatively related, 28 word–word pairs with the prime and target unrelated, 24 nonword–word pairs with rhyming prime and target, 24 nonword–word pairs with the prime and target sharing the two initial letters, 24 unrelated nonword–nonword pairs, 24 nonword–nonword pairs of rhyming prime and target, 24 pseudohomophone–nonword pairs sharing the two initial letters, 4 word–pseudohomophone pairs, and 3 nonword–pseudohomophone pairs. Separate from the preceding stimulus pairs, an additional 57 stimulus pairs were generated for practice trials.

There were two additional features: First, all nonword primes and targets, in both the experimental pairs and the filler pairs, were orthographically legal and pronounceable as single syllables. Second, 80% of the experimental targets and filler targets seen by any given participant were regular; the remaining 20% were irregular.

In Experiment 4, the preceding sets of 48 pairs were reduced to 24 pairs (Appendix B), and the number of filler pairs was augmented to 203. All word targets in this reduced set were irregular words. The reduction resulted in a restriction of homophonically related pairs to 9.5% of the total number of pairs seen by a participant. The filler pairs were diverse, as above.

Design. The major constraint of the design was that a given participant never encountered a given prime–target pair more than once. This was achieved by dividing the participants in each experiment into two groups, A and B. Each Group A participant saw one half of the pairs from the word test list and from the pseudohomophone test list, one half of the pairs from the word control list and from the pseudohomophone control list, and all filler pairs. Each Group B participant saw the other halves of the test and control lists together with all filler pairs.

In this design, Group A experienced the control (e.g., *HOGZ–hoze, FOLK–fowl*) and test (e.g., *KNOWS–nose, LEVE–leev*) prime–target pairs that corresponded, respectively, to Group B's test (*HOEZ–hoze, FOUL–fowl*) and control (*KNEES–nose, LEDE–leev*) prime–target pairs. The contrast between performance on test and control stimuli within a group, therefore, was meaningless, as was the contrast between the two groups in the magnitude of the test–control contrast. For the preceding reasons, interactions involving Group were ignored in the 2 × 2 × 2 (Group ×

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[1] Target frequency did not interact with the phonology of the primes in the experiments of Lukatela and Turvey (1994b) with a four-field presentation similar to that of the present Experiments 1–7. Similarly, no interaction involving target frequency was observed in the three-field (mask–prime–target) experiments on phonological priming reported by Ferrand and Grainger (1992, 1993). Where target frequency has been systematically manipulated relative to prime frequency in three-field presentations with homophone pairs, positive priming has been found for lower prime frequency and negative priming has been found for higher prime frequency (Grainger & Ferrand, 1994). However, in this latter study, the high versus low frequency contrast was 1,432 occurrences per million versus 36 occurrences per million. In contrast, for the present stimuli, the difference between the more frequent prime source words and the less frequent target source words was merely 33 occurrences per million.

Homophony × Lexicality) analysis of variance (ANOVA) used to evaluate the experimental results.

In summary, within an experimental sequence, each participant saw a total of 251 stimulus pairs of which 48 pairs were homophonic in Experiments 1, 2, 3, and 5, and 24 pairs were homophonic in Experiment 4. The experimental sequence was divided into three approximately equal subsets, with a brief rest after each. The experimental sequence was preceded by the practice sequence of 57 stimulus pairs.

Procedure. Participants, tested one at a time, sat in front of the monitor of a DIGITAL 466 computer in a well-lit room. The viewing distance was about 60 cm. The refresh rate of the VENTURIX monitor was 70 Hz making a refresh cycle (i.e., a *tick*) of 14.3 ms.

Each trial consisted of a sequence of five visual events in the same location on the center of the screen. The five events were (a) a fixation line consisting of a row of five letter-width underscores (__ __ __ __ __) presented for 30 ticks (429 ms); (b) the prime stimulus in uppercase letters presented for 9 ticks (129 ms); (c) an interpolated mask consisting of a row of five pound symbols (#####) presented for either 65, 36, 9, or 0 ticks (930, 516, 129, or 0 ms, respectively); (d) the target presented for 12 ticks (172 ms); and (e) a row of five lowercase *x*s presented for 1 tick (14.3 ms). Consequently, the prime–target ISI was 930, 516, 129, or 0 ms, and the prime–target SOA was 1,059, 645, 258, or 129 ms. The interval between sequences, that is, between trials in a block, was 1 s, measured as the interval between the fifth event of the preceding trial and the first event of the following trial.

Presentation and control of stimuli were through DMASTR software (Forster & Forster, 1990). Participants were told that on each trial, there would be a rapid sequence of visual events, two of which would be letter strings with the first letter string in uppercase and the second letter string in lowercase. Participants were instructed to ignore the uppercase letter string and to read aloud into the microphone as quickly and as accurately as possible the lowercase letter string. The participants were encouraged to read quickly but not at the expense of accuracy. The practice session of 57 trials was marked by the experimenter correcting errors, usually with the phrase "please be careful." Naming latencies were measured from target onset. If the latency exceeded 1,400 ms, a warning message (*READ FASTER!*) appeared on the screen, and if the participant's voice did not trigger the voice key, a brief warning (*WRONG*) appeared on the screen.

Results and Discussion

All naming latencies were trimmed minimally by applying a 100-ms cutoff for fast responses and a 1,400-ms cutoff for slow responses. The outliers constituted less than 0.5% of all responses (see criteria for truncation suggested by Ulrich & Miller, 1994, p. 69).

The amount of priming for the word and pseudohomophone conditions as a function of ISI (that is, across the five experiments) is shown in Figure 1. The notable features of Figure 1 are (a) a decline in amount of priming with ISI and (b) a tendency for priming in the pseudohomophone condition to be greater than, rather than less than, priming in the word condition. Feature (a) is expected from the DRC simulations; feature (b) is counter to the DRC simulations.

Experiment 1 (ISI = 930 ms). For word–word pairs, the reaction time (RT) and error means for the targets were 568 ms and 1.1% for the test condition (*KNOWS–nose*) and 575 ms and 1.1% for the control condition (*KNEES–nose*). For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 598 ms and 1.1% for the test condition (e.g., *HOEZ–hoze*) and 615 ms and 1.1% for the control condition (*HOGZ–hoze*). A 2 × 2 × 2 (Group × Homophony × Lexicality) ANOVA was conducted on the correct naming latencies. Lexicality was significant, meaning that words were named more quickly than nonwords, $F_1(1, 18) = 144.54, p < .0001$, and $F_2(1, 92) = 14.62, p < .001$. Homophony was significant, meaning that HP occurred, $F_1(1, 18) = 10.49, p < .01$, and $F_2(1, 92) = 11.80, p < .001$. Homophony × Lexicality was not significant, meaning that the degree of HP was equivalent for the word condition and the pseudohomophone condition, $F_1(1, 18) = 2.85, p > .05$, and $F_2(1, 92) = 1.67, p > .05$. There were no significant effects in the corresponding error analysis.

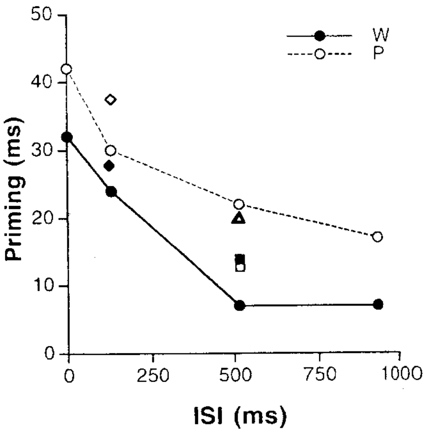

Figure 1. Amount of homophonic priming as a function of condition (W = word, P = pseudohomophone) and prime–target interstimulus interval (ISI). Connected open and closed circles represent the results of Experiments 1, 2, 3, and 5. The open and closed diamonds represent the results of Experiment 4 with the reduced set of stimuli, the open and closed squares represent the results of Experiment 6, and the overlapping open and closed triangles represent the results of Experiment 7.

Experiment 2 (ISI = 515 ms). For word–word pairs, the RT and error means for the targets were 570 ms and 1.5% for the test condition and 577 ms and 1.9% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 605 ms and 0.6% for the test condition and 627 ms and 2.9% for the control condition. Lexicality was significant in the latency ANOVA, meaning that words were named more quickly than nonwords, $F_1(1, 18) = 48.47, p < .0001$, and $F_2(1, 92) = 19.95, p < .0001$. Homophony was significant, meaning that HP occurred, $F_1(1, 18) = 17.75, p < .0001$, and $F_2(1, 92) = 19.64, p < .0001$. The interaction of homophony and lexicality was significant by participants, $F_1(1, 18) = 8.31, p < .01$, and almost significant by items, $F_2(1, 92) = 3.64, p = .06$. The implication is that HP tended to be greater in the pseudohomophone condition than in the word condition. In the error analysis, the Lexicality × Homophony interaction was significant by participants, $F_1(1, 18) = 10.63, p < .01$.

Experiment 3 (ISI = 129 ms). For word–word pairs, the RT and error means for the targets were 606 ms and 1.3% for the test condition and 629 ms and 1.1% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 651 ms and 1.5% for the test condition and 681 ms and 0.8% for the control condition. Lexicality was significant, meaning that words were named more quickly than nonwords, $F_1(1, 18) = 84.96, p < .0001$, and $F_2(1, 92) = 21.72, p < .0001$. Homophony was significant, meaning that HP occurred, $F_1(1, 18) = 25.15$, $p < .0001$, and $F_2(1, 92) = 46.61$, $p < .0001$. Homophony × Lexicality was not significant (both Fs < 1) meaning that the degree of HP was equivalent for the word condition and the pseudohomophone condition. There were no significant effects in the error analysis.

Experiment 4 (ISI = 129 ms; reduced set). For word–word pairs, the RT and error means for the targets were 625 ms and 0% for the test condition and 653 ms and 1.7% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 648 ms and 2.1% for the test condition and 686 ms and 1.7% for the control condition. An ANOVA was conducted on the correct naming latencies. Lexicality was only significant by items, $F_1(1, 18) = 28.02$, $p < .001$, and $F_2(1, 44) = 2.78$, $p > .05$. Homophony was significant, meaning that HP occurred, $F_1(1, 18) = 30.00$, $p < .001$, and $F_2(1, 44) = 36.33$, $p < .001$. Homophony × Lexicality was not significant, meaning that the degree of HP was equivalent for the word condition and the pseudohomophone condition, $F_1(1, 18) = 1.91$, $p > .05$, and $F_2(1, 44) < 1$. No effects were found in the error analysis.

Experiment 5 (ISI = 0 ms). For word–word pairs, the RT and error means for the targets were 630 ms and 0.8% for the test condition and 662 ms and 0.8% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 670 ms and 2.3% for the test condition and 712 ms and 3.1% for the control condition. Lexicality was significant, meaning that words were named more quickly than nonwords, $F_1(1, 18) = 73.00$, $p < .0001$, and $F_2(1, 92) = 21.13$, $p < .0001$. Homophony was significant, meaning that HP occurred, $F_1(1, 18) = 62.02$, $p < .0001$, and $F_2(1, 92) = 60.35$, $p < .0001$. Homophony × Lexicality was not significant, meaning that the degree of HP was equivalent for the word condition and the pseudohomophone condition, $F_1(1, 18) = 1.52$, $p > .05$, and $F_2(1, 92) = 1.16$, $p > .05$. The only effect in the error analysis was the trivial effect of lexicality (more errors on nonwords than words).

In summary, the results of Experiments 1–5 are inconsistent with the predictions of the DRC model: "The DRC model—by virtue of its local word representation—predicts that for any ISI condition, if there is priming for lexical items, this priming must be larger than it is for nonlexical items" (Rastle & Coltheart, 1999a, p. 471). As is evident from Figure 1 and the ANOVAs, HP was equivalent for the word and pseudohomophone conditions at each ISI. It is also evident from Figure 1 that the magnitude of HP declined with ISI. A comparison of Experiment 5 (0 ms) and Experiment 1 (930 ms) revealed that the difference between test and control pairs depended on ISI. For the word condition (32 ms for ISI = 0 ms, 7 ms for ISI = 930 ms), $F_1(1, 36) = 18.06$, $p < .001$, and $F_2(1, 46) = 9.77$, $p < .01$. For the pseudohomophone condition (42 ms for ISI = 0 ms, 17 ms for ISI = 930 ms), $F_1(1, 36) = 7.56$, $p < .01$, and $F_2(1, 46) = 9.19$, $p < .01$.

An additional conclusion follows from the comparison of Experiments 3 and 4. The magnitudes of HP in the two experiments were approximately equal despite the fact that the number of homophonic pairs in Experiment 4 was one half the number of homophonic pairs in Experiment 3. The stability of HP over variations in proportions of homophonic stimuli suggests that HP arises less from strategic processes and more from automatic processes.

Experiment 6: A Reexamination of HP at an ISI of 516 ms

Experiment 2 suggested that at an ISI of 516 ms, priming in the word condition was less than in the pseudohomophone condition. Given that any real priming difference between the two conditions invites hypotheses about qualitative differences between word and nonword processing, we felt the need for a further examination of priming under the conditions of Experiment 2.

Method

Participants. There were 24 participants from the same population as the participants in Experiments 1–5. None had participated in the preceding experiments.

Materials, design, and procedure. These were identical to those of Experiment 2.

Results

For word–word pairs, the RT and error means for the targets were 565 ms and 0.4% for the test condition and 580 ms and 1.4% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 604 ms and 1.1% for the test condition and 618 ms and 2.1% for the control condition. Lexicality was significant in the latency ANOVA (words were named more quickly than nonwords), $F_1(1, 22) = 157.66$, $p < .0001$, and $F_2(1, 92) = 16.64$, $p < .0001$. Homophony was significant (HP occurred), $F_1(1, 22) = 24.47$, $p < .0001$, and $F_2(1, 92) = 20.51$, $p < .0001$. The interaction of homophony and lexicality was not significant (both Fs < 1). In the error analysis, homophony was significant (fewer errors for homophonic pairs), $F_1(1, 18) = 4.52$, $p < .05$, and $F_2(1, 92) = 5.26$, $p < .02$.

In brief, Experiment 6 confirmed the general impression from Experiments 1–5 that HP was equivalent for word and pseudohomophone conditions. The suggestion of a Homophony × Lexicality interaction in Experiment 2, favoring the pseudohomophone condition, was not substantiated. As a further evaluation of the equivalency between conditions, we conducted an ANOVA on the data of Experiments 1–6 with two exclusions: the reduced data set of Experiment 4 and the data of the last 2 participants in each group of Experiment 6 (making all experiments thereby equal in number of participants). The Homophony × Lexicality interaction was significant by subjects, $F_1(1, 90) = 5.82$, $p < .02$, but not significant by items, $F_2(1, 92) = 3.64$, $p > .05$. The interaction did not vary with experiments, $F_1(4, 90) = 1.04$, $p > .05$, and $F_2 < 1$.

Experiment 7: HP at an ISI of 516 ms, With Shared Onsets Equated in Pseudohomophone Conditions

In priming experiments with masked primes and latency of target naming as the dependent measure, there is evidence that latency is reduced if prime and target share initial phonemes (e.g., Forster & Davis, 1991; Kinoshita, 2000). Although the prime durations of Experiments 1–6 are more than double the prime durations of the cited masked priming experiments, there remains the possibility that an effect of shared onsets may have been a contributing factor to the HP results. In the stimuli of Experiments

1–6, shared onsets were less common in the control prime–target pairs of the pseudohomophone condition than in the test prime–target pairs (see Appendix A). Experiment 7 replicated the presentation conditions of Experiments 2 and 6, with pseudohomophone test and control pairs equated for shared onsets.

Method

Participants. There were 24 participants from the same population as the participants in Experiments 1–6. None had participated in the preceding experiments.

Materials, design, and procedure. These were identical to those of Experiments 1, 2, 3, 5, and 6, with the exception of the pseudohomophone control primes (compare Appendix C with Appendix A).

Results

For word–word pairs, the RT and error means for the targets were 569 ms and 1.2% for the test condition and 590 ms and 1.6% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the targets were 610 ms and 1.9% for the test condition and 631 ms and 2.6% for the control condition. Lexicality was significant in the latency ANOVA (words were named more quickly than nonwords), $F_1(1, 22) = 57.43$, $p < .0001$, and $F_2(1, 92) = 18.80$, $p < .0001$. Homophony was significant (HP occurred), $F_1(1, 22) = 27.64$, $p < .0001$, and $F_2(1, 92) = 44.41$, $p < .0001$. The interaction of Homophony × Lexicality was not significant (both Fs < 1). There were no significant effects in the error analysis. In summary, Experiment 7 replicated the results of Experiments 1–6, with all test and control primes in the pseudohomophone condition sharing the initial phonemes of their corresponding targets.

Experiment 8: Rastle and Coltheart's (1999a) Continuous Procedure With Indistinguishable Primes and Targets

In Rastle and Coltheart's (1999a) experiments, primes and targets followed each other in a continuous stream. There were no circumscribed trials with distinct primes and targets as in the present Experiments 1–7. Any uppercase letter string (either prime or target) presented to the participant remained visible until the participant began to name it. At that instant, the letter string was replaced by a fixation bracket that persisted for 900 ms until the next letter string was presented. Accordingly, the prime$_n$–target$_n$ (and target$_n$–prime$_{n+1}$) SOA was approximately 1,400–1,500 ms, given that naming latencies were of the order of 500–600 ms. The presentation conditions of Experiment 8 reproduced the continuous stream procedure used by Rastle and Coltheart. All letter strings were functionally equivalent in that all were presented in the same case, all had to be named, and there was no noticeable separation of trials.

In keeping with Experiments 1–7 of the present series, Experiment 8 included both word–word and pseudohomophone–pseudohomophone conditions, randomly interspersed. In their applications of the continuous stream procedure, Rastle and Coltheart (1999a) did not conduct a direct comparison between the word and pseudohomophone conditions. Their observations of successful priming in the word condition and unsuccessful priming in the pseudohomophone condition were made in separate experiments.

Method

Participants. There were 26 participants from the same population as the participants in Experiments 1–7. None had participated in the preceding experiments.

Materials and design. The experimental design and pairs of stimuli were identical to those used in the preceding experiment (see Appendix C). All stimuli were in uppercase.

Procedure. Each trial began with a row of five hash marks that was presented for 63 ticks (900 ms). This was followed immediately by a letter string in uppercase that had to be named. The letter string persisted until response initiation, at which time a new trial began with the same structure as the preceding trial, but with a different target letter string. Sometimes the successive letter strings were words, sometimes they were pseudohomophones, sometimes they were homophonic, and sometimes they were nonhomophonic. The design diminished the opportunity for participants to discern the planned interitem relations of experimental significance.

Results and Discussion

The present method permitted tabulating errors on the nominal primes along with errors on the nominal targets. Following Rastle and Coltheart (1999a), RTs for nominal targets were discarded for those nominal trials in which the homophone prime was pronounced incorrectly. The latter restriction was added to mispronunciations of nominal targets and RTs exceeding 1,400 ms, forming the criteria for the data entering the subsequent analyses.

For word–word pairs, the RT and error means for the nominal targets were 562 ms and 2.9% for the test condition and 571 ms and 4.2% for the control condition. For pseudohomophone–pseudohomophone pairs, the RT and error means for the nominal targets were 614 ms and 4.8% for the test condition and 628 ms and 7.1% for the control condition. In the latency ANOVA, lexicality was significant (words were named more quickly than nonwords), $F_1(1, 24) = 165.92, p < .0001$, and $F_2(1, 92) = 23.53$, $p < .0001$, and homophony was significant, meaning that HP occurred, $F_1(1, 24) = 8.72$, $p < .01$, and $F_2(1, 92) = 15.38$, $p < .0001$. Importantly, the Lexicality × Homophony interaction was not significant (both Fs < 1), meaning that the degree of HP was equivalent for the word condition and the pseudohomophone condition. The corresponding error ANOVA found significance for lexicality and homophony restricted to the subjects analysis, $F_1(1, 24) = 9.36$, $p < .01$, and $F_2(1, 92) = 2.76$, $p > .05$; and $F_1(1, 24) = 6.78, p < .05$, and $F_2(1, 92) = 2.50, p > .05$, respectively.

The results of Experiment 8 obtained with Rastle and Coltheart's (1999a) continuous procedure paralleled those of Experiments 1–7, in which primes and targets and the trials in which they were embedded were clearly demarcated. In Experiment 8, as in Experiments 1–7, HP was significant and of equivalent magnitude for words and pseudohomophones. Using the continuous procedure, Rastle and Coltheart (1999a) had found HP in the word condition (investigated in their Experiment 1) but not in the pseudohomophone condition (investigated in their Experiment 5). By examining both conditions in one and the same experiment, the present Experiment 8 provided a more direct test of Rastle and Coltheart's (1999a) hypothesis that HP in the word condition must necessarily be greater in magnitude than HP in the pseudohomophone condition.

Experiments 9 and 10: HP When Homophony Is Restricted to Pseudohomophones

In Experiments 9 and 10, we returned to the presentation conditions of Experiments 1–7 and focused upon HP in the pseudohomophone condition evaluated in the absence of the word condition. In terms of the stimulus materials used in Experiments 1–8, we removed the homophonic word–word pairs and replaced them by unrelated filler pairs. There were, therefore, only 24 homophonic pairs in the 251 pairs presented to any given participant. This low percentage (less than 10%) of homophonic pairs limited the payoff of predicting target phonology from prime phonology. The low percentage manipulation was coupled with two SOAs, one within and one outside the classically defined nonstrategic (expectation-free) magnitude of SOA = 250 ms (Neely, 1991). The low percentage and short SOA were expected to minimize the tendency to anticipate that the target would be named identically to the prime.

Method

Participants. Twenty-two University of Connecticut undergraduates participated in Experiment 9, and another 22 undergraduates participated in Experiment 10. The undergraduates were drawn from the same population as those in the preceding experiments. None had participated in the preceding experiments.

Materials. The stimulus pairs were those identified in Appendix A, with the exception that the stimulus pairs composing the word condition were excluded (see Appendix D).

Design and procedure. The design was identical to that of the preceding experiments. The presentation sequence was identical to that of Experiment 5 (prime–target ISI = 0 ms), with prime durations of 129 ms (Experiment 9) and 429 ms (Experiment 10). There were, therefore, two SOAs of 129 ms and 429 ms.

Results

Experiment 9. The RT and error means for the targets were 681 ms and 3.6% for the test condition and 710 ms and 2.5% for the control condition. A 2 × 2 (Group × Homophony) ANOVA was conducted on the correct naming latencies. Homophony was significant, $F_1(1, 20) = 19.10$, $p < .001$, and $F_2(1, 46) = 16.05$, $p < .001$. The corresponding error ANOVA found no effect of homophony.

Experiment 10. The RT and error means for the targets were 605 ms and 2.6% for the test condition and 624 ms and 1.5% for the control condition. In the RT analysis, homophony was significant, $F_1(1, 20) = 21.28$, $p < .001$, and $F_2(1, 46) = 24.53$, $p = .001$. The corresponding error ANOVA found no effect of homophony.

The magnitude of the difference between test primes and control primes did not differ between the two experiments; an ANOVA on RT found no interaction between homophony and experiment ($Fs < 1$). In summary, at both prime–target SOAs, pseudohomophones primed phonologically identical pseudohomophones to the same degree. This latter equivalency of effects across SOA reinforces the impression that strategic effects are not playing a major role in the present investigation of HP.

The conclusion to be drawn from Experiments 1–10, which used the naming task, is that HP with pseudohomophones is equivalent to HP for words over short and long time scales and over differences in experimental methods. As observed in the introduction, such equivalency of HP for pseudohomophones and words implies an important modification of the DRC model, namely, comparable processing speeds on the lexical and nonlexical routes. The detailed structure of the DRC model, under standard assumptions and parameters, importantly suggests a direct test within the lexical decision task of the comparable-speed explanation of the naming data of Experiments 1–10.

Experiment 11: HP With Words and Pseudohomophones in the Lexical Decision Task

The key ideas in the DRC account of HP are that (a) the lexical route is faster than the nonlexical route, (b) words produce greater activation in the orthographic and phonological lexicons than nonwords, and (c) activation on the lexical route is more persistent than activation on the nonlexical route. The aforementioned ideas can be subjected to a special test through the lexical decision version of HP.

In the DRC model, the *yes* lexical decision is made if any entry in the orthographic lexicon reaches a criterion level of activation. The *no* decision is made if a temporal deadline (in terms of number of cycles) elapses before reaching the *yes* decision (Rastle & Coltheart, 1999b). The deadline is not fixed, but rather varies according to the summed activation of all orthographic lexical units measured prior to the *yes* response. The greater the overall level of activation in the orthographic lexicon, the more likely it is that the stimulus is a word. In consequence, the deadline is a function of the degree to which the orthographic lexicon (as a whole) is excited.

In light of the preceding notions, in the word condition of the present series of experiments, a word prime will strongly activate its representation in the orthographic lexicon and, subsequently, its whole word phonological representation in the phonological lexicon. The two-way interaction between the lexicons will mean that the prime's representation in the orthographic lexicon will be reinforced, and homophonic words will have their orthographic representations activated. Consequently, a target word homophonic with the prime will benefit from the prior presentation of the prime: Positive lexical decision should be facilitated relative to the nonhomophonic prime–target control pair.

The situation for a pseudohomophone–pseudohomophone pair will be very different. If the test prime–target pair is *HOEZ–hoze*, with *HOGZ–hoze* as its corresponding control pair, then the two primes, *HOEZ* and *HOGZ*, will activate the orthographic representation of *hose* equally. According to Coltheart and Rastle's (1994) simulation, the activation by *HOEZ* and *HOGZ* of *hose* in the orthographic lexicon should be negligible given that each prime shares in the same position only two of *hose*'s letters. In contrast, activation of other units in the orthographic lexicon (e.g., *hoes* and *hogs*) should be higher. These latter active orthographic representations should bring about activation of the corresponding phonological lexical representations, with a consequent reinforcing of activity in the orthographic representations. With respect to the target *hoze*, it is important to underscore that its contribution to the overall level of activity in the orthographic lexicon is the same for both the test and control prime–target pairs.

The important feature of the preceding description of the lexical route is that with respect to the activation of the target, no systematic differential influence, on average, can emerge between the pseudohomophone condition's test and control pairs: An effect of homophony on lexical decision in the pseudohomophone condition cannot arise on the lexical route.

Could such an effect arise on the nonlexical route? The primes *HOEZ* and *HOGZ* would activate whole-word phonologies in the phonological lexicon, and *HOEZ* would activate, in turn, the orthographic representation *hose*. The activity level of the orthographic unit *hose* would be further elevated through excitation in the phonological lexicon, induced by the occurrence of *hoze*. The homophonic pair *HOEZ–hoze*, therefore, would produce on the nonlexical route an overall greater level of activity in the orthographic lexicon than the nonhomophonic pair *HOGZ–hoze*. Of considerable theoretical significance to the interpretation of HP is whether this greater activity in the orthographic lexicon resulting from *hoze* following *HOEZ* would occur fast enough to extend the deadline.

According to Rastle and Coltheart (1999b), the deadline is computed on each trial on the basis of the overall level of activity measured at a point in processing that is earlier than any *yes* decision time. The lower limit on the *yes* decision is set by the shortest amount of time needed for any one entry in the orthographic lexicon to reach a particular criterion level of activation. This lower limit, would presumably be associated with very high frequency words processed on the lexical route. Consequently, for *HOEZ–hoze* to produce a longer *no* latency than *HOGZ–hoze*, the activation by *hoze* of the orthographic lexicon over the nonlexical route must occur at a speed greater than the speed needed to achieve criterial activation of any orthographic lexical unit over the lexical route.

In summary, a cornerstone of classical dual-route thinking as implemented by the DRC model is the following processing requirement: No word unit in the orthographic lexicon can reach threshold before the nonword deadline has been set. In the present experiment, we examined whether targets in the pseudohomophone condition are rejected more slowly following homophonic primes than following nonhomophonic primes. If rejection latencies are slowed by homophonic pseudohomophones, then it would have to be concluded that contrary to the DRC model with standard parameters, the nonlexical route cannot be slower than the lexical route.

Method

Participants. Twenty-four undergraduates participated in the experiment in partial fulfillment of a course requirement. The undergraduates were drawn from the same population as those in the preceding experiments. None had participated in the preceding experiments.

Materials. Materials (see Appendix A) were the same as those in Experiments 1–6, except that 155 filler pairs were chosen to provide for approximately the same total number of word–word pairs, word–nonword pairs, nonword–word pairs, and nonword–nonword pairs in each experimental list.

Design and procedure. The design was the same as that of Experiments 1–6. The five-field procedure of Experiments 1–6 was used with a prime duration of 129 ms and a prime–target ISI of 0 ms. Instructions were the same as those given in Experiments 1–6.

Results and Discussion

For the word condition, the mean lexical acceptance times and errors for the targets were 664 ms and 12.5% for the test pairs and 680 ms and 17.7% for the control pairs. For the pseudohomophone condition, the mean lexical rejection times and errors were 688 ms and 14.4% for the test pairs and 669 ms and 16.3% for the control pairs.

ANOVA on latencies revealed a significant interaction between lexicality and homophony, $F_1(1, 22) = 10.55$, $p < .01$, and $F_2(1, 92) = 9.88$, $p < .01$. For the word condition, a planned comparison found the 16-ms difference between test and control pairs to be marginal, $F_1(1, 22) = 3.71$ $p = .07$, and $F_2(1, 46) = 3.52$, $p = .07$. For the pseudohomophone condition, a planned comparison found the −19-ms difference between test and control pairs to be highly significant, $F_1(1, 22) = 13.30$, $p < .001$, and $F_2(1, 46) = 7.04$, $p < .01$. In the error analysis, homophony was the only significant effect, $F_1(1, 22) = 7.92$, $p < .01$, and $F_2(1, 92) = 5.17$, $p < .05$.

In summary, the results of Experiment 11 suggest that homophony reduced latency in the word condition (*yes* responses) and increased latency in the pseudohomophone condition (*no* responses). In addition, these HP effects were of comparable magnitudes in the word and pseudohomophone conditions, consonant with the conclusion drawn from the naming experiments (Experiments 1–10). The major implication of the results of Experiment 11 is that activation of the orthographic lexicon by the nonlexical route of the DRC model occurs at a speed commensurate with activation by the lexical route. A further implication of Experiment 11 is that HP in the word condition and HP in the pseudohomophone condition may both be the outcomes of a common mechanism. In more general terms, the implication is that words and pseudohomophones are processed similarly. That is, instead of assuming that words—especially high frequency and irregular words—are privileged in respect to use of the lexical route, one should assume that they are just like pseudohomophones in that the earliest and primary representations are generated over the nonlexical route. Consistent with the preceding argument is the demonstration that the effects of attentional load, associations, and frequency are the same for words and pseudohomophones (Lukatela & Turvey, 1993).

Experiment 12: Phonological Priming With Ordinary Nonwords in the Lexical Decision Task

Over the nonlexical route, a pseudohomophone can activate a specific entry in the orthographic lexicon. In contrast, over the nonlexical route, an ordinary nonword (one that does not have the phonology of a word) cannot activate a specific entry in the orthographic lexicon. The reversed effect found for phonologically identical pseudohomophones in Experiment 11 should not, therefore, be found for phonologically identical ordinary nonwords. That is, the rejection latency of an ordinary nonword target homophonic with its ordinary nonword prime should not be different from the rejection latency of an ordinary nonword target nonhomophonic with its ordinary nonword prime. Data consistent with this latter expectation were reported for Serbo-Croatian by Lukatela et al. (1990). Although the response to an ordinary nonword target was affected by the phonological similarity of its ordinary nonword prime in the naming task, it was not so affected in the lexical decision task.

Experiment 12 compared HP for the word condition of the preceding experiments with an ordinary nonword condition. The prediction was an effect of phonological identity for the word condition but not for the ordinary nonword condition. Aside from its theoretical significance within the DRC framework, Experiment

12 provided a means of evaluating a possible alternative interpretation of the slower rejections of pseudohomophones following test primes in Experiment 11. Perhaps lexical decisions were slowed simply because, compared with control primes, test primes resulted in amplified phonological activity at the time of target processing. In Experiment 12, the hypothesized amplification of phonological activity would occur for homophonic ordinary nonwords. That is, no difference in RTs for the nonword homophonic and nonhomophonic prime–target pairs was expected.

Method

Participants. Twenty-four undergraduates participated in the experiment in partial fulfillment of a course requirement. The undergraduates were drawn from the same population as those in the preceding experiments. None had participated in the preceding experiments.

Materials. The pseudohomophone prime–target pairs of Experiment 11 were replaced by prime–target pairs composed from ordinary nonwords (see Appendix E).

Design and procedure. The design and procedure were the same as in Experiment 11.

Results and Discussion

For the word condition, the mean lexical acceptance times and errors for the targets were 649 ms and 11.6% for the test pairs and 671 ms and 16.6% for the control pairs. For the ordinary nonword condition, the mean lexical rejection times and errors were 671 ms and 14.1% for the test pairs and 675 ms and 9.21% for the control pairs.

An ANOVA on latencies revealed a nonsignificant interaction between lexicality and phonology (same vs. different), $F_1(1, 22) = 2.68, p < .11$, and $F_2(1, 92) = 2.36, p < .13$. The marginal status of the interaction encouraged the planned comparisons. The 22-ms difference between test and control pairs in the word condition was significant, $F_1(1, 22) = 8.54, p < .01$, and $F_2(1, 46) = 6.58, p < .01$; the 4-ms difference between test and control pairs in the ordinary nonword condition was nonsignificant, $F_1(1, 22) < 1$, and $F_2(1, 46) < 1$.

In the error analysis, Lexicality × Phonology was significant, $F_1(1, 22) = 14.57, p < .001$, and $F_2(1, 92) = 4.20, p < .05$. Planned comparisons found significance for the 5% difference between test and control pairs in the word condition, $F_1(1, 22) = 7.55, p = .01$, and $F_2(1, 46) = 8.25, p < .01$, and for the −5% difference between test and control pairs in the ordinary nonword condition, $F_1(1, 22) = 7.87, p < .01$, and $F_2(1, 46) = 10.06, p < .01$.

The word condition of Experiment 12 replicated the word condition of Experiment 11 in respect to both latencies and errors. In contrast, the ordinary nonword condition of Experiment 12 produced different latency and error patterns than did the pseudohomophone condition of Experiment 11. ANOVAs comparing the two experiments with factors of nonword type (ordinary nonword vs. pseudohomophone) and phonology revealed significant interactions in the latency data, $F_1(1, 44) = 7.53, p < .01$, and $F_2(1, 92) = 3.89, p < .05$, and in the error data, $F_1(1, 44) = 7.56, p < .01$, and $F_2(1, 92) = 6.07, p < .01$. When latencies were slowed by test primes relative to control primes in the pseudohomophone condition of Experiment 11, latencies were equal in magnitude for the test and control primes of the ordinary nonword condition of Experiment 12. When errors were equal in magnitude for the test and control primes of the pseudohomophone condition of Experiment 11, errors were reduced by test primes relative to control primes in the ordinary nonword condition of Experiment 12. One conclusion is that identical phonology of two ordinary nonwords does not affect the word recognition system in the same way as identical phonology of two nonwords that are homophones of words. Another conclusion is that the observed HP with pseudohomophones in Experiment 11 was not simply because test pairs (e.g., *HOEZ–hoze*) generated higher levels of phonological activity than control pairs (e.g., *HOGZ–hoze*). If the latter were the case, then rejection latencies in Experiment 12 should have been longer for test pairs (e.g., *TOAB–tobe*) than control pairs (*TOIB–tobe*). As reported above, test and control latencies in Experiment 12 were equal.

An influence of homophony on the rejection latency data of the ordinary nonword condition was not expected from the theoretical argument that motivated Experiment 11. That argument, phrased in terms of the mechanism for setting the lexical decision deadline, requires that primes and targets are able to activate specific whole-word units in the phonological lexicon and, thereby, in the orthographic lexicon. With respect to nonwords, the argument applies to pseudohomophone pairs such as *HOEZ–hoze* but not to ordinary nonword pairs such as *TOAB–tobe*. What requires addressing in the data of Experiment 12 is the suggestion of a negative effect of phonological identity in the error data of the ordinary nonword condition. Why should *TOAB–tobe* produce more *yes* responses in the lexical decision task than *TOIB– tobe*? An answer can be pursued in the framework of the DRC model. Although the model does not yet address error production, reasonable hypotheses about the origin of nonword errors can be derived from the model's architecture.

The ordinary nonwords *TOAB* and *TOIB* would produce low-level activity in a number of whole-word representations in the orthographic and phonological lexicons. Over the lexical route, they would partially match the letter sequences of some words, and over the nonlexical route, they would partially match the phoneme sequences of some words. When *tobe* follows *TOIB*, the units partially activated by *tobe* would be, in both lexicons, largely different from those made partially active by *TOIB*. The processing consequences of *TOIB–tobe*, therefore, would be approximately equal degrees of low-level excitation of orthographic and phonological whole-word units. Importantly, the same consequences would not be expected in the case of *TOAB–tobe*. The subsequent processing of *tobe* over the nonlexical route would reinforce the same representations in the phonological lexicon that were partially activated by *TOAB*. In contrast, over the lexical route, the subsequent processing of *tobe* would not necessarily reinforce the same representations in the orthographic lexicon that were partially activated by *TOAB*. The upshot in the case of *TOAB–tobe* would be an asymmetry in the dynamics of the orthographic and phonological lexicons. If the lexical decision process consults both lexicons in determining a letter string's status, then the possibility arises that the representations in the phonological lexicon, partially activated by *TOAB* and reinforced by *tobe*, stand out sufficiently to evoke, on occasion, a *yes* response. If the latter occasions are reasonably frequent, then *yes* responses will occur more often for *TOAB–tobe* than for *TOIB–tobe*. The errors in the case of *TOIB–tobe* presumably reflect the baseline level of noise in the lexical decision process.

There is much less potential for inconsistency between orthographic and phonological lexicons in the pseudohomophone condition of Experiment 11 than in the ordinary nonword condition of the present experiment. The orthographic and phonological units receiving the highest levels of activation by a pseudohomophone will typically tend to represent the same word. For example, from the nonlexical route, *hoze* will activate the phonology of *hose* and, subsequently, the orthography of *hose*. From the lexical route, *hoze* will activate a number of orthographic units and, in turn, a number of phonological units, but none will be fully activated in either lexicon. In summary, the two lexicons will be uniformly activated by *hoze*, with strong activation occurring in the orthographic lexicon for the same word that receives strong activation in the phonological lexicon. This identified uniformity or consistency of activation in the two lexicons would be expected to hold for both test and control prime–target pairs. Although one can imagine a number of factors that would give rise to erroneous decisions on target pseudohomophones, those factors are not exaggerated, under the present analysis, by the nature of the prime. As mentioned previously, in Experiment 11, errors in test and control prime–target pairs were not significantly different.

Finally, if the preceding account of errors in the ordinary nonword condition is correct, then the present data complement the data of Experiment 11 in showing that processing on the nonlexical route is at least as fast as processing on the lexical route. For the proposed inconsistency to arise, the phonological lexicon must be activated by the target, a nonword, within the time scale of the ordinary process of lexical evaluation as described in Experiment 11.

General Discussion

The 12 experiments reported in the present article are unequivocal in their major finding: HP occurs equally for words and pseudohomophones. According to the arguments of Rastle and Coltheart (1999a), this finding favors the hypothesis of a critical early stage in the process of visual word recognition in which words are represented in purely phonological form. Also according to their arguments, the finding of equal HP for words and pseudohomophones favors the hypothesis that knowledge of orthography and phonology is not represented locally in the reading system (as proposed, e.g., by Plaut, McClelland, Seidenberg, & Patterson, 1996).

On first examination, the outcome of the present research would seem to disconfirm the DRC model. A more conservative evaluation would be that the outcome of the present research disconfirms the DRC model as currently parameterized. Despite the arguments advanced by Rastle and Coltheart (1999a), the present finding of equivalent HP for words and pseudohomophones need not be interpreted as calling into question the architecture proposed by Coltheart and colleagues (e.g., Coltheart et al., 1993, 2001; Coltheart & Rastle, 1994; Rastle & Coltheart, 1999a, 1999b). The finding might be more properly interpreted as calling into question how the architecture has been put to use. Following the suggestion advanced in the introduction, a relatively simple modification of the DRC model's current parameter settings might suffice to accommodate the lexical independence of HP. If activation on the nonlexical route precedes activation on the lexical route, then phonological codes would be the earliest representations of both words and nonwords. As simulation shows (Appendix F), the results of Experiment 11 are not accommodated by the standard form of the DRC model, according to which the nonlexical route is delayed relative to the lexical route and produces lower and more rapidly decaying levels of activation. In contrast, the results of Experiment 11 can be simulated with adjustments to the parameters for the nonlexical route and the phonological lexicon that make the speeds of processing and levels of activation on the two routes more commensurate (Appendix F). For this nonstandard DRC model to apply more generally, additional adjustments will be required. One likely adjustment is a broader application of context-sensitive rules. The use of such rules in the standard DRC model's nonlexical route is limited. Their widened application would facilitate the nonlexical processing of so-called irregular words (Cortese & Simpson, 2000).

That one should be circumspect about the standard form of the DRC model is suggested by the simulation summarized in Rastle and Coltheart's (1999a) Figure 3. The simulation is for the magnitudes of HP generated in the range of prime–target delays extending from 37 cycles to 46 cycles. The simulated functions imply that HP in the word condition will become indefinitely large at small prime–target delays (below 20 cycles). For the short prime–target delays evaluated in the present experiments, no such (physically anomalous) hyperbolic function is in evidence. There is clearly a need for more realistic simulations at brief ISIs. Greater realism might follow from the suggested parameter changes.[2]

As noted in the introduction, the equivalence of HP for words and pseudohomophones in English was expected from the Serbo-Croatian results on phonological priming in naming (Lukatela et al., 1990; Lukatela & Turvey, 1990). The confirmed expectation reinforces our impression that the lessons learned from investigations of Serbo-Croatian generalize to English. The necessity of a distinct phonological level and recognition of the leading role it plays in visual word recognition are becoming, with increasing frequency, the lessons learned from investigations of English (Carello, Turvey, & Lukatela, 1992; Lukatela, Frost, & Turvey, 1998; Lukatela & Turvey, 1998). The framework developed for understanding the Serbo-Croatian results has proven to be a source of nonintuitive and nontrivial predictions about both Serbo-Croatian and English word processing (e.g., Lukatela, Frost, & Turvey, 1998, 1999; Lukatela, Savic, Urosevic, & Turvey, 1997; Lukatela & Turvey, 1998). In Serbo-Croatian, for example, the framework has led to the correct prediction that there are phonological conditions under which nonwords can activate semantics faster than words (Lukatela, Carello, Savic, Urosevic, & Turvey, 1998). In English, for example, it has led to the correct prediction that a phonologically inconsistent word will fail to prime itself at

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[2] There might be an additional reason for being circumspect about the simulations with the word condition reported by Rastle and Coltheart (1999a). Within the phonological output lexicon of the DRC model, the assignment of frequency values to homophones is inappropriately determined. That is, some homophones receive the frequency associated with the more frequent written form, and others receive the frequency associated with the less frequent written form. This quasi-random assignment procedure is likely to have consequences for the activation of homophones in the phonological lexicon. (See also http://www.maccs.mq.edu.au/~max/DRC/.)

short time scales sufficient for a phonologically consistent word to prime itself (Lukatela et al., 1999). Both predictions run counter to expectations from the DRC model operating under the standard set of parameters.

The key idea behind the latter predictions can be stated succinctly: The time to resolve a letter string's phonological representation dictates the time course of visual word recognition. The refined expression of this idea is the phonological coherence hypothesis of Van Orden and colleagues (e.g., Gotlob, Goldinger, Stone, & Van Orden, 1999; Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). It is typically expressed in terms of adaptive resonances within the triangular framework—which is how Rastle and Coltheart (1999a) described modeling of the kind pursued by Van Orden and others (e.g., Plaut et al., 1996). Within this framework, a stable (coherent) phonological representation mediates, in the sense of resolves, the competing states of visual–semantic and phonological–semantic interactions. As noted above, however, there is no reason that this leading role for a purely phonological level of representation cannot be made explicit in the architecture of the DRC model. It will be interesting to see how the two architectures, the triangular and DRC, fare in respect to accommodating expectations from the phonological coherence hypothesis.

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Appendix A

Test Primes, Control Primes, Targets, and Target Latencies (in Milliseconds) for Experiments 1, 2, 3, 5, 6, and 11

			Experiment 1		Experiment 2		Experiment 3		Experiment 5		Experiment 6		Experiment 11	
Test prime	Control prime	Target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target
						Word condition								
SITE	SIGHS	sight	569	594	560	580	632	650	645	673	577	602	585	713
ROWS	ROBS	rose	493	523	515	532	600	560	560	587	491	522	685	652
STAKE	STORE	steak	629	672	611	625	630	683	676	727	602	643	643	659
HARE	HIRE	hair	488	566	508	541	553	602	554	641	503	567	573	641
MANE	MAN	main	499	547	501	546	545	524	618	627	517	542	639	677
ORE	JAR	oar	508	545	524	591	598	608	589	697	555	622	611	672
SALE	SALT	sail	567	626	587	614	679	643	642	749	608	603	647	683
PLAIN	PLANK	plane	524	595	550	611	611	570	598	585	529	560	605	643
SINE	SING	sign	571	638	551	619	692	605	655	669	583	602	644	752
SUN	SIN	son	575	622	579	601	653	644	693	713	591	596	655	678
PACED	PESTS	paste	528	559	533	593	575	575	601	664	515	604	689	683
KNOWS	KNEES	nose	505	578	471	523	591	592	585	625	531	554	619	632
BRAKE	BROOK	break	525	539	495	579	579	585	601	644	526	527	594	604
DOE	DOT	dough	547	585	560	565	584	635	581	695	576	598	651	720
FOUL	FOLK	fowl	519	601	555	595	608	612	628	688	557	596	647	794
MOAN	MOON	mown	532	670	633	640	653	631	600	702	560	633	739	961
CUE	SUE	queue	695	691	707	736	761	749	703	764	658	719	762	732
CORD	CROWD	chord	595	711	671	643	666	726	667	740	616	671	698	763
HART	HURT	heart	522	598	547	590	531	642	592	740	517	607	550	686
PAIR	PIER	pear	501	565	515	551	550	572	569	695	504	526	651	597
TIDE	TILL	tied	526	582	552	573	577	629	644	677	514	551	699	668
DYED	DEED	died	494	548	480	545	580	592	569	599	528	579	569	665
YOKE	YOUR	yolk	532	627	496	594	608	612	586	653	524	589	765	834
PORE	PURE	pour	520	591	499	607	561	633	597	642	508	519	706	604
STEAL	STALL	steel	685	594	639	631	648	718	705	660	643	636	768	649
BEET	BELT	beat	567	522	585	559	553	612	665	643	590	565	704	632
BAWL	BILL	ball	567	513	573	519	596	600	574	579	533	531	662	665
GAIT	GALL	gate	594	509	589	545	581	611	601	731	606	582	660	779
LUTE	LOST	loot	570	484	576	548	597	586	581	583	519	498	754	791
NUN	NUT	none	504	537	544	502	543	542	602	558	545	543	630	679
POLL	PILE	pole	557	513	566	536	580	624	604	644	563	546	684	616
REIN	RUIN	rain	541	512	534	514	535	563	557	567	543	516	655	617
CELL	SILL	sell	614	575	628	651	604	687	648	660	616	606	652	634
SEAS	SETS	seize	657	598	681	615	672	703	750	665	592	598	781	692
STARE	STAIN	stair	641	605	673	589	635	690	682	712	616	655	613	730
WAIL	WALL	whale	536	512	512	520	576	567	632	558	532	537	654	726
GRATE	GRANT	great	595	519	557	528	615	636	642	615	529	549	692	567
CREWS	CROWS	cruise	663	567	577	592	633	668	684	633	660	602	696	665
ROOT	ROAST	route	633	525	583	579	612	623	657	661	551	585	762	861
BARE	BARK	bear	516	523	524	531	615	617	612	654	525	560	649	665
HIM	HAM	hymn	599	606	645	600	631	717	649	692	662	608	863	806
BRED	BREW	bread	542	518	547	512	566	619	564	630	505	512	603	620
SWEET	SHEET	suite	690	655	652	641	657	708	759	771	665	652	781	726
SHOOT	SHORT	chute	722	675	719	718	713	825	790	781	706	675	710	625
URN	BORN	earn	563	535	562	569	591	592	660	668	611	536	736	663
WHERE	WEST	wear	497	525	534	512	530	579	604	596	487	496	570	677
BREWS	BRIMS	bruise	549	542	570	519	563	568	609	621	538	522	616	677
FRAYS	GRAMS	phrase	677	568	597	554	614	713	672	725	594	586	713	721

Appendix A (*continued*)

			Experiment 1		Experiment 2		Experiment 3		Experiment 5		Experiment 6		Experiment 11	
Test prime	Control prime	Target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target	Test–target	Control–target
Pseudohomophone condition														
HOEZ	HOGZ	hoze	584	572	591	571	665	617	645	722	550	599	718	638
GAWZE	GAIZE	gauzz	618	650	627	615	723	689	703	700	636	662	675	691
DAYZ	DABZ	daiz	561	620	592	610	652	665	617	782	584	588	655	644
CLAIM	FLAIM	klame	635	708	630	694	719	756	695	839	642	693	648	674
CLAMZ	SLAMZ	klamz	636	678	655	737	690	769	650	766	642	672	575	624
COYN	LOYN	koin	586	625	581	660	626	655	607	780	577	635	659	656
KREEM	DREEM	creem	558	598	587	618	679	650	607	650	586	583	874	765
CAIV	SAIV	kave	566	610	589	680	699	619	664	773	590	641	635	714
NOAD	NODD	noed	530	666	588	648	574	586	636	644	571	574	680	699
FAIZ	GAIZ	phaze	521	630	601	631	675	670	638	689	587	609	687	755
LAYZ	LAMZ	laiz	536	626	546	606	619	628	626	691	553	582	724	655
LEFE	LENE	leeph	555	635	587	643	644	708	720	664	629	616	650	604
RHIME	RHOME	wryme	611	670	610	664	660	696	687	683	630	687	664	588
KOF	KOD	kough	595	710	609	689	682	715	695	735	619	682	637	606
FAIK	CAIK	phake	591	701	602	665	649	648	693	718	609	610	615	647
WAID	WAUD	wayd	534	617	505	590	559	611	620	642	494	603	605	632
MEKE	MENE	meak	469	578	504	626	514	587	547	610	494	539	795	730
KOTE	BOTE	koat	532	586	569	573	611	682	646	753	536	639	686	701
FONE	KONE	phoan	555	618	563	648	675	638	679	714	560	632	598	639
SCOAP	SLOAP	skope	623	727	633	756	724	743	703	780	642	747	662	623
PAUSE	PAUNE	pauzz	535	571	535	577	580	608	597	649	492	556	639	587
SOYL	SOAL	soile	566	593	549	593	614	656	657	722	602	615	786	676
FOME	KOME	phoam	557	627	546	631	696	644	619	697	531	603	660	613
TOYL	TOUL	toile	537	594	552	608	563	621	619	671	532	569	648	705
SEASE	GEASE	ceese	689	667	649	694	757	766	783	767	701	641	696	694
COYL	FOYL	koil	596	608	594	595	675	683	704	753	646	619	690	675
KRANE	TRANE	crain	613	550	596	610	619	697	652	736	587	646	1028	756
BEAZ	BEDZ	beze	602	575	591	649	642	669	661	682	616	629	661	644
COAP	ROAP	kope	592	559	603	608	640	680	638	687	579	613	737	664
SEAK	MEAK	ceak	745	703	823	721	770	819	821	824	772	721	772	766
TEAZE	TEAME	teese	579	569	595	593	623	657	632	674	614	563	818	732
COED	ROED	kode	597	543	613	590	640	715	684	679	598	590	643	614
CAYN	CANN	kain	560	556	547	583	586	634	578	632	592	531	620	634
KRATE	FRATE	crait	624	575	584	577	616	658	690	666	613	584	785	741
TAYL	TAWL	taile	656	586	633	602	707	737	669	700	650	605	691	711
CEAD	FEAD	sead	664	627	654	667	706	792	721	734	667	635	803	757
SCOAR	STOAR	skore	681	678	684	680	751	777	730	812	653	696	734	691
CHEKE	CHEPE	cheak	664	636	639	629	617	761	696	723	658	685	867	928
LEVE	LEDE	leev	652	553	627	581	615	654	645	694	585	594	631	601
JERM	FERM	germe	621	613	585	572	606	663	660	678	583	597	647	640
COAK	POAK	koke	640	572	645	599	649	691	723	675	597	586	627	683
FAID	FADD	fayd	619	605	602	602	603	668	683	693	613	583	574	564
KREW	TREW	crue	558	574	631	556	630	632	648	655	546	558	827	727
HAUK	HAWL	hawck	639	567	655	630	608	667	714	695	668	581	650	622
SKAIT	SLAIT	scate	662	626	681	646	708	766	758	810	708	655	790	736
CRAIV	GRAIV	krave	583	594	643	611	589	683	625	763	593	618	749	655
SKALE	SNALE	scail	677	606	689	620	694	693	766	689	657	627	707	758
COAN	BOAN	kone	617	568	596	595	690	680	704	705	598	611	694	616

Note. Target latencies for each experiment are for test prime–target and control prime–target pairings in the word and pseudohomophone conditions. All word targets and a few of the pseudohomophone targets, together with their corresponding test and control primes, are from "Lexical and Nonlexical Phonological Priming in Reading Aloud," by K. Rastle and M. Coltheart, 1999, *Journal of Experimental Psychology: Human Perception and Performance, 25*, pp. 477, 480. Copyright 1999 by the American Psychological Association. Adapted with permission of the author.

(*Appendixes continue*)

Appendix B

Test Primes, Control Primes, Targets, and Target Latencies (in Milliseconds) for Experiment 4

Test prime	Control prime	Word target	Test–target	Control–target	Test prime	Control prime	Pseudohomophone target	Test–target	Control–target
BRAKE	BROOK	break	590	595	GRAWZE	GAIZE	gauzz	679	737
DOE	DOT	dough	625	674	DAYZ	DABZ	daiz	655	636
TIME	TAME	thyme	669	723	CLAMZ	SLAMZ	klamz	712	754
MOAN	MOON	mown	614	657	COYN	LOYN	koin	636	697
CUE	SUE	queue	770	773	CAIV	SAIV	kave	661	730
CORD	CROWD	chord	679	703	LAYZ	LAMZ	laiz	675	680
HART	HURT	heart	589	606	RHIME	RHOME	wryme	696	707
PAIR	PIER	pear	585	597	FAIK	CAIK	phake	674	649
TIDE	TILL	tied	616	614	MEKE	MENE	meak	602	615
DYED	DEED	died	583	565	KOTE	BOTE	koat	608	649
YOKE	YOUR	yolk	619	646	SCOAP	SLOAP	skope	712	692
SOLE	SOLD	soul	611	679	TOYL	TOUL	toile	579	605
GRATE	GRANT	great	565	610	SEASE	GEASE	ceese	679	815
CREWS	CROWS	cruise	661	645	COYL	FOYL	koil	625	673
ROOT	ROAST	route	611	656	KRANE	TRANE	crain	625	669
BARE	BARK	bear	581	632	COAP	ROAP	kope	592	682
HIM	HAM	hymn	637	744	TEAZE	TEAME	teese	543	682
BRED	BREW	bread	542	569	COED	ROED	kode	673	655
SWEET	SHEET	suite	683	754	CAYN	CANN	kain	581	592
SHOOT	SHORT	chute	742	794	KRATE	FRATE	crait	600	667
URN	BORN	earn	606	636	TAYL	TAWL	taile	726	693
WHERE	WEST	wear	622	575	CEAD	FEAD	sead	716	724
BREWS	BRIMS	bruise	569	614	SCOAR	STOAR	skore	718	811
FRAYS	GRAMS	phrase	618	666	CHEKE	CHEPE	cheak	549	653

Note. All word targets and a few of the pseudohomophone targets, together with their corresponding test and control primes, are from "Lexical and Nonlexical Phonological Priming in Reading Aloud," by K. Rastle and M. Coltheart, 1999, *Journal of Experimental Psychology: Human Perception and Performance, 25*, pp. 477, 480. Copyright 1999 by the American Psychological Association. Adapted with permission of the author.

Appendix C

Test Primes, Control Primes, Targets, and Target Latencies (in Milliseconds) for Experiments 7 and 8

			Experiment 7		Experiment 8					Experiment 7		Experiment 8	
Test prime	Control prime	Target	Test–target	Control–target	Test–target	Control–target	Test prime	Control prime	Target	Test–target	Control–target	Test–target	Control–target
		Word condition							Pseudohomophone condition				
SITE	SIGHS	sight	577	602	562	586	HOEZ	HOGZ	hoze	550	599	545	574
ROWS	ROBS	rose	491	522	521	515	GAWZE	GAIZE	gauzz	636	662	601	643
STAKE	STORE	steak	602	643	571	650	DAYZ	DABZ	daiz	584	588	540	606
HARE	HIRE	hair	503	567	498	568	CLAIM	CLAMM	klame	642	693	596	661
MANE	MAN	main	517	542	499	560	CLAMZ	CLANZ	klamz	642	672	642	697
ORE	JAR	oar	555	622	485	571	COYN	LOYN	koin	577	635	568	646
SALE	SALT	sail	608	603	557	592	KREEM	KREEP	creem	586	583	582	650
PLAIN	PLANK	plane	529	560	568	596	CAIV	CARV	kave	590	641	603	670
SINE	SING	sign	583	602	561	580	NOAD	NODD	noed	571	574	516	650
SUN	SIN	son	591	596	551	597	FAIZ	FAIT	phaze	587	609	575	612
PACED	PESTS	paste	515	604	511	539	LAYZ	LAMZ	laiz	553	582	523	568
KNOWS	KNEES	nose	531	554	490	491	LEFE	LENE	leeph	629	616	636	630
BRAKE	BROOK	break	526	527	511	536	RHIME	RHOME	wryme	630	687	649	711
DOE	DOT	dough	576	598	562	605	KOF	KOD	kough	619	682	645	759
FOUL	FOLK	fowl	557	596	560	614	FAIK	FAIM	phake	609	610	592	647
MOAN	MOON	mown	560	633	587	633	WAID	WAUD	wayd	494	603	514	635
CUE	SUE	queue	658	719	728	787	MEKE	MENE	meak	494	539	493	537
CORD	CROWD	chord	616	671	599	690	KOTE	KORE	koat	536	639	536	615
HART	HURT	heart	517	607	515	552	FONE	FONTE	phoan	560	632	604	640
PAIR	PIER	pear	504	526	507	561	SCOAP	SLOAP	skope	642	747	641	750
TIDE	TILL	tied	514	551	570	580	PAUSE	PAUNE	pauzz	492	556	545	588
DYED	DEED	died	528	579	472	523	SOYL	SOAL	soile	602	615	559	672
YOKE	YOUR	yolk	524	589	498	540	FOME	FORME	phoam	531	603	561	596
PORE	PURE	pour	508	519	498	550	TOYL	TOUL	toile	532	569	528	612
STEAL	STALL	steel	643	636	641	612	SEASE	SEAME	ceese	701	641	708	722
BEET	BELT	beat	590	565	557	564	COYL	COYN	koil	646	619	650	607
BAWL	BILL	ball	533	531	537	515	KRANE	KRAZE	crain	587	646	614	605
GAIT	GALL	gate	606	582	522	543	BEAZ	BEDZ	beze	616	629	685	707
LUTE	LOST	loot	519	498	530	478	COAP	KOAL	kope	579	613	619	584
NUN	NUT	none	545	543	498	487	SEAK	SEAP	ceak	772	721	777	758
POLL	PALE	pole	563	546	578	572	TEAZE	TEAME	teese	614	563	609	594
REIN	RUIN	rain	543	516	556	528	COED	KOLD	kode	598	590	655	567
CELL	SILL	sell	616	606	587	559	CAYN	CANN	kain	592	531	583	537
SEAS	SETS	seize	592	598	642	573	KRATE	KRAPE	crait	613	584	636	570
STARE	STAIN	stair	616	655	629	57	TAYL	TAWL	taile	650	605	618	5981
WAIL	WALL	whale	532	537	520	500	CEAD	CEAL	sead	667	635	643	620
GRATE	GRANT	great	529	549	536	496	SCOAR	STOAR	skore	653	696	759	704
CREWS	CROWS	cruise	660	602	619	599	CHEKE	CHEPE	cheak	658	685	642	642
ROOT	ROAST	route	551	585	578	532	LEVE	LEDE	leev	585	594	680	571
BARE	BARK	bear	525	560	543	539	JERM	JEMM	germe	583	597	626	599
HIM	HAM	hymn	662	608	638	641	COAK	COAV	koke	597	586	647	591
BRED	BREW	bread	505	512	531	478	FAID	FADD	fayd	613	583	596	579
SWEET	SHEET	suite	665	652	689	652	KREW	KROW	crue	546	558	601	569
SHOOT	SHORT	chute	706	675	699	702	HAUK	HAWL	hawck	668	581	674	594
URN	BORN	earn	611	536	592	527	SKAIT	SLAIT	scate	708	655	655	605
WHERE	WEST	wear	487	496	574	480	CRAIV	KRAIK	krave	593	618	630	570
BREWS	BRIMS	bruise	538	522	566	521	SKALE	SNALE	scail	657	627	650	626
FRAYS	GRAMS	phrase	594	586	570	598	COAN	KORN	kone	598	611	627	612

Note. Target latencies for each experiment are for test prime–target and control prime–target pairings in the word and pseudohomophone conditions. All word targets and a few of the pseudohomophone targets, together with their corresponding test and control primes, are from "Lexical and Nonlexical Phonological Priming in Reading Aloud," by K. Rastle and M. Coltheart, 1999, *Journal of Experimental Psychology: Human Perception and Performance, 25*, pp. 477, 480. Copyright 1999 by the American Psychological Association. Adapted with permission of the author.

(*Appendixes continue*)

Appendix D

Test Primes, Control Primes, Targets, and Target Latencies (in Milliseconds) for Experiments 9 and 10

			Experiment 9		Experiment 10	
Test prime	Control prime	Target	Test–target	Control–target	Test–target	Control–target
HOEZ	HOGZ	hoze	809	739	694	690
GAWZE	GAIZE	gauzz	686	653	652	597
DAYZ	DABZ	daiz	670	625	585	547
CLAIM	FLAIM	klame	741	791	680	664
CLAMZ	SLAMZ	klamz	708	628	625	533
COYN	LOYN	koin	743	700	609	584
KREEM	DREEM	creem	637	667	632	564
CAIV	SAIV	kave	724	748	619	587
NOAD	NODD	noed	710	706	728	641
FAIZ	GAIZ	phaze	684	676	594	572
LAYZ	LAMZ	laiz	771	716	673	682
LEFE	LENE	leeph	867	763	612	660
RHIME	RHOME	wryme	730	753	604	641
KOF	KOD	kough	667	620	579	535
FAIK	CAIK	phake	732	741	635	605
WAID	WAUD	wayd	746	703	674	618
MEKE	MENE	meak	627	592	519	498
KOTE	BOTE	koat	673	615	565	563
FONE	KONE	phoan	701	643	571	579
SCOAP	SLOAP	skope	704	787	720	681
PAUSE	PAUNE	pauzz	608	642	648	550
SOYL	SOAL	soile	718	697	582	602
FOME	KOME	phoam	663	681	629	586
TOYL	TOUL	toile	614	640	575	541
SEASE	GEASE	ceese	724	793	629	737
COYL	FOYL	koil	635	779	545	631
KRANE	TRANE	crain	588	777	566	646
BEAZ	BEDZ	beze	714	802	544	644
COAP	ROAP	kope	650	774	550	638
SEAK	MEAK	ceak	740	758	637	740
TEAZE	TEAME	teese	658	632	567	613
COED	ROED	kode	684	722	588	650
CAYN	CANN	kain	557	610	519	628
KRATE	FRATE	crait	666	698	570	651
TAYL	TAWL	taile	626	758	554	594
CEAD	FEAD	sead	676	786	603	648
SCOAR	STOAR	skore	590	694	534	625
CHEKE	CHEPE	cheak	623	720	544	602
LEVE	LEDE	leev	675	844	587	666
JERM	FERM	germe	631	713	558	591
COAK	POAK	koke	629	749	561	650
FAID	FADD	fayd	594	656	543	608
KREW	TREW	crue	628	627	576	624
HAUK	HAWL	hawck	715	744	605	656
SKAIT	SLAIT	scate	701	761	632	700
CRAIV	GRAIV	krave	639	722	555	646
SKALE	SNALE	scail	715	769	622	694
COAN	BOAN	kone	726	717	615	672

Note. All primes and targets are pseudohomophones. All word targets and a few of the pseudohomophone targets, together with their corresponding test and control primes, are from "Lexical and Nonlexical Phonological Priming in Reading Aloud," by K. Rastle and M. Coltheart, 1999, *Journal of Experimental Psychology: Human Perception and Performance, 25*, pp. 477, 480. Copyright 1999 by the American Psychological Association. Adapted with permission of the author.

Appendix E

Test Primes, Control Primes, Targets, and Target Latencies (in Milliseconds) for Experiment 12

Test prime	Control prime	Target	Test–target	Control–target	Test prime	Control prime	Target	Test–target	Control–target
		Word condition					Nonword condition		
SITE	SIGHS	sight	702	637	PRUE	PRUD	proo	675	638
ROWS	ROBS	rose	702	598	WOLE	WOTE	woal	765	712
STAKE	STORE	steak	602	654	SLOAV	SLOOV	slove	751	688
HARE	HIRE	hair	588	604	RAYM	RALM	raim	642	725
MANE	MAN	main	638	619	SAIB	SARB	sabe	690	698
ORE	JAR	oar	673	703	ZAWSE	ZALSE	zauce	762	652
SALE	SALT	sail	701	615	MEFE	MEFT	meeph	635	709
PLAIN	PLANK	plane	769	579	YAIN	YANT	yane	709	645
SINE	SING	sign	688	736	REPH	RETH	reff	649	671
SUN	SIN	son	677	619	VAYZ	VAGZ	vaiz	659	616
PACED	PESTS	paste	670	681	CHOAM	CHOOM	chome	648	692
KNOWS	KNEES	nose	593	611	FOAP	FOOP	phope	704	630
BRAKE	BROOK	break	545	621	PHAIP	PHALP	fape	733	716
DOE	DOT	dough	719	666	YAIK	YARK	yake	748	583
FOUL	FOLK	fowl	759	678	FREW	FREG	frue	686	639
MOAN	MOON	mown	652	579	ZAWT	ZAIT	zaut	678	610
CUE	SUE	queue	713	770	SKOAM	SKOOM	scome	707	650
CORD	CROWD	chord	700	735	SEECH	SELCH	seach	764	764
HART	HURT	heart	550	587	QUAIM	QUARM	kwame	563	582
PAIR	PIER	pear	616	613	ROATS	RORTS	rotes	656	719
TIDE	TILL	tied	613	698	PITE	POTE	pight	820	649
DYED	DEED	died	561	666	PUMM	PUME	pumb	662	699
YOKE	YOUR	yolk	725	812	CHOFE	CHOFS	choaf	655	663
PORE	PURE	pour	585	584	POFE	PUFE	poaf	665	754
STEAL	STALL	steel	682	736	WROIF	WROFF	roiph	580	739
BEET	BELT	beat	641	669	PHEAN	PHRAN	feen	627	753
BAWL	BILL	ball	603	671	TOOF	TOLF	tooph	633	692
GAIT	GALL	gate	611	814	TOAM	TOIB	tobe	702	873
LUTE	LOST	loot	681	700	WREEN	WRENN	rean	681	688
NUN	NUT	none	624	693	VODE	VOZE	voad	587	691
POLL	PILE	pole	635	766	MOAF	MAAF	mofe	652	686
REIN	RUIN	rain	598	644	NAIT	NAST	knate	720	808
CELL	SILL	sell	666	713	QUIB	QUIG	kwib	602	672
SEAS	SETS	seize	640	629	ZAWZE	ZANZE	zauze	594	594
STARE	STAIN	stair	577	718	TAWZE	TAYZE	tauzz	603	638
WAIL	WALL	whale	667	736	ZAIR	ZOIR	zare	678	653
GRATE	GRANT	great	575	633	MOAKS	MOIKS	mokes	708	667
CREWS	CROWS	cruise	634	675	HEEM	HERM	heam	776	711
ROOT	ROAST	route	671	728	MEEZ	MERSE	meaz	650	645
BARE	BARK	bear	583	648	TROYT	TROOT	troit	640	643
HIM	HAM	hymn	854	828	KWOON	KWORN	quoon	701	707
BRED	BREW	bread	557	591	KNOPH	KNETH	nof	550	604
SWEET	SHEET	suite	610	769	POILE	PORLE	poyl	650	605
SHOOT	SHORT	chute	697	701	KNAIR	KNART	nare	805	720
URN	BORN	earn	690	699	PAUK	PAYK	pawk	612	699
WHERE	WEST	wear	657	632	BEWCK	BOWCK	buke	716	662
BREWS	BRIMS	bruise	669	695	ZAY	ZAX	zeigh	643	662
FRAYS	GRAMS	phrase	683	661	DOICK	DOAK	doyck	628	590

Note. Nonword targets are ordinary nonwords. All word targets and a few of the pseudohomophone targets, together with their corresponding test and control primes, are from "Lexical and Nonlexical Phonological Priming in Reading Aloud," by K. Rastle and M. Coltheart, 1999, *Journal of Experimental Psychology: Human Perception and Performance, 25*, pp. 477, 480. Copyright 1999 by the American Psychological Association. Adapted with permission of the author.

(*Appendixes continue*)

Appendix F

DRC Simulation of Experiment 11

We feel that it is of importance to show the DRC model can simulate the outcome of Experiment 11 if system parameters are chosen to make the processing speed on the phonological route and on the orthographic route approximately equal. This objective was achieved by preserving DRC's standard parameters at the feature, letter, and orthographic-lexicon levels, but introducing modifications to the parameters at the grapheme–phoneme correspondencies (GPC), phoneme, and phonological lexicon levels.

The lexical decision task was simulated in strict adherence to the procedure prescribed by Coltheart et al. (2001). According to their procedure, there are two different criteria for making a *yes* decision: (a) the normal criterion and (b) the fast-guess criterion. Under (a), the *yes* decision is made if an entry in the orthographic lexicon has reached an activation level of A = 0.69. Under (b), the *yes* decision is made if the summed activation (SA) of all entries in the orthographic lexicon has reached a value of 0.200 by Cycle 20. If it has, then the fast-guess criterion (S) is reduced from its original value of S = 10.0 to a new value of S = 1.98. However, if the SA has not reached a value of 0.200 by Cycle 20, then S remains at its original value of 10.0

For *no* responses, the DRC model's deadline procedure was applied: If the criterion for a *yes* response is not reached by cycle D = 42, a *no* decision is made. The deadline value is lengthened on Cycle 20 if there is sufficient activity in the orthographic lexicon at that cycle. If the summed activation of all entries in the orthographic lexicon has reached a value of 0.112 by Cycle 20, then the value of D is extended from its original value of 42 cycles to a new value of 48 cycles. If the summed activation of all entries in the orthographic lexicon has not reached a value of 0.112 by Cycle 20, then D remains at its original value of 42 cycles.

In our simulation, two different sets of parameters were used, the standard set and the modified set (see Table F1). The standard set of parameters was downloaded from the internet at http://www.maccs.mq.edu.au/~max/DRC. The downloaded set was similar to that identified by Rastle and Coltheart (1999b, p. 486, Table 1). This standard set of parameters, however, was designed to simulate reading aloud, and therefore the letter-to-words inhibition was reduced to −0.300 as prescribed by Coltheart et al. (2001) for simulation of the lexical decision task. In addition, to simulate priming paradigms, all decay values were set to 0.150, and to prevent a premature end of computation, the minimum activation of pronunciation latency was raised to 0.930.

Table F1
Simulation Parameters

Parameter	Standard value	Modified value
Feature noise	0.000	
Letter noise	0.000	
Orthographic noise	0.000	
Phonological noise	0.000	
Phoneme noise	0.000	
Activation rate	0.200	
Letter decay	0.150	
Orthographic decay	0.150	
Phonological decay	0.150	
Phoneme decay	0.150	
Frequency scale	0.050	
Inh: Features to letters	−0.150	
Exc: Features to letters	0.005	
Inh: Words to letters	0.000	
Exc: Words to letters	0.300	
Lat: Letters to letters	0.000	
Inh: Letters to words	−0.300	
Exc: Letters to words	0.070	
Exc: Phonological to words	0.200	0.350
Lat: Words to words	−0.600	
Exc: Words to phonological	0.200	
Inh: Phoneme to phonological	−0.160	−0.430
Exc: Phoneme to phonological	0.040	0.070
Lat: Phonological to phonological	−0.070	−0.150
Inh: Phonological to phoneme	0.000	
Exc: Phonological to phoneme	0.140	0.300
Lat: Phoneme to phoneme	−0.150	0.000
Exc: GPC to phoneme	0.055	0.355
GPC: Activation offset	10.000	0.000
GPC: Left-to-right interval	17.000	1.000
Pronunciation latency: Minimum activation	0.430	0.930

Note. Inh = inhibition; Exc = excitation; Lat = lateral inhibition; GPC = grapheme–phoneme correspondence.

As intended, the set of modified parameters was generated with the goal of simulating the results of Experiment 11. To achieve this goal with the DRC model, we needed to accelerate the impact of phonology on lexical word units without changing any feature of the standard orthographic lexicon. The modified set of parameters was consequently made identical to the standard set in respect to the lexical aspect, but it was made different from the standard set in respect to the nonlexical aspect. For example, the GPC activation offset was reduced from 10.00 to 0, and the GPC left-to-right interval was reduced from 17.00 to 1.00. Thus, the modified parameters provided for a faster activation of phoneme units, although phoneme activation still lagged by several cycles behind letter activation. Given that the downloaded program is compiled, further reduction of the GPC left-to-right interval to 0 cycles was impossible. Into the modified set of parameters we introduced a notable increase of both the phoneme-to-phonology inhibition (−0.430) and the phonology-to-phonology inhibition (−0.150). These increases were intended to prevent an excessive activation of phonological neighborhood in response to the input pseudohomophone. Additionally, we introduced an increase in the phonology-to-words excitation (0.350).

The modified set of parameters was dedicated to simulating the lexical decision task only. For simulation of reading aloud (Experiments 1–10), a different set of parameters are needed. Coltheart et al. (2001) offered a justification for the necessity of two different parameter sets: "Reading aloud requires knowledge of the specific item that has been presented, but lexical decision does not" (p. 228).

With eight exceptions, the pseudohomophone triplets of Appendix A were used for the simulations under the standard and modified sets of parameters. (The eight exceptions were in respect to the targets: KAVE, KOUGH, PHOAN, PHOAM, KOPE, KANE, SEAD, and KONE.) Specifically, the input to the DRC model consisted of 40 nonword quadruples, of which each quadruple contained a homophonic pair of pseudohomophones (e.g., *HOEZ–HOZE*) and a nonhomophonic pair of pseudohomophones (e.g., *HOGZ–HOZE*). Important, both the homophonic prime (e.g., *HOEZ*) and the nonhomophonic prime (e.g., *HOGZ*) within a given quadruple always shared the same pseudohomophone target (e.g., *HOZE*). The prime–target interstimulus interval was set to 30 cycles of decay. The proportion of decay, in agreement with Rastle and Coltheart's (1999a) experiments, was made equal to .15.

At the response deadline (by Cycle 42 or by Cycle 48), the SA of orthographic word units was recorded. This critical value of SA was considered to be a viable substitute for the nonword rejection latency: the larger the recorded SA, the longer would have been the nonword rejection latency.

At the outset, SA was evaluated considering nonword primes in isolation. With the standard set of parameters, the homophonic primes (such as *HOEZ*) and the nonhomophonic primes (such as *HOGZ*) produced average

SAs of 0.615 and 0.622, respectively. This difference was not significant ($F < 1$). Similarly, using the modified set of parameters, SAs for isolated homophonic and nonhomophonic primes were 0.769 and 0.748, respectively. The latter difference was similarly not significant ($F < 1$). Therefore, within the orthographic lexicon, the average SA was the same in response to the *HOEZ*-like nonwords and the *HOGZ*-like nonwords. This sameness was notably preserved with both the standard and the modified set of parameters.

Next, SA was evaluated for nonword targets (e.g., *HOZE*) when each target was preceded either by its homophonic prime or by its nonhomophonic prime. With the standard set of parameters, the homophonic prime–target pairs (such as *HOEZ–HOZE*) and nonhomophonic prime–target pairs (such as *HOGZ–HOZE*) produced average SAs of 0.627 and 0.630, respectively. This difference was not significant ($F < 1$). In contrast, with the modified set of parameters, the homophonic pairs and the nonhomophonic pairs produced average SAs of 0.782 and 0.765, respectively. The latter difference was significant, $F(1, 39) = 13.05$, $p < 0.001$.

In summary, with the standard parameters, average SAs in the orthographic lexicon were indifferent to the homophony between prime and target pseudohomophones; with the modified parameters, average SAs were reliably larger for homophonic than for nonhomophonic prime–target pairs. The latter distinction was the main outcome of Experiment 11.

The present simulation confirmed the theoretical expectations presented in previously published work (e.g., Lukatela & Turvey, 2000) and in the present article. The DRC model is able to simulate results demonstrating a fast-acting and leading role for phonology in the lexical decision task if the processing speed on the nonlexical route is made comparable with the processing speed on the lexical route.

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