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Homophone Dominance Modulates the Phonemic-Masking Effect

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Four experiments tested whether homophone dominance modulates the phonemic-masking effect. Dominance was estimated by the relative frequency of homophone pairs. Positive phonemic-masking effects occurred for dominant homophones, and null phonemic-masking effects occurred for subordinate homophones. Also, subordinate homophones were much more likely to be falsely identified as their dominant mate. The source of these null phonemic-masking effects was traced to a competition between the homophone's spelling mediated by their common phonology—a null phonemic-masking effect that is itself a phonology effect. These findings converge with a growing body of phonology effects produced under conditions thought to prejudice word perception against phonology. Phonology, thus, appears to supply mandatory constraints in the perception of printed words.

The role of phonology in skilled reading is subject to intense debate. The study of visual word identification offers insight into this controversy. Efficient and precise word identification is necessary for skilled reading (e.g., Perfetti, 1985, 1992). Evidence for the routine and general role of phonology in visual word identification thus indicates phonology's contribution to reading.

Phonology's role in visual word identification has been widely investigated by the use of a variety of task performances (i.e., marker effects). One family of marker effects is composed of the various consistency effects: Inconsistency in the mapping of spelling to phonology (or phonology to spelling) yields slower and more error-prone performance in a variety of reading tasks (e.g., naming perfor-

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mance, see Andrews, 1982; Jared, 1997; Jared, McRae, & Seidenberg, 1990; Paap & Noel, 1991; Rosson, 1985; Taraban & McClelland, 1987; lexical decision performance, see Stone, Vanhoy, & Van Orden, 1997; Ziegler, Montant, & Jacobs, 1997). Another family of marker effects is the homophone errors in categorization (e.g., *ROWS* falsely categorized as a flower; Bosman & de Groot, 1996; Jared & Seidenberg, 1991; Van Orden, 1987; Van Orden, Johnston, & Hale, 1988), lexical decision (e.g., *ROZE* falsely identified as a word; Bosman & de Groot, 1996; Van Orden et al., 1992), and proofreading (e.g., the spelling *ROWS* or *ROZE* is accepted in a sentence context appropriate to *ROSE*; Van Orden, 1991; Van Orden et al., 1992). A third family of marker effects—a focus of this article—is the mask-reduction effects in which a masked target (e.g., *rake*) is better identified if its mask is a pseudohomophonic nonword (e.g., *RAIK*; see Berent & Perfetti, 1995; Perfetti & Bell, 1991).

Indeed, there is a growing body of research demonstrating phonology's contribution in a variety of experimental settings (see Berent & Perfetti, 1995; Carello, Turvey, & Lukatela, 1992; R. Frost, 1998; Lukatela & Turvey, 1998; Perfetti, Zhang, & Berent, 1992; Van Orden, Pennington, & Stone, 1990, for reviews). However, all phonology effects are embedded in complex interactions. Phonology variables interact with other cognitive variables (e.g., Andrews, 1982; Azuma & Van Orden, 1997; Strain, Patterson, & Seidenberg, 1995; Waters & Seidenberg, 1985), with task demands (e.g., Berent, 1997; Gibbs & Van Orden, 1998; Jared & Seidenberg, 1991; Van Orden, Holden, Podgornik, & Aitchison, in press; Waters & Seidenberg, 1985; Xu & Perfetti, 1999), task (e.g., Berent & Perfetti, 1995; Bosman & de Groot, 1996; Jared, 1997; Van Orden et al., 1992), and even the language of presentation (R. Frost, 1998). Interactions often combine null phonology effects and positive effects. Such null effects lead to fierce debates: Does a null phonology effect indicate the absence of reliance on phonology in performing the experimental task? Does phonology play a general or specialized role in reading?

The presence of both positive and null effects forces researchers to choose which effect (positive or null) is most indicative of typical word identification. Whether to emphasize reliable positive or reliable null findings is a theory-driven choice; it cannot be decided based on the results of experiments alone (Van Orden, Aitchison, & Podgornik, 1996). However, predictions regarding the form of interactions with phonology variables in particular experimental settings are testable. Investigating these interactions may illuminate the source of null effects. Our experiments tested for an interaction pattern in a backward masking paradigm.

In masking experiments, a target word (e.g., *rake*) is briefly presented for about 30 ms and replaced by one of three types of nonword masks (e.g., *RAIK*, *RASK*, *BLIN*). Nonword masks themselves are also presented briefly and replaced by a pattern mask. Participants identify targets by writing the target down. Target words can be very difficult to identify under these extreme conditions. Participants usually report only 50% or fewer.

The critical manipulation compares the effect of two particular nonword masks on target identification (e.g., the pseudohomophone mask *RAIK* vs. the graphemic control mask *RASK* for the target *rake*). The two masks are matched for spelling similarity to the target but contrast in their phonological similarity. The pseudohomophone mask is identical in phonology to the target, whereas its graphemic control is only similar. Every nonword mask interferes with the identification of its preceding target word (Perfetti & Bell, 1991). However, if phonology constrains the identification of masked words, then its reinstatement by the pseudohomophone should reduce the deleterious masking effect relative to the graphemic control. This reduction of masking effect is called the phonemic-masking effect.

Perfetti and colleagues (Perfetti & Bell, 1991; Perfetti, Bell, & Delaney, 1988) published a series of influential papers that reported reliable phonemic-masking effects. Corroborative evidence has also been obtained by using closely related, forward priming methods. In the priming studies, the target is preceded, rather than followed, by a briefly presented nonword or word mask. Task performance is typically better when targets are preceded by a prime that matches their phonology, compared to a graphemic control prime (e.g., Berent, 1997; Lesch & Pollatsek, 1993; Perfetti & Bell, 1991). Phonemic-masking and priming effects are found in a variety of languages, including Chinese (Perfetti & Zhang, 1991; Tan & Perfetti, 1997), French (Ferrand & Grainger, 1993, 1994), Serbo-Croatian (Lukatela & Turvey, 1990), and Hebrew (Berent & Frost, 1997). This large body of masking and brief priming results suggests that phonology constrains the identification of masked words.

Why does phonology contribute to the identification of masked words? According to the phonological hypothesis, phonological constraints are fast and mandatory (e.g., Carello et al., 1992; Kawamoto, 1993; Lukatela & Turvey, 1993; Perfetti et al., 1992; Van Orden & Goldinger, 1994). The robustness of phonemic-masking effects are thus attributed to the generality of phonology's contribution to reading. Conversely, according to the slow phonology hypothesis (e.g., M. Coltheart, 1978; Seidenberg, 1985; Seidenberg, Waters, Barnes, & Tanenhaus, 1984), the contribution of phonology to reading is slow and optional. Phonemic-masking effects are the product of task-specific strategies. Specifically, masking selectively disrupts graphemic constraints on identification (e.g., Carr, Davidson, & Hawkins, 1978; Carr & Pollatsek, 1985; Hawkins, Reicher, & Peterson, 1976; Wydell, Patterson, & Humphreys, 1993). In the absence of sufficient graphemic constraints, the reader is forced to rely on phonology. Masking paradigms thus overestimate the actual contribution of phonology by effectively encouraging its use.

Given the previous scenario, it should be possible to eliminate strategic reliance on phonology by using a countermanipulation. The countermanipulation could induce a "no-phonology counterstrategy" by creating conditions that are no longer conducive to the default reliance on phonology in masking experiments. This prediction was recently investigated in a series of experiments by Verstaen, Humphreys, Olson, and D'Ydewalle (1995). To counter the advantage of using the phonological strategy under masking, Verstaen et al. included homophone words (e.g., *rose*) as targets. The identity of a homophone is not uniquely determined by its phonology, so there would be no advantage in relying on phonology, and it may be ignored.

Verstaen et al.'s (1995) Experiments 2 and 3 produced null phonemic-masking effects with homophone targets. However, their strongest evidence for a counterstrategy hypothesis comes from Experiment 4. In Experiment 4, they manipulated the salience of homophone targets by ordering two blocks consisting entirely of homophones or of nonhomophones, respectively. In a *phonology-encouraging* condition, the block of nonhomophone targets preceded the block of homophone targets, rendering the homophones less conspicuous. Also, participants were purposely not informed that homophones would appear in the experiment. In this phonology-encouraging condition, a reliable, phonemic-masking effect was found across the two blocks (nonhomophones vs. homophones) with no interaction of block × type of nonword mask. Conversely, a *phonology-discouraging* condition presented the homophone block before the nonhomophone block, and participants were told of the presence of homophones. In this condition, no phonemic-masking effect was observed in either block.

Verstaen et al. (1995) attributed the absence of the phonemic-masking effect to the elimination of reliance on phonology under conditions discouraging its use. They postulated two potential loci of control: "input control," whereby participants do not activate phonology, and "output control," whereby phonology is activated but does not determine word identities (p. 352). Their data do not discriminate between these loci of control. Either way, however, strategic control eliminates phonology's causal contribution to word identification. We thus use the term *reliance on phonology* to refer jointly to both input and output control.

Tacit in this account, however, are two assumptions. The first is that null phonemic-masking effects indicate the absence of reliance on phonology. The problems in the interpretation of null effects has been largely recognized, especially when they must be trusted to indicate the absence of an underlying cognitive structure or capacity (Van Orden, Jansen op de Haar, & Bosman, 1997; Van Orden, Pennington, & Stone, in press; Watkins, 1990).[1] The investigation by Verstaen et al. (1995), however, was not confined to the search for null effects. Their elegant design identified a factor that was *manipulated* to elicit both positive and null effects.

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[1] Another, deeper source of controversy concerns the generality of the processing mode observed in the experimental setting to normal reading. One version of the strategy explanation claims that the processing mode inferred in a certain experimental situation is task specific. Such a strategy explanation simply restates the demonstrated facts in a way that sustains a no-phonology view of reading for the paricular

Central to their logic, then, is the (second) assumption that null phonemic-masking effects are caused by their strategy manipulation. In particular, their phonology discouraging manipulation must be *sufficient* to eliminate reliance on phonology.

We challenge these two assumptions. We demonstrated that the strategy manipulation is insufficient to eliminate reliance on phonology. Phonemic-masking effects are observed despite a phonology-discouraging manipulation that is stronger than the one used by Verstaen et al. (1995). We thus question the attribution of null phonemic-masking effects with homophones to the absence of reliance on phonology. We do not dispute the empirical findings of Verstaen et al. Homophones can systematically yield null phonemic-masking effects, and our first experiment replicates this finding. Our proposal strictly concerns the interpretation of these null effects. In our view, both positive and null phonemic-masking effects directly stem from the presence of phonology, rather than its absence.

Our account parts from the hypothesis that reliance on phonology is mandatory. However, reliance on phonology does not necessarily benefit the identification of homophone words. The activation of a homophone's phonology triggers a competition between all its spellings and meanings. For instance, the phonology of /sIn/ activates the spellings and meanings of the homophone mates *sign* and *sine*. Such a competition is known to impair the identification of unmasked homophone words (e.g., Pexman, Lupker, Jared, Toplak, & Rouibah, 1996; Rubenstein, Lewis, & Rubenstein, 1971). Masking homophone targets by a pseudohomophone accentuates this competition (Van Orden, 1987). The pseudohomophone (e.g., *syne*) not only fails to resolve the competition, but further introduces an additional incorrect spelling of its own. The outcomes of this competition may depend on homophone dominance. Because dominant homophones (e.g., *sign*) win the competition, the reinstatement of phonology should benefit their identification, resulting in significant phonemic-masking effects. Conversely, reinstating the phonology of subordinate targets (e.g., *sine*) only strengthens their dominant competitors. Subordinate homophones are thus unlikely to exhibit significant phonemic-masking effects. Subordinate homophones are also more prone to be erroneously identified as their dominant competitors, resulting in homophonic errors (e.g., the report of *SIGN* to the target *sine*). It is important that both positive and null phonemic-masking effects are a consequence of reliance on phonology, rather than its strategic elimination. We thus predicted phonemic-masking effects for dominant homophones, even under conditions that strongly discourage reliance on phonology.

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task conditions (cf. R. Frost, 1998; Van Orden et al., 1990). Thus, ad hoc strategies are "... a mere restatement of a fact in a special jargon [and] cannot claim to be an *explanation* of that fact" (Putnam, 1994, p. 475). Our use of the term *strategy* simply refers to a mode of processing. This use is neutral with regard to the generality of the strategy in question. In particular, a strategy does not imply a mode of processing that is specific to a given experimental setting.

To test this prediction, we presented our participants with a phonology-discouraging manipulation that was stronger than the one used by Verstaen et al. (1995). Participants in the following experiments were always presented with two successive blocks of homophone targets. One of these blocks corresponded to the homophone targets used by Verstaen et al. This block contains an almost equal mixture of dominant and subordinate homophones. The second block corresponded to a new set of homophones whose dominance was manipulated. Experiment 1 presented a second block of exclusively subordinate homophones, whereas in Experiment 2, the second block was replaced with their dominant mates. Our participants were explicitly warned of the presence of homophones and advised to pay close attention to the target's spelling. As part of this warning, a warm-up session included only homophone targets, and participants were instructed to pay careful attention to spelling because of the existence of two "possible" spellings for these warm-up targets. This should create extreme phonology-discouraging conditions (cf. V. Coltheart, Avons, Masterson, & Laxon, 1991).

According to the logic of Verstaen et al. (1995), the presentation of their block of homophones was sufficient to eliminate reliance on phonology. Thus, reliance on phonology must be eliminated when these targets were followed by an additional block of homophones. We examined this prediction by testing for phonemic-masking effects in the second block of homophones. The slow phonology hypothesis predicts no evidence for phonology in the second block of homophones. Conversely, according to the phonological hypothesis, reliance on phonology is mandatory. Phonology should thus constrain the identification of homophones presented in the second block. However, its detection as a phonemic-masking effect will depend on homophone dominance. Subordinate homophones should fail to exhibit phonemic-masking effects. In contrast, significant phonemic-masking effects should emerge for dominant homophones. Experiments 3 and 4 extended and replicated the findings of Experiments 1 and 2 by manipulating the dominance of homophones presented in the first block of trials.

EXPERIMENT 1

Experiment 1 examined evidence for phonology in a block of subordinate homophones preceded by the block of homophones used by Verstaen et al. (1995). The slow phonology and phonological account converge in predicting null phonemic-masking effects for subordinate targets. They disagree, however, with regard to their source. The phonological account attributes these null effects to a competition from dominant mates activated by a common phonology. Conversely, according to the "no-phonology" account, such null effects reflect the absence of reliance on phonology.

Systematic null phonemic-masking effects may also stem from an additional source that is unrelated to either of the previous accounts. In a recent set of experiments, Xu and Perfetti (1999) demonstrated that phonemic-masking effects were large only when overall identification rates were below the subjective threshold, defined by Xu and Perfetti as 50% for targets followed by a control mask (e.g., *PARF* following the target *sine*). As Xu and Perfetti noted, all of Verstaen et al.'s (1995) experiments produced relatively high overall performance, and three of Verstaen et al.'s experiments produced overall performance well over 50% correct, including Experiment 4. This is substantially higher than the subjective threshold and substantially higher than the overall performance in other studies (e.g., near or below 30% for Perfetti & Bell, 1991; Perfetti et al., 1988). To rule out above threshold identification accuracy as an explanation for the absence of the phonemic-masking effect, we examined the identification of masked homophones whose exposure duration was decreased below the subjective threshold. If the null phonemic-masking effects reported by Verstaen et al. are due to the presence of homophones, then they should generalize to conditions of brief exposure duration, resulting in a null phonemic-masking effect.

Method

Participants

Twenty-four Arizona State University undergraduate students participated in the experiment in partial fulfillment of a course requirement. All were native English-speakers with normal or corrected-to-normal vision.

Apparatus

The experiment was conducted by using a personal computer with a 25 × 80 color VGA monitor and the Micro Experimental Lab software. Precise, brief displays of the target and mask were achieved by locking the electron gun to the top of the screen and specifying their duration as multiples of full refresh cycles (14.21 ms).

Materials and Design

Experimental materials. The target words consisted of two blocks of homophones. The first block included 51 of the 54 homophone targets employed by Verstaen et al. (1995). One target (*court*) was excluded because its "homophone mate" (*caught*) is not homophonic in American English. Two other targets (*know*, *chute*) were excluded for the purpose of counterbalancing. Each of the these homophones was matched with a set of the three masks used by Verstaen et al..

A second new block of 48 homophone targets was constructed (see Appendix A). The mean frequency count (Kucera & Francis, 1967) of these homophones was 20.87 per million (*SD* = 65.35), and the average difference between these homophone targets and their dominant competitors was 263.26 (*SD* = 499.62). Of our 48 homophones, 40 were strictly subordinate—for example, their homophone mate was at least 2 per million more frequent than the target homophone. Of the remaining 8 items, 2 differed in frequency from their mate by only 1 per million (*mown*, *serf*), 2 had the same frequency count as their mate (*genes*, *queue*), and the remaining 4 (*cellar*, *brows*, *paced*, *chord*) were slightly more frequent than their competitors.[2] Note, however, that the imperfection of our dominance manipulation is clearly biased against our hypothesis, as any dominance effect should be diluted by the presence of these weakly subordinate targets. Following Experiment 4, we report a meta-item-analysis of strictly subordinate and dominant items. As we demonstrate, that more restricted analysis is fully congruent with the analyses that included all targets.

For each target, we constructed three types of nonword masks: a *pseudohomophone* that was identical to the target in its pronunciation but not its spelling, a *graphemic mask* that was matched to the pseudohomophone for its spelling similarity to the target but was not identical to the target in its pronunciation, and a *control mask* sharing no letters or phonemes with the target.

The requirement that we use homophone targets severely restricted our choice of pseudohomophone masks. Nevertheless, we required a sufficiently strong manipulation of pseudohomophony—the match in phonology between homophone targets and pseudohomophone masks. To estimate the strength of this manipulation, we tested our pseudohomophones by using the naming procedure of Van Orden et al. (1988), with 11 judges. Thirty-four pseudohomophones were named as their sound-alike words by all 11 judges, 8 by 10 judges, 3 by 9 judges, 2 by 8 judges, and 1 (*yowk*) by only 4 judges. If we convert these estimates to a pseudohomophone scale, then the group, on average, was strongly pseudohomophonic (*M* = 10.44, *SE* = 0.18).[3]

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[2] Of the four items whose frequency was lower than their competitors, two had a difference of 1 per million (*paced*, *chord*). The remaining two (*brows*, *cellar*) were less frequent than their competitors by a count of 5 and 20 per million, respectively. Although the frequency of these items was very similar to those of their competitors, they were nevertheless likely to suffer from their activation. Furthermore, the frequency of at least one of these competitors (*browse*, o) probably underestimates its frequency in actual use.

[3] We derived a pseudohomophone scale from pronunciation norms (see the method of Experiment 1), to estimate the strength of Verstaen et al.'s (1995) pseudohomophone manipulation. Of the 24 pseudohomophones paired with dominant word–homophones, 13 were named as their sound-alike words by all 11 judges, 6 by 10 judges, 2 by 6 judges, 1 by 5 judges, and 2 by only 4 judges (*M* = 9.50, *SE* = 0.50). Of the 27 pseudohomophones paired with subordinate word–homophones, 9 were named as their sound-alike words by all 11 judges, 7 by 10 judges, 4 by 9 judges, 2 by 8 judges, 1 by 6 judges, 2 by 5 judges, 1 by 1 judge, and 1 was never pronounced by judges as a word–homophone (*M* = 8.78, *SE* = 0.67).

The contrast between pseudohomophone and graphemic masks was a difference in phonological similarity (identical phonology in pseudohomophone, similar phonology in graphemic control). However, the graphemic mask differed from the control mask in both spelling and phonology. Thus, similarity in either spelling or phonology, or both, could produce an advantage because of a graphemic mask (compared to its yoked control mask).

Warm-up materials. A third set of 30 homophones was used in warm-up trials. These warm-up items did not overlap with the set of homophones used in the experimental blocks. Each was followed by a control mask. Targets were all presented in lowercase, whereas masks were presented in uppercase.

Stimuli were presented at the center of the screen at a distance of approximately 18 in. and a visual angle of approximately 2°. To reduce the visual contrast, all stimuli were presented in a light blue color on a black background.

Design. Mask type (3: pseudohomophone, graphemic, and control) and block (2: first vs. second block) were manipulated within participants. Inside each block of homophones, presentation of a target and its masks was counterbalanced in a Latin Square design. Each target was presented only once, and each participant saw the same number of targets with each of the three masks. Across participants, a target was presented the same number of times with each of the three masks.

Procedure. At the beginning of the experiment, participants were told of the presence of homophone targets: "[homophones] have more than one possible spelling (e.g., *sun, son*). You should therefore pay close attention to their spelling and ignore their sound." The instructions were followed by a warm-up session. Target duration in the warm-up trials was set initially to 84 ms and gradually reduced to two refresh cycles (28 ms) to make participants accustomed to the brief duration of the display. In the warm-up, participants reported the identity of targets and masks aloud. They were also required to indicate which of the two meanings or spellings of the homophone were seen, again emphasizing the presence of homophones in the task and the need to rely on spelling.

At the end of the warm-up trials, participants were given an opportunity to ask questions regarding the procedure. They were then presented with the experimental session, consisting of two consecutive blocks of homophones. Participants were not told that the experimental session included two blocks.

At the beginning of each trial, a pattern mask (XXXXXXXX) appeared at the center of the screen. The participant initiated the trial by pressing the space bar. The trial consisted of a target mask, followed immediately (interstimulus interval = 0) by a nonword mask and then a pattern mask. The target and nonword masks were each presented for two refresh cycles (about 28 ms). Targets, nonword masks, and the pattern mask were all presented at the same location at the center of the screen such that each event replaced its prior event. To control for the visual salience of letters at word external positions, targets and nonword masks were presented with pound signs (#*rake*#) immediately to their left and right. Trials were randomly ordered within each block. At the end of each trial, participants wrote down the target and mask that they perceived.

Results

The significance level for all statistical tests was $p < .05$. The dependent variable was the percentage of trials in which participants correctly identified the target. Summary statistics, as a function of mask type and block, are presented in Table 1.

According to the rationale presented in Verstaen et al. (1995), the salience of homophones in the first block should lead participants to abandon reliance on phonology. To the extent that a no-phonology strategy develops over time, it should be fully developed by the second block of trials. To ensure that the evaluation of the no-phonology strategy is not contaminated by the initial experimental trials, we tested for its presence separately in each of the two blocks in all of the following experiments.

Identification Accuracy

First block. Analyses of variance (ANOVAs) conducted on percentage-correct identification yielded a reliable main effect of mask type, $F_1(2, 46) = 4.80$, $MS_e = 67.62$; $F_2(2, 100) = 3.10$, $MS_e = 222.65$. Graphemic masks yielded reliably better performance than control masks, $\Delta = 7.35\%$, $F_1(1, 46) = 9.59$; $F_2(1, 100)$

TABLE 1
Target Identification Accuracy (% Correct) and Homophone Errors (% Error) as a Function of Block and Mask Type in Experiment 1

	Target Identification	*Homophone Errors*
Block 1		
Mask type		
Pseudohomophone	20.09	2.206
Graphemic	23.52	1.961
Control	16.17	1.225
Block 2		
Mask type		
Pseudohomophone	11.97	2.344
Graphemic	10.15	2.344
Control	6.51	3.125

= 6.192. In contrast, pseudohomophone masks did not reliably improve identification accuracy relative to control masks, D = 3.97%, $F_1(1, 46) = 2.729$, $p = .11$; $F_2(1, 100) = 1.76$, $p = .19$ and the phonemic-masking effect was not statistically reliable D = −3.43%, $F_1(1, 46) = 2.09$, $p = .16$; $F_2(1, 100) = 1.348$, $p = .25$. The latter finding is the key finding: Identification accuracy was not reliably improved by pseudohomophone masks compared to graphemic masks.

Second block. Again, ANOVAs conducted on percentage-correct identification yielded a reliable main effect of mask, $F_1(2, 46) = 3.97$, $MS_e = 46.82$; $F_2(2, 94) = 3.16$, $MS_e = 120.44$. Pseudohomophone masks yielded reliably better target identification compared to control masks, $\Delta = 5.46$, $F_1(1, 46) = 7.66$; $F_2(1, 94) = 5.96$. Graphemic masks, compared to control masks, produced a trend in the same direction that was not quite statistically reliable, $\Delta = 3.64$, $F_1(1, 46) = 3.41$, $p = .07$; $F_2(1, 94) = 3.04$, $p = .08$. It is important that, as in the first block, the phonemic-masking effect was not reliable, $\Delta = 1.82$, $F_1 < 1$, $F_2 < 1$.

Homophone Errors

Homophone errors occur when a participant responds with the target homophone's mate (e.g., *rose* reported for the target *rows*). (Please note that homophone errors are never reports of pseudohomophone masks; no participant correctly identified a mask in any of the trials.) In the first block, 22 of the 1,224 responses (51 targets × 24 participants) were homophone errors. In the second block, 23 of 1,152 responses (48 targets × 24 participants) were homophone errors. These homophone errors were submitted to separate ANOVAs, one per block. The main effect of mask type was not reliable in either analysis: Block 1, $F_1(2, 46) < 1$, $MS_e = 0.34$; $F_2(2, 100) = 1$, $MS_e = 13.28$; Block 2, $F_1(2, 46) < 1$, $MS_e = 15.07$; $F_2(2, 94) < 1$, $MS_e = 19.74$.

Discussion

Our results present a conceptual replication of Verstaen et al.'s (1995) findings. We observed a null phonemic-masking effects under phonology-discouraging conditions. This effect was obtained by using Verstaen et al.'s homophones, and it was also replicated in a second block of new targets consisting of subordinate homophones. More important, this finding was obtained despite identification rates that were below the subjective threshold (Xu & Perfetti, 1999). Thus, the null phonemic-masking effect with homophones was not due to an overall high identification accuracy in Verstaen et al.'s experiments. Conversely, the absent phonemic-masking effects cannot be simple floor effects. Omnibus ANOVAs yielded reliable mask effects in each of the two blocks. However, identification accuracy was not reliably affected by the reinstatement of the target's phonology. Our findings thus converge with Verstaen et al.'s results in demonstrating that homophones may yield null phonemic-masking effects.

EXPERIMENT 2

Why do homophones yield null phonemic-masking effects? According to the no-phonology hypothesis, the null phonemic-masking effect in the presence of homophones is due to the absence of reliance on phonology. In contrast, the phonological hypothesis attributes these null effects to a competition mediated by phonology. The phonological account leads us to the following counterintuitive prediction: We expected that high frequency homophones should be most likely to yield a phonemic-masking effect. To test this prediction, we substituted dominant, high-frequency, homophone mates for the subordinate mates used in the second block of Experiment 1. Our account predicted a resurrection of the phonemic-masking effects for the dominant homophones presented in the second block.

Our prediction disagreed with the no-phonology explanation for Verstaen et al.'s (1995) findings. Recall that Verstaen et al. observed that the presentation of one block of homophones abolished the phonemic-masking effect for that block as well as a subsequent block of nonhomophonic targets (Verstaen et al., 1995, Experiment 4). According to the no-phonology account, this null phonemic-masking effect reflects a *strategy shift.* The presence of homophones leads participants to abandon a phonological processing strategy, a strategy encouraged by the disruption of graphemic constraints under masking, in favor of a nonphonological strategy, a strategy that persists throughout a subsequent block of nonhomophone targets. If a single block of homophones used in Verstaen et al.'s fourth study was sufficient to induce and maintain a nonphonological strategy, then, surely, no evidence for phonology should be obtained if participants were presented with two blocks of homophones.

The prediction of a phonology effect for our second block of dominant homophones also contradicts many reading theories. The traditional view of phonology as a relatively slow source of constraint (e.g., M. Coltheart, 1978; Seidenberg, 1985) predicts a reduction in the contribution of phonology for frequent words. If there is any basis for a phonology effect, it should be specific to low frequency homophone words (Jared & Seidenberg, 1991). If so, then Experiment 2 includes more extreme phonology-discouraging conditions than did Experiment 1 (or did Verstaen et al., 1995).

One more prediction is possible. Verstaen et al. (1995) related that participants in their experiments sometimes reported the homophone mate of a target. Such homophonic errors were also observed in each of the two blocks in Experiment 1 (see also Berent & Van Orden, 1996). This agrees with our hypothesis that homophone identification entails an inherent competition between sound-alike identities. However, the use of dominant homophones tilts the competition in favor of correct word identification (Bosman & de Groot, 1996). Dominant competitors are more likely to appear as false reports of subordinate targets than vice versa. Thus, we may expect fewer homophone errors in the second block of Experiment 2—a block of dominant homophones—compared to the second block of Experiment 1—the block of subordinate homophones.

Method

Participants

Twenty-four Arizona State University undergraduate students participated in the experiment in partial fulfillment of a course requirement. All were native English-speakers with normal or corrected-to-normal vision.

Materials

The first block of homophone targets and masks was identical to those used in Experiment 1. The second block of homophone targets switched the respective homophone mates of the 48 targets from Experiment 1. Thus, the 40 subordinate homophone targets were all replaced by higher frequency, dominant homophone targets (see Appendix B). The mean frequency count (Kucera & Francis, 1967) of all these targets was 185.65 per million (*SD* = 527.1). As in Experiment 1, these new targets were masked by a pseudohomophone, a graphemic, or a control mask. Pseudohomophone and control masks were identical to those used in Experiment 1, but graphemic masks were sometimes altered to better control for graphemic similarity between pseudohomophones and the new homophone targets. The apparatus, design, and procedure were identical to those used in Experiment 1.

Results

Identification accuracy scores and homophone errors as a function of mask type and block are presented in Table 2.

TABLE 2
Target Identification Accuracy (% Correct) and Homophone Errors (% Error) as a Function of Block and Mask Type in Experiment 2

	Target Identification	*Homophone Errors*
Block 1		
Mask type		
Pseudohomophone	25.50	2.696
Graphemic	23.77	1.961
Control	20.873	0.980
Block 2		
Mask type		
Pseudohomophone	39.06	0.781
Graphemic	32.03	0.260
Control	27.08	0

Identification Accuracy

First block. ANOVAs conducted on accuracy scores for the homophones from Verstaen et al. (1995) did not yield a reliable effects of mask type, $F_1(2, 46) = 1.77, MS_e = 75.53, p = .18; F_2(2, 100) = 1.66, MS_e = 152.25, p = .20$. In particular, the phonemic-masking effect was not statistically reliable. Performance in the pseudohomophone mask condition (25.50%) did not differ from the graphemic mask condition (23.78%), $\Delta = 1.71\%$, $F_1 < 1$, $F_2 < 1$.

Second block. ANOVAs conducted on the second block's scores produced a reliable main effect of mask type, $F_1(2, 46) = 9.83, MS_e = 88.43; F_2(2, 94) = 6.47, MS_e = 268.84$. Identification accuracy for pseudohomophone masks was reliably higher than for control masks, $\Delta = 11.98, F_1(1, 46) = 19.47; F_2(1, 94) = 12.81$. Conversely, the advantage of the graphemic mask over the control mask was not statistically reliable, $\Delta = 4.95, F_1(1, 46) = 3.32, p = .07; F_2(1, 94) = 2.19, p = .14$. Most important, the phonemic-masking effect reemerged: Target identification was reliably more accurate in the pseudohomophone mask condition, compared to the graphemic control condition, $\Delta = 7.03\%; F_1(1, 46) = 6.71; F_2(1, 94) = 4.41$.

Homophone Errors

First block. Of 1,224 trials in the first block (51 targets × 24 participants), there were 23 incorrect reports of a target homophone's mate (e.g., *rose* reported for the target *rows*). Homophone errors were numerically more frequent with pseudohomophone masks (11 responses) than either graphemic (8 responses) or control masks (4 responses), but the difference was not statistically reliable, $F_1(2, 46) = 1.16$, $MS_e = 15.27$, $p = .32$; $F_2(2, 100) = 1.16$, $MS_e = 32.58$, $p = .32$.

Second block. Of 1,152 trials in the second block (48 targets × 24 participants) there were only four incorrect reports of the target's homophone, despite the fact that performance fell far from the ceiling, leaving sufficient opportunities to produce homophone errors. Three errors were observed in the pseudohomophone mask condition and one in the graphemic mask condition (too small a number to contrast statistically).

The comparison with the homophone errors from Experiment 1 was as expected. Dominant homophone competitors were more often reported to subordinate target homophones than vice versa, $\Delta = 6.771$, $t_1(23) = 3.09$; $t_2(47) = 2.684$.

Discussion

According to the no-phonology account, the conspicuous presentation of homophone trials should lead readers to shift into a no-phonology strategy. If one block of homophones is sufficient to eliminate reliance on phonology (Verstaen et al., 1995, Experiment 4), then clearly, no evidence for phonology should be obtained when participants were presented with two blocks of homophones in our experiments. Our use of dominant homophones and an exposure duration that was shorter than the one employed by Verstaen et al. should have only enhanced such null effects. Indeed, the view of graphemic information as the earliest constraint on word identification (M. Coltheart, 1978) predicts that highly familiar words should override the contribution of phonology. Likewise, brief exposure durations are believed to reduce the availability of phonological information (Ferrand & Grainger, 1993). Contrary to these predictions, our second block of homophones revealed a significant phonemic-masking effect. These findings agree with Xu and Perfetti's (1999) observation of phonemic-masking effects that used below-threshold durations. Our results thus demonstrate a reliance on phonology in phonology-discouraging conditions that are far stronger than those used in the studies of Verstaen et al.

Despite this strong evidence for the presence of phonology, we observed a null effect of phonology in first block of trials, which consisted of the homophones used by Verstaen et al. (1995). Given that phonology was present in the second block of trials, why was the phonemic-masking effect absent in the first block? Does the absence of phonemic-masking effect indicate the absence of phonology?

According to the phonological account, reliance on phonology is maintained in each of the two blocks but is detectable only in the second because of the dominance of the homophones. However, our results allow for alternative explanations for phonological effects in our second block. In contrast to the phonological account, these explanations assume that the null phonemic-masking effect in the first block indicates the absence of a reliance on phonology. The positive phonology effects in the second block thus reflect a *reshift* into a phonological strategy. We consider two explanations for a shift in strategy in our second block.

One explanation attributes the reshift into a phonological strategy to the dominance of the homophones (see also Verstaen et al., 1995, p. 351, for a similar claim). On this account, the dominance of the homophones encourages participants to switch from a nonphonological strategy in the first block into a phonological strategy in the second. However, this strategy reshift account is inconsistent. Recall that Verstaen et al. observed a null phonemic-masking effects for a block of nonhomophones preceded by a block of homophones. According to Verstaen et al., the null phonemic effects for nonhomophones reflects the absence of reliance on phonology, presumably because of the persistence of a no-phonology strategy induced by the homophones. If the dominance of a single spelling induces a reshift toward a phonological strategy, then, certainly, nonhomophonic targets should have produced the same reshift in Verstaen et al.'s second block (Experiment 4). The claim that dominant homophones induce a reshift from a nonphonological into a phonological strategy is thus incompatible with the claim that null effects observed for nonhomophonic targets reflect the absence of reliance on phonology.[4]

Conversely, an alternative account may attribute the reshift into a phonological strategy to some "fatigue" in the suppression of phonology rather than specifically the type of materials we presented. To be sure, this account is unmotivated and contradicts the specific explanation proposed by Verstaen et al. (1995). The following experiments, nevertheless, counter this strategy reshift account by decoupling dominance from block order. The principle prediction of the "fatigue" account is that the emergence of the phonemic-masking effect should be systematically predicted by block order. Specifically, if the confinement of the phonemic-masking effect to the second block in our previous study is due to a shift from a no-phonology to a phonological strategy, then the second block of homophones should systematically yield phonemic-masking effects. No phonemic-masking effects are predicted in the first block. Conversely, according to our phonological account, the emergence of the phonemic-masking effects in the second block of Experiment 2 is due to the dominance of the homophones, rather than to block order. Thus, our account must predict that a block of dominant homophones should

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[4] One may criticize the phonological account on the grounds that it predicts significant phonemic-masking effect for the second block of nonhomophones in Verstaen et al.'s (1995) discouraging condition. This criticism, however, rests on a fallacy: Our claim that phonology persists despite the presence of homophones does not imply that a phonological strategy can never results in a null phonemic-masking effect. Indeed, no hypothesis is immune to Type II error. Our feedback consistency account must predict that nonhomophones should yield positive phonemic-masking effect when followed by a block of homophones but cannot guarantee against occasional failure to observe a positive effect caused by random variability.

also yield significant phonemic-masking effects when it is presented in the first block of trials. No such effects are expected for the subordinate homophones. Our following experiments test these predictions by switching the order of the blocks used in Experiments 1 and 2. Experiment 3 reverses the block order of Experiment 2. Experiment 4 reverses the block order of Experiment 1. Following Experiment 4, we report a meta-analysis that combines the key data of the four experiments.

EXPERIMENT 3

Experiment 3 tests for a phonemic-masking effect to dominant homophones in the first block of trials—it is the mirror image of Experiment 2..

Method

Participants

Thirty-six Florida Atlantic University students participated in the experiment in partial fulfillment of a course requirement. All were native English-speakers who had normal or corrected-to-normal vision. One additional participant was excluded from the experiment because he could not correctly identify any target words.

Procedure

Experiments 1 and 2 were conducted at Arizona State University. Experiments 3 and 4 were conducted at Florida Atlantic University. Pilot work at Florida Atlantic University, to replicate Experiment 2 using the exposure durations of Experiment 2, yielded performance close to floor. To raise performance off of floor, the exposure duration of the target was increased to 42 ms, which still yielded acceptably low overall accuracy (cf. Xu & Perfetti, 1999). The only other difference in procedure from Experiment 2 was the change in block order.

Results

Identification accuracy scores and homophone errors as a function of mask type and block are presented in Table 3.

Identification Accuracy

Block 1. Block 1 presented the dominant homophones from Experiment 2. One-way ANOVAs conducted on accuracy scores revealed a reliable main effect of mask, $F_1(2, 70) = 16.25$, $MS_e = 146.86$; $F_2(2, 94) = 16.33$, $\mathrm{MS_e} = 194.82$. Identification accuracy was higher in the pseudohomophone mask condition than in the control condition, $\Delta = 16.15\%$, $F_1(1, 70) = 31.95$; $F_2(1, 94) = 32.11$. The graphemic mask condition also produced higher identification accuracy compared to the control condition, $\Delta = 9.9\%$, $F(1, 70) = 12.00$; $F_2(1, 94) = 12.06$. Most important, Experiment 4 replicated the phonemic-masking effect to dominant homophones that we found in Experiment 2: Identification accuracy was reliably higher in the pseudohomophone mask conditions compared to the graphemic mask condition, $\Delta = 6.25\%$, $F_1(1, 70) = 4.79$; $F_2(1, 94) = 4.81$.

Block 2. Block 2 presented the homophones from Verstaen et al. (1995). One-way ANOVAs conducted on accuracy scores revealed a reliable main effect of mask type, $F_1(2, 70) = 5.27$, $MS_e = 110.28$; $F_2(2, 100) = 5.77$, $MS_e = 136.14$. The pseudohomophone, $\Delta = 5.88$, $F_1(1, 70) = 5.65$; $F_2(1, 100) = 6.13$, and graphemic mask conditions, $\Delta = 7.68\%$, $F_1(1, 70) = 9.63$; $F_2(1, 100) = 10.58$, both produced reliably higher identification accuracy compared to the control condition. The phonemic-masking effect was not statistically reliable however, $\Delta = 1.8\%$, $F_1 < 1$, $F_2 < 1$.

Homophone Errors

Block 1. Five of the 1,728 responses (48 targets × 36 participants) observed in the first block were homophone errors. Two were produced following a pseudohomophone mask, 2 following a graphemic mask, and 3 following a control mask.

Block 2. Thirty-three of the 1,836 (51 trials × 36 participants) observed in the second block resulted in homophone errors. There were numerically more homophone errors following a pseudohomophone mask (15 errors) compared to graphemic masks (8 errors) and control masks (10 errors), but this trend was not statistically reliable, $F_1(2, 70) = 1$, $MS_e = 12.50$, $p = .37$; $F_2(2, 94) = 1.72$, $MS_e = 10.29$, $p = .18$.

Discussion

Experiment 2 reported a resurrection of the phonemic masking in the second block of homophones. Experiment 3 contrasted two accounts for those findings. The phonological account attributes the reemergence of the phonemic-masking effect to dominance. The dominance of the homophone's spelling breaks the symmetry between the competitive spellings activated by its phonology in favor of the target's correct spelling. Conversely, an alternative artifactual explanation attributes this effect to block position. This account predicts significant phonemic-masking effects in the second, but not in the first, block of our study. The results of Experiment 3 fully support to the predictions of the phonological account: Replicating the results of Experiment 2, the dominant homophones produce significant phonemic-masking effect despite the change in their block position. Contrary to the prediction of the block position account, the replacement of dominant homophones by a mix of dominant and subordinate homophones used in Verstaen et al.'s fourth study (1995), as well as in the first block of our Experiments 1 and 2, did not yield a phonemic-masking effect in the second block. These results support our hypothesis that phonemic-masking effects are modulated by homophone dominance.

EXPERIMENT 4

Experiment 4 was the mirror image of Experiment 1. It presented the two homophone blocks in reverse order: first the block of subordinate homophones that we constructed, then the block of homophones from Verstaen et al. (1995). If the absence of the phonemic-masking effect for the block of subordinate homophones Experiment 1 was due to competition from their dominant mates, then no phonemic-masking effects would be expected when these homophones were placed in the first block.

Method

Participants

Thirty-six Florida Atlantic University students participated in the experiment in partial fulfillment of a course requirement. All were native English-speakers who had normal or corrected-to-normal vision.

Procedure

The design was identical to Experiment 1, except for the reverse of the block order. Otherwise, the procedure was identical to that of Experiment 3.

Results

Identification accuracy scores and homophone errors as a function of mask type and block appear in Table 4.

Identification Accuracy

Block 1. Block 1 presented our subordinate homophones. One-way ANOVAs conducted on percentage-correct target identifications yielded a reliable

TABLE 4
Target Identification Accuracy (% Correct) and Homophone Errors (% Error) as a Function of Block and Mask Type in Experiment 4

	Target Identification	*Homophone Errors*
Block 1		
Mask type		
Pseudohomophone	22.38	7.118
Graphemic	22.90	6.250
Control	13.19	6.076
Block 2		
Mask type		
Pseudohomophone	37.75	3.43
Graphemic	33.16	1.79
Control	29.57	0.098

main effect of mask, $F_1(2, 70) = 11.40$, $MS_e = 94.20$; $F_2(2, 94) = 11.98$, $MS_e = 124.02$. Pseudohomophone, $\Delta = 9.19\%$, $F_1(1, 70) = 16.13$; $F_2(1, 94) = 17.64$, and graphemic masks, $\Delta = 9.72\%$, $F_1(1, 70) = 18.02$; $F_2(1, 94) = 18.29$, both resulted in reliably higher identification accuracy compared to control masks. However, the phonemic-masking effect was not statistically reliable: Performance in the pseudohomophone mask and graphemic mask conditions was virtually identical, $\Delta = 0.52\%$, $F_1 < 1$, $F_2 < 1$.

Block 2. Block 2 presented the homophones of Verstaen et al. (1995). As in Block 1, one-way ANOVAs performed on correct identification scores revealed a reliable main effect of mask, $F_1(2, 70) = 4.89$, $MS_e = 123.81$; $F_2(2, 100) = 6.60$, $MS_e = 129.66$. Pseudohomophone masks, $\Delta = 8.18\%$, $F_1(1, 70) = 9.73$; $F_2(1, 100) = 13.13$, but not graphemic masks, $\Delta = 3.59\%$, $F_1(1, 70) = 1.88$, $p = .18$; $F_2(1, 100) = 2.54$, $p = .11$, resulted in higher recognition accuracy relative to the control mask. Interestingly, the phonemic-masking effect showed a strong trend toward statistical reliability: Identification accuracy in the pseudohomophone condition was higher than in the graphemic control condition, and this effect was marginal in the participant analysis and reliable in the item analysis, $\Delta = 4.59\%$, $F_1(1, 70) = 3.06$, $p = .08$; $F_2(1, 100) = 4.12$.

Homophone Errors

Block 1. Again, Block 1 presented our subordinate homophones. Of 1,728 total trials (48 trials × 36 participants), 112 resulted in homophone errors. There was a trend for more homophone errors in the presence of the pseudohomophone (41 errors) relative to the graphemic (36 errors) and control mask (35 errors). However, ANOVAs conducted on homophone errors did not yield a statistically reliable effect of mask, $F_1 < 1$, $F_2 < 1$.

Block 2. Thirty-eight of 1,836 trials total (51 trials × 36 participants) resulted in homophone errors. Twenty-one of these errors were observed in the presence of the pseudohomophone mask, whereas 11 and 6 errors were observed in the presence of the graphemic and control mask, respectively. ANOVAs conducted on these homophone errors yielded a reliable main effect of mask type, $F_1(2, 70) = 4.46$, $MS_e = 12.57$; $F_2(2, 100) = 4.57$, $MS_e = 17.39$. The pseudohomophone masks, $\Delta = 2.45\%$, $F_1(1, 70) = 8.60$; $F_2(1, 100) = 8.81$, but not the graphemic masks, $\Delta = 0.81\%$, $F_1 < 1$, $F_2 < 1$, resulted in more homophone errors than did the control masks. Most interestingly, the difference in number of homophone errors between the pseudohomophone and graphemic mask conditions sat on the brink of statistical reliability, $\Delta = 1.64\%$, $F_1(1, 70) = 3.82$, $p = .05$; $F_2(1, 100) = 3.91$, $p = .05$—an apparent phonology effect.

Just as in the contrast between dominant and subordinate homophones across Experiments 1 and 2, there were numerically fewer homophone errors to dominant homophones in Experiment 3 compared to subordinate homophones in Experiment 4, $\Delta = 18.5276\%$, $t_1(35) = 8.264$; $t_2(47) = 3.245$. Thus, dominant homophones were much more likely to be misreported for subordinate targets than vice versa.

Discussion

Experiment 4 presents converging evidence to the modulation of the phonemic-masking effect by homophone dominance. Subordinate homophones do not benefit from the reinstatement of their phonology, even if they are placed in the initial block of trials. Interestingly, however, the homophones from Verstaen et al. (1995) produced a phonemic-masking effect that was reliable by items and marginal by participants.

The reasons for the emergence of these phonemic-masking effects are not entirely clear. Because Verstaen et al.'s (1995) homophones failed to produce a significant phonemic-masking effect in our previous experiments, its emergence in Experiment 4 may not be reliable. If proven reliable, however, this finding may be linked to the block position of these homophones in this experiment. The masking of a homophone by a pseudohomophone mask creates an uncertainty regarding its spelling because of the activation of multiple competing spellings. Participants' willingness to interpret such incoherent ("noisy") spelling as a target may depend on its context. When this mixed block of targets was preceded by dominant homophones (in Experiment 3), whose spelling was more coherent because of the weakness of their competitors, participants may have set a relatively high signal to noise ratio as a criterion for target report. Compared to such a high criterion, many targets in the mixed block of dominant and subordinate homophones used by Verstaen et al. would not be reported when followed by the pseudohomophone. Conversely, when the same targets were preceded by a pure block of subordinate targets (Experiment 4), targets whose spelling was yet noisier, the response criterion may have been more liberal. Consequently, more targets would be reported in the presence of the pseudohomophone. Note, however, that the strategic control assumed by this account is in the setting of the response criterion. This account is thus perfectly compatible with a mandatory contribution of phonology to the activation of the target.

Although the emergence of a phonemic-masking effect in the second block of Experiment 4 requires further research, its presence clearly lends no support for the no-phonology account. Such a phonemic-masking effect was obtained by using Verstaen et al.'s (1995) targets despite strong phonology-discouraging conditions. The emergence of the phonemic-masking effect for these materials cannot be attributed to a reshift from a no-phonology strategy (in the first block) to a phonological strategy (in the second). Such a claim is clearly contradictory to the account proposed for Verstaen et al.'s findings. Specifically, the claim that the mixed block of homophones induces a phonological strategy is incompatible with the claim that the same materials are sufficient to induce a no-phonology strategy when presented in the first block of Verstaen et al.'s fourth experiment. The rejection of a strategy shift explanation has important consequences to the interpretation of the null effect in the initial block of subordinate homophones. If the presence of phonology in the second block does not reflect a *change* in strategy, then phonology could have been latent in the first block as well. The presence of the phonemic-masking effect under conditions that are strongly biased against phonology corroborates the following claim: Two blocks of homophone stimuli do not discourage reliance on phonology.

META-ANALYSES

Experiments 1 through 4 suggest that the phonemic-masking effect is systematically determined by homophone dominance, and this pattern is robust with regards to block presentation order. To secure these conclusions, we conducted a meta-analysis on the combined data from Experiments 1 through 4 examining the combined effects of dominance and block order. To simplify this analysis, however, these comparisons focused exclusively on contrasts between pseudohomophone and graphemic mask conditions.

Identification Accuracy

ANOVAs (2 block × 2 dominance × 2 mask) conducted on identification accuracy revealed a reliable main effect of mask type, $F_1(1, 116) = 6.72$, $MS_e = 113.69$; $F_2(1, 47) = 5.62$, $MS_e = 229.66$. Identification accuracy was higher in the pseudohomophone mask condition compared to the graphemic control. More important, however, the phonemic-masking effect was modulated by target dominance, as indicated in a reliable Mask × Dominance interaction effect, $F_1(1, 116) = 4.54$, $MS_e = 113.87$; $F_2(1, 47) = 5.13$, $MS_e = 165.39$. The phonemic-masking effect was essentially limited to dominant homophones.

The previous interaction effect was not modulated further by block: The three-way Block × Dominance × Mask interaction effect showed no promise of statistically reliability (all Fs < 1). The only other reliable effects were main effects of block, $F_1(1, 116) = 9.18$, $MS_e = 691.16$; $F_2(1, 47) = 55.51$, $MS_e = 191.55$, and dominance, $F_1(1, 116) = 45.64$, $MS_e = 691.16$; $F_2(1, 47) = 52.51$, $MS_e = 987.57$. Dominant homophones were identified more accurately, as were targets in the first block.

Homophone Errors

ANOVAs conducted on homophone errors revealed reliable significant main effects of block, $F_1(1, 116) = 10.48$, $MS_e = 23.86$; $F_2(1, 47) = 8.26$, $MS_e = 48.88$, and dominance, $F_1(1, 116) = 40.18$, $MS_e = 23.86$; $F_2(1, 47) = 9.54$, $MS_e = 163.15$, and a Dominance × Block interaction effect, $F_1(1, 116) = 12.30$, $MS_e = 23.86$; $F_2(1, 47) = 9.84$, $MS_e = 47.80$. Participants falsely responded with dominant homophones to subordinate targets ($M = 4.468\%$), but not vice versa ($M = 0.434\%$). Homophone errors for subordinate homophones were also more numerous in the first ($M = 6.593\%$) compared to the second block ($M = 2.343\%$). No other effect approached statistical reliability.

Meta-Item-Analyses

We also conducted an item analysis excluding all items that were not strictly dominant or subordinate (see Method of Experiment 1). The outcome for identification accuracy paralleled the previous analyses. In particular, there was a reliable Mask × Dominance interaction effect, $F_2(1, 39) = 5.348$, $MS_e = 176.75$—the reliable phonemic-masking effect was essentially limited to dominant homophones.

The only new results came from the analysis of homophone errors. The main effect of mask type approached statistical reliability, $\Delta = 0.7291\%$, $F_2(1, 39) = 3.853$, $MS_e = 11.04$, $p = .057$. More homophone errors were made to targets in the pseudohomophone mask condition compared to its graphemic control. Planned comparisons suggested that this effect is due to subordinate homophones, $\Delta = 1.146\%$, $F_2(1, 39) = 3.939$, $p = .054$; $\Delta = 0.31\%$, $F_2(1, 39) < 1$, for subordinate and dominant targets, respectively. This finding indicates that the reinstatement of a subordinate target's phonology by the pseudohomophone mask increases the interference effect of dominant homophone competitors.

Discussion

The results of the meta-analysis demonstrate a strong link between dominance and phonemic-masking effects. Phonemic-masking effects are present with dominant homophones but are absent with subordinate homophones. Subordinate homophones are more difficult to identify and are more likely to be erroneously reported as their dominant mates. More important, homophone errors for subordinate targets are sensitive to phonology: They increase in the presence of the pseudohomophone relative to the graphemic mask (see also Berent & Van Orden, 1996).

According to our phonological account, homophonic errors reflect the activation of the dominant competitor by a phonology shared with the subordinate target. Conversely, proponents of the no-phonology account may attribute these homophonic errors to "guessing" based on the pseudohomophone mask. The labeling of a response to the target as "guessing" implies that such a response is independent of the target identity. Thus, a guessing account must assume that the increase in the erroneous report of dominant mates is independent of the effect of the mask's phonology on target processing. Such an account is inconsistent with our findings. First, regardless of their source, homophonic errors are sensitive to the phonology of the mask. Thus, they demonstrate reliance on phonology under phonology-discouraging conditions. Second, homophonic errors clearly depend on target's identity, as they always correspond to the target's mate. The increased likelihood of guessing dominant homophones must reflect their level of activation. To explain why the activation of dominant mates is increased by reinstating the phonology of their subordinate mates, it is further necessary to assume that these errors are triggered by the activation of the subordinate mate via its phonology. This guessing explanation is merely a relabeling of our phonological account.

Thus, the erroneous reports of dominant mates demonstrate that subordinate homophones activate their dominant mates via a common phonology. The sensitivity of homophonic errors to phonology, despite null phonemic-masking effects in correct target identification, further demonstrates that these null effects are not due to the absence of reliance on phonology.

GENERAL DISCUSSION

Verstaen et al. (1995) observed that the presentation of a block of homophones leads to null phonemic-masking effects. In their account, these null effects reflect the absence of reliance on phonology. The results of Experiments 1 indicate that homophones indeed exhibit null phonemic-masking effects under certain conditions. However, the pattern of results emerging from our subsequent studies cannot be easily explained by assuming that reliance on phonology is eliminated.

A strategic adjustment of the reliance on phonology over time should depend on the position of the strategy-inducing element. According to Verstaen et al. (1995), their mixed block of homophones induces a no-phonology strategy, a strategy that is maintained for a subsequent block of nonhomophones. Thus, a strategy shift account must demonstrate a *systematic* link between the phonemic-masking effect and the position of these homophones. This account was tested in Experiment 2. Our manipulation followed a simple logic: If one block of homophones is sufficient to invoke a no-phonology strategy, then surely two blocks of homophones should yield null phonemic-masking effects. Contrary to this prediction, and despite the relative high frequency of these targets, Experiment 2 demonstrates a significant phonemic-masking effect following two blocks of homophones.

We claim that the resurrection of the phonemic-masking effect for dominant homophones cannot be explained by invoking a reshift from a no-phonology strategy (in the first block) into a phonological strategy (in the second). We considered two strategy reshift explanations for our positive findings. On one account, the shift back to phonology is induced by the dominance of the homophones in the second block. This explanation, however, is inconsistent with the no-phonology account for the findings of Verstaen et al. (1995). If the dominance of a single spelling encourages reliance on phonology, then certainly the nonhomophones used in the second block of Verstaen et al.'s discouraging condition should have produced such a shift, contrary to the original claim. Our results are also incompatible with the claim that the reliance on phonology in our second block is caused by some "fatigue" in discouraging phonology. Contrary to the null phonemic-masking effects in the first block of Experiments 1, 2, and 4, Experiment 3 demonstrated significant effects in the first block. Null phonemic-masking effects in the second block were observed in Experiments 1 and 3. Thus, there is no evidence that participants systematically shift their reliance on phonology depending on the position of the dominant or subordinate homophones in the experiment.

Given the inadequacy of the "strategy shift" account, we turn now to an alternative explanation. This account does not assume any change in reliance on phonology across the four experiments. The entire pattern of positive and null phonemic-masking effects is predicted from the relative stability of the homophone's spelling compared to its competitors. In contrast to the contradictory links between block order and phonology effects, there is a clear and systematic link between the dominance of the homophones and the emergence of phonemic-masking effects. Dominant homophones yield significant phonemic-masking effects (Experiment 2 and 3); subordinate homophones do not (Experiment 1 and 4). In each case, the effect of dominance replicates across block positions.

We suspect that the null effects observed by Verstaen et al. (1995), and replicated by using these materials in Experiments 1 through 3, are at least partly caused by the failure to discriminate between these two types of homophones. Although separate analyses of their dominant and subordinate targets did not reveal a significant facilitation by the pseudohomophone mask relative to its graphemic control for either dominant or subordinate targets in our experiments, subsequent experiments using the same materials replicated the pattern of results observed with our new set of homophones. These experiments (Berent & Van Orden, in press) examined phonemic-masking effects by using the homophones of Verstaen et al. in conditions that either discourage or encourage reliance on phonology. Their findings revealed a sizable phonemic-masking effect (8%) in correct target identification for dominant homophones under either phonology-encouraging or phonology-discouraging condition. In contrast, no evidence for facilitation was observed for subordinate homophones ($\Delta = -3.8\%$, $\Delta = 1.9\%$ for the phonology-encouraging and phonology-discouraging condition, respectively). Given the small number of dominant homophones in the mixed set of homophones used by Verstaen et al. (about half the number of items used in our pure block), and their weaker, between-items manipulation of dominance (contrary to the within-homophone pair and within-mask manipulation in our design), the failure to observe this pattern in these experiments may well be due to random variability.

The effect of dominance on the phonemic-masking effect is readily explicable in terms of a spelling competition mediated by phonology. The reinstatement of a homophone's spelling by a pseudohomophone mask activates multiple spellings: The pseudohomophone activates not only the target's correct spelling but also that of its competitors. In addition, it introduces an incorrect spelling of its own. The benefits of reinstating the target's phonology thus come at the price of activating inconsistent spellings. The balance between the benefits and costs associated with the pseudohomophone depends on the relative dominance of the target's spelling. Dominant homophones benefit from the reinstatement of their phonology because the activation of their own correct spelling is stronger than their competitors'. Conversely, for subordinate homophones, phonology activates a highly noisy spelling that is governed by their competitors' spellings.

Our findings provide several pieces of evidence suggesting that the null phonemic-masking effects with subordinate homophones are due to the activation of inconsistent spellings via a shared phonology. First, subordinate homophones result in a significant increase in homophone errors, regardless of block position. Second, homophone errors are linked to a shared phonology. Homophonic errors were significantly more frequent in the presence of the pseudohomophone mask relative to its graphemic control in the second block of Experiment 4. The meta-analysis conducted on our new set of homophones indicated that these effects are primarily due to subordinate homophones. Similar findings were obtained in an additional line of research we pursed by using the materials of Verstaen et al. (1995; Berent & Van Orden, in press). Replicating the findings of Experiment 4, Block 2, these materials yielded a significant increase in homophonic errors in the presence of the pseudohomophone relative to the graphemic mask, indicating the phonological source of these errors. More important, the outcomes of this competition was modulated by dominance. Homophone errors for subordinate, but not dominant, targets increased significantly in the presence of the pseudohomophone mask relative to its graphemic control, regardless of the strategy manipulation. This finding agrees with the view of subordinate homophones as subject to a competition from their dominant mates, a competition mediated by phonology. Thus, the attribution of null phonemic-masking effects with subordinate homophones to phonological competition is not only parsimonious in its ability to account for our entire set of data, but is, in fact, directly supported by our findings.

Why does reading a homophone result in the activation of its competitors? In one view, the activation of spelling by phonology is a phenomenon that is restricted to whole-word spellings (Peerman, Content, & Bonin, 1998).[5] Conversely, the activation of spelling by phonology may reflect a more general principle—namely, feedback inconsistency. Feedback inconsistency is the association of a phonological units with multiple spellings. Feedback inconsistency is known to impair the identification of printed words, both unmasked and masked (S. J. Frost, Fowler, & Rueckl, 1998; Stone et al., 1997; Ziegler et al., 1997). Homophones are the quintessential example of feedback inconsistency. Their inconsistency is not simply a matter of rimes and bodies; it involves whole-word pronunciations, spellings, and meanings. As with feedforward competition (Jared, 1997; Jared et al., 1990), the outcomes of the competition evoked by feedback inconsistency depends on the relative strength of the competing elements.[6] Dominance may thus present another example of feedback inconsistency. Feedback inconsistency, however, is a phonological principle. It is activation of homophones' competitors via a common phonology that allows dominance to modulate the phonemic-masking effect. Thus, both the presence or absence of phonemic-masking effects are phonology effects.

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[5] Peerman et al.'s (1998) account is motivated by their repeated failures to detect feedback inconsistency in French after controlling for familiarity. However, their reanalyses of Stone et al.'s (1997) English findings revealed significant effects of feedback inconsistency even after the effect of familiarity was partialled out. Furthermore, the lower familiarity of feedback inconsistent words may reflect systematic effects of feedback inconsistency rather than random error in the selection of inconsistent targets (see also S. J. Frost et al., 1998).

[6] The tendency of dominant homophone to benefit from a nonword sharing its phonology may be affected by task demands (e.g., whether a nonword prime precedes or follows a word target or whether the word must be fully identified, as here, or merely recognized as a word, as in lexical decision). Forward priming studies demonstrate costs in lexical decision performance for high frequency words primed by a nonword or a word prime sharing their spelling or phonology (Colombo, 1986; Lukatela & Turvey, 1990). These costs may be explained by lexical inhibition by using Grossberg's (1978) principle of self-modulation—namely, the modulation of net facilitatory and inhibitory input to a unit by the unit's current activity level (Lukatela & Turvey, 1990). A dominant homophone should be more strongly activated by a preceding pseudohomophone (or homophone) prime than its subordinate mate. Hence, its

Our results join a growing family of related findings. For example, it has become commonplace to counter null or marginal phonology effects with reliable positive effects in more refined studies (compare Andrews, 1982, with Berent, 1997, and Stone et al., 1997; compare Brysbaert & Praet, 1992, with Xu & Perfetti, 1999; compare Davelaar, Coltheart, Besner, & Jonasson, 1978, with Pexman et al., 1996; compare Jared & Seidenberg, 1991, with Nielson, 1991; Nielson & Van Orden, 1992; and Stone & Van Orden, 1993; compare Hawkins et al., 1976, with Hooper & Paap, 1997; compare Gibbs & Van Orden, 1998, with Pugh, Rexer, & Katz, 1994, etc.). Concurrently, it becomes commonplace to observe phonology effects under methodological conditions thought to be phonology discouraging (e.g., Azuma & Van Orden, 1997; Berent, 1997; Berent & Perfetti, 1995; Bosman & de Groot, 1996; Gibbs & Van Orden, 1998; Lukatela & Turvey, 1993; Lukatela, Savi´c, Urosevi´c, & Turvey, 1997; Peter & Turvey, 1994; Pexman et al., 1996; Stone & Van Orden, 1993; Ziegler & Jacobs, 1995; Ziegler, Van Orden, & Jacobs, 1997).

Each contradiction of a reported null phonology effect also questions a logic that accepts null effects as evidence for "no reliance on phonology." Instead, the primary utility of reported null phonology effects has been the impetus they provide for a more refined and subtle understanding of how phonology constrains reading performance. Null phonology effects cannot be trusted to signify "absent reliance on phonology," and they cannot be signify a "no-phonology process in reading" (see Van Orden et al., 1990, 1992, 1997, for more extensive discussion of this issue). Superficial effects of phonology variables, like the effects of all cognitive variables, are modulated by task and stimulus contexts. However, underlying phonologic constraints may not be strategically eliminated (Berent, 1997; Gibbs & Van Orden, 1998; Stone & Van Orden, 1993). To perceive a printed word is to engage its phonology.

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lexical node may be more strongly inhibited on its subsequent presentation as a target. It is thus conceivable that the forward priming of a high frequency, dominant target by a pseudohomophone (or its subordinate mate) could inhibit its identification (although this prediction is not forced by our results and discussion). A test of this prediction, using high-frequency, dominant homophones, awaits future investigation. Note, however, that, regardless of direction (i.e., cost or benefit), any differential effect of a pseudohomophone (or a homophone) compared to a graphemic control must implicate phonology.

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APPENDIX A
Subordinate Homophones and Corresponding Pseudohomophone, Graphemic, and Control Masks

barque	BARC##	BARG##	LING##
bass	BACE	BAFE	KRIX
berth	BURTH	BEETH	PLOOK
billed	BILD#	BULDE#	GROR#
bored	BORD#	BORK#	PRIK#
caul	KAWL	LAWL	GRED
chews	CHOOZE	CHOO	MEBLANDY
sercle	CIRKLE	CIRBLE	GOONTA
clothes	CLOZE##	CLOME##	MIMPY##
dew	DOO	DRA	NUR
genes	JEENZ	JERNT	CROCO
quay	KEE#	KEB#	POG#
lien	LEEN	LERN	PROG
lo	LOE	LOF	KEL
maul	MAWL	MAUB	PIGE
mown	MONE	MOND	KLAX
knew	NUE#	KLE#	POF#
knight	NITE##	NITH##	SMED##
won	WUN	WOH	DRA
ceil	CEEL	CRIL	BROR
shone	SHOAN	SHOBE	TRATY
chute	SHUTE	CRUTE	PLEEG
towed	TODE#	TOWBE	SHOZZ
vary	VAIRY	VANRY	PLOKA
hoarse	HORCE#	HORGE#	BLUGZ#
root	RUTE	ROUE	BINB
serf	SURPH	SURGH	MONGH
rode	WRODE	GORDE	SHMAZ
paced	PAIST	PASHT	GRING
poll	POAL	PROL	TRAX
cellar	SELLAR	GELLAR	BLONBY
seam	CEEM	LEEM	KROG
bate	BAYT	BAST	GLOG
ate	AIT	ANE	DAX
fare	PHARE	SLARE	CHONG
pleas	PLEEZE	PLENGE	BRAGDY
cede	CEED	CADE	PROL
chord	KORD#	RORD#	DENG#
wade	WAID	WADZ	BALB
hoes	HOZE	HOGE	MARM
cote	KOTE	FOTE	BENB
queue	KUE##	LUE##	NAX##
sail	SAYL	SARL	BINB

(Continued)

APPENDIX A (*Continued*)

brows	BROWZ	BROWG	MIXDA
creak	KREEK	DREEK	PLITH
yolk	YOWK	YOSK	BRIX
bruit	BROOT	BRAST	DENGH
pail	PAYL	PARL	CROD

APPENDIX B
Dominant Homophones and Corresponding Pseudohomophone, Graphemic, and Control Masks

bark	BARC	BARG	LENG
base	BACE	BAFE	KRIX
birth	BURTH	BARTH	PLOOK
build	BILD#	BULD#	GROR#
board	BORD#	BROD#	PRIK#
call	CAWL	CHAL	GRED
choose	CHOOZE	CHOOME	BLANDY
circle	CIRKLE	CIRBLE	GOONTA
close	CLOZE	CLOME	MIMPY
due	DOO	DRA	NER
jeans	JEENZ	JERNT	CROCO
key	KEE	KEB	PAG
lean	LEEN	LERN	PROG
low	LOE	LOF	KEL
mall	MAWL	MALZ	PIGE
moan	MONE	MOND	KLAX
new	NUE	NAD	POF
night	NITE#	NITH#	SMED#
one	WUN	BON	DRA
seal	CEEL	BERL	CROR
shown	SHOAN	SHARN	TRATY
shoot	SHUTE	SHATH	PLEEG
toad	TODE	TODZ	SHOZ
very	VAIRY	VANRY	PLOKA
horse	HORCE	HORGE	BLAGZ
route	RUTE#	ROUE#	BINB#
surf	SURPH	SURGH	MONGH
road	WRODE	GORAD	SHMOZ
paste	PAIST	PASHT	GRING
pole	POAL	POTE	TRAX
seller	CELLER	GELLER	BLONBY
seem	CEEM	LEEM	KRAG
bait	BAYT	BAST	GLEG
eight	AIT##	HIG##	DAX##
fair	PHARE	SLARE	CHONG

(*Continued*)

APPENDIX B (*Continued*)

please	PLEEZE	PLENGE	BRAGDY
seed	CEED	GEED	PROL
cord	KORD	RORD	DENG
weighed	WAID###	WEGH###	BALB###
hose	HOZE	HOGE	MARM
coat	KOTE	FOTE	BENB
cue	KUE	LUE	NAX
sale	SAYL	SARL	BINB